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Review Article

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Reliability of Cardiac Percussion Technique to Determine Left Ventricular Geometry in Comparison with Transthoracic Echocardiography

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Abstract

Background: *Cardiac percussion (CP) is a bedside technique to evaluate cardiac borders and chamber size. Although advanced cardiac imaging has revolutionized the methods to detect cardiomegaly, art of CP remains the most convenient option, especially in emergent situations. Although transthoracic echocardiography (TTE) is considered the gold standard to determine left ventricular (LV) size, CP can estimate LV size with equal accuracy as TTE in appropriate clinical setting. The aim of this study was to investigate the correlation of LV size assessed by CP technique versus standard TTE, as well as cardiothoracic ratio (CTR) on chest roentgenography (CXR).*

Methods: *This descriptive study was conducted on Telemetry units. Patients were positioned in supine position at Gatch angle of 30-45 degrees. Cardiac dullness was measured in cm by percussing from mid clavicular line towards gladiolus of sternal body. Subsequently, findings were correlated with TTE dimensions of left ventricular end-diastolic diameter (LVEDD).*

Results: *In 200 patients, mean age was 63+15.8 years, with 51% females. The LV diameter (LVD) measured by CP technique was observed to be similar to LVEDD measured by TTE (Mean- 4.65+0.67 cm versus 4.69+0.76 cm, COV 7.6%). The Bland-Altman comparison of CP technique and TTE measurements indicated significant differences in variances between the two measures (r=0.270, p=<0.001). The LVD measured by CXR did not show correlation with LVEDD (5.79+1.21 cm, COV 14.3%) with significant differences in the variances between the two measures (r=-0.475, p<0.001). The LV volumes measured by CP technique were observed to have correlation with LV volumes measured by TTE (COV 14.9%).*

Conclusion: *CP technique is a convenient bedside method that can be utilized to assess LVD and volume. It is shown to have a precise correlation with LVEDD measured by TTE. The study emphasizes role of bedside estimation of LV size by using the art of physical examination.*

Keywords: Cardiac Percussion, Left Ventricular Geometry, Cardiothoracic Ratio

Introduction

The history and physical examination remain the backbone of medical evaluation and assessment [1]. Several recent studies have described a deterioration in physical examination skills among modern physicians [2, 3]. Cardiac percussion (CP) technique has been historically utilized to assess cardiac borders and size. It dates to 1950, when William Dressler proclaimed that CP can be useful in the determination of mitral stenosis, tricuspid regurgitation and pericardial effusion. With recent advancements in diagnostic testing, the skill of physical examination is fading to an extent that physicians are relying more on imaging techniques. However, it has been emphasized by Heckerling et al that CP can have diagnostic yield if applied in a classic setting with an appropriate indication and population [4]. In the ancient literature, its utilization is considered gratifying for clinicians as well as for the patient.

In early 1990s, the accuracy of CP technique was compared to radiographic techniques with reproducible results and reliable correlation between chest roentgenography (CXR) and apical impulse palpation [3, 4]. Later, Ehara et al determined by utilizing CT scanning techniques that the left ventricle (LV) apex beat can be reliably used to estimate LV mass [5]. Additionally, transthoracic echocardiography (TTE) has shown to predict (LV) enlargement in limited data with good specificity (91%) [6]. In another study, percussion dullness distance in the left fifth intercostal space was the best discriminator of LVEDV and LV mass [7]. This indicates that CP technique can have a role in the estimation of cardiac geometry, but the data remains elusive.

The role of CP technique in the current clinical world is questioned due to its limitation in diagnosis. Many physicians argue about its significance when innovative imaging techniques are available [1]. However, in emergent situations and when technology is unavailable, its usefulness cannot be denied. Another interesting application of CP technique is during the current COVID-19 pandemic when TTE is not readily available. In such situations, CP method can be used at the bedside to estimate cardiac geometry and pericardial effusion with accuracy.

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Methodology

Study Design

This was an observational study conducted on patients admitted to the Telemetry unit as well as those who underwent TTE and CXR. Pregnancy, age less than 18 years of age, chest trauma, skin infection, refused verbal consent or any other contraindications for CP technique were excluded from the study. The CP technique was performed on the patients and findings were correlated with TTE dimensions of left ventricular end-diastolic diameter (LVEDD) during the same hospitalization. Additionally, the CTR on CXR was assessed. Electronic medical records were used to evaluate the demographics of each patient. The physicians conducting CP technique were blinded from clinical history and imaging findings. The primary objective of the study was to compare the techniques used to estimate the LVEDD. The study was approved by the BronxCare Institutional Review Board (IRV#110917 04).

Cardiac Percussion Technique

As part of physical exam and after obtaining verbal consent, the patient was positioned at a Gatch angle of 30-45 degrees. Cardiac dullness was assessed by percussing from the mid clavicular line toward the gladiolus of the sternal body. (Figure-01) A ruler was then utilized to measure the LV size (cm) and the reference point (middle left parasternal border) [7]. Subsequently, the findings were correlated to the TTE dimensions of LVEDD during the same hospitalization. The parasternal long-axis view was used to measure LVEDD, using the leading-edge convention, as recommended by the American Society of Echocardiography [8]. Additionally, we assessed the CTR on CXR (PA or AP view based on availability) by using ruler to measure the distance between left sternal border to left cardiac silhouette [9]. Teichholz method was used to calculate LV volumes using the Teichholz formula, Volume = $7D^3/(2.4+D)$ [10].

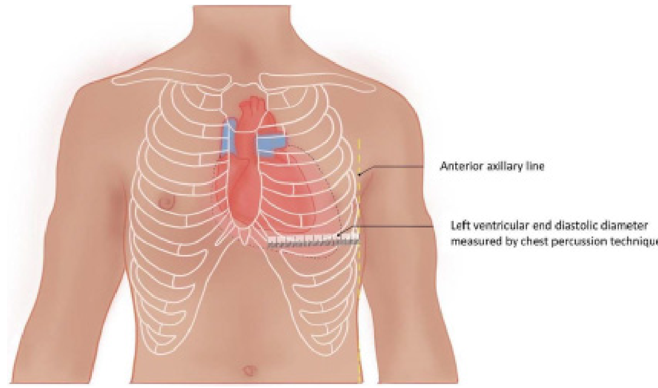

Figure 1: LVEDD Measurement by CP Technique

Statistical Analysis

Descriptive statistics were reported using mean(+/-SD) for the LV measurements. Bivariate linear regression with Coefficient of variation (COV) was used to estimate the variability in each estimate. Due to the evidence of non-normal distribution of the continuous variables, as evaluated by using Shapiro-Wilk W test for normal data, we used Spearman's rank correlation method to assess the correlation between measurements. Bland-Altman plots were also created to compare any pair of measurements using their mean as x-axis and difference as y-axis with Pitman's test to examine the significant difference in variance between the two measurements. Akaike's information criterion (AIC) for model fit were used to select the bivariate model that better predicted LVEDD.

Results

The average age of the 200 patients was 63 (±15.82) years, with females constituting 51% of the patients. The average BMI was 28.45 kg/m2 and 33% had a normal BMI. Among the patients included, 22% were observed to have heart failure diagnosis. The agreement in the LV diameter measured by CP technique was observed to be similar to LVEDD **(Figure 2a)** measured by TTE (Mean 4.65 ±0.67 cm versus 4.69 ±0.76 cm respectively, coefficient of variation after regressing LVEDD by TTE on LV diameter measured by CP, COV=7.6%). The bivariate linear regression indicated that for every 1-unit increase in LV diameter measured by CP, LVEDD also increase by equal amount (i.e. 1 unit; Coefficient=1.01 [95% CI=0.93, 1.08], p<0.001) **(Figure 2b)**. The Coefficient of variation (COV) was low i.e. 7.6% indicating less variability and that the data points are closer to the regression line. The AIC was computed to be 156.99. There was a strong correlation (rho=0.84, p<0.001) between the measurements by the two techniques. However, the Bland-Altman with Pitman's test comparing CP technique and TTE measurements indicated significant differences in the variances between the two measures (r=0.270, p=<0.001). The LV diameter measured by CXR was observed to have weaker correlation (rho=0.42, p<0.001) with

LVEDD **(Figure 3a) (Figure 3b)** (Mean 5.79 ±1.21 cm versus 4.65 ±0.67 cm, COV 14.3%) with significant differences in the variances between the two measures (r=-0.475, p<0.001). The AIC was 411.24. The LV volumes measured by CP technique were observed to have strong correlation (rho=0.84, p<0.001) with LV volumes measured by TTE (Mean 66.5 ±23 ml versus 65 ±19 ml, COV 14.9%) **(Figure 4)**. The AIC was 1484.14. The Bland-Altman with Pitman's test comparing CP technique and TTE measurements indicated significant differences in the variances between the two measures (r=0.341, p=<0.001). With lower AIC and lower variance, we observed accurate and reliable estimation of LV dimensions by using CP technique. The interobserver variability was 0.5cm and intra-observer variability was 0.2cm. Table-01 represents the baseline demographics of the study population. Table-02 represents the subgroup analysis of LVEDD by CP technique, TTE and CXR based on age, BMI, gender and history of CHF.

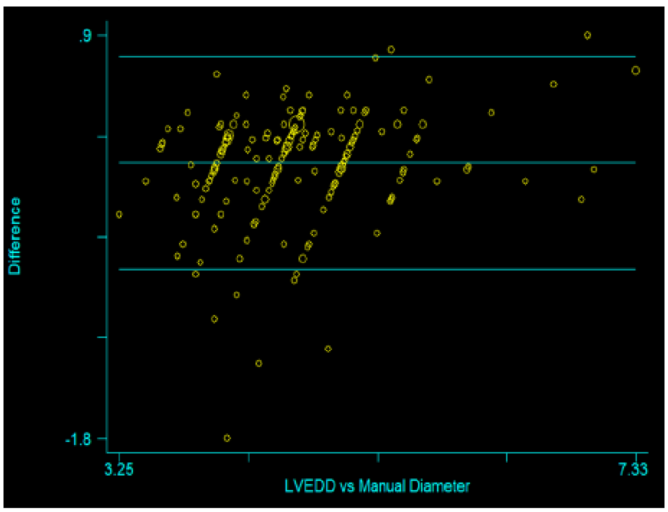

Figure 2a: CP Technique LV Diameter as Compared to TTE LVEDD.

Abbreviations:

LV= Left Ventricle
LVEDD= Left Ventricle End Diastolic Diameter

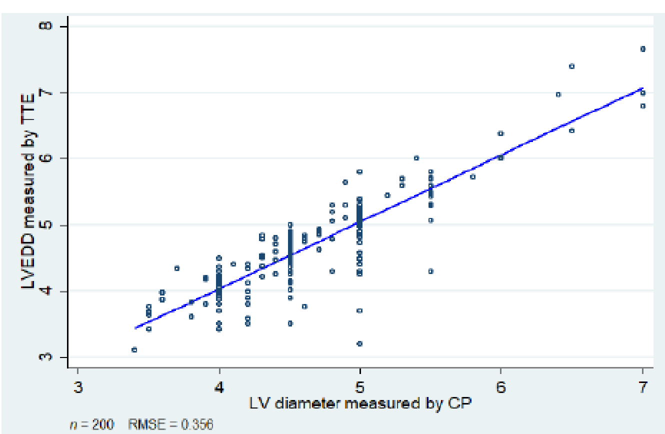

Figure-2b: Bivariate Linear Regression Showing Relationship Between LVEDD by CP Technique and TTE.

Abbreviations:

LV= Left Ventricle
LVEDD= Left Ventricle End Diastolic Diameter
CP= Cardiac Percussion
TTE= Transthoracic Echocardiogram

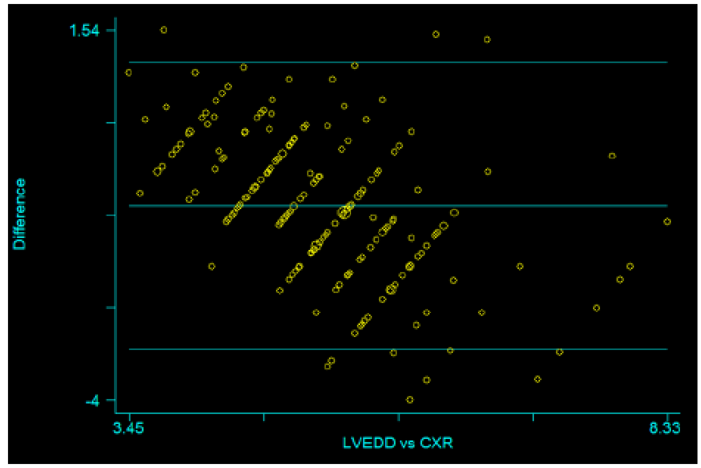

Figure 3a: TTE LVEDD Compared to CTS CXR.

Abbreviations:

TTE= Transthoracic Echocardiogram
CTS= Cardiothoracic Size
CXR= Chest Xray
LV= Left Ventricle
LVEDD= Left Ventricle End Diastolic Diameter

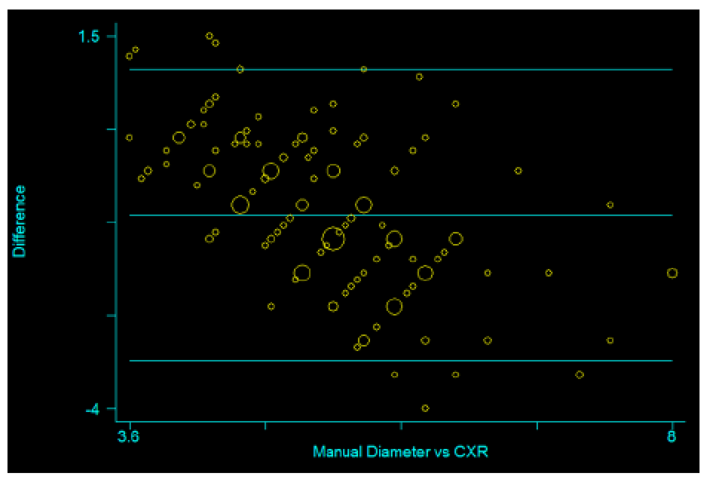

Figure 3b: CP LV Diameter Compared to CXR CTS.

Abbreviations:

TTE= Transthoracic echocardiogram
CTS= Cardiothoracic size
CXR= Chest Xray
LV= Left ventricle
LVEDD= Left ventricle end diastolic diameter

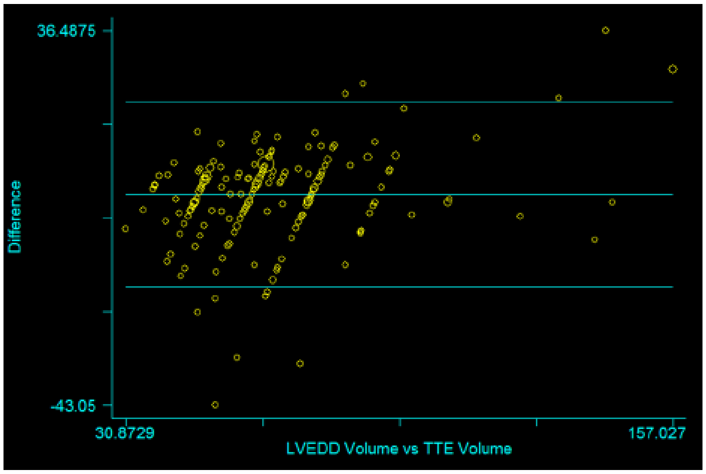

Figure 4: CP LV Volume Compared to TTE LV Volume

Abbreviations:

TTE= Transthoracic Echocardiogram
CTS= Cardiothoracic Size
CXR= Chest Xray
LV= Left Ventricle
LVEDD= Left Ventricle End Diastolic Diameter

Table 01: Demographic and Clinical Information All Patients

Variables	CP technique (N=200)	p value
Age	63 (15.9)	0.190
Gender (females)	101 (51%)	0.856
BMI	28.5(6.98)	0.217
Ethnicity (Hispanics)	111(55%)	0.233
CHF	42(22%)	0.326
Hypertension	110(55%)	0.186

Table 02: Subgroup Analysis of LVEDD Based on Age, BMI, Gender, and History of CHF

	LVEDD by CP	LV VOLUME by CP	LVEDD by CXR	LVEDD by TTE
Age (years)				
<55	4.74+/-0.77	67.37+/- 23.53	5.90 +/-1.33	4.89+/- 0.81
>55	4.61+/-0 .63	63.35+/-18.43	5.75+/-1.16	4.63+/-0 .74
BMI (kg/m2)				
<25	4.56+/-0 .55	61.54+/- 14.83	5.76+/- 1.27	4.60+/-0 .61
>25	4.70+/-0 .73	65.97+/- 22.12	5.80+/-1.17	4.75+/-0.83
Gender				
Male	4.73+/-0 .66	66.71+/- 19.95	5.81+/-1.21	4.80+/-0.77
Female	4.56+/-0 .67	62.04+/-19.56	5.77+/-1.21	4.58+/-0.75
CHF	5.13+/-0.89	79.22+/- 28.68	6.35+/- 1.38	5.19+/- 1.07
Without CHF	4.51+/-0.54	60.21+/-14.71	5.70+/-1.08	4.59+/-0.59

Discussion

To the best of our knowledge, this study is the first to validate CP technique as a diagnostic modality and demonstrated the correlation of cardiac geometry (LV diameter and volume) by physical examination with TTE measurements. Furthermore, we demonstrated that dimensions of cardiac geometry calculated by CXR do not correlate well with TTE.

TTE has always been considered as a gold standard of LV size and volume. Heckerling and colleagues described in 103 subjects that percussion of the precordium can be utilized with accuracy to exclude cardiomegaly due to increased LVEDV or LV mass [4]. In their study, CT scan of the heart was used, and LV apex beat was palpable only in one-half of the subjects. In another study on 200 subjects, the LV apex beat was reliably implemented to exclude cardiomegaly when assessed in the supine position [5]. Although it described accurate correlation, the clinical application was poorly described. On the other hand, Eilen et al concluded in 40 subjects using TTE that cardiac percussion is not a good predictor of LV size especially in the setting of LV hypertrophy (LVH) [6-11]. In our study, we observed accurate and reliable correlation of LV dimensions by using CP technique in comparison with TTE irrespective of underlying medical condition (Table 02).

CTR has been considered the most common interpretation of cardiac size on CXR [9-15]. Frishman and colleagues demonstrated that cardiomegaly on CXR is a poor prognostic factor and can be translated to higher mortality regardless of the cause [16]. Similarly, another study on 197 subjects indicated that CXR guided TTE to assess cardiac dimensions increases the diagnostic yield at a reduced cost [17]. On the other hand, Clark et al suggested that CXR is an unreliable indicator of the LV dimension compared to TTE and multigated acquisition radionuclide ventriculography (MUGA) [9]. In our study, we did not see any correlation of CXR based LV dimensions with either CP technique or TTE. This could be due to the fact that we utilized any available CXR image to calculate dimensions instead of posteroanterior (PA) view only.

Age and underlying medical conditions are reported to have limitations in accurate estimation of LV dimensions by physical exam techniques [18, 19]. In a study on 100 hospitalized subjects, LV apex beat percussion as well as CXR dimensions are not considered a reliable tool to predict cardiac size in an elderly population [18]. The author described it due to the thoracic cage abnormalities in the higher age. In our study, the mean age observed was 64 years. Similarly, baseline LVH was not included in many studies, as it was often associated with variable findings. Additionally, we found 22% of our subjects had congestive heart failure (CHF) as a co-morbid condition. Obesity is reported to be a limitation, with lean population included in the majority of the cases [19]. Our population had an average BMI of 28 Kg/m2, which indicates that higher BMI may not be a limitation for CP technique (Table 02).

Although many physicians argue about the utilization of CP technique in clinical practice, our data indicates that CP technique can be applied at the bedside in an appropriate clinical setting. An interesting application is during the COVID 19 pandemic, when use of CXR and TTE was restricted. The CP technique can be useful in estimating cardiac borders and pericardial effusion in conjunction with biochemical testing. Similar application is in rural areas and emergent situations when advanced techniques are unavailable. Our experience showed that clinical expertise is required to implement the CP technique. Since our study was conducted by an experienced cardiologist and hospitalist, this might have provided more precise measurements. Therefore, we did not notice a wide range of interobserver variability in this study. We also noticed that experience can be easily gained by practice under supervision of an expert clinician.

Our study has certain limitations. First of all, our population was hospitalized patients. We did not include the outpatient population. Secondly, we did not relate our findings to outcomes such as mortality. Thirdly, our study was conducted by expert clinicians so we cannot conclude that similar results can be obtained by non-expert physicians. Fourth, we included all available CXR irrespective of anteroposterior (AP) or PA views to record measurements, which may have generated different results. Lastly, we did not include complex conditions such as patients with mechanical ventilation, COPD, pleural effusions, and dementia.

Conclusion

Our study showed that CP technique can reliably be utilized to estimate LV geometry when implemented in an appropriate clinical setting. It can be useful in situations when advance imaging techniques are not readily available. Future studies with a larger sample size are required to validate our findings.

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