Cardiovascular Topics

Evaluation of left ventricular enlargement in the lateral position of the chest using the Hoffman and Rigler sign

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Summary

***Objective*: To evaluate left ventricular enlargement in the lateral projection of the chest using the Hoffman and Rigler sign.**
***Background*: The Hoffman and Rigler sign for determining left ventricular enlargement was suggested as early as 1965 before the routine use of echocardiography.**
***Methods*: We studied 136 patients who had had cardiac ultrasound and chest X-rays with lateral projections. We assessed left ventricular size on the lateral projection using the Hoffman and Rigler method (measurement A) and compared this measurement to the value obtained by cardiac ultrasound. The effect of right ventricular size on this measurement was also evaluated.**
***Results*: The average value of measurement A in all patients with echocardiographic evidence of left ventricular enlargement (LVED above 59 mm) was 19 mm (SD ± 4.03) (95% CI 17.96 to 20.04). Of the 48 patients with a normal size left ventricle on echocardiography, 25.58% had measurement A 18 mm and above, and 13.95% had a value 19 mm and above. Of the 19 patients with right ventricular enlargement (normal left ventricle) on echocardiography, 36.84% had measurement A 18 mm and above, whereas 21.05% had this value 19 mm and above. Measurement A in patients with left ventricular enlargement compared with those with right ventricular enlargement showed a significant difference ($p < 0.05$).**
***Conclusions*: When the crossing of the inferior vena cava and the left ventricle can be adequately visualised, the Hoffman and Rigler sign of evaluating left ventricular enlargement in the lateral projection of the chest is a valuable alternative where cardiac ultrasound is not readily available.**

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Chest radiography is often the first and sometimes the best investigation means by which a clinician can evaluate cardiac chamber enlargement. Although the cardiothoracic ratio in the posteroanterior projection of the chest has been traditionally employed to estimate cardiac size, there is evidence to suggest that some early cases of left ventricular enlargement will be missed if the posteroanterior view alone is used. It has long been recognised that the enlargement of the left ventricle occurs more posteriorly than laterally, and Parkinson first made this point in 1942.[1]

Hoffman and Rigler proposed the determination of left ventricular enlargement using the lateral projection of the chest in their article in *Radiology* in 1965.[2] In this article they concluded that when the posterior border of the left ventricle extends posteriorly to the posterior border of the inferior vena cava by more than l8 mm at a level 2 cm above the crossing of the inferior vena cava and the left ventricle on a

lateral projection of the chest in an adult, one can postulate left ventricular enlargement with a considerable degree of certainty. A suggestion regarding the use of the lateral view for evaluating left ventricular enlargement had been made earlier on by Eyler and associates in an article in *Radiology* in July 1951.[3] Their article had looked at left ventricular enlargement in patients with rheumatic heart disease and one of their conclusions had been that when the left ventricle was enlarged, it has in most cases projected behind the shadow of the inferior vena cava for a distance of 15 mm or more.

In their article, Hoffman and Rigler pointed out the fact that the crossing of the inferior vena cava and the left ventricle is poorly defined in many cases. As a result, a number of factors may invalidate this method as a tool for determining left ventricular enlargement, whereas in those cases where this junction is clearly defined, this method should be of diagnostic value. However, Eugene Braunwald[4] argues in his textbook on cardiology that although the Hoffman and Rigler sign may be helpful, it is far from being accurate because of the obliquity of the chest and the backward displacement of the left ventricle owing to right ventricular enlargement, which may influence this measurement.

To evaluate the accuracy of this sign as well as the effect of the right ventricle on it, we looked at a series of patients who had had chest X-rays with lateral projection as well as cardiac ultrasound, and correlated the radiological findings with the echocardiographic findings. Whereas Hoffman and Rigler made use of autopsy studies as comparatives for their radiological findings, the advent of previously unused technology such as echocardiography would offer a much better and easier alternative to review Hoffman and Rigler's original work of more than 30 years ago.

At the onset of this study we took cognisance of the fact that at any tertiary institution it may be difficult to find subjects with normal cardiac ultrasound dimensions or lateral chest films. However, this challenge to find sufficient relevant comparables in each of our groups encouraged the need for this type of study. We were further motivated by the fact that the results of such a study may he useful in assisting bedside management of patients and in providing cost-effective decision making. It is also worthwhile to highlight the fact that in most secondary and smaller hospitals in South Africa and in most Third World countries for that matter, echocardiography is unavailable. If therefore the accuracy of a simple radiological measurement like this can be validated, this can, in support of history, physical findings and electrocardiogram (ECG) evidence, assist the clinician in detecting left ventricular enlargement with much more certainty in the absence of echocardiography.

Methods

Selection of patients

We randomly selected 464 patients over the age of 14 years who had undergone echocardiography at Tygerberg academic complex in the Western Cape, South Africa, between January 1998 and December 1999. These patients were divided into the following categories according to the echocardiographic findings:

- those with normal-sized chambers [left ventricular end diastolic diameter (LVED) ≤ 58 mm]
- those with enlarged left ventricle (LVED ≤ 59)[5-7]
- those with right ventricular enlargement only, and
- those with left atrial enlargement but normal left ventricle.

All our patients considered to have normal ventricular size on echocardiography had a LVED of 58 mm or less. We used a cut-off LVED measurement of 59 mm or above to indicate left ventricular (LV) enlargement. Those patients who had had chest X-rays with lateral projection within three months of the echocardiography were then considered for the study. Exclusion criteria were divided into technical and non-technical reasons and incorporated films in which the visualisation of the crossing of the inferior vena cava and the posterior border of the left ventricle was poor. These were, in order of frequency, (i) poor technique, (ii) significantly large pleural effusions, (iii) lung parenchymal disease overlying the lower lung fields, (iv) anomalies involving cardiac rotation, and vertebral deformities, and (v) those cases where the date difference between echocardiography and chest X-ray was more than 3 months.

Study design and materials

The enlargement of the left ventricle was determined both in the posteroanterior and the lateral projection. Enlargement in the posteroanterior projection was determined using the cardiothoracic ratio with the use of a 30-cm measuring ruler (which we regard to be an instrument accessible to even those physicians in remote areas) while the Hoffman and Rigler method was used to measure the enlargement of the left ventricle in the lateral projection. The later is depicted in Fig. 1 as measurement A. This measurement is determined by drawing a 20-mm line upward along the inferior vena cava from the point where the left ventricle and the inferior vena cava cross in the lateral projection. At the upper end of this line, a second line is drawn posteriorly parallel to the

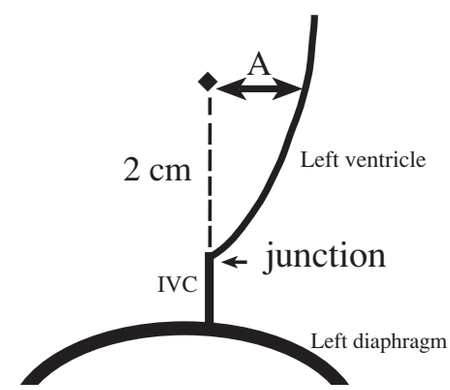

Fig. 1. Measurement A is determined by drawing a 20-mm line upward along the inferior vena cava from a point where the left ventricle and the inferior vena cava cross in the lateral projection. At the upper end of this line, a second line is drawn posteriorly, parallel to the vertebral bodies up to the point where it crosses the posterior margin of the left ventricle.

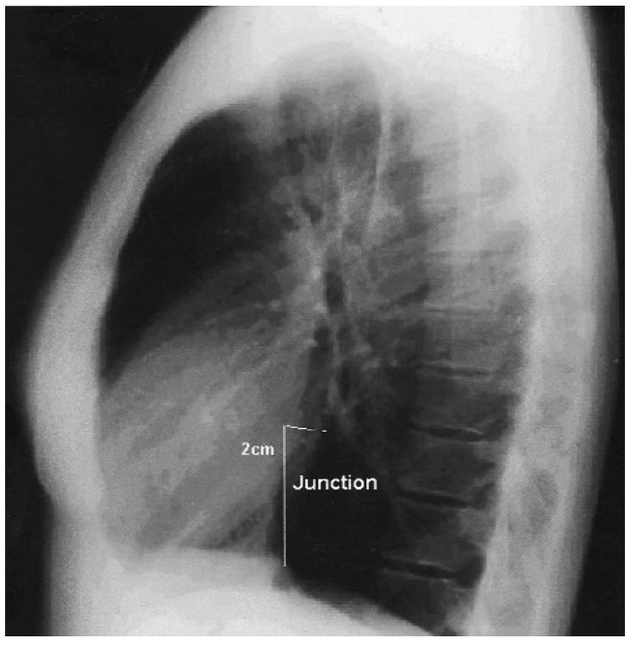

Fig. 2. A practical view on how to obtain measurement A in the lateral chest X-ray projection.

endplates of the vertebral bodies up to the point where it crosses the posterior margin of the left ventricle (as illustrated in Fig. 2).

Statistical analysis

Measurement A and left ventricular end diastolic measurements were assessed as continuous variables. Characteristics assessed as continuous variables are presented as means ± standard deviation (SD). Comparisons of left ventricular ejection fractions were made with the use of the Student's *t*-test for two-samples of unequal variance. All statistical tests were two-sided. Two-sided *p*-values of less than 0.05 were considered to indicate statistical significance.

Results

We calculated the average, range as well as the standard deviation for the three groups (see Table I).

Echocardiographic reports from 464 patients were initially looked at. Out of these, 102 patients had no chest X-rays, 42 had had chest X-rays but without lateral films, 34 had had a chest X-ray but this had either been destroyed or could not be found for various reasons at the time of the study. Of the 177 patients whose chest X-rays were available with a lateral projection, the crossing of the inferior vena cava and the aorta could be seen in 136 patients (76.84%). Table I shows the results of the total number of patients in each of the three categories and the average value of measurement A, as well as the range and the standard deviation.

TABLE I. MEAN, RANGE AND STANDARD DEVIATION (SD) FOR MEASUREMENT A (IN MM) FOR PATIENTS WITH NORMAL LEFT VENTRICULAR SIZE, ENLARGED LEFT VENTRICULAR SIZE AND ENLARGED RIGHT VENTRICULAR SIZE ACCORDING TO ECHOCARDIOGRAPHIC CRITERIA.

	A	*Range*	*SD*
Normal left and right ventricular size	15.62	9–25	3.15
LV enlarged	19	10–30	4.03
RV enlarged (LV normal)	16.05	8–22	3.38

TABLE II. MEASUREMENT A ABOVE 18, 19 AND 20 MM FOR PATIENTS WITH NORMAL LEFT VENTRICULAR SIZE, ENLARGED LEFT VENTRICULAR SIZE AND ENLARGED RIGHT VENTRICULAR SIZE, EXPRESSED AS PERCENTAGE VALUES.

	Above 18 mm	*Above 19 mm*	*Above 20 mm*
Normal left and right ventricular size	27.08	14.58	8.33
LV enlarged	65.52	56.9	39.7
RV enlarged (LV normal)	36.84	21.05	21.1

From Table I it can be seen that the mean value of measurement A in all patients with echocardiographic evidence of left ventricular enlargement was 19.00 (SD ± 4.03) [95% confidence interval (CI) of 17.96 to 20.04]. In Table II, 38 (65.52%) of these patients had measurement A 18 mm and above, whereas 33 (56.9%) had this value 19 mm and above. In patients with right ventricular enlargement and normal left ventricle on echo, the mean was 16.05 mm (SD ± 3.38) (95% CI of 14.53 to 17.57) (Table I). In this group, seven people (36.84%) had measurement A equal to or greater than 18 mm. However, the mean value of A in this category was 16.05 mm, a value that is not significantly different from the average for those patients with normal echoes ($p = 0.63$).

LVED below 58 mm constituted a normal echocardiography. The mean for measurement A in patients with normal echoes was 15.62 mm (SD ± 3.15) (95% CI of 14.72 to 16.50) (Table I). Despite a range of 9–25 mm, only 4 (8.33%) of patients with normal echoes had a value two standard deviations above the mean (>22 mm). When considering 19 mm as the value to indicate left ventricular enlargement (LVED >59 mm) the sensitivity of this measurement was 56.90% with a specificity of 84.62% (Table II). When 18 mm was used, the sensitivity rose to 65.52% but with a lower specificity of 75.00% (see Tables III and IV). Table V clearly illustrates the significance of different measurements to distinguish patients with left ventricular enlargement from normal left ventricular dimensions.

TABLE III. SENSITIVITY OF MEASUREMENT A AT 18, 19 AND 20 MM FOR PATIENTS WITH ENLARGED LEFT VENTRICULAR SIZE AND ENLARGED RIGHT VENTRICULAR SIZE, EXPRESSED AS PERCENTAGE VALUES.

Sensitivity	*18 mm*	*19 mm*	*20 mm*
LV enlarged	65.52	56.90	44.83
RV enlarged (LV normal)	33.33	16.66	16.66

TABLE IV. SPECIFICITY OF MEASUREMENT A AT 18, 19 AND 20 MM FOR PATIENTS WITH ENLARGED LEFT VENTRICULAR SIZE AND ENLARGED RIGHT VENTRICULAR SIZE, EXPRESSED AS PERCENTAGE VALUES.

Specificity	*18 mm*	*19 mm*	*20 mm*
LV enlarged	75.00	84.62	92.00
RV enlarged (LV normal)	71.93	82.46	89.46

TABLE V. *P*-VALUES CALCULATED FOR MEASUREMENT A UP TO 18, 19 AND 20 MM RESPECTIVELY FOR PATIENTS WITH NORMAL LEFT VENTRICULAR SIZE, ENLARGED LEFT VENTRICULAR SIZE.

Normal LV compared to enlarged LV	*Up to 18 mm*	*Up to 19 mm*	*Up to 20 mm*
P-value	0.234	0.031	0.002

Comparing all the variables in patients with left ventricular enlargement with those with right ventricular enlargement a *p*-value of 0.002 was obtained showing a significant difference of measurement A between these categories. Measurement of A from patients with LV enlargement without RV enlargement was compared with that obtained from patients who had LV and RV enlargement. A *p*-value of 0.17 indicates that RV enlargement has no significant influence on measurement A.

Discussion

The purpose of this study was to evaluate the accuracy of the Hoffman and Rigler sign for determination of left ventricular enlargement in the lateral projection of the chest. It was also our intention to determine the effect of right ventricular enlargement on this measurement. One of the prerequisites for this measurement to be applicable was that the crossing of the inferior vena cava and the left ventricle must be adequately visualised. We found that this was possible in 76.84% of the X-rays that were examined. This figure corresponds to that found by Hoffman and Rigler in their study, where the crossing was visualised in 76% of the patients. The Hoffman and Rigler method should not be used in patients with pectus excavatum, left hemi-diaphragm abnormalities and giant left atrium. Our study was not prospective, which could account for the many patients rejected for different reasons.

Using this method, Hoffman and Rigler concluded that when measurement A is 18 mm or above, there is a strong probability that the left ventricle is enlarged. We found that when this figure is used as the cut-off point for left ventricular enlargement, only 65.52% of patients with left ventricular enlargement on cardiac ultrasound will be correctly identified. With this value (18 mm), 27.08% would be false positives whereas 34.48% will be false negatives. However, when 19 mm is used, 56.9% of patients will be correctly diagnosed, with only 14.58% false positives.

We find this measurement a useful tool to assist clinicians in evaluating left ventricular enlargement. In the majority of cases (barring technical, and in some cases non-technical reasons) this method should provide additional support for assessing the severity of cardiac disease and offer reasonable motivation for early referral to cardiac units. Absence of a measurement above 19 mm should therefore discourage 'unnecessary' referral to the often-overburdened tertiary healthcare sector and offer the primary healthcare provider much-needed reassurance.

We caution that this measurement, proven to be highly specific (19 mm) for diagnosing left ventricular enlargement, can never be used as the sole criterion for this diagnosis and stress that history and clinical findings remain the paramount arms in decision-making. As Table V illustrates, a measurement of 18 mm does not provide enough distinguishing power and that a minimum measurement of 19 mm provides the statistical power to assume enlargement of the left ventricle. This sign should therefore be used to complement other evidence of left ventricular enlargement when echocardiography is not readily available.

Conclusion

When the crossing of the inferior vena cava and the left ventricle can be adequately visualised, the Hoffman and Rigler sign of evaluating left ventricular enlargement in the lateral projection of the chest is a valuable alternative where cardiac ultrasound is not readily available. However, when a value of 18 mm is used as a cut-off point for left ventricular enlargement, the specificity of this method decreases significantly, and we would propose a value of 19 mm, which we found has a sensitivity of 56.9% and a specificity of 84.62%. Right ventricular enlargement does not seem to influence the accuracy of this method significantly when 19 mm is used as the cut-off point.

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