ORIGINAL ARTICLE

# REFERRAL PATTERN AND FINDINGS FOLLOWING PLANAR EQUILIBRIUM RADIONUCLIDE ANGIOCARDIOGRAPHY IN A TERTIARY HOSPITAL

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## ABSTRACT

Introduction: Planar Equilibrium Radionuclide Angiocardiography (ERNA) is a non-invasive, reproducible and non-operator dependent Nuclear Medicine gamma camera-based technique of assessing cardiac function. Aim: To determine the common indications and findings from ERNA in a tertiary hospital in Cape Town, South Africa. Methods: The use of this database was approved by the Human Research Ethics Committee of the faculty of Health Sciences, University of Cape Town. All ERNAs conducted within a six-month period (January to June 2014), processed and reported by the authors were reviewed. The ERNAs were performed on an e.Cam dual head gamma camera (Siemens Medical Solutions, Erlangen, Germany) fitted with Low Energy High Resolution (LEHR) collimators after intravenous administration of stannous pyrophosphate and $^{99m}$Tc-pertechnetate. ECG-gated cardiac blood pool images were acquired. Images were reviewed and processed on a Siemens workstation. Cardiac morphology, size, contraction pattern, left ventricular wall motion and ejection fraction were assessed. Results: Of the 351 ERNAs of patients reviewed, 283 (80.6%) were females while 68 (19.4%) were males with a mean age of 48.3 ± 12.6 years and age range of 29 to 71 years. Indications for ERNA requests were chemotherapy 303 (86.3%), pre-operative evaluation 37 (10.5%) and ischaemic heart disease 9 (2.6%). LV size was dilated in 24 (6.8%) of the patients. Normal LV wall motion was recorded in 303 (86.3%) patients, while hypokinesia, akinesia and dyskinesia were recorded in 12.8%, 0.3% and 0.6% of the LVs respectively. Normal LVEF was recorded in 301 (85.8%) of the patients while mild, moderate and severe LV dysfunction were recorded in 12.8%, 0.8% and 0.6% of the patients respectively. Conclusion: ERNA is a frequently requested nuclear medicine examination for assessment of cardiac function in patients undergoing cardiotoxic chemotherapy.

Key words: ERNA, indications, LV function, LVEF

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## INTRODUCTION

Planar Equilibrium Radionuclide Angiocardiography (ERNA), also known as multigated acquisition (MUGA) or radionuclide ventriculography (RNVG) is a non-invasive, reproducible and non-operator dependent Nuclear Medicine

gamma camera-based technique of assessing cardiac function. It is a technique that makes use of 99mTc-erythrocyte labeling, applying an in vivo, an in vitro, or a combined in vivo-in vitro approach.[1-4] ERNA allows the quantitative assessment of left ventricle (LV) dynamics and qualitative observation of wall motion. Its advantages include accuracy, reproducibility, and repeatability compared to other techniques of assessing cardiac function.

Some indications for the use of ERNA include; Measurement of left ventricular systolic function in patients with Coronary Artery Disease (CAD) for prognosis, suspected heart failure (e.g. selection of patients for the choice of angiotensin converting enzyme inhibitor therapy), patients receiving cardiotoxic chemotherapy (anthracyclines, trastuzumab) and patients with valvular heart disease (timing of cardiac surgery).[1,3-5] Serial ERNA is regarded as the gold standard to measure LVEF and is considered the best non-invasive method for identifying subclinical left ventricular dysfunction in adult patients treated with cardiotoxic agents.[6-9] It allows identification of left ventricular dysfunction with high reproducibility and low interobserver variability.[10] ERNA together with echocardiography are considered as the widely accepted methods to assess patients' LVEF during cancer treatment.[6]

Indications for the use of ERNA to assess cardiac function vary according to institutions. The aim of this study is to determine the common indications as well as various findings from ERNA examination in a tertiary hospital in Cape Town, South Africa.

## MATERIALS AND METHODS

This is a retrospective cross-sectional study. The use of this database was approved by the Human Research Ethics Committee of the faculty of Health Sciences, University of Cape Town. All ERNAs conducted within a six-month period (January to June 2014), processed and reported by the authors were retrieved and reviewed.

The ERNAs were performed on an e.Cam dual head gamma camera (Siemens Medical Solutions, Erlangen, Germany) fitted with Low Energy High Resolution (LEHR) collimators after intravenous administration of stannous pyrophosphate and $^{99m}$Tc-pertechnetate. ECG-gated cardiac blood pool images were acquired in anterior, left anterior oblique and left lateral views for all new patients, while only left anterior oblique and left lateral views were acquired in follow-up patients (Figure 1). The images were reviewed and processed on a Siemens workstation. Cardiac morphology, size, contraction pattern and left ventricular wall motion were assessed. The left ventricular ejection fraction (LVEF) was automatically calculated by the software from region of interests (ROIs) of left ventricle in end-diastole and end-systole, and a background ROI obtained outside the LV (Figure 2).

Cardiac contraction abnormalities were described using the conventional scoring system as outlined in the Society for Nuclear Medicine (SNM) procedure guideline for gated equilibrium radionuclide ventriculography; 1=Normal wall motion, 2=Hypokinesia, 3=Akinesia, or 4=Dyskinesia.[4] Left Ventricular Ejection Fraction (LVEF) was categorized according to the British Nuclear Medicine Society (BNMS) guidelines; Normal (LVEF>50%), Mild LV dysfunction (LVEF 40-49%), Moderate LV dysfunction (LVEF 30-39%), Severe LV dysfunction (LVEF 20-29%) or Very severe LV dysfunction (LVEF <20%).[1] Data was analyzed using IBM SPSS Statistics software Version 23.

## RESULTS

Table 1: Patient demographics and various indications for ERNA evaluation of cardiac function.

| Gender | N (%) | Mean Age ±SD, years | Indication for ERNA | N (%) |
|---|---|---|---|---|
| Female | 283 (80.6) | 48.7±10.6 | Chemotherapy | 303(86.3) |
| Male | 68 (19.4) | 46.7±18.8 | IHD | 9(2.6) |
| | | | Pre-operative evaluation | 37(10.5) |
| | | | Dialysis | 1(0.3) |
| | | | Post cardiac transplant | 1(0.3) |
| Total | 351 (100) | 48.3±12.6 | Total | 351(100) |

IHD; Ischaemic Heart Disease

Table 2: Distribution of LV size and wall motion abnormalities.

| LV Size | N (%) | LV wall motion | N (%) |
|---|---|---|---|
| Normal | 327 (93.2) | Normal | 303 (86.3) |
| Dilated | 24(6.8) | Hypokinesia | 45 (12.8) |
| | | Akinesia | 1 (0.3) |
| | | Dyskinesia | 2 (0.6) |
| Total | 351 (100) | Total | 351 (100) |

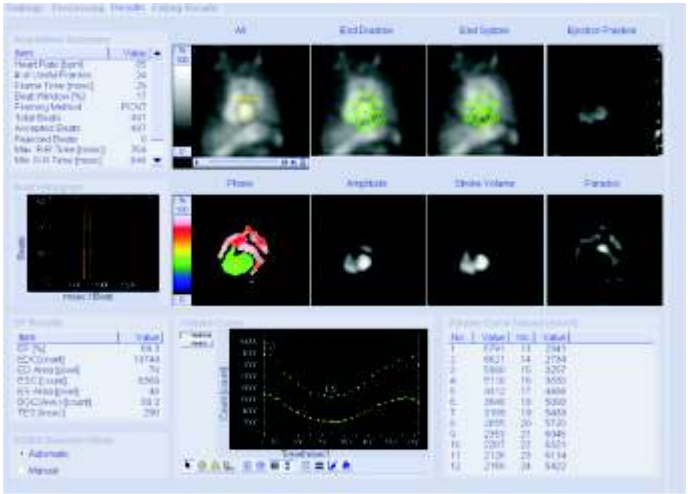

Figure 2: ERNA images showing LV ROIs on cine images as well as in end diastole (ED) and end systole (ES).

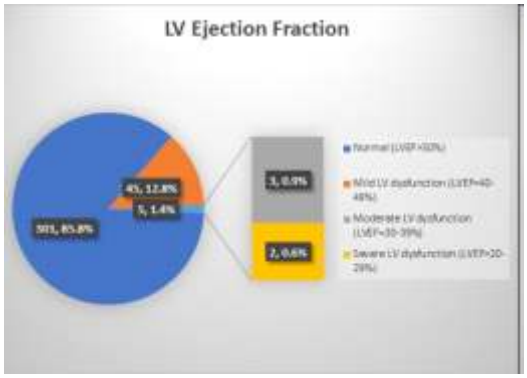


**Figure 4:** Pie Chart showing the distribution of LV function based on the LVEF.

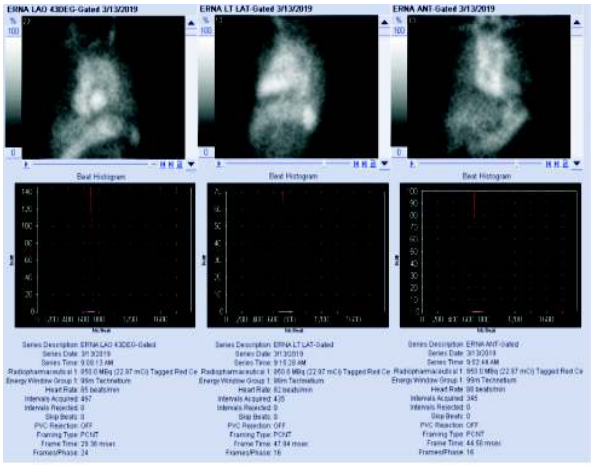

Figure 1: ERNA images showing the three views (LAO, Left lateral, and Anterior) in the first row while their corresponding beat histograms are shown in the second row.

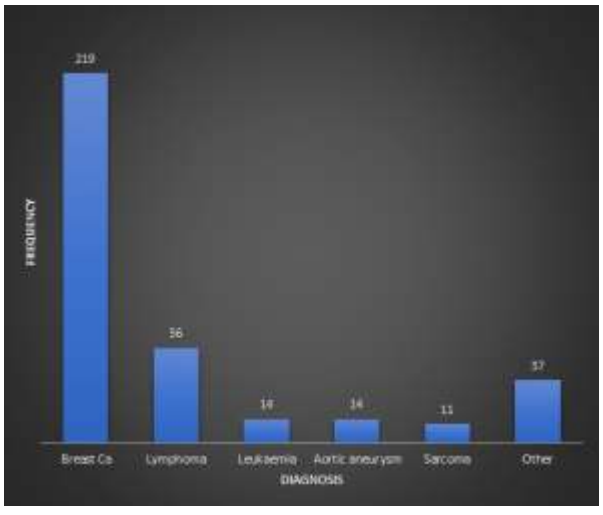


**Figure 3:** Distribution of various reasons for patient referral for ERNA according diagnosis. "Other" refers to other rarer diagnosis such as Heart failure, Valvular heart disease, Peripheral vascular disease, Cardiac transplant, Arteritis, Myelofibrosis, Multiple myeloma, Critical limb ischaemia, Giant cell tumor, as well as Gastric, Ovarian, Testicular, and Uterine carcinomas.

The count statistics and the LVEF in percentage are shown in the results section in the third row. The LV volume curve is also shown in the third row.

Figure 3: Distribution of various reasons for patient referral for ERNA according diagnosis. "Other" refers to other rarer diagnosis such as Heart failure, Valvular heart disease, Peripheral vascular disease, Cardiac transplant, Arteritis, Myelofibrosis, Multiple myeloma, Critical limb ischaemia, Giant cell tumor, as well as Gastric, Ovarian, Testicular, and Uterine carcinomas.
Figure 4. Pie Chart showing the distribution of LV function based on the LVEF.

Of the 351 ERNAs of patients reviewed, 283 (80.6%) were females while 68 (19.4%) were males with a mean age of 48.3 ± 12.6 years and age range of 29 to 71 years. Indications for ERNA requests were chemotherapy 303 (86.3%), pre-operative evaluation 37 (10.5%) and ischaemic heart disease 9 (2.6%). Majority of the patients were receiving chemotherapy for breast carcinoma, 219 (62.4%), Lymphoma, 56 (16.0%) and Leukaemia, 14 (4.0%). Infrequent indications for ERNA were dialysis and post-cardiac transplant with one request each during the study period (Table 1 and Figure 3). LV size was dilated in 24 (6.8%) of the patients. Normal LV wall motion was recorded in 303 (86.3%) patients, while hypokinesia, akinesia and dyskinesia were recorded in 12.8%, 0.3% and 0.6% of the LVs respectively (Table 2). Normal LVEF was recorded in 301 (85.8%) of the patients while mild, moderate and severe LV dysfunction were recorded in 12.8%, 0.8% and 0.6% of the patients respectively (Figure 4).

## DISCUSSIONS

Indications for the use ERNA found in the current study agree with those endorsed in guideline statements for radionuclide ventriculography (RNVG) use.[1-4] Patients receiving cardiotoxic chemotherapy (e.g. anthracyclines, trastuzumab) were more predominant. This is consistent with the fact that, ERNA is a frequently requested nuclear medicine examination, for assessment of cardiac function in patients undergoing cardiotoxic chemotherapy. Large trials have shown that 2-27% of patients treated with Herceptin developed LV systolic impairment and eventually heart failure depending on clinical profile.[5] Therefore. herceptin use was approved but with cardiac monitoring and ERNA is well placed to undertake cardiac monitoring due to its accuracy and reproducibility.[1,5]

It is pertinent to note that 2D-Echocardiography has the advantages of portability, lack of radiation and increased availability but is less sensitive for the detection of a decline in LVEF and it has a poorer specificity and reproducibility with higher interobserver and intra-individual variability compared to ERNA.[12-13] These limitations of 2D echocardiography were largely due to variable operator skills and dependence on acoustic windows. In addition, 2D echocardiography suffers from gain-dependent edge identi? cation and transducer positioning artifacts during imaging. However, the interobserver variability for real-time 3-dimensional echocardiography is signi? cantly lower than for 2-dimensional echocardiograph because the former technique provides volumetric measurements without geometric assumptions.[14] Other limitations of echocardiography are as a result of inadequate echocardiographic windows. Adequate echocardiographic windows will be dif? cult to attain in obese patients, as well as in other variations of thoracic anatomy, such as emphysema, tight intercostal spaces, and heavily calci? ed ribs.[15]

Infrequent indications encountered in this study such as post-cardiac transplant

evaluation may be due to replacement of ERNA by other imaging methods such as Echocardiography and MRI.[1] These imaging modalities do not use ionizing radiation unlike ERNA. However, in pediatric patients, echocardiography is preferred because of the lack of ionizing radiation.[15]

LV function impairment was found in up to 14.2% of the subjects examined in this study. There is some evidence that early detection of diastolic dysfunction in patients treated with chemotherapy may indicate subsequent systolic dysfunction.[2,3,4,17,18] Therefore, serial ERNA examination among patients receiving anthracycline chemotherapy is an easy way of detecting early diastolic dysfunction. Discontinuation of doxorubicin is recommended if LVEF decreases by 10% (EF units) from baseline and reaches LVEF of less than 50%. For patients with abnormal baseline LVEF less than 50%, serial studies are recommended after each dose of doxorubicin, and discontinuation of doxorubicin is recommended if LVEF decreases by 10% (absolute EF units) from baseline or reaches LVEF of 30%.[17,18]

## CONCLUSION

ERNA is a frequently requested nuclear medicine examination for assessment of cardiac function in patients undergoing cardiotoxic chemotherapy as more than 80% of the patients in this study were referred as a result of chemotherapy for different types of cancer.

## Conflicts of Interest

The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

## Authors' contribution

G.H.Y. was responsible for study conception, design, data analysis and manuscript writing. S.S.M. made conceptual contributions and reviewed the manuscript. All the authors read and approved the final manuscript.

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