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ECHOCARDIOGRAPHY IN NIGERIA: EXPERIENCE FROM UNIVERSITY OF NIGERIA TEACHING HOSPITAL (UNTH) ENUGU

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ABSTRACT
This study evaluated our experience with echocardiographic studies over a period of 10 years (February 1991 to January 2001). Two thousand five hundred and twenty seven patients (1577 males, 950 females), aged between 3 weeks to 85, years were referred for echocardiography at the University of Nigeria Teaching Hospital (UNTH) Enugu.

The commonest indications for echocardiography were found to be Valvular Heart Diseases (16%), Hypertensive Heart Disease (15%) and Congenital Heart Diseases (14.3%).

Echocardiography was able to confirm 868 (34.4%) of Valvular Heart Diseases (n = 868), 436 (17.3%) Hypertensive heart Diseases, (13.2%) Congenital Heart Diseases and Cardiomyopathies 237(9.5%). Normal studies were documented in 275(10.9%) of the patients.
The functional states of prosthetic valves as well as the position of pacemakers were some of the clinical usefulness of echocardio-graphic studies documented by the study.

More accurate diagnoses and influencing the direction of management were definitely the outcomes of the echocardiographic studies of these patients.

The principles, types and newer developments in echocardiography, as a noninvasive imaging technique, are also discussed in this paper.

ABSTRAIT
Cette étude a évalué notre expérience avec des etudes échocardiographiques pendant 10 ans (février 1991 à janvier 2001). Deux mille cinq cents et vingt sept patients (1577 mâles, 950 femelles), âgé entre 3 semaines à 85, des années ont été référées pour l'échocardiographie à l'université de l'hôpital d'enseignement du Nigéria (UNTH) Enugu.

Les indications les plus communes pour l'échocardiographie se sont avérées les maladies de coeur de Valvular (16%), Maladie de coeur hypertendue (15%) et maladies de coeur congénitales (14.3%).

L'échocardiographie pouvait confirmer 868 (34.4%) de maladies de coeur de Valvular (n = 868), 436 (17.3%) maladies de coeur hypertendues, (13.2%) Maladies de coeur et cardiomyopathies congénitales 237(9.5%). Des études normales ont été documentées dans 275(10.9%) des patients.

Les états fonctionnels de valves prosthétiques aussi bien que la position des stimulateurs étaient une partie de l'utilité clinique des études échocardiographiques documentées par l'étude. Des diagnostics plus précis et influencer la direction de la gestion étaient certainement les résultats des études échocardiographiques de ces patients.

Les principes, types et plus nouveaux développements en échocardiographie, comme technique non envahissante de formation image, sont également discutés en cet article.

INTRODUCTION

The world of Echocardiography has witnessed a phenomenal growth, from the first attempts in echocardiography, by Elder and Hertz, in Lund in Sweden in 1954[3], to 3-Dimensional echocardiography in current use.

Echocardiography is now a particularly attractive and established technique for evaluation and accurate diagnosis of various forms of cardiovascular disorders. It gives validated simple, reliable, serial and non-invasive assessment of the heart. Findings from 2D, M-mode and Doppler echocardiography correlate well with those of cardiac catheterization and radionuclide studies and offer prognostic options and may influence management and longitudinal follow-up of patients[4-8].

Despite the rapid phenomenal growth in the use of echocardiography worldwide, there is little information about the utility of two dimensional and Doppler echocardiography in Nigerians with various categories of heart disease[8,9].

Echocardiography made a debut in Nigeria about three decades ago[10]. Since then, physicians have found it most useful both in diagnosis of various forms of heart disease and clinical research[11].

M-mode echocardiography was the first form to be introduced in Nigeria, with Lawal and Falase having used this to assess left ventricular function in a study of hypertensive patients at University College Hospital, Ibadan[12].

Two dimensional echocardiography became available at the University of Nigeria Teaching Hospital (UNTH), Enugu in 1987[13], followed by Doppler echocardiography (pulsed-wave and continuous-wave Doppler) in 1990. Many other health institutions, especially the private hospitals, have since then acquired both the two-dimensional and Doppler echocardiography facilities, both for diagnosis and medical research[8,14,15].

This study evaluates the diagnostic profile of Nigerian patients presenting for echocardiography at the University of Nigeria Teaching Hospital (UNTH) Enugu a designated National Centre of Excellence for Cardiovascular Diseases in Nigeria. It also highlights the principles of, and emerging global trends in, echocardiography.

MATERIALS AND METHODS

A retrospective study of all patients referred for echocardiographic study at the University of Nigeria Teaching Hospital, (UNTH), Enugu, over a 10 year period, from February 1991 to January 2001, is reported. Information was collected from the Echocardiography Register maintained at the echocardiographic scanning room. All the patients had undergone M-mode, Two-Dimensional and Pulsed Doppler echocardiographic study, in standard positions.

Data collected were analysed for age, gender, indications for echocardiography, and the echocardiographic diagnoses.

RESULTS

General

During the study period, a total of 2527 referral cases for echocardiographic study, was recorded. One thousand five hundred and seventy seven (67%) of these patients were males, while 950 (38%) were females, giving a male: female ratio of 1.7:1. Their ages ranged from 3 weeks to 85 years.

The referral sources were from different units at the UNTH, general and private hospitals within Enugu metropolis and from state hospitals from Southeast zone of Nigeria.

Indications for Echocardiography
From the analysis of our data in Table I, the commonest indications for echocardiography were: Valvular Heart Diseases (16%), Hypertensive Heart Diseases (15%), Congenital Heart Diseases (14.3%) and Cardiomyopathies (8.1%). Cardiovascular related diseases alone accounted for 1814 (71.8%) of the indications. Non-specific diagnoses formed 524 (20.7%) of the indications 335 of which had no stated diagnostic indication. The latter is made up 13.3% of the total number of documented indications and had such indications as; pansystolic murmur, organic heart disease and tachypnoea. The rest of the systems contributed 7.5% of the indications for echocardiography in our study population.

Echocardiographic Diagnoses
Table 2 shows that valvular heart diseases were diagnosed in 868 (34.4%) of the patients, hypertensive heart disease in 436 (17.3%) patients, congenital heart disease in 334 patients, cardiomyopathies in 237% (9.5%) of the patients, and pericardial diseases in 228(9%) patients. Normal study was demonstrated in 275 (10.9%) of the patients. Nine (0.4%) of the studies returned inconclusive these were studies aborted by power failure, progressive discomfort (such as dyspnoea) warranting stoppage of scanning or children whose excessive crying and restlessness make continuation of the study impossible.

Table 3 shows that 344 (13.6%) of the patients were in clinical congestive heart failure, while 295 (11.7%) were also documented from echocardiographic study. Dilated cardiomyopathy accounted for 161 (46.8%) of the pre-echo indications and 171 (58%) of the echocardiographic studies, while hypertensive heart disease was recorded in 92 (26.7%) of the pre-echo indications and 91 (30.8%) of the echocardiographic cases of congestive cardiac failure.
One hundred and seventy five (6.9%) of the patients had diastolic dysfunction.

DISCUSSION
The study shows Valvular heart diseases as the commonest indication for echocardiography, as well as the most documented echocardiographic finding. Equally significant is the high percentage of congenital heart diseases presenting, both as indications (14.3%), and diagnoses (13.2%). These findings are in contrast to the picture in related works at other centres in Nigeria. Ukoh et al,[16] in a similar retrospective study, spanning about the same period, January 1992 to May 2001, rated systemic hypertension and hypertensive heart disease respectively as the commonest indication and diagnoses, while congenital heart disease contributed just 6% of the 820 echocardiographic diagnoses. Balogun et al,[8] in a retrospective study at Okada, Edo State, Nigeria, in 100 patients, documented valve dysfunction as an indication in 11% of the patients and diagnosis in 7%, with congenital heart disease presenting just once as an indication, and not at all as a diagnosis[8].
The disparity in these findings may be explained by a number of factors. Ukoh et al[16] studied only adult patients, which may account for the relatively low rate of congenital heart disease presentations. The Okada study by Balogun et al[8] was on comparatively fewer patients just 100. The UNTH Enugu, is a National centre of Excellence for Cardiovascular Diseases and Surgery. It thus attracts a comparatively higher number of patients for assessment, and stabilization for heart surgeries. The post surgical indications (32 in the study), and prosthetic valve functional status, further lend credence to this observation. The study corroborates the findings in

related works in the country, as to the relative rarity of Ischaemic heart disease. While this study reported 0.8% prevalence, Ukoh et al[16] recorded 2.7% and Balogun et al,[8] 2%. This may need further prospective study, as current trends tend to portend an increase in prevalence.

It is noteworthy that as many as 275 (10.9%) of the patients had normal echocardiographic study. This definitely influenced their management outcome, obviating the need for any additional medication.

PRINCIPLE OF ECHOCARDIOGRAPHY

Three inter-related modalities of echocardiography in common use now are: M-mode, two dimensional and Doppler echocardiography. M-mode echocardiography uses a narrow ultrasound beam to depict a one-dimensional image of the heart. Two dimensional echocardiography records a spatially correct image of the heart while Doppler echocardiography tracks the velocity of blood flow through the heart and great vessels.

The Doppler echocardiography utilises the principle that moving objects alter the frequency of any sound they reflect to recognize blood flow and to characterize its pattern.[1,2,17]

TYPES OF ECHOCARDIOGRAPHY

1. *M-Mode* echocardiographic equipments use a transducer containing one crystal which emits a single ultrasound beam of 1000 to 2000 pulses per second. This produces a very narrow "ice-pick" image of the cardiac structures. The depth of the echo is displayed on the vertical axis, and time on the horizontal axis. The recording thus appears as a continuous graph of the depth of the structures with respect to time. The spatial resolution (the ability to differentiate and recognise structures that are close together) is very high, about 1 to 2cm along the axis of the sound beam. The temporal resolution is also very high. This makes it possible to obtain high resolution images of rapidly moving structures such as valve opening, closing, fluttering, and subtle wall motion abnormalities.
   M-Mode echocardiography is useful in measuring left ventricular wall thickness and internal dimensions. It is superior to electrocardiography in detecting left ventricular hypertrophy.[18] Left ventricular internal dimensions can be used to assess the systolic function of the left ventricle by calculating the fractional shortening. Left ventricular mass is also derived from M-mode measurements.
   The main disadvantages of M-mode echocardiography are that: it provides only a one-dimensional view of the heart; the cardiac structures are displayed in an unfamiliar format that bears no resemblance to the cardiac anatomy and it is limited in its ability to provide information regarding the spatial orientation of the cardiac structure. Two dimensional echocardiography was introduced to overcome these disadvantages.

2. *Two Dimensional* echocardiographic equipments use a transducer containing one or more crystals that are mechanically rotated or electronically fired in a sequential manner. The transducer transmits and receives 120 discrete ultrasound beams through a 60 to 90° sector in order to produce a fan-shaped image of the heart in a cross section. Since it utilises multiple ultrasound beams, processing of a two-

dimensional image takes a longer time than an M-mode image. The sampling rate is thus lower (30 to 60 times per second as against 1000 times per second with M-mode). There is therefore, a substantial decrease in resolution.

A cross-sectional image of the heart is depicted with two-dimensional echocardiography. Thus direct and accurate visualisation of the entire heart, intracardiac structures and great vessels is possible. Global left ventricular function can be assessed by this technique. Left ventricular systolic and diastolic volumes are calculated using the Simpson's rule.[19] Stroke volume and cardiac output can be derived from these values.

The major limitation of two-dimensional echocardiography is its inability to image blood cells and provide data about velocity, direction, timing and spatial profile of blood flow. To correct this limitation, Doppler echocardiography was introduced.

3. *Doppler Echocardiography* is based on a physical principle known as the 'Doppler Effect'. This was first described in 1842 by an Austrian mathematician and physicist, Johann Christian Doppler.[20] Doppler effect is the change in the frequency of sound waves when the source of sound is moving in relation to the receiver. If the source of sound is moving towards the receiver, the frequency would be increasing but if the source of sound is moving away from the receiver, the frequency would be decreasing. Doppler echocardiography is, therefore, based on the frequency shift between the transmitted and the returning ultrasound. When a transmitted ultrasound meets a moving target such as a column of blood, the frequency of the returning echo is different; higher if the target is moving towards the transducer. This difference in frequency-the Doppler shift-is within the audible range and can be displayed as audible signals or as visual signals called spectral trace, on an oscilloscope.

There are several types of Doppler studies, all of which can be performed using a single probe: Pulsed Doppler Echocardiography uses a single crystal to study the patterns of blood flow, including the detection of abnormal flows, shunts and cardiac output; continuous wave Doppler with two separate adjacent crystals, one that continuously transmits sound and the other, which continuously receives reflected sound. This adds the possibility of studying pressure gradients across valves from flow and valve area observations.

Doppler echocardiography can thus detect diastolic dysfunction, which results from left ventricular filling abnormalities, a possible consequence of hypertension. Transmitral Doppler recordings are now actually the most frequently used methods for evaluating left ventricular diastolic filling.

The main limitation of Pulsed Doppler echocardiography is that determination of diastolic function by this technique is imprecise: it permits only an indirect measure of diastolic function in relation to left ventricular filling, since it cannot assess all the factors influencing left ventricular diastolic filling directly. Combined alterations of influencing factors may actually "pseudonormalize" the trans-mitral flow pattern, thus complicating the evaluation of diastolic filling, especially with the presence of both prolonged relaxation and restrictive filling abnormalities.[4,5,21]

There is a recent development in Doppler echocardiography, known as Colour Flow Mapping: This technique allows the visualisation of intracardiac blood flow super-imposed on a two-dimensional echocardio-graphic display. Flow towards the transducer is depicted as red, flow away from transducer as blue. Green is added in a mosaic pattern to represent turbulent flow. Colour-coded Doppler is very useful in the detection and mapping of regurgitant and shunt lesions, while facilitating the evaluation of congenital heart disease.

4. *Newer Developments in Echocardiography*

Other echocardiography modalities have come into use to a varying extent in the recent past, especially within the last decade. These include:

a) *Transoesophageal Echocardiography:* This is of great use in patients in whom the examination from the usual transthoracic approach is technically difficult or impossible. It allows examination of structures such as the atria, assessing prosthetic valves, aortic dissection, vegetations and intracardiac masses. It has a major application now in cardiac surgery, both during and after surgery.

b) *Intravascular Ultrasound.* The ultrasonic transducer is placed in a small catheter so that a vessel can be imaged through the lumen. This can evaluate athero-sclerosis from within the arteries, and the heart from within the cardiac chambers, using a rotation transducer, rotating ultrasonic mirror, or phased array multielement systems.

(c) *Contrast Echocardiography:* This makes use of the fact that ultrasound is an extremely sensitive detector of intravascular bubbles. The injection of almost any liquid into the intravascular spaces will introduce many microbubbles that appear as a cloud of echoes on the echo-cardiogram. Thus the injection into the blood stream of a marker such as saline, agitated or sonicated angiographic contrast agents, sonicated albumen, indocyanine or some of the patients own blood, may be used as a substitute for the Doppler examination for certain types of flow and shunt visualization. This technique has potential for numerous clinical uses.

(d) *Stress Echocardiography:* This aids the overall management of patients with suspected coronary artery disease and acute myocardial infarction since stunned or hibernating myocardium can be unmasked, even before patient reports chest pain or ST segment changes are seen in the electrocardiogram. Global changes in left ventricular function can also be assessed. Dobutamine is commonly used as the biochemical stress agent.

(e) *Digital Echocardiography:* This is the digital acquisition, formatting, analysis, storage and review of ultrasound data. The technique was initially developed to reduce some of the practical difficulties encountered during the performance of stress echocardiography. The most common format used for the observation of cardiac wall motion is 'quad screen' format where four synchronized image loops are displayed simultaneously on the screen.

(f) *Doppler Tissue Imaging and Colour Kinesis:* These are new technologies which directly examine myocardial motion and encode movement of the myocardium or endocardium in colour. Hypokinetic, akinetic or

dyskinetic segments of cardiac wall are thus demonstrated. Regional myocardial thickening and ventricular synchrony are readily apparent, and chamber volume measurements may be more accurately defined. These new techniques need additional studies before they can be applied clinically.

(g) *Automated Boundary Detection:* This is a recently developed technique which uses ultrasonic backscatter technology to characterize tissue properties. It incorporates a border detection algorithm for delineating the endocardial blood interface. The system automatically detects the blood and tissue borders, which can be displayed on a two-dimensional sector image. It is of use in calculating blood area changes in the cardiac cycle, and subsequently diastolic function indices.

(h) *Three-Dimensional Echocardiography:* Reconstructed three-dimensional images of the heart using multiple two-dimensional image are now being proposed and actually put into use. A technique that orientates a two-dimensional transducer in a three-dimensional space using spark gap sensors. Another technique creates 3-D images of the heart using gated, reconstructed 2-D examinations. Chamber dimensions can, with this technique, be estimated with greater accuracy than is possible using cross-sectional methods. Valves can be seen and assessed with great accuracy.[6, 7, 22-25]

CONCLUSION AND RECOMMENDATIONS

This study has provided a profile of the clinical usefulness of echocardiography in a tertiary specialist centre with referrals drawn from all over Nigeria - especially with a bias to performance of cardiac surgeries. It has also highlighted the more recent developments in echocardiography, pointing out the way forward for other modalities.

Further longitudinal studies are recommended to investigate the changing trends in cardiac diseases, especially with respect to ischaemic heart disease in developing countries like Nigeria.

Echocardiographic examination can be performed as a safe, non-invasive procedure, with insignificant adverse effects, in a relatively short period of 15 to 30 minutes[26, 27]. These advantages, however, lend its request to abuse, with the attendant result that insufficient effort is made to establish a definite clinical diagnosis before referring patients for the investigation. Consequently, as shown in the study, many patients end up undergoing echocardiography without any stated diagnosis [up to 335 (13.3%) in this study]. With the financial implication to the patient echocardiographyic studies should not be regarded as a clearing house: A more rational and painstaking referral approach to be adopted by all referring practitioners, is therefore, strongly recommended from this study.

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TABLE 1: INDICATIONS FOR ECHOCARDIOGRAPHY

PRESUMED INDICATIONS	NUMBER OF PATIENTS	PERCENTAGE (%)
1. Cardiovascular-Related Diseases		
Valvular Heart Diseases	403	16.0
Hypertensive Heart Diseases	378	15.0
Congenital Heart Diseases	362	14.3
Cardiomyopathies	204	8.1
Pericardial Diseases	105	4.2
Congestive Cardiac Failure (Cause Unspecified)	91	3.6
Arrhythmias/Conduction Disorders	62	2.5
Ischaemic Heart Diseases	59	2.3
Rheumatic Heart Diseases	34	1.4
Cardiac Tumours/Mass	30	1.2
Other Circulatory Disorders	23	0.9
Aortic Dissection/Aneurysm	18	0.7
Endomyocardial Fibrosis	17	0.7
Infective Endocarditis	17	0.7
Pacemaker Displacement/Malfunction	11	0.4
Total	1814	(71.8)
2. Non-Specific		
Not-stated	335	13.3
Routine Check	97	3.8
Chest Pain	63	2.5
Palpitation	26	1.0
Anxiety State	3	0.1
Total	524	(20.7)
3. Central Nervous System Indications		
Transient Ischaemic Attack/Cerebro Vascular Accident	28	1.1
Syncope	11	0.4
Total	39	(1.5)
4. Post-Surgical Conditions	32	1.3
5. Pulmonary Disorders	30	1.2
6. Musculoskeletal Disorders	29	1.2
7. Congenital Anomalies	25	1.0
8. Endocrine/Metabolic Disorders	10	0.4
9. Malignancies	8	0.3
10. Renal Diseases	7	0.3
11. Haematological Disorders	6	0.2
12. Hepatobiliary System	3	0.1
TOTAL	2527	100.0

TABLE 2: ECHOCARDIOGRAPHIC DIAGNOSES

DIAGNOSES	NUMBER OF PATIENTS	PERCENTAGE (%)
Valvular Heart Diseases	868	34.4
Hypertensive Heart Diseases	436	17.3
Congenital Heart Diseases	334	13.2
Normal Study	275	10.9
Cardiomyopathies	237	9.5
Pericardial Diseases	228	9.0
Other Cardivascular Diseases	39	1.5
Pulmonary Disorders	31	1.2
Ischaemic Heart Diseases	20	0.8
Endomyocardial Fibrosis	18	0.7
(Good) Prosthetic Valve Function	14	0.6
Inconclusive	9	0.4
Cardiac Tumour	8	0.3
Infective Endocarditis	6	0.2
Pacemaker In Situ	4	0.2
Total	**2527**	**100.0**

TABLE 3: CONGESTIVE CARDIAC FAILURE: PRE AND POST ECHOCARDIOGRAPHIC DIAGNOSES

PRE-ECHO INDICATIONS				ECHOCARDIOGRAPHIC DIAGNOSES			
Aetiology	**No of Patients**	**%**	**% of Total 2527**	**Aetiology**	**No of Patients**	**%**	**% of Total 2527**
Dilated Cardiomyopathy	161	46.8		Dilated Cardiomyopathy	171	58.0	
Hypertension	92	26.7		Hypertension	91	30.9	
Cause Unspecified	91	26.5		Valvular Disease	20	6.8	
				Cor. Pulmonale	13	4.4	
Total	**344**	**(100)**	**13.6**	**Total**	**295**	**(100.1)**	**11.7**

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