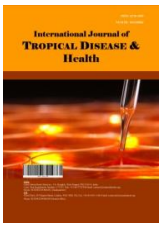

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Appropriate Use Criteria for Paediatric Echocardiography – Applicability in a Resource Poor Setting in the Niger Delta Region of Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author PNT designed the study, wrote the protocol and first draft and did the literature search; while author UCO contributed to the protocol performed the statistical analysis and analysis of the study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To make comparative analysis of the indications and outcome of paediatric echocardiography in tertiary centers in Rivers State, Nigeria using the Appropriate Use Criteria (AUC) guidelines [11].
Methodology: A retrospective analysis of 645 echocardiography requests done between July 2019 to June 2020. Patients' biodata and indications for echocardiography and echocardiography diagnosis were retrieved. Using the AUC guidelines, each indication was scored from 1 to 9, after which they were categorized into Appropriate, May be appropriate and Rarely appropriate to determine the respective percentages accordingly. Cochran-Armitage test for trend was done to assess degree of yield of cardiac anomaly for each level of AUC classification while bivariate associations were assessed using persons chi squared tests.

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Results: There were 645 echocardiography requests within the study period. The median age was 5months, with interquartile range of 2months to 24months. There were 355(55%) males and 290(45%) females. The clinical indication for echocardiography was appropriate in 490(76.0%), May be appropriate in 32(5.0%) and Rarely appropriate in 104(16.1%). Nineteen (2.9%) clinical indications were "Unclassified" under the AUC. Echocardiography showed abnormality in 544(84.3%) reports, among which children with "Appropriate indications" had the highest yield 457(93.3%), while "unclassified indications" had the lowest yield 8(42.1%). The yield for cardiac anomalies significantly decreased with decreasing appropriateness (p=0.00001).
Conclusion: Most indications for paediatric echocardiography in our centers were appropriate according to the AUC guidelines. The AUC guidelines are applicable in resource poor settings.

Keywords: Echocardiography; Appropriate Use Criteria (AUC); applicability; resource poor settings.

1. INTRODUCTION

Echocardiography is a key diagnostic tool in the evaluation of congenital and acquired heart diseases of children [1]. The request for paediatric transthoracic echocardiography has increased over time due to greater availability of the tool and trained paediatric cardiologist [2,3] more so in the developed countries with well-established health care systems and functional health insurance schemes for healthcare funding [4]. The same cannot be said for some developing countries where there exist weak health care systems, limited health infrastructures/diagnostic facilities (such as echocardiography), and non-functional health financing schemes [4,5] As such, the cost of health care is borne by out of pocket expenses by parents and caregivers which amounts to huge cost. In Nigeria, there has been a modest increase in the availability of echocardiography and paediatric cardiology services [6] and this has led to increase in paediatric echocardiography request by doctors for a variety of clinical diagnoses. However, the relative safety and ease of the procedure sometimes lead to overuse [7,8]. Inappropriate referrals of echocardiography services is not just costly for the parents/caregivers, it also diverts scarce resources which could lead to deficits in funding crucial needs that would adversely affect the overall care and outcome for children in resource poor settings like ours [9,10]. Requests for paediatric echocardiography are usually based on the clinician's suspicion of a cardiac disorder and official guidelines/protocols for paediatric echocardiology request were non-existence until the publication of the Appropriate Use Criteria (AUC) for initial outpatient paediatric transthoracic echocardiography in 2014 [11]. This research seeks to compare the indications for echocardiography requests in our centers with those in the Appropriate Use Criteria to determine the appropriateness of such requests, and the outcome of the echocardiography for presence or absence of cardiac anomalies. This is important for rational use of this important diagnostic tool.

1.1 Aim

To determine the appropriateness and outcome of echocardiography requests by doctors in tertiary hospitals in Rivers State, Nigeria, using the 2014 Appropriate Use Criteria (AUC) [11] for paediatric echocardiography.

2. METHODOLOGY

This was a retrospective analysis of all paediatric echocardiography data over one year from 1st of July 2019 to 30th of June 2020 from the two tertiary Hospitals in Rivers State. Rivers State is located in the petroleum oil-rich Niger Delta region of Southern Nigeria and has a population over five million people, with only two tertiary hospitals that offer paediatric cardiology services namely the University of Port Harcourt Teaching Hospital (UPTH) and the Rivers State University Teaching Hospital (RSUTH). These two centers have paediatric cardiologist who render echocardiography services. Ethical clearance for the study was obtained from both centers. The echocardiography requests forms covering the period stated above were retrieved from both sites and data obtained from the forms include age, gender, indication for echocardiography and clinical findings (as stated in the request forms). The echocardiography diagnoses were reviewed and categorized into normal or abnormal based on the presence or absence of cardiac anomalies respectively. Abnormal echocardiography reports were further sub-categorized into congenital heart diseases, Acquired Heart Diseases and Cardiomyopathies.

Based on the AUC [11] for paediatric echocardiography, specific indications were

scored (1 to 9), and then categorized into rarely appropriate (scores 1-3), May be appropriate (scores 4-6) and Appropriate (scores 7-9) as shown below:

Score of 1-3 (Rarely appropriate indications)

Echocardiography is not generally acceptable and not a reasonable approach for the indication [11].

Score of 4-6 (Maybe appropriate indications)

Echocardiography may be generally acceptable and may be a reasonable approach for the indication. More research and/or patient information is needed to classify the test definitively [11].

Score of 7-9 (Appropriate indications)

Echocardiography is generally acceptable and is a reasonable approach for the indication. That is a study in which the expected incremental information, combined with clinical judgment, exceeds the expected negative consequence by a sufficiently wide margin for a specific indication [11].

Indications that do not fall into any of the above stated standard AUC criteria [11] were grouped as "Unclassified."

2.1 Data Analysis

Data was entered into a excel spread sheet and statistical analysis was done using IBM SPSS statistics version 23 [12]. Categorical variables were expressed in frequencies and percentages. Cochran-Armitage test for trend was done to asses degree of yield of cardiac pathology for each level of AUC classification while bivariate associations were assessed using persons chi squared tests. Level of significance was set at a p value of<0.05 with 95% confidence interval.

3. RESULTS

There were 645 echocardiography requests within the study period. The median age was 5months, with interquartile range of 2months to 24months. There were 355(55%) males and 290(45%) females with a M:F ratio of 1.2 :1. The clinical indication for echocardiography was appropriate in 490(76.0%), may be appropriate in 32(5.0%) and rarely appropriate in 104(16.1%). A total of 19(2.9%) clinical indications were "Unclassified" under the Appropriate Use Criteria and they included 6 Pre-operation work up, 4 babies delivered via invitro fertilization who were being screened with no symptoms, 4 children being investigated for noisy breathing, A set of triplets being screened for CHD without symptoms, 1 child with irritability and another for routine screening not fully clarified.

3.1 Appropriate Use Criteria and Echo-cardiography Diagnosis for Cardiac Anomalies

The results of the echocardiography showed cardiac abnormality in 544(84.3%) patients, among whom children with appropriate criteria classification had the highest yield of cardiac pathology 457(93.3%) while children with unclassified clinical indication for echocardiography had the lowest yield for cardiac pathology 8(42.1%). The yield of cardiac anomalies from the echocardiography significantly (p=0.00001) decreased with decreasing appropriateness of clinical indications based on AUC (Table 1).

3.2 Clinical Indications for Echo-cardiography and Yield for Cardiac Anomalies

The most common clinical indication for requesting echocardiography is cardiac murmur, 271(42%) among whom 241(88.9%) yielded a cardiac pathology.

The clinical indication with the highest yield of cardiac anomalies from echocardiography was presence of other symptoms and signs with 93% (198); It was also the second common clinical indication for echocardiography request 213(33%). The least common clinical indication for echocardiography request was presence of a family history of cardiovascular disorder 4(0.6%) with abnormal echocardiography yield of 50% (2), followed by having a prior test suggestive of cardiac pathology 10(1.6%) with an abnormal echocardiography yield of 70% (7). Presence of cardiac murmur (OR: 1.71, 95% CI: 1.18, 2.9, P= 0.006), and "other symptoms and signs" (OR: 3.2, 95% CI 1.8, 5.8, P= 0.000002) significantly had a higher likelihood of producing abnormal echocardiography results when compared to other clinical indications.

Chest pain (OR: 0.26, 95% CI: 0.1, 0.7, P= 0.002), "Unclassified indications" (OR: 0.12, 95% CI: 0.04, 0.3, P= 0.027), and "outpatient neonate"

(OR: 0.38, 95% CI: 0.2, 0.9, P= 0.03) significantly had a higher likelihood of not having an abnormal echocardiography when compared to other clinical indications (Table 2).

3.3 AUC Category and Echocardiography Yield for Cardiac Anomaly According to Age

Children aged <3months significantly had the highest appropriate clinical indication - 168(79.6%), (OR: 1.5, 95% CI: 1.2, 2.1, P=0.002) for echocardiography and their yeild of abnormal echcardiography was significantly the highest when compared to other age groups, 203(96.2%), (OR: 5.6 95% CI 2.7, 11.3, P=0.001). The proportion of those with appropriate clinical inidication for echocardiography and the yeild of abnormal echocardigraphy decreased with increasing age such that those aged >9yrs significantly had decreased likelihood of having an appropriate use crteria for echocardiography 65 (10.1%) (OR: 0.5, 95% CI: 0.4, 0.7, P=0.001), and an abnormal yeild from echocardiographgy 38(58.5%), (OR: 0.3, 95% CI: 0.2, 0.4, P= 0.001). This is illustrated in Table 3.

3.4 Types of Cardiac Anomalies Detected

Table 4 shows the types of cardiac anomalies detected within each category of the AUC. The most common cardiac anomalies were congenital heart defects (CHD) in 524(81.2%) of the children who had echocardiography done, followed by cardiomyopathies 11(1.7%).

3.5 Specific Clinical Indications within the AUC Classification and Echo-cardiography Findings

Cardiac murmur 227(46.3%) and presence of other symptoms and signs 187(38.2%) were the common indications for Appropriate referral for echocardiography using the AUC and they had a high yield for CHD of 93.3% and 92% respectively. The most common clinical indication for those with Rarely Appropriate referrals was presumptive innocent cardiac murmur with no clinical symptom nor family history of cardiovascular disease 44(41.1%), however, it had an average yield of 52.3% (23) for CHD; while the most common clinical indication for those with "Maybe Appropriate" AUC is systemic disorders seen in 12(41.4%). This is illustrated in Table 5.

4. DISCUSSION

The study revealed that over three quarters of the indication for echocardiography in the study centers were appropriate when compared with the AUC, while 5% and 16% of indications fell in the category of Maybe appropriate and Rarely appropriate respectively. It also showed that of those who had Appropriate indications, there was a very high yield for cardiac anomalies compared with those whose indications were rarely appropriate. Our study also highlights that the most common indication for referral for echocardiography in our setting are clinically derived (i.e presence of cardiac murmur followed by symptoms and signs of cardiac diseases). Few indications found in the study were not classified under the AUC and their yield for cardiac anomalies was poor.

Although there was a high level of appropriate use of echocardiography in the study centers as shown by 76% of indications being "appropriate" according to the AUC guidelines, higher levels of appropriateness have been reported by Patil et al [13] where 82% of the indications were appropriate, and Ballo et al [14] who found 80.3% appropriateness of indications in their study of 931 patients in a community hospital. The latter studies were in adult populations and used the 2011 AUC [15] for adult echocardiology, as such symptoms/complaints by adult population requiring echocardiography may be more specific compared to children and thus result in a higher yield.

Table 1. Appropriate use criteria and echocardiography yield for cardiac anomalies

AUC classification	Normal echo. No (%)	Abnormal no. (%)	Total no. (%)
Appropriate	33(6.7)	457(93.3)	490(76.0)
May be Appropriate	8(27.6)	21(72.4)	29(4.5)
Rarely Appropriate	49(45.8)	58(54.2)	107(16.6)
Unclassified	11(57.9)	8(42.1)	19(2.9)
Total	101(15.7)	544(84.3)	645(100)

df =3, p= 0.00001

AUC – Appropriate Use Criteria; Echo - Echocardiography

Table 2. Clinical indications for echocardiography and yield for cardiac anomalies

Indication	Normal echo no. (%)	Abnormal echo no. (%)	Total (%)	P-value	OR (95% CI)
Murmur	30(11.7)	241(88.9)	271(42.0)	0.006	1.71 (1.18, 2.9)
Other symptoms and signs	15(7.0)	198(93)	213(33.0)	0.00002	3.2 (1.8, 5.8)
Systemic disorder	13(22)	46(78)	59(9.1)	0.15	0.68 (0.4, 1.1)
Palpitations and arrhythmias	8(28.6)	20(71.4)	28(4.3)	0.056	0.55 (0.3, 1.0)
Chest Pain	8(40)	12(60)	20(3.1)	0.002	0.26 (0.1, 0.7)
Syncope	7(63.4)	4(36.4)	11(1.7)	0.15	0.68 (0.4, 1.1)
Outpatient Neonate	4(40)	6(60)	10(1.6)	0.03	0.38 (0.2, 0.8)
Prior CVS test result	3(30)	7(70)	10(1.6)	0.2	0.51 (0.2, 1.3)
Family history of CVS disorder	2(50)	2(50)	4(0.6)	0.057	0.18 (0.1, 1.3)
Unclassified	11(57.9)	8(42.1)	19(2.9)	0.027	0.12 (0.04, 0.3)
Total	101(15.7)	544(84.3)	645(100)		

Echo – Echocardiography; CVS – Cardiovascular System

Table 3. AUC category and echocardiography yield for cardiac anomaly according to age

Age Groups	Total (%)	Appropriate use criteria category				Yield of echocardiography			
		Appropriate (%)	Inappropriate (%)	P-value	OR (95%CI)	Abnormal Echo (%)	Normal Echo (%)	P-value	OR (95%CI)
< 3mths	211 (32.7)	168 (79.6)	43 (20.4)	**0.002**	1.5 (1.2, 2.1)	203 (96.2)	8 (3.8)	0.001	5.6 (2.7, 11.3)
3-11mths	188 (29.1)	136 (72.3)	52 (27.7)	0.8	1.0 (0.7, 1.3)	155 (82.4)	33 (17.6)	0.3	0.8 (0.5, 1.2)
1 – 4yrs	127 (19.7)	89 (70.1)	38 (29.9)	0.64	0.9 (0.6, 1.2)	103 (81.1)	24 (18.9)	0.2	0.7 (0.5, 1.1)
5 – 9yrs	46 (7.1)	32 (69.6)	14 (30.4)	0.7	0.9 (0.5, 1.4)	39 (84.8)	7 (15.2)	0.95	1.02 (0.5, 2.1)
> 9yrs	65 (10.1)	32 (49.2)	33 (50.8)	0.001	0.5 (0.4, 0.7)	38 (58.5)	27 (47.5)	0.001	0.3 (0.2, 0.4)

Echo=Echocardiography; OR= Odds ratio,

Table 4. AUC criteria and categories of cardiac anomalies detected

	Uncategorized	Rarely appropriate	May be appropriate	Appropriate	Total
Acquired Heart Disease	0(0)	3(33.3)	0(0)	6(66.7)	9(1.4)
Cardiomyopathies	0(0)	2(18.2)	0(0)	9(81.9)	11(1.7)
Congenital Heart Defects (CHD)	8(1.5)	53(49.5)	21(4.0)	442(84.4)	524(81.2)
Normal heart	11(10.9)	49(48.5)	8(7.9)	33(32.7)	101(15.7)
Total	19(2.9)	107(16.6)	29(4.5)	490(76.0)	645(100)

Table 5. Specific Symptoms within AUC Categories and Echocardiography Findings

AUC Classification/Specific symptoms		Echocardiography findings				Within group Total
		Acquired Heart disease	Cardiomyopathies	Congenital heart defects	Normal heart	
Appropriateness not categorized	Unclassified			8(42.1)	11(57.9)	19(100)
Rarely Appropriate	Chest pain	1(11.1)	0(0)	3(33.3)	5(55.6)	9(8.4)
	Innocent Murmur with no symptoms/signs	0(0)	1(2.3)	23(52.3)	20(45.5)	44(41.1)
	Out Patient Neonate	0(0)	0(0)	2(50)	2(50)	4(3.7)
	Other Symptoms and signs	2(9.1)	1(4.5)	12(54.5)	7(31.8)	22(20.6)
	Palpitations and arrhythmia	0(0)	0(0)	8(53.3)	7(46.7)	15(14.0)
	Syncope	0(0)	0(0)	2(25.0)	6(75.0)	8(7.5)
	Systemic disorder	0(0)	0(0)	3(60)	2(40)	5(4.7)
Total		**3(2.8)**	**2(1.9)**	**51(49.5)**	**48(45.8)**	**107(100)**
May be Appropriate	Chest pain			4(100)	0(0)	4(13.8)
	Family History of CV Disorder			2(50)	2(50)	4(13.8)
	Other Symptoms and signs			2(50.0)	2(50.0)	4(13.8)
	Palpitations and arrhythmia			3(100)	0(0)	3(10.3)
	Syncope			1(50.0)	1(50.0)	2(6.9)
	Systemic disorder			9(75.0)	3(25.0)	12(41.4)
Total				**21(72.4)**	**8(27.6)**	**29(100)**
Appropriate	Chest pain	0(0)	0(0)	4(57.1)	3(42.9)	7(1.4)

AUC Classification/Specific symptoms		Echocardiography findings				Within group Total
		Acquired Heart disease	Cardiomyop athies	Congenital heart defects	Normal heart	
	Pathologic Murmur	3(1.3)	1(0.4)	213(93.9)	10(4.4)	227(46.3)
	Out Patient Neonate	0(0)	0(0)	4(66.7)	2(33.3)	6(1.2)
	Other Symptoms and signs	1(0.5)	8(4.3)	172(92.0)	6(3.2)	187(38.2)
	Palpitations and arrhythmia	0(0)	0(0)	9(90)	1(10)	10(2.0)
	Prior test results	0(0)	0(0)	7(70)	3(30)	10(2.0)
	Syncope	0(0)	0(0)	1(0.2)	0(0)	1(0.2)
	Systemic disorder	2(4.8)	0(0)	32(76.2)	8(19.0)	42(8.6)
Total		**6(1.2)**	**9(1.8)**	**442(90.2)**	**33(6.7)**	**490(100)**

It is noteworthy that amongst those who were appropriately referred for echocardiography in this study, there was a high yield of 93.3% for cardiac anomalies and the yield tended to decrease with decreasing levels of appropriateness such that those with rarely appropriate or unclassified indication had the lowest yield for cardiac anomalies. This is in contrast to a study by Catoski et al [16] in Baltimore where the yield for abnormal echocardiography amongst those with appropriate indication was much lower at 16.1%. This huge difference may be related to the differences in the common "specific' indications for echocardiography between the two studies as the present study recorded murmur and presence of clinical signs & symptoms which are related to structural heart diseases, while the study by Catoski et al [16] had systemic disorders as the most common indication, which usually take a long time of disease progression for cardiac anomalies to manifest either late in childhood or well into adulthood. This difference is also reflected in the much younger and older median ages of the two studies at 5 months and 11 years [16] respectively. Also, younger children are more likely to have cardiac referrals from suspicion of congenital cardiac defects when compared older children who are more likely to have other pathologies that could mimic a cardiovascular disorder and thus result in a lower yield of abnormal echocardiography.

The commonest indication for echocardiography in our study is pathologic cardiac murmurs followed by presence of other symptoms and signs. This is not surprising considering the median age of 5 months and interquartile range of 2months to 24 months which encompasses the period for clinical presentation of congenital heart diseases (CHD) that missed detection in the newborn period. Other studies have also reported pathologic murmurs as the commonest indication for echocardiography [5,17].

The relatively small percentage of "out-patient neonate" referred for echocardiography in the study suggest a dearth of targeted fetal cardiac echocardiography screening in high risk pregnancies in the locale, and/or lack of appropriate referral of infants of mothers with underlying disorders such as diabetes, autoimmune disorders or infections during pregnancy with a risk of fetal cardiac anomalies. This is worrisome considering the prevalence of maternal diabetes, and use of herbal concoction during pregnancy in the locale [18-22].

It is interesting to note that the common indications for echocardiography in this study (pathologic murmur and presence of symptoms and signs of cardiac disease) is quite difference from those in studies done in the developed countries (systemic disorders and syncope) as observed Catoski et al. [16]. The reason for this may be due to existence of newborn screening for CHD in developed countries resulting in early detection and intervention. While in resource poor countries like the study centers, lack of newborn CHD screening could result in late presentation in infancy and later childhood with signs and symptoms of CHD in the out-patient setting.

The least common indication for echocardiography in the present study was presence of family history of cardiac anomalies. This is followed by "prior positive test for cardiovascular disorders" which had a high yield of 70% for cardiac anomaly. This finding highlights the need to actively seek information on "prior tests" for cardiac related complaints during clinical encounters so as not to miss patients that may benefit from an appropriate referral for echocardiography.

From the study, the proportion of those with rarely appropriate indications for echocardiography was small compared to those who had appropriate indications. However, the yield for abnormal echocardiography amongst those with rarely appropriate indications was surprisingly average at 54.2%. Further analysis revealed that the most common indication within the rarely appropriate category in this study was "presumably innocent murmur with no symptoms or signs of cardiac disease." This finding is interesting as it suggests that this type of "innocent murmur" may be an appropriate indication for echocardiography in our setting, although generalization should be done with caution as further studies are required to eliminate other confounders such as the skills of the referring doctors at grading and categorizing cardiac murmurs.

Rarely appropriate indications also constituted almost half of all the normal echocardiography report in the study, further highlighting the need for prudence amongst referring doctors to save cost for parent/caregivers.

Nineteen indications seen in the present study were unclassified under the AUC and these included pre-operative workup for surgeries unrelated to the CVS, screening of children born

via *in vitro* fertilization, multiple gestation, noisy breathing and one unspecified reason written as "routine screening." These indications also had the least yield for cardiac anomalies. Considering the high cost of echocardiography and need to pay out of pocket in our centers, it becomes important to educate referring doctors on appropriate indications for cost-effective patient care. The AUC guidelines have been shown in several studies [22-25] to effectively predict important echocardiographic abnormalities and impact optimal patient care, and findings from the present study suggests that the guidelines are also applicable to resource poor settings.

5. CONCLUSION

The study concluded that the majority of requests/indication for echocardiography in the study centers was appropriate when compared those in the Appropriate Use Criteria (AUC). As such, the AUC is applicable in resource poor settings like Nigeria. Also, in our centers, detection of innocent murmurs without signs and symptoms of cardiac disease may be an appropriate indication for echocardiography.

6. LIMITATION

The study is a retrospective analysis of data retrieved from echocardiography forms and as such certain data such as clinical severity and outcome of the patients could not be determined.

7. RECOMMENDATIONS

The 2014 AUC for pediatric echocardiography should be used as a guide for requesting paediatric echocardiography in Nigeria.

CONSENT AND ETHICAL APPROVAL

As per international standard or university standard guideline participant consent and ethical approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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