The Effectiveness of an Educational Intervention in the Appropriate Use of Pediatric Echocardiography

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Background: Congenital heart defects (CHD) include most congenital malformations. Despite the constant prevalence of CHD, inappropriate echocardiography requests pose a healthcare burden.

Objective: To evaluate the effectiveness of an educational intervention of the use of pediatric echocardiography as a primary diagnostic tool.

Design: A Prospective Clinical Study.

Setting: Bahrain Defence Force Hospital, Bahrain.

Method: The study was performed from October 2012 to January 2018. Pediatric echocardiography requests over 1,170 consecutive days were documented. Initial analysis was performed followed by an application of Appropriate Use Criteria (AUC) and subsequent reanalysis. Follow-up echocardiography were excluded. New cases echocardiograms were classified as having normal or abnormal findings. Abnormal findings were classified as required or not required intervention.

Result: One thousand six hundred forty-eight (55.3%) echocardiography tests were performed before the educational intervention and 1,329 (44.5%) were performed after. The follow-up cases were excluded. Two hundred twenty-eight had (15%) abnormal findings in the initial analysis compared to 138 (11.1%) in the reanalysis (OR: 0.71; 95% CI: 0.56 to 0.89). Abnormal findings requiring intervention were common after education (3.4% versus 7.8%. OR: 2.1; 95% CI: 1.3 to 3.5).

Conclusion: **The implementation of an AUC intervention decreased the diagnostic yield of echocardiography but increased the yield of cases that required intervention.**

Bahrain Med Bull 2019; 41(4): 218 - 221

Congenital malformations are the leading cause of infant mortality worldwide; congenital heart defects (CHDs) comprise one-third of all congenital malformations[1]. The prevalence of CHD (9.1 cases per 1,000 live births) has remained consistent since 1995[2]. CHDs have a complex multifactorial etiology which includes genetic defects as well as environmental factors. Some require no intervention while others are fatal if not corrected. Thus, early and accurate detection of CHD is necessary to plan for optimal disease management.

Investigations of CHD include electrocardiogram (ECG), chest x-ray, echocardiogram, magnetic resonance imaging (MRI), computerized tomography (CT) scanning, and cardiac catheterization with angiogram. Pediatric echocardiography is a non-invasive test which utilizes sonography to visualize heart structure and hemodynamics[3].

Requests for echocardiography have been increasing at a rate of 7.7% per year[4]. A study of 978 fetal and pediatric echocardiograms and post-mortem examinations found that only 74 of high-risk referrals had CHD[5]. Most echocardiography findings were normal, which indicates that referrals are exaggerated. Early detection and intervention of CHD in pediatric patients would result to an increasing number of adults with heart defects who require long-term medical care[2]. The inappropriate request of pediatric echocardiograms adds to the global health burden.

Appropriate use criteria (AUC) for pediatric echocardiography were recently published in 2014[6]. It describes clinical scenarios where it is appropriate (A), moderately appropriate (M), and rarely appropriate (R) to request pediatric echocardiography as primary diagnostic modality[6].

The aim of this study is to evaluate the effectiveness of an educational intervention on the use of pediatric echocardiography as a primary diagnostic tool.

METHOD

The study was performed from October 2012 to January 2018. All pediatric patients who underwent echocardiography over 1,170 consecutive days were included. Pediatric echocardiograms

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were grouped as new or follow-up. Follow-up cases were excluded.

Clinical records were reviewed and the following information was recorded: the referring department, date, echocardiogram findings, and intervention. Data were recorded into an Excel spreadsheet for analysis.

The study was performed during two equal stages; pediatric echocardiography appropriateness was performed from October 2012 to May 2015 followed by an educational intervention and a subsequent reanalysis from June 2015 to January 2018. The educational intervention consisted of the researchers meeting three times; once with all hospital staff and twice with members of the departments which referred the patients for echocardiography. Physicians were asked to follow clinical guidelines for echocardiography indications, specifically the AUC.

The primary outcome measure of the audit was whether the echocardiography findings were normal or abnormal. A normal finding is defined as an echocardiogram without lesions and abnormal finding is defined as an echocardiogram with congenital or acquired lesions; if abnormal, the nature of the lesion is recorded[7]. Furthermore, abnormal echocardiograms were classified as requiring or not requiring catheter-based or surgical intervention.

Statistical analysis was performed using Microsoft Excel. The Chi-squared test was used for categorical data to compare frequencies between the analysis and reanalysis. Significance was defined as a P-value of less than 0.05.

RESULT

The initial analyses of 1,648 (55.4%) echocardiograms were performed prior to the educational intervention; 133 echocardiograms were previously diagnosed with a CHD elsewhere and, thus, excluded from further analysis. Therefore 1,515 cases were included in the study. The reanalysis of the 1,329 (44.6%) echocardiograms performed after the educational intervention yielded 91 echocardiograms previously diagnosed and were excluded. Therefore, 1,238 echocardiograms fulfilled the study's patient criteria.

After the analysis, 1,100 had normal and 138 had abnormal findings. Forty-two required intervention and 96 did not require intervention, see figure 1 and 2.

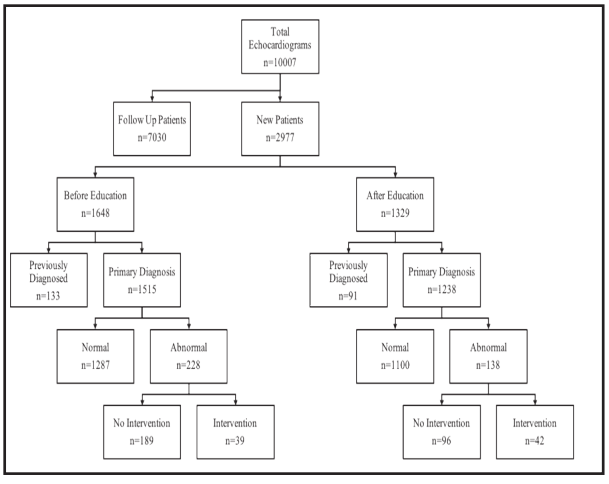


Figure 1: Flow Chart of Study Sample Size

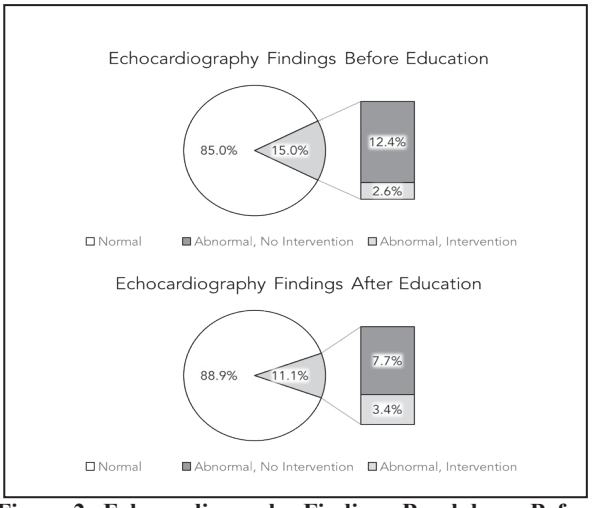


Figure 2: Echocardiography Findings Breakdown Before and After the Educational Intervention

Overall, the abnormal rate decreased from 228 (15%) to 138 (11.1%) after the educational intervention, see table 1. The following departments had decreased abnormal rates: pediatric outpatient department (POPD), neonatal intensive care (NICU), pediatric wards (PW), and King Hamad University Hospital (KHUH). Conversely, departments that had an increase in abnormal rate were cardiac outpatient department (COPD), neonatal units (NU), ICU, A & E and other units. All cardiac wards had no change in abnormal rate.

Table 1: Echocardiography Findings for Each Department Before and After the Educational Intervention Including Those Previously Diagnosed (133) Before Education and (91) After the Education

	Number of Echocardiography Findings (%)					
	Before Education (1,648)			After Education (1,329)		
Department	Normal	Abnormal	Total	Normal	Abnormal	Total
COPD	214 (12.9%)	174 (10.6%)	**388 (23.5%)**	41 (3.1%)	93 (6.9%)	**134 (10.1%)**
POPD	393 (23.8%)	33 (2%)	**426 (25.8%)**	465 (34.9%)	38 (2.9%)	**503 (37.8%)**
NICU	177 (10.7%)	40 (2.4%)	**217 (13.2%)**	229 (17.2%)	34 (2.6%)	**263 (19.8%)**
NU	121 (7.3%)	28 (1.7%)	**149 (9%)**	92 (6.9%)	24 (1.8%)	**116 (8.7%)**
PW	149 (9%)	20 (1.2%)	**169 (10.3%)**	131 (9.9%)	13 (0.9%)	**144 (10.8%)**
CW/CSW/ CICU	0	9 (0.5%)	**9 (0.5%)**	0	2 (0.2%)	**2 (0.2%)**
OTHER	89 (5.4%)	14 (0.8%)	**103 (6.3%)**	93 (6.9%)	15 (1.1%)	**108 (8.1%)**
KHUH	142 (8.6%)	45 (2.7%)	**187 (11.3%)**	49 (3.7%)	10 (0.8%)	**59 (4.4%)**
All Departments	1,287 (78.1%)	346 (20.9%)	**1,648 (100%)**	1,100 (82.8%)	238 (17.9%)	**1,329 (100%)**

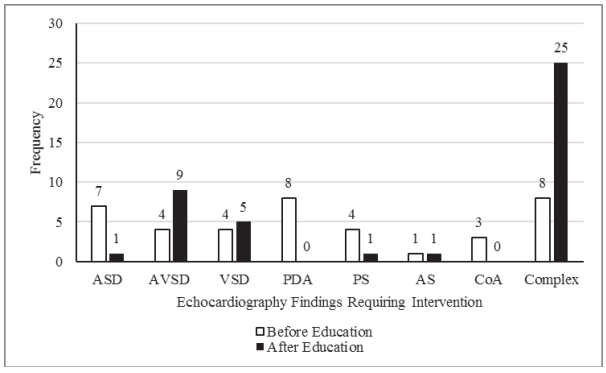
COPD = cardiac outpatients department; POPD = pediatrics outpatients department; NICU = neonatal intensive care unit;NU = neonatal unit; PW = pediatrics ward; CW = cardiac ward; CSW = cardiac surgery ward ; CICU = cardiac intensive care unit; KHUH = University hospital

The percentage of abnormal findings decreased from 15% in the initial analysis to 11.1% in the reanalysis; the OR of an echocardiogram with an abnormal finding between the two was 0.71 (95% CI: 0.56 to 0.89). Abnormal echocardiography findings were more likely to have been conducted in the initial analysis (X^2=9.00, 1 degree of freedom, P=0.003).

The reanalysis was found to have a higher intervention rate than the initial analysis as the percentage of abnormal findings that required intervention increased from 17.1% to 30.4% (OR: 2.1; 95% CI: 1.3 to 3.5). Abnormal echocardiography findings that required intervention were more likely to have been conducted in the reanalysis (X^2=8.86, 1 degree of freedom, P=0.003). In addition, the percentage of all primary echocardiograms, which

were abnormal and required intervention, increased from 2.6% to 3.4% after education.

The CHD diagnosed by echocardiography and required intervention included atrial septal defects (ASD), atrioventricular septal defects (AVSD), ventricular septal defects (VSD), patent ductus arteriosus (PDA), pulmonary stenosis (PS), aortic stenosis (AS), aortic coarctation (CoA), and complex lesions. The most common indication in the initial analysis was PDA, 8 (0.5%), and complex lesions, 8 (0.5%), while the most common indication in the reanalysis was complex lesions, 25 (2%), followed by AVSD, 9 (0.7%), see figure 3.



ASD = atrial septal defects; AVSD = atrioventricular septal defects; VSD = ventricular septal defects; PDA = patent ductus arteriosus; PS = pulmonary stenosis; AS = aortic stenosis; CoA = aortic coarctation

Figure 3: Frequency of Echocardiography Findings Requiring Surgical Intervention

DISCUSSION

Pediatric patients with congenital heart defects (CHD) encompass a wide range of pathologies from minor defects to complex malformations that require prompt intervention and lifelong follow-up. Therefore, these conditions necessitate an efficient and sensitive tool to determine a management plan. Echocardiography has been established as the primary diagnostic tool for patients with CHD. Inappropriate referrals have led to increasing costs and added to the healthcare burden. To alleviate this, the Appropriate Use Criteria (AUC) for pediatric echocardiography was published by the American College of Cardiology and American Society of Echocardiography in 2014 to guide physicians.

This study evaluated the effectiveness of the AUC in terms of abnormal and intervention rates in echocardiography findings. The abnormal findings on echocardiography decreased from 15% in the initial analysis to 11.1% after introducing the AUC. A study of the diagnostic yield of pediatric echocardiograms revealed an abnormal rate of 15%[7]. Similarly, another study revealed a 15% abnormal rate after AUC implementation[8]. The AUC indications have been corroborated by several studies[9].

The intervention rate provides a better measure of the appropriateness of requests since it considers the clinical impact of the findings. After introducing AUC, a higher number of abnormal findings required intervention (17.1% versus 30.4% of abnormal). This increase was seen in the reanalysis, which is similar to a study that revealed an intervention rate of 31.8%[10]. Likewise, abnormal findings requiring intervention comprised a greater portion of all primary echocardiograms conducted (2.6% versus 3.4%). These findings indicate that the implementation of AUC resulted in more significant CHD that require intervention.

Inappropriate use of pediatric echocardiography is likely to be due to non-enforcement of guidelines and application of adult cardiology principles on a pediatric population. Chest pain, dyspnea, and palpitations are high yield symptoms in the adult echocardiography and AUC[11]. On the other hand, three of these symptoms have a pediatric AUC rating of rarely appropriate unless presented with multiple symptoms, abnormal ECG findings, or a family history[6]. This divergence in standards of practice in the adult and pediatric patient results in inappropriate use of echocardiography. Moreover, there is a high incidence of non-pathological murmurs in childhood that are due to physiological conditions which resolve towards adulthood. The inability of physicians to differentiate between innocent and pathological murmurs results in echocardiography referrals[12]. The COPD department had the highest increase in abnormal rate between analyses.

Reluctance to clinically diagnose normality as well as parental demands for confirmatory investigations contributes to the increase in the use of echocardiography.

Although we might be urged to strive to a high abnormal finding rate, negative echocardiography findings have significant clinical benefits. Patients presenting with symptoms suggestive of CHD would be advised to limit physical exertion and restrict sports participation. In this group, a diagnosis of normality by echocardiogram would reassure parents and allow for unlimited physical exercise. These patients are positively impacted by a normal finding when considering the negative effects of decreased exercise and high pediatric obesity rates[13].

The passive mode of delivery of the AUC document should be replaced with an active application of the criteria through effective patient-mediated interventions and multifaceted activities[14]. Furthermore, education and awareness of the guidelines should be promoted to primary care physicians. Echocardiography access should be limited to specialized physicians and consultants[15].

It is worth noting that AUC applies to the selection of patients for echocardiography based on clinical findings and not the outcome of the investigation[11].

CONCLUSION

The clinical implementation of the pediatric echocardiography AUC had limited success. There are areas to improve the adoption of the guidelines and overall efficiency and effectiveness of patient care. Clinically significant echocardiograms were conducted after the AUC leading to direct improvements in patient care. The yield of abnormal findings on echocardiography decreased.

Author Contribution: All authors share equal effort contribution towards (1) substantial contributions to conception and design, acquisition, analysis and interpretation of data; (2) drafting the article and revising it critically for important intellectual content; and (3) final approval of the manuscript version to be published. Yes.

Potential Conflicts of Interest: None.

Competing Interest: None.

Sponsorship: None.

Acceptance Date: 18 August 2019.

Ethical Approval: Approved by the Research Ethical Committee, Bahrain Defence Force Hospital, Bahrain.

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