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Roles of MRI and Doppler Echocardiographic In Evaluation of Aortic Coarctation: Review

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Abstract: **Coarctation of the aorta represent 5% -7% of all congenital heart disease [(4)], with an incidence of roughly 3 cases per 10000 birth. Coarctation may be seen in isolation or with additional heart lesions, such as bicuspid aortic valve, ventricular septal flaw, patent ductus arteriosus, transposition of the fantastic arteries, atrioventricular canal defects, or left-sided obstructive heart problems, consisting of hypoplastic left heart syndrome .**

Objectives: This review article was aimed to focus in discussing the roles of MRI and Doppler echocardiographic in evaluation and assessment of aortic coarctation.

Methods: We conducted a comprehensive computerized search of literature published in English language, up to December, 2016. Involving human subjects only, the search was perfumed through the well-known medical databases; Medline/PubMed, and Embase, searching studies that discussing the roles of MRI and Doppler echocardiographic in evaluation and assessment of aortic coarctation.

Results: Doppler echocardiography (DE) is presently the very first imaging modality utilized, demonstrating the location and the intensity of the constriction and has the advantage of estimating noninvasively the pressure gradient throughout the narrowing. Magnetic resonance imaging (MRI) has been acknowledged as the noninvasive imaging method of option for the examination of aortic coarctation before repair surgery.

Conclusion: MRI also appears to be the most efficient technique to follow-up patients after coarctation repair work and identify postoperative complications. Echocardiography is the primary imaging modality for evaluation of the heart. Among the major benefits of DE is the ability to measure the gradient throughout the coarctation sector. In addition, the existence of associated hereditary heart and valve abnormalities and heart function can also be examined effectively in a noninvasive way.

Keywords: **Doppler echocardiography (DE), Magnetic resonance imaging (MRI).**

1. INTRODUCTION

Coarctation of the aorta (CoA) was first explained by Morgagni in 1760 [(1)], and in its most basic kind refers to hereditary constricting of the proximal thoracic aorta. While aortic coarctation most commonly occurs as a discrete stenosis in the juxtaductal position, it might likewise be connected with long segment narrowing, hypoplasia of the transverse aortic arch, or stenosis of the abdominal aorta [(2,3)]. Coarctation of the aorta represent 5% -7% of all congenital heart disease [(4)], with an incidence of roughly 3 cases per 10000 births [(5)]. Coarctation may be seen in isolation or with additional heart lesions, such as bicuspid aortic valve, ventricular septal flaw, patent ductus arteriosus, transposition of the fantastic arteries, atrioventricular canal defects, or left-sided obstructive heart problems, consisting of hypoplastic left heart syndrome [(6,7)].

Medical diagnosis and evaluation of coarctation is of fantastic significance, not only before stenting but also after implantation, in order to evaluate the occurrence of restenosis. With regard to examination of aortic coarctation, cardiovascular magnetic resonance (CMR) imaging is the treatment of choice [(8)]. Nevertheless, its usage might be restricted because of lack of accessibility or medical contraindications.

On one hand, due to the large schedule, in the presence of scientific suspicion of aortic coarctation, echocardiography is the only readily available bedside diagnostic tool. It is likewise used in the initial evaluation and subsequent after the intervention of patients with coarctation. On the other hand, two-dimensional and colour Doppler echocardiographic techniques including analysis of continuous-wave and pulse-wave Doppler throughout the coarctation site and at the stomach aorta are also used for the indirect assessment of coarctation [9]. A Doppler echocardiographic index, independent of heart function or other lesions and based on two-dimensional measurements of the transverse aortic arch would supply a simple tool to improve the precision of identifying coarctation [10].

This review article was aimed to focus in discussing the roles of MRI and Doppler echocardiographic in evaluation and assessment of aortic coarctation.

2. METHODOLOGY

We conducted a comprehensive computerized search of literature published in English language, up to December,2016. Involving human subjects only, the search was perfumed through the well-known medical databases; Medline/PubMed, and Embase, searching studies that discussing the roles of MRI and Doppler echocardiographic in evaluation and assessment of aortic coarctation. In addition, we manually searched the references of each identified study for more relevant articles to be included in this review.

3. RESULTS

- ***General view of diagnosis of aortic coarctation:***

Coarctation of the aorta is characterized by anatomical blockage in the descending aorta. It is challenging to evaluate this blockage because of the irregularity in heart output, number and size of collaterals, and peripheral resistance [10]. Primary scientific medical diagnosis and subsequent evaluation of the intensity of coarctation and re-coarctation of the aorta have typically been made based upon the judgment of the character of the femoral pulse. Likewise referred to as a secondary occasion, absent, compromised or postponed femoral pulses occur as a result of obstruction in aortic coarctation.

Doppler echocardiography (DE) is presently the very first imaging modality utilized, demonstrating the location and the intensity of the constriction and has the advantage of estimating noninvasively the pressure gradient throughout the narrowing [11]. A restricted acoustic window encountered with DE might lead to non-consistent outcomes, while a precise evaluation of aortic anatomy and associated malformations is required before interventional or surgical repair [12]. Magnetic resonance imaging (MRI) has been acknowledged as the noninvasive imaging method of option for the examination of aortic coarctation before repair work, frequently superior to DE [13,14]. In addition to acquiring morphologic outcomes similar to angiography (site, degree and degree of the narrowing, associated aortic arch tubular hypoplasia and collateral pathways), MRI, with the help of velocity-encoded cine (VEC) method, can provide quantitative evaluation of circulation velocities in all segments of the thoracic aorta [15,16].

Doppler echocardiography can examine the existence and severity of aortic coarctation and any associated cardiac problems and is the diagnostic gold requirement in infants and neonates (**Figure 1**) [16]. Although transthoracic echocardiogram stays the preliminary test of choice for coarctation, in larger children and adults [17], DE windows may be suboptimal. When this is the case, a computed tomography scan or magnetic resonance imaging (MRI) offers outstanding anatomic detail at the site of coarctation, and these techniques are commonly utilized to create three-dimensional images for interventional planning (**Figure 2**) [16]. MRI has the additional benefit of measuring and defining collateral vessel circulation. Although cardiac catheterization was often utilized for medical diagnosis of coarctation in the past, it is now normally scheduled for restorative intervention or in those cases where hemodynamic information is additive to the diagnostic examination [17,18].

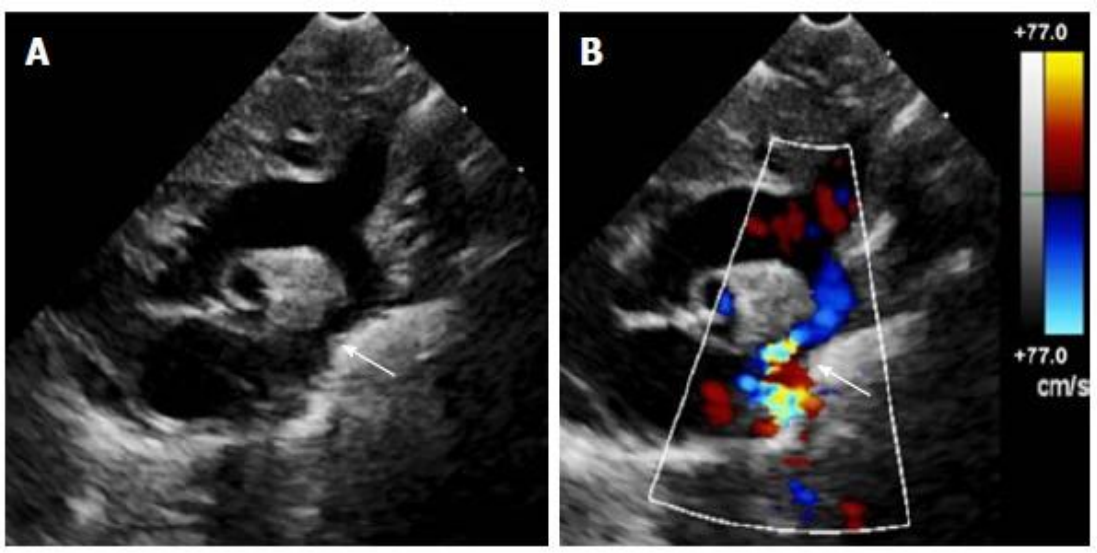

Figure 1: DE of aoratic coarctation. [16]

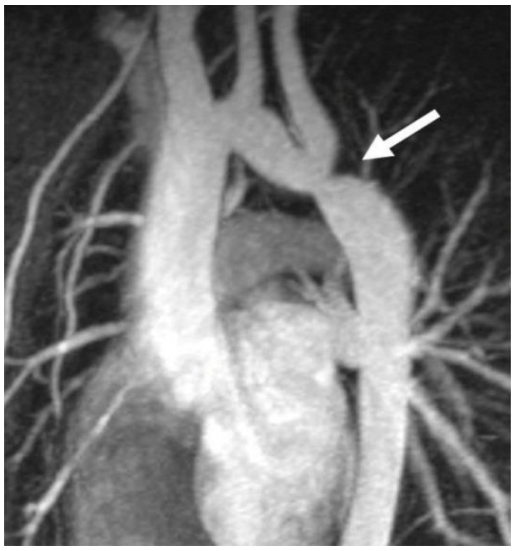

Figure 2: MRI of aortic coarctation [16]

- ***Roles of MRI in assessment of Turner syndrome (TS) especially aortic coarctation:***

Turner's syndrome (TS) or Ullrich-Turner's syndrome is a condition defined by a missing or structurally unusual 2nd X chromosome and impacts around 1 in 2000 newborn women [19]. The variable phenotypes can be divided into 3 main classifications: monosomy X karyotype (45, X) (in 36 - 45%); mosaic karyotype (44 - 54%); and an isochromosome Xq, (5 - 11%) [20,21]. Brief stature, gonadal dysgenesis, and genetic cardiovascular defects prevail functions of TS [22].

MRI offers a ionising radiation free and non-invasive assessment of cardiovascular anatomy with great visualisation of the heart chambers, myocardium, and the valves and a clear visualisation of the whole thoracic aorta, enabling recognition of the scientifically and sonographically quiet abnormalities, such as a mild dilatation of the aorta or an elongation of the transverse aortic arch with kinking [23,24]. As pointed out previously, MRI can supplement transthoracic echocardiography in cases of inadequate visualisation of the aortic valve leaflets and mix of both imaging techniques yields diagnostic visualisation of the valve in almost all cases [25].

Aortic coarctation affects 12% of females with TS [26]. In addition, extended transverse arch and kinking of the isthmic part of aorta can be seen in around half of all TS cases (**Figure 3 & 4**) [26,27]. This is likely part of a spectrum of irregularities affecting the thoracic aorta, with elongated transverse arch as the mildest expression, and aortic arch hypoplasia/aplasia representing the most extreme end of the spectrum, observed in around 2% of TS women [27]. Aortic coarctation has actually been shown to be associated with dissection, and it has actually been proposed that extended

transverse arch may likewise predispose to dissection due to unusual circulation speeds and shear stress within the arch, although this has actually not been properly evaluated [26]. Aortic coarctation is well evaluated with MRI, using either MR angiography (MRA) or a 3D bSSFP series, with both strategies revealing a tight stenosis at the aortic isthmus with or without security development. Present guidelines of European Society of Cardiology suggest intervention when there is > 50% stenosis at the coarctation compared with the aortic size at the diaphragm with high blood pressure (Class IIa suggestion) with factor to consider to step in even in the absence of high blood pressure (Class IIb suggestion) [28]. Additional functional assessment can be carried out with velocity-encoded cine-MRI. Indicators of substantial circulation disability consist of: greater flow through the distal thoracic aorta than through the thoracic aorta right away distal to the coarctation; retrograde intercostal artery flow; and a diastolic tail with loss of the normal systolic-- diastolic variation in circulation. A pressure gradient throughout the stenosis can be calculated utilizing the customized Bernoulli formula ($\Delta P = 4_v^2$) where v is the maximum speed through the coarctation. A gradient above 15 mmHg has been recommended as being substantial on MRI, whereas echocardiography utilizes a threshold of 20 mmHg, which is similar to that used in intrusive catheter measurements, although MRI often underestimates the peak speed, thus the inconsistency [28,29]. Considerable collateral circulation can result in the pressure gradient being artificially low, and thus, metrology of collateral circulation is thought about a more accurate assessment of the haemodynamic significance of the stenosis [30].

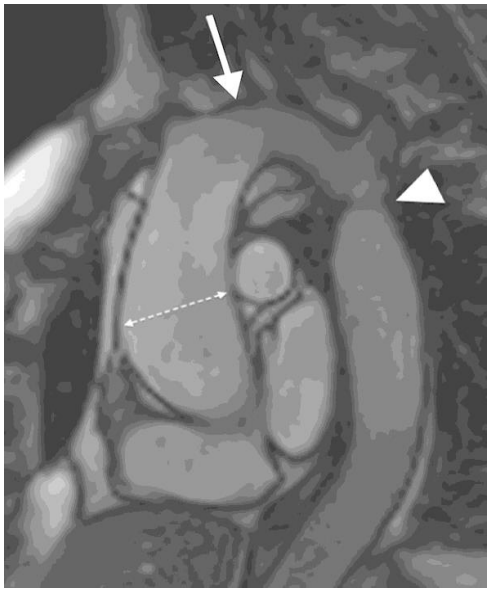

Figure 3: MRI aortic coartication of descending thoracic aorta (white arrowhead) [26]

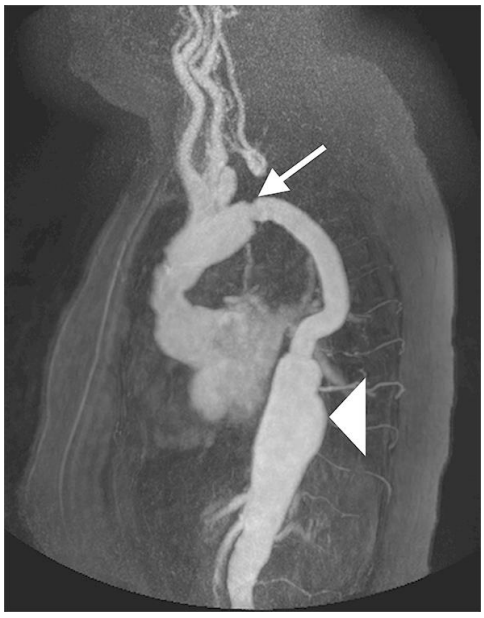

Figure 4: MRI for residual coarctation after surgical repair [27]

- ***Roles of Doppler Echocardiographic in assessment of coarctation of aorta:***

Doppler echocardiography is non-invasive, inexpensive, and quickly repeatable. Besides, it not just exposes the accurate anatomy of CoA, but likewise supplies much info concerning other cardiovascular structures, heart function and hemodynamics. Hence, color echocardiography should be a primary technique for diagnosis of CoA [31,32], specifically for pregnant females to prevent irradiation [33]. The echocardiographic medical diagnosis of 48 of our 53 patients remained in line with findings at surgical treatment; the precision rate was 90.6%, which is consistent with those reported in the literature [34,35].

Echocardiography is also extremely helpful in the postoperative assessment of patients with CoA. The life span of patients with CoA has been revealed to decrease although the operation has succeeded [36,37]. The postoperative patients of CoA are still at risk for such issues as consistent hypertension and problems of chronic high blood pressure including coronary heart disease, myocardial infarction, stroke, dissecting aneurysm and early deaths [36]. Moreover, consistent hypertension leads to left ventricular hypertrophy and lowered left ventricular diastolic function [36,37]. Resting high blood pressure persists in 10 - 30% of patients following surgical repair work, and exercise might induce high blood pressure in 30 - 65% of such patients [37]. Nevertheless, workout test might not be suitable for young children; pharmacological stress test should be employed for this reason. Banaszaketal [38] suggested dobutamine tension echocardiography for examination of the results of surgical repair of CoA in children. Echo- cardiography is also very valuable in finding postoperative re-coarctation [39], aortic aneurysm development at the site of repair work [40], and pulmonary hypertension [41].

Transthoracic echocardiography likewise has diagnostic worth on other congenital heart diseases, consisting of sinus of valsalva aneurysm [42], coronary sinus septal problem [43], coronary artery fistula [44], left coronary artery emerging from the ideal lung artery [45] and so on excerpt aortic coarctation. Inaccordance with the relationship of the place of the coarctation with the ductus arteriosus, coarctation of the aorta is divided into coarctation of aorta-preductal type and coarctation of aorta-postductal type. Echocardiographic functions of coarctation of aorta are as, in coarctation of aorta-preductal type, the inner diameters of distal aortic arch and aortic isthmus narrow significantly, and the aortic arch and/or descending aorta expose an irregular stricture. In coarctation of aorta-postductal type, the descending aortic constraint situated distal to the left subclavian artery provides a gourd-shaped look (**Figure 5**) [40]. Whether the coarctation of aorta is of the postductal or preductal type, the distal descending aorta exposes dilatation after the coarctation.

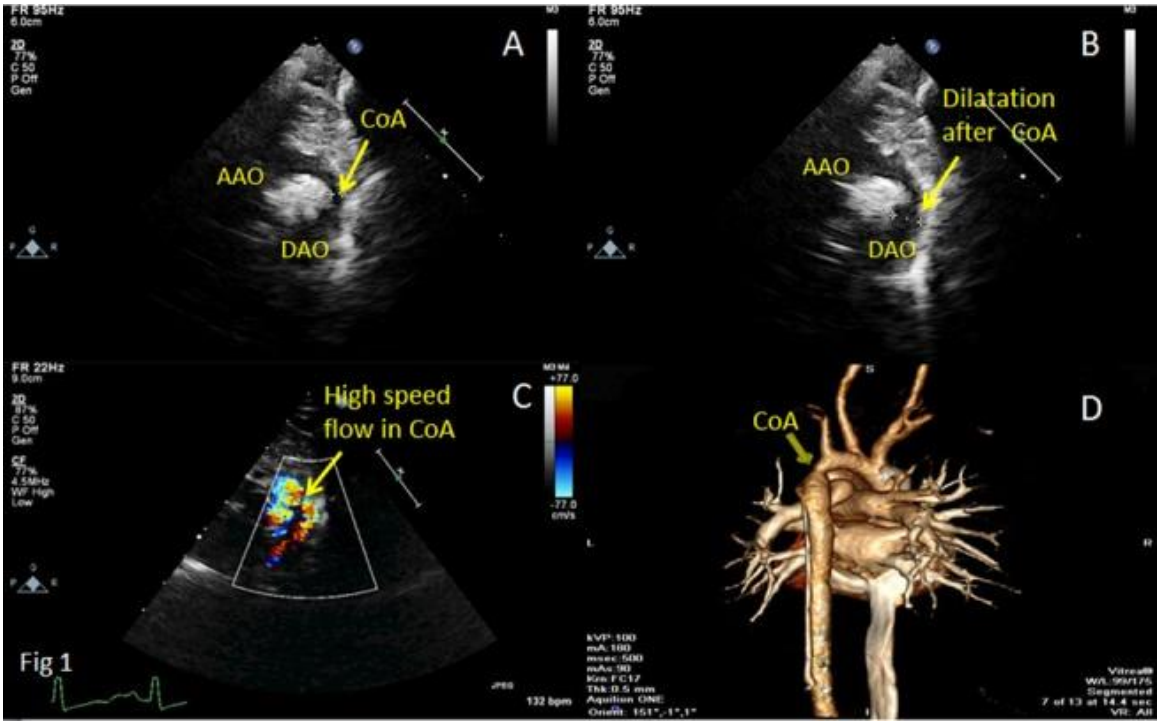

Figure 5: DE in suprasternal view of a 2-month-old boy showing[A] the location of the coarctation of aorta (CoA) between the ascending aorta (AAO) and descending aorta (DAO), [B] dilatation of the aorta after the CoA, [C] high speed flow in the CoA. [40]

4. CONCLUSION

MRI is the noninvasive technique of option for assessing the morphology of aortic coarctation and particularly to illustrate the place, the degree and the length of the narrowing, the degree of associated aortic arch hypoplasia, the presence of security flow, the poststenotic dilatation and the relationship to the left subclavian artery; all these parameters are essential to prepare interventional or surgical repair. MRI also appears to be the most efficient technique to follow-up patients after coarctation repair work and identify postoperative complications. Echocardiography is the primary imaging modality for evaluation of the heart. Among the major benefits of DE is the ability to measure the gradient throughout the coarctation sector. In addition, the existence of associated hereditary heart and valve abnormalities and heart function can also be examined effectively in a noninvasive way.

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