

BACKGROUND

- The current AHA/ACC guidelines recommend maximal exercise stress testing (m-EST) for inducible ischemia detection in anomalous aortic origin of a coronary artery (AAOCA).
- Asymptomatic patients with anomalous aortic origin of right coronary artery (AAORCA) may be cleared for competitive sports based on a negative EST.
- Data on EST characteristics and its sensitivity/specificity for inducible ischemia detection is limited.
- Dobutamine stress cardiac magnetic-resonance-imaging (DS-CMR) has reliably identified myocardial perfusion abnormalities in AAOCA.

PURPOSE

- To describe EST characteristics, including ECG-EST and cardiopulmonary exercise testing (CPET), in a large cohort of pediatric patients with AAOCA
- Compare data between the AAORCA and AAOLCA subgroups.
- Evaluate association of EST findings with inducible ischemia detected on DS-CMR.

METHODS

- AAOCA patients ≤ 20 years old prospectively enrolled from 6/2014-12/2019. Patients presenting with cardiac arrest, physical limitations & complex congenital heart disease were excluded.
- A m-EST was defined as respiratory exchange ratio (RER) ≥ 1.05 .
- Abnormal-ECG-EST= significant ST changes or high-grade-arrhythmia; Abnormal-CPET= $\dot{V}O_{2max}$ and/or O_2 pulse $< 85\%$ predicted or abnormal O_2 pulse curve. Abnormal-ECG-EST+CPET was a composite.
- A +DS-CMR had findings of inducible ischemia (Fig 1).

Variables	AAORCA (n = 126)	AAOLCA (n = 29)	p value
Age, median (IQR)	13 (11 - 15)	14 (7 - 17)	0.81
Male Sex, n (%)	78 (62)	19 (66)	0.85
Race, n (%)			0.45
African American	35 (28)	5 (17)	
Caucasian	71 (56)	19 (66)	
Other/Unknown	20 (16)	5 (17)	
Presenting symptoms, n (%)			0.85
Only rest	39 (31)	7 (24)	
Only exertion	25 (20)	7 (24)	
Both	20 (16)	4 (14)	
No symptoms	42 (33)	11 (38)	
Exertional symptoms, n (%)	45 (36)	11 (38)	0.82
Intramural course (mm), Median (IQR)	5.4 (4 - 7)	3.5 (3 - 5.5)	0.48
Any Symptoms with exercise, n (%)	21/116 (18)	5/25 (20)	0.82
EST symptoms, n (%)			0.17
Chest pain	12 (55)	2 (33.3)	
Dizziness	5 (23)	2 (33.3)	
SOB	0	1 (16.7)	
Other	5 (23)	1 (16.7)	
Max HR ($>85\%$ ile), n (%)	111/116 (96)	23/25 (92)	0.44
Max RER ≥ 1.05 , n (%)	74/103 (72)	12/20 (60)	0.19
Max HR ($>85\%$ ile) or RER ≥ 1.05 , n (%)	115/126 (91)	23/29 (79)	0.09
Inducible ischemia on DS-CMR, n (%)	17/126 (13.5)	10/29 (35)	0.007*

AAOCA: Anomalous aortic origin of coronary artery (right: AAORCA; left: AAOLCA); EST: Exercise stress test; m-EST: maximal-Exercise stress test; IQR = interquartile range; SOB: Shortness of breath; HR = heart rate; RER: respiratory exchange ratio; DS-CMR: dobutamine stress cardiac magnetic resonance imaging; * statistically significant.

Table 1. Baseline Characteristics.

	+ DS-CMR (n = 19)	- DS-CMR (n = 67)	p value
AAOLCA	5 (26)	7 (10)	0.13
Age, median (IQR)	15 (13 - 17)	14 (13 - 16)	0.49
Sex Male n (%)	13 (68)	43 (64)	0.73
Black race, n (%)	7 (37)	20 (30)	0.56
Exertional symptoms, n (%)	8 (42)	23 (33)	0.45
Intramural course, n (%)	15 (79)	53 (79)	1.00
ECG-EST variables			
Hypotension, n (%)	1 (5.3)	1 (1.6)	0.41
Sig ST depression, n (%)	0	5 (7.5)	0.58
Significant ST change, n (%)	2 (10.5)	6 (9)	1.00
Symptoms and ST changes, n (%)	0	3 (4.5)	1.00
Significant arrhythmia, n (%)	1 (5.3)	1 (1.5)	0.39
Non-significant arrhythmia, n (%)	6 (32)	12 (18)	0.20
CPET variables			
Abnormal $\dot{V}O_{2max}$ ($< 85\%$ predicted), n (%)	9/18 (50)	23/65 (35)	0.21
$\dot{V}O_2$ relative, median (IQR)	32.2 (23.5 - 43.3)	39.1 (31.3 - 46.3)	0.30
$\dot{V}O_2$ relative % predicted	77 (63 - 94)	93 (69 - 108.5)	0.14
O_2 pulse (mL/min)	11.8 (9.9 - 12.7)	13 (8.6 - 16)	0.43
O_2 pulse %predicted	82 (77 - 98)	101 (89 - 118)	0.001*
Abnormal O_2 pulse ($< 85\%$ predicted)	9/15 (60)	13/58 (22)	0.005*
Abnormal O_2 pulse curve, n (%)	5/5 (100%)	4/28 (14)	$< 0.001^*$
Normal $\dot{V}O_2$ at VAT ($> 40\%$ predicted), n (%)	17/19 (89.5)	59/66(89)	1.00
Normal $\dot{V}E/\dot{V}CO_2 \leq 30$, n (%)	10/18 (55)	40/67 (60)	0.16

AAOLCA: Anomalous aortic origin of left coronary artery; CPET: cardiopulmonary exercise stress test; ECG-EST: electrocardiographic evaluation of exercise stress test; m-EST: maximal-Exercise stress test; O_2 pulse: oxygen pulse; VAT: ventilatory anaerobic threshold; $\dot{V}E/\dot{V}CO_2$: minute ventilation/carbon dioxide production; $\dot{V}O_2$: peak oxygen consumption.

Table 2. Comparison of EST characteristics and DS-CMR

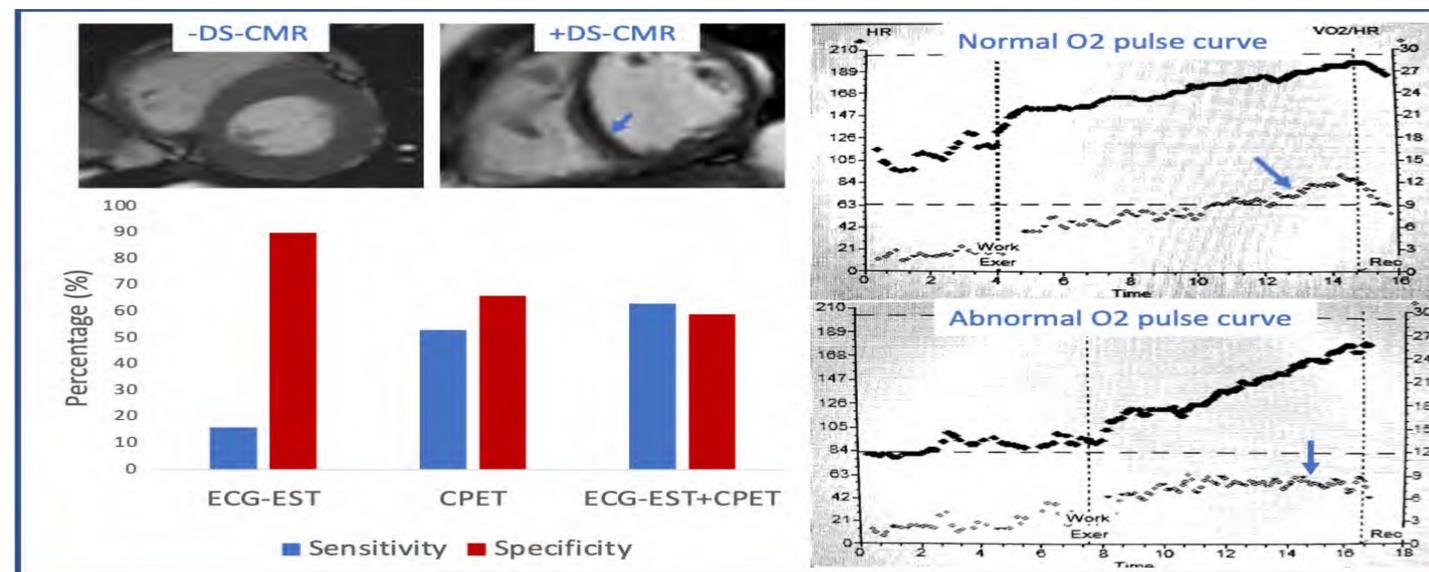


Fig 1: CPET and ECG-EST+CPET have higher sensitivities for detection of inducible ischemia on DS-CMR compared to ECG-EST alone. Abnormal O_2 pulse curve is significantly associated with +DS-CMR.

METHODS – ANALYSIS

- Mann-Whitney and Fisher's exact/ χ^2 tests were used for continuous and categorical variables respectively.
- Univariate analysis was done to evaluate association of previously reported high-risk features and EST. Assuming DS-CMR as gold-standard, McNemar test was used to calculate sensitivity/specificity and agreement between ECG-EST, CPET, ECG-EST+CPET and DS-CMR.

RESULTS

- A total of 155 AAOCA patients were included; AAORCA (n = 126) and AAOLCA (n = 29) had similar demographics and presenting symptoms (Table 1).
- 123 (79%) had a CPET and 86 (70%) achieved a m-EST. AAOLCA was associated with abnormal-ECG-EST and black race was associated with both an Abnormal-CPET and Abnormal-ECG-EST+CPET.
- Abnormal O_2 pulse ($< 85\%$ predicted) and abnormal O_2 pulse curve (Fig 1) were significantly associated with +DS-CMR.
- CPET and ECG-EST+CPET (53% and 63%) had higher sensitivities for the detection of inducible ischemia compared to ECG-EST (16%) alone.
- There was no agreement between ECG-EST, CPET or ECG-EST+CPET and DS-CMR for detection of inducible ischemia.

CONCLUSION

- EST in AAOCA patients should include CPET if possible.
- CPET variables of particular importance include O_2 pulse % predicted and O_2 pulse curve.
- EST should be used as an adjunct to stress perfusion imaging (like DS-CMR) for the detection of inducible ischemia.