

Utility of PET MPI for identifying ischemia and guiding treatment in anomalous coronary arteries

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Background

- Anomalous coronary arteries (AAOCA) are congenital aberrancies where the coronary artery arises from the inappropriate sinus, superior to the sinus of Valsalva or from the pulmonary artery.
- Although AAOCA may be discovered incidentally, they are associated with sudden cardiac death (SCD) particularly in young athletes during exertion.
- **Guidelines recommend both anatomic and ischemic evaluation for AAOCA patients. However the preferred stress testing modality remains controversial.**



Objective

To evaluate the utility, predictors and management of AAOCA patients undergoing PET/CT for ischemia assessment.



Methods

- Consecutive adult patients (n=82) with AAOCA undergoing PET/CT during 1/2015-6/2021 at Cleveland Clinic were studied. Ethics approval obtained.
- Relevant clinical, multi-modality imaging, management and outcomes data were collected. The primary endpoint is AAOCA surgery during follow-up (given few clinical events).
- Statistical analyses: multivariable using logistic regression and stepwise chi-squared test to demonstrate incremental prognostic value of pre-specified covariates.

Results



| | Total | PET/CT positive | PET/CT negative | P value |
|--|-------------|-----------------|-----------------|-------------|
| Number of patients | 82 | 26 | 56 | |
| Demographics | | | | |
| Age (years) | 45 ± 20 | 45 ± 20 | 45 ± 20 | .967 |
| Female | 30 (37%) | 10 (39%) | 20 (36%) | .811 |
| Body mass index (kg·m ⁻²) | 28 ± 6 | 28 ± 7 | 28 ± 6 | .778 |
| Body surface area (m ²) | 1.98 ± 0.28 | 1.90 ± 0.27 | 2.02 ± 0.27 | .064 |
| Symptoms | | | | |
| Chest pain | 45 (55%) | 16 (62%) | 29 (52%) | .479 |
| New York Heart Association class | | | | .375 |
| 1 | 56 (68%) | 15 (58%) | 41 (73%) | |
| 2 | 15 (18%) | 6 (23%) | 9 (16%) | |
| 3 | 10 (12%) | 5 (19%) | 5 (9%) | |
| 4 | 1 (1%) | 0 (0%) | 1 (2%) | |
| Pre-syncope/syncope | 15 (18%) | 4 (15%) | 11 (20%) | .765 |
| Cardiac arrest | 2 (2%) | 0 (0%) | 2 (4%) | 1.000 |
| Past history | | | | |
| Cardiac surgery | 1 (1%) | 0 (0%) | 1 (2%) | 1.000 |
| Cardiac implantable electronic device | 1 (1%) | 0 (0%) | 1 (2%) | 1.000 |
| Myocardial infarction | 3 (4%) | 0 (0%) | 3 (5%) | .548 |
| Coronary artery disease | 7 (9%) | 4 (15%) | 3 (5%) | .200 |
| Hypertension | 32 (39%) | 8 (31%) | 24 (43%) | .339 |
| Hyperlipidemia | 38 (46%) | 12 (46%) | 26 (46%) | 1.000 |
| Diabetes | 7 (9%) | 4 (15%) | 3 (5%) | .200 |
| Current smoker | 7 (9%) | 2 (8%) | 5 (9%) | 1.000 |
| Stroke | 2 (2%) | 1 (4%) | 1 (2%) | .536 |
| Atrial fibrillation | 5 (6%) | 1 (4%) | 4 (7%) | 1.000 |
| Estimated glomerular filtration rate (mL·m ⁻²) | 82 ± 17 | 80 ± 16 | 83 ± 17 | .574 |
| Hemoglobin (g·dL ⁻¹) | 14.4 ± 3.4 | 14.0 ± 1.8 | 14.6 ± 4.0 | .477 |
| Medications | | | | |
| Aspirin | 27 (33%) | 9 (35%) | 18 (32%) | 1.000 |
| P2Y12 inhibitor | 4 (5%) | 1 (4%) | 3 (5%) | 1.000 |
| Anticoagulant | 3 (4%) | 1 (4%) | 2 (4%) | 1.000 |
| Statin | 34 (42%) | 11 (42%) | 23 (41%) | 1.000 |
| Beta-blocker | 31 (38%) | 11 (42%) | 20 (36%) | .632 |
| Calcium channel blocker | 14 (17%) | 5 (19%) | 9 (16%) | .758 |
| Nitrates | 11 (13%) | 8 (31%) | 3 (5%) | .003 |
| Angiotensin converting enzyme inhibitor/angiotensin receptor blocker | 19 (23%) | 9 (35%) | 10 (18%) | .158 |
| Diuretic | 7 (9%) | 3 (12%) | 4 (7%) | .673 |



Anatomic Characteristics

| | Total | PET/CT positive | PET/CT negative | P value |
|--------------------------------------|----------|-----------------|-----------------|---------|
| Anatomical diagnosis modality | | | | |
| Computed tomography angiography | 69 (84%) | 24 (92%) | 45 (80%) | .209 |
| Left heart catheterization | 80 (98%) | 26 (100%) | 54 (96%) | 1.000 |
| Magnetic resonance angiography | 2 (2%) | 1 (4%) | 1 (2%) | .536 |
| Transthoracic echocardiography total | 77 (94%) | 25 (96%) | 52 (93%) | 1.000 |
| Anomalous vessel | | | | |
| Left coronary artery/branches | 24 (29%) | 10 (39%) | 14 (25%) | .297 |
| Left main | 19 (23%) | 10 (39%) | 9 (16%) | .046 |
| Left anterior descending | 5 (6%) | 0 (0%) | 5 (9%) | .173 |
| Left circumflex | 2 (2%) | 0 (0%) | 2 (4%) | 1.000 |
| Right coronary artery | 58 (71%) | 16 (62%) | 42 (75%) | .297 |

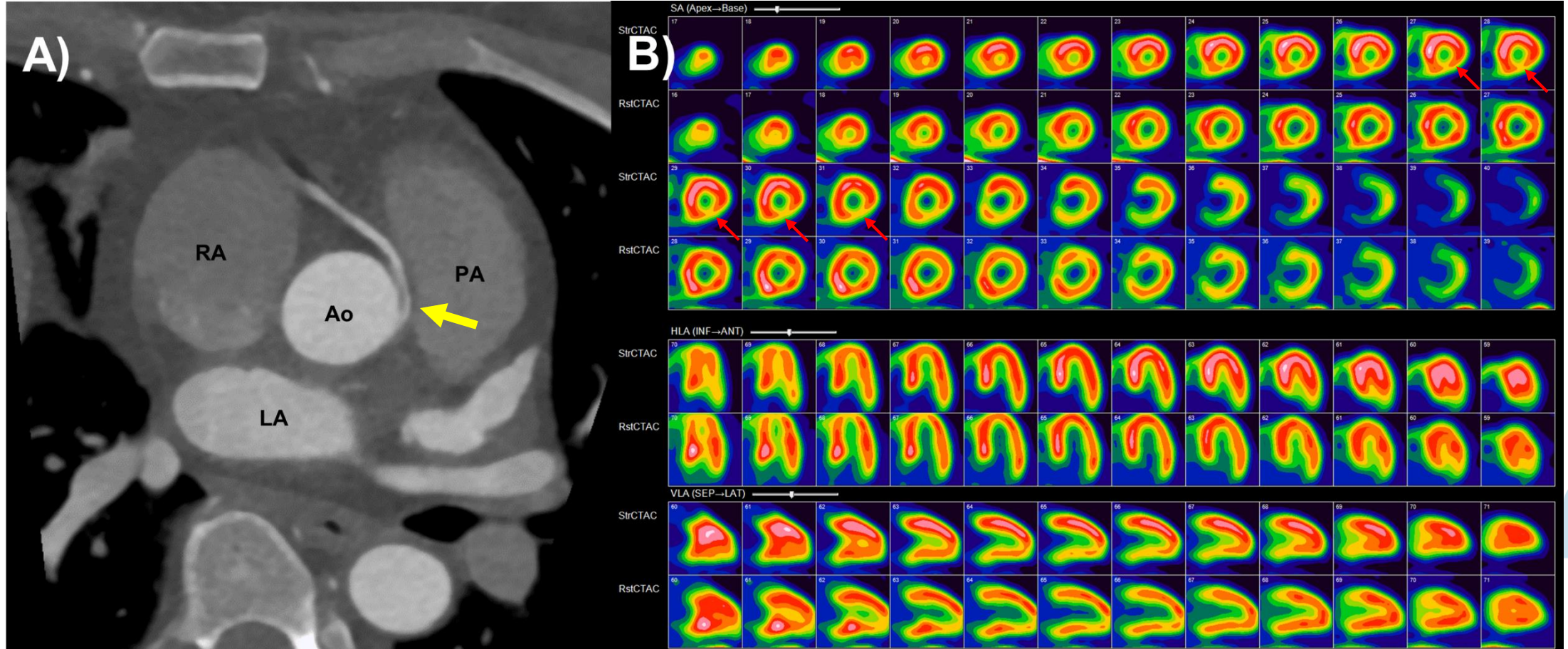


Nuclear Results

| | Total | PET/CT positive | PET/CT negative | P value |
|---|---------------|-----------------|-----------------|---------|
| Nuclear stress test | | | | |
| Method | | | | |
| Nitrogen13-Ammonia | 54 (66%) | 21 (81%) | 33 (59%) | .079 |
| Rubidium-82 | 28 (34%) | 5 (19%) | 23 (41%) | |
| Stress method | | | | |
| Exercise | 54 (66%) | 21 (81%) | 33 (59%) | .079 |
| Dobutamine | 28 (34%) | 5 (19%) | 23 (41%) | |
| Heart rate rest (bpm) | 67 ± 12 | 68 ± 10 | 66 ± 13 | .582 |
| Heart rate maximum (bpm) | 151 ± 23 | 157 ± 24 | 149 ± 23 | .134 |
| Systolic blood pressure maximum (mmHg) | 156 ± 25 | 159 ± 25 | 154 ± 25 | .414 |
| Heart rate x blood pressure product | 23,613 ± 5740 | 25,004 ± 6021 | 22,967 ± 5542 | .136 |
| Estimated metabolic equivalents of task | 9.8 ± 2.6 | 9.2 ± 2.4 | 10.2 ± 2.7 | .181 |
| Left ventricular ejection fraction rest (%) | 60 ± 10% | 61 ± 8 | 59 ± 10 | .379 |
| Left ventricular ejection fraction stress (%) | 65 ± 8% | 65 ± 8 | 65 ± 8 | .820 |
| Chest pain with exercise | 6 (73%) | 1 (4%) | 5 (9%) | .659 |
| ST depression with exercise | 13 (16%) | 6 (23%) | 7 (13%) | .329 |
| Summed rest score | 0.5 ± 2.6 | 0.3 ± 0.9 | 0.5 ± 3.0 | .681 |
| Summed stress score | 2.8 ± 5.3 | 7.8 ± 5.7 | 0.5 ± 3.0 | < .001 |
| Summed difference score | 2.5 ± 5.0 | 8.2 ± 5.9 | 0.0 ± 0.0 | < .001 |
| Scan risk | | | | < .001 |
| Indeterminate | 5 (6%) | 3 (12%) | 2 (4%) | |
| Low | 57 (70%) | 6 (23%) | 51 (91%) | |
| Intermediate | 13 (16%) | 11 (42%) | 2 (9%) | |
| High | 7 (9%) | 6 (23%) | 1 (2%) | |
| Ischemia positive | 26 (32%) | 26 (100%) | N/A | N/A |



Correlation with CT and PET



Outcomes

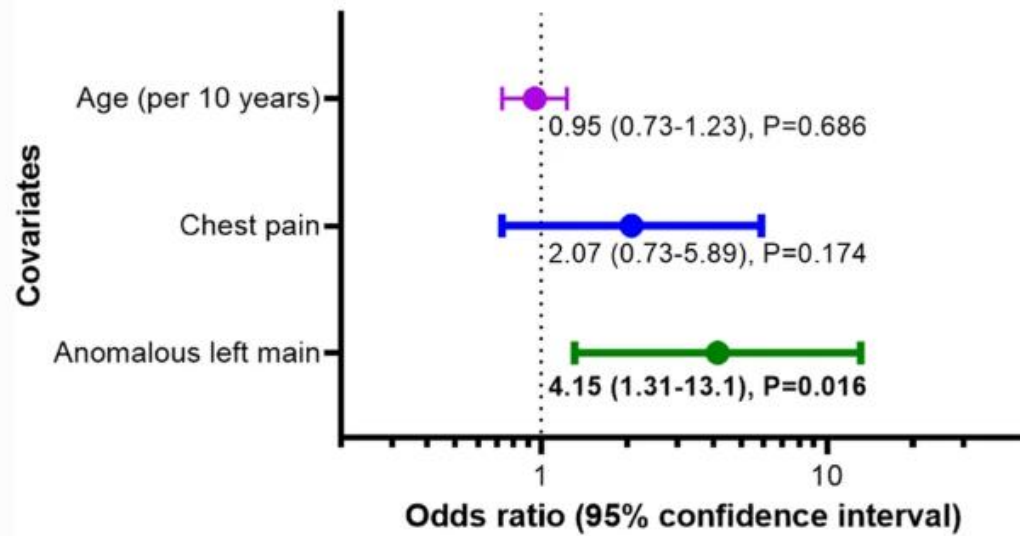
| | Total | PET/CT positive | PET/CT negative | P value |
|--|----------|-----------------|-----------------|-------------|
| Number of patients | 82 | 26 | 56 | |
| Surgery | 37 (45%) | 19 (73%) | 18 (32%) | .001 |
| Unroofing | 29 (78%) | 12 (63%) | 17 (94%) | .042 |
| Coronary artery bypass grafting | 6 (17%) | 5 (28%) | 1 (6%) | .177 |
| Reimplantation | 2 (6%) | 2 (11%) | 0 (0%) | .486 |
| Medication changes (after nuclear stress test) | | | | |
| Aspirin | 22 (27%) | 10 (39%) | 12 (21%) | .117 |
| P2Y12 inhibitor | 3 (4%) | 2 (8%) | 1 (2%) | .235 |
| Anticoagulant | 3 (4%) | 3 (12%) | 0 (0%) | .029 |
| Statin | 3 (4%) | 3 (12%) | 0 (0%) | .029 |
| Beta-blocker | 16 (20%) | 7 (27%) | 9 (16%) | .369 |
| Calcium channel blocker | 5 (6%) | 2 (8%) | 3 (5%) | .650 |
| Nitrates | 1 (1%) | 1 (4%) | 0 (0%) | .317 |
| ACE inhibitor/ARB | 1 (1%) | 1 (4%) | 0 (0%) | .317 |
| Diuretic | 20 (24%) | 10 (39%) | 10 (18%) | .056 |

Follow-up

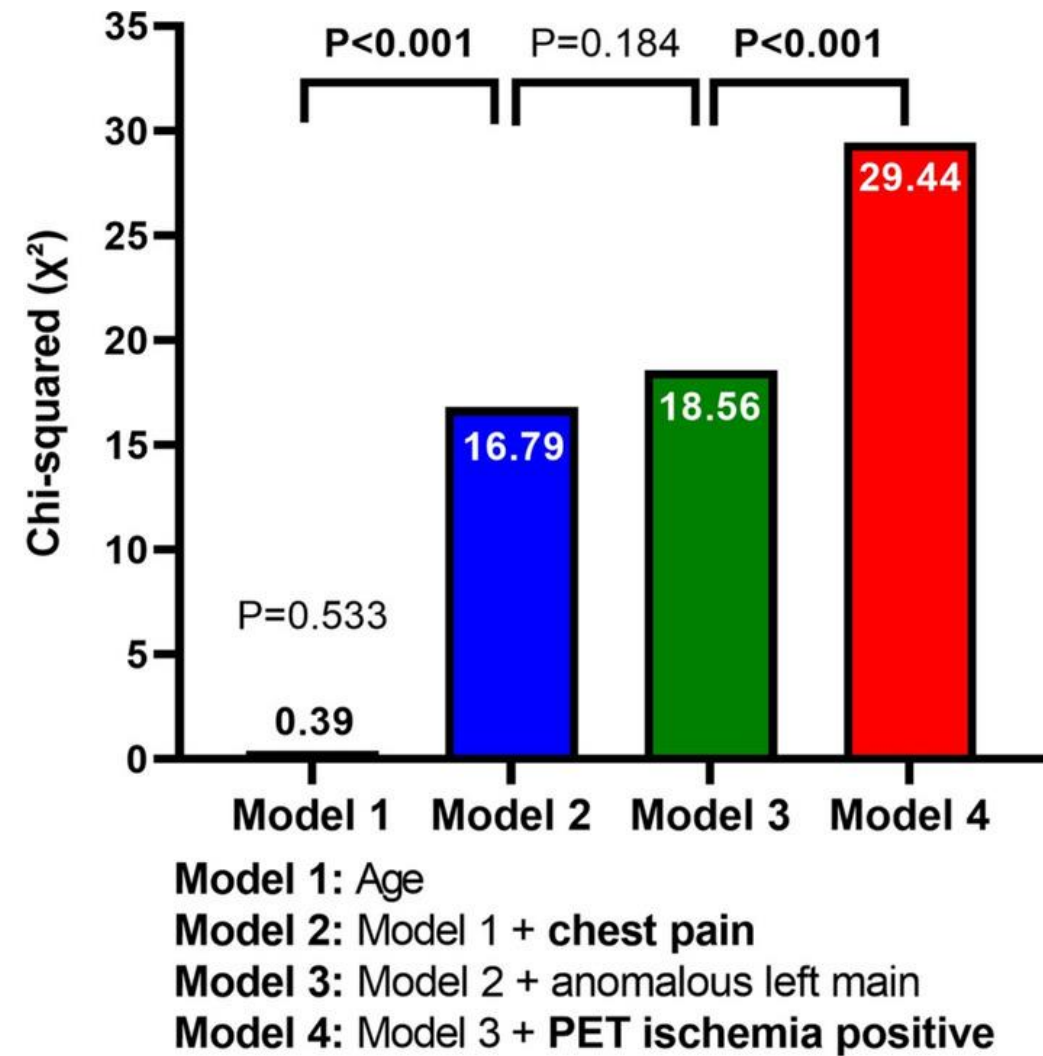
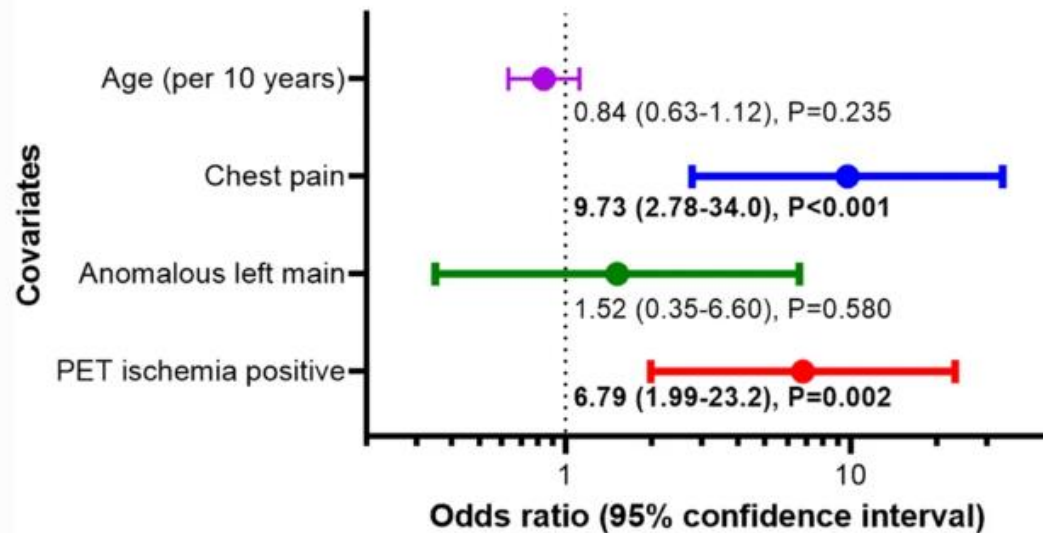
| | Total | PET/CT positive | PET/CT negative | P value |
|----------------------------------|-----------|-----------------|-----------------|---------|
| Outcomes | | | | |
| Follow-up duration (years) | 2.2 ± 1.8 | 2.2 ± 1.5 | 2.1 ± 1.9 | .864 |
| Death (all-cause) | 1 (1%) | 0 (0%) | 1 (2%) | .000 |
| Death (cardiovascular) | 1 (1%) | 0 (0%) | 1 (2%) | .000 |
| Myocardial infarction | 2 (2%) | 0 (0%) | 2 (4%) | .000 |
| Stroke/transient ischemic attack | 1 (1%) | 1 (4%) | 0 (0%) | .317 |
| Arrhythmia hospitalization | 4 (5%) | 2 (8%) | 2 (4%) | .588 |
| Heart failure hospitalization | 0 (0%) | 0 (0%) | 0 (0%) | .000 |
| Chest pain hospitalization | 10 (12%) | 3 (12%) | 7 (13%) | .000 |
| Chest pain at end of follow-up | 21 (26%) | 6 (29%) | 15 (71%) | .792 |
| Cardiovascular hospitalization | 14 (17%) | 7 (27%) | 7 (13%) | .124 |



(A) PET ischemia positive



(B) AAOCA surgery



Discussion

- 1/3 of AAOCA are not low-risk anatomically have +ischemia on PET-CT
- Ischemia on PET-CT is 4x for anomalous LM
- Chest pain or +ischemia on PET drives referral to surgery
- Short-term outcomes of anomalous surgery are excellent



Limitations

- Single-center retrospective observational cohort design
- Small cohort size & number of events
- Possible selection bias due managing cardiologists
- Rare adverse events



Conclusion

- PET-CT by both exercise N13-ammonia and dobutamine regadenason are feasible to assess ischemia in AAOCA and has valuable role in addition to anatomy and chest pain symptoms in the decision-making for AAOCA surgery.
- AAOCA patients carefully managed had good outcomes. Predictors of AAOCA surgery (chest pain and PET/CT ischemia) were identified.



ORIGINAL ARTICLE



Utility of positron emission tomography myocardial perfusion imaging for identifying ischemia and guiding treatment in patients with anomalous coronary arteries

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Thank you!





Every life deserves world class care.