From the treadmill to Cardiac PET: the evolution of the diagnostic armamentarium

Yin Ge, MD FRCPC

ST. MICHAEL'S
UNITY HEALTH TORONTO

Presenter Disclosure

Dr. Yin Ge

From the treadmill to Cardiac PET: the evolution of the diagnostic armamentarium

Relationships with financial sponsors:

- **Grants/Research Support:** N/A
- **Speakers Bureau/Honoraria:** CHRC
- **Consulting Fees:** N/A
- **Patents:** N/A
- **Other:** N/A

ST. MICHAEL'S
UNITY HEALTH TORONTO

HPI

45 M

2-month history of intermittent, left sided chest pain

Pressure-like; lasts a few minutes

Occurs during daily runs, relieved when stops

Sometimes accompanied by headaches and dizziness

Past Medical History

Hypertension

Home Medications

Valsartan 80mg daily

Physical Exam

VS: BP 117/73 mmHg, HR 88 and regular.
CV: S1, S2 with physiologic split, no murmurs.
Chest: No crackles.

Extremities: No edema. Good equal bilateral pulses.

Labs

Electrolytes: WNL
CBC: WNL

TC: 5.2 mmol/L
HDL 1.1 mmol/L
TG: 1.5 mmol/L
LDL: 3.4 mmol/L

ST. MICHAEL'S
UNITY HEALTH TORONTO

Question 1:

What is this patient's pre-test probability of having obstructive CAD?

A) 0-10 %

B) 20-30 %

C) 50-60%

D) >80%

ST. MICHAEL'S
UNITY HEALTH TORONTO

What is the Pre-test likelihood of CAD?

Age, Years	Chest Pain Criteria 1. Substernal chest discomfort with characteristic quality and duration 2. Provoked by exertion or emotional stress 3. Relieved promptly by rest or nitroglycerin					
	Nonanginal Chest Pain 1 of 3 Criteria		**Atypical Angina** 2 of 3 Criteria		**Typical Angina** 3 of 3 Criteria	
	Male	Female	Male	Female	Male	Female
30 – 39	4%	2%	34%	12%	76%	26%
40 - 49	13%	3%	51%	22%	87%	55%
50 - 59	20%	7%	65%	33%	93%	73%
60 - 69	27%	14%	72%	51%	94%	86%

Mancini et al. CJC 2014.

ST. MICHAEL'S
UNITY HEALTH TORONTO

What is the Pre-test likelihood of CAD?

	Non-anginal		Atypical		Typical		Dyspnoea[a]	
Age	Men	Women	Men	Women	Men	Women	Men	Women
30–39	1%	1%	4%	3%	3%	5%	0%	3%
40–49	3%	2%	10%	6%	22%	10%	12%	3%
50–59	11%	3%	17%	6%	32%	13%	20%	9%
60–69	22%	6%	26%	11%	44%	16%	27%	14%
70+	24%	10%	34%	19%	52%	27%	32%	12%

Knuuti et al. EHJ. 2019.

ST. MICHAEL'S
UNITY HEALTH TORONTO

What is the Pre-test likelihood of CAD?

A Risk Factor-Weighted Clinical Likelihood

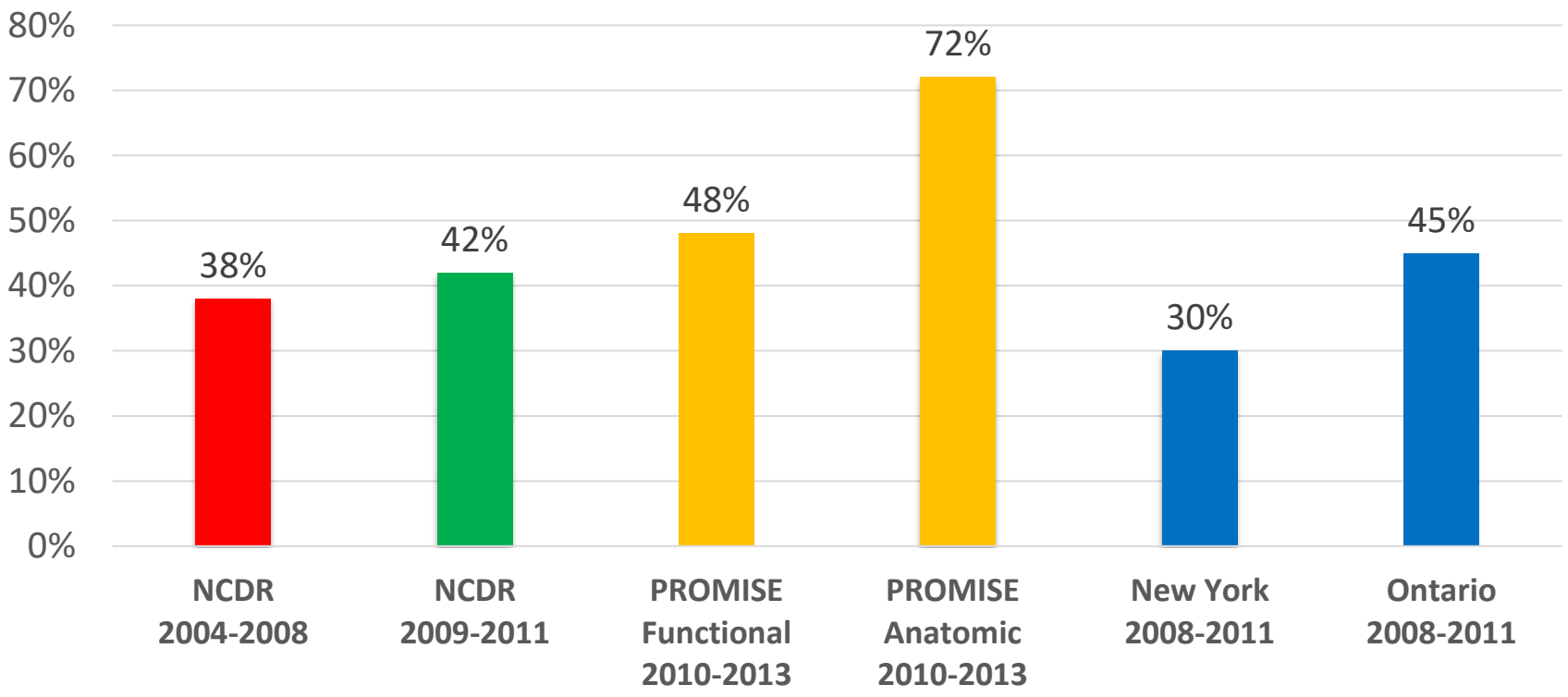
	Nonanginal Pain						Atypical Angina or Dyspnea						Typical Angina					
	Women			Men			Women			Men			Women			Men		
Number of Risk Factors	0-1	2-3	4-5	0-1	2-3	4-5	0-1	2-3	4-5	0-1	2-3	4-5	0-1	2-3	4-5	0-1	2-3	4-5
Age: 30-39	0	1	2	1	2	5	0	1	3	2	4	8	2	5	10	9	14	22
Age: 40-49	1	1	3	2	4	8	1	2	5	3	6	12	4	7	12	14	20	27
Age: 50-59	1	2	5	4	7	12	2	3	7	6	11	17	6	10	15	21	27	33
Age: 60-69	2	4	7	8	12	17	3	6	11	12	17	25	10	14	19	32	35	39
Age: 70-80	4	7	11	15	19	24	6	10	16	22	27	34	16	19	23	44	44	45

Risk factors: *Family history, smoking, dyslipidemia, hypertension, diabetes*

Winther et al. JACC. 2020.

ST. MICHAEL'S
UNITY HEALTH TORONTO

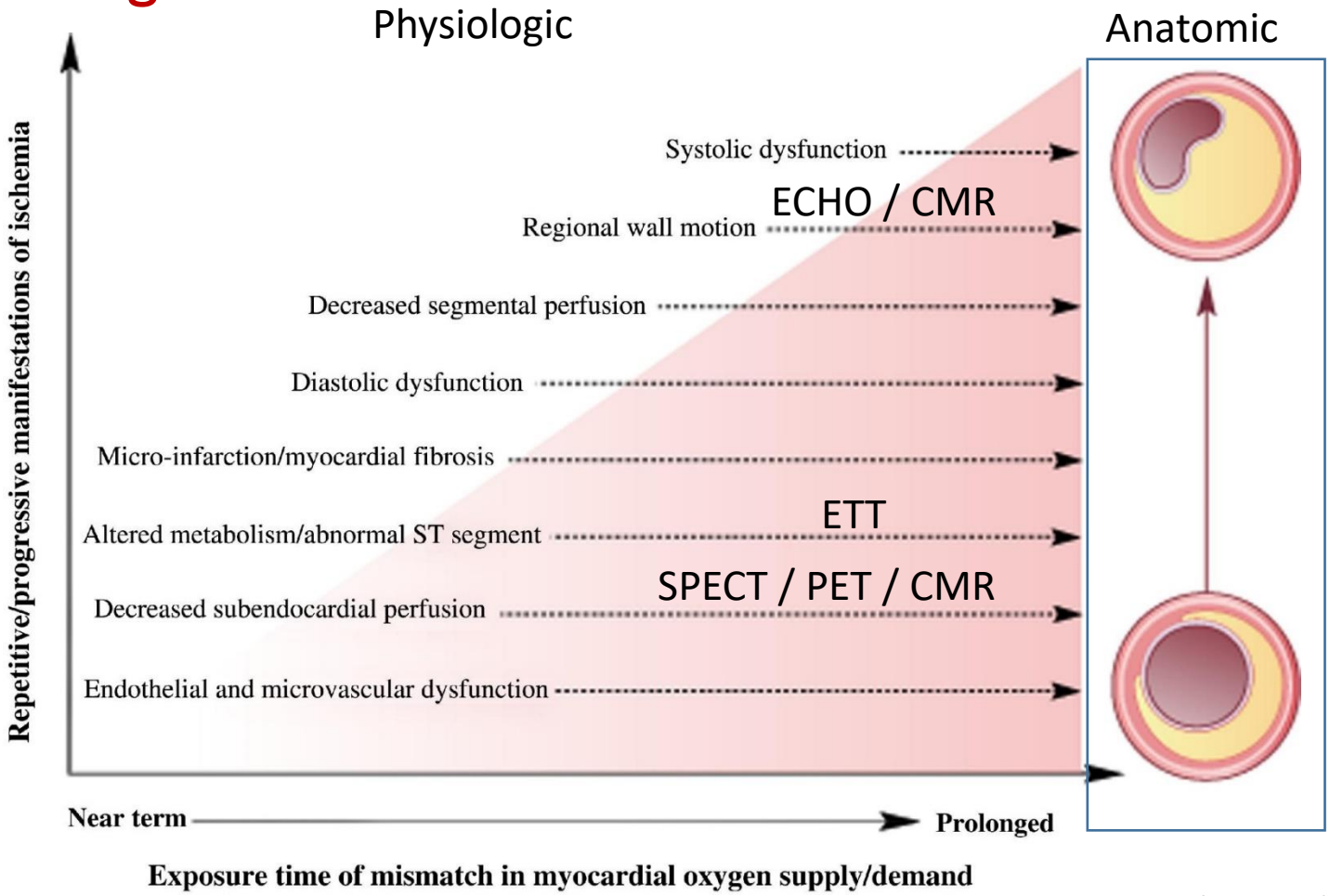
Elective invasive coronary angiography with obstructive CAD



Patel et al. NEJM 2010. Patel et al. AHJ 2014. Douglas et al. NEJM 2015. Ko et al. JAMA. 2013.

ST. MICHAEL'S
UNITY HEALTH TORONTO

Diagnosing CAD



Shaw et al. JACC. 2009.

ST. MICHAEL'S
UNITY HEALTH TORONTO

Diagnostic performance

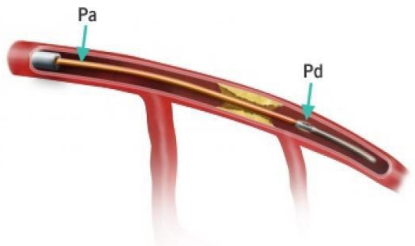
Anatomically significant CAD		
Test	**Sensitivity (%), (95% CI)**	**Specificity (%), (95% CI)**
Stress ECG	58 (46–69)	62 (54–69)
Stress echo	85 (80–89)	82 (72–89)
CCTA	97 (93–99)	78 (67–86)
SPECT	87 (83–90)	70 (63–76)
PET	90 (78–96)	85 (78–90)
Stress CMR	90 (83–94)	80 (69–88)

Functionally significant CAD		
Test	**Sensitivity (%), (95% CI)**	**Specificity (%), (95% CI)**
ICA	68 (60–75)	73 (55–86)
CCTA	93 (89–96)	53 (37–68)
SPECT	73 (62–82)	83 (71–90)
PET	89 (82–93)	85 (81–88)
Stress CMR	89 (85–92)	87 (83–91)

Gold standard: ICA with FFR

$$FFR = \frac{\text{Distal Coronary Pressure (Pd)}}{\text{Proximal Coronary Pressure (Pa)}}$$

(During Maximum Hyperemia)



Knutti et al. EHJ. 2018.

ST. MICHAEL'S
UNITY HEALTH TORONTO

Question 2:

Which of the following test have the best *negative* predictive value?

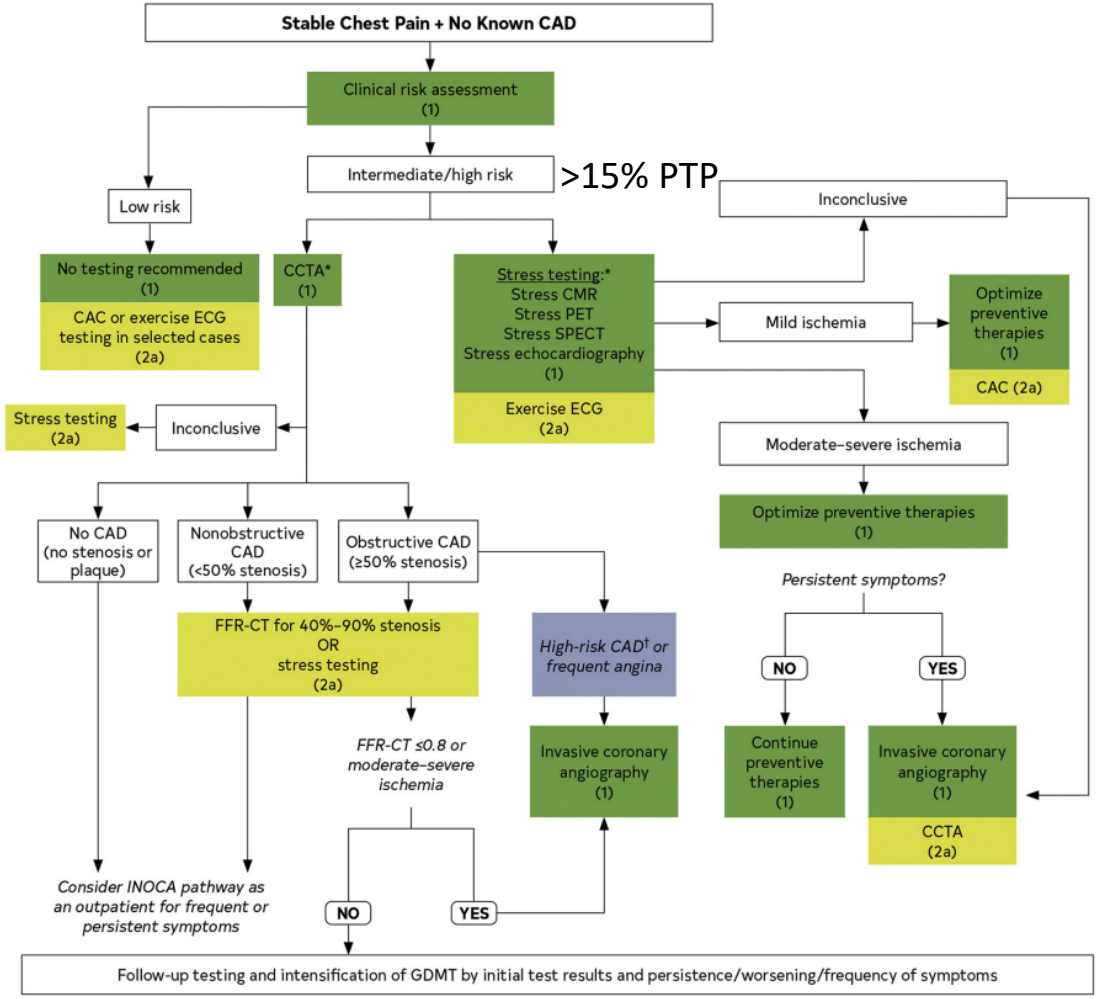
A) Stress echo

B) CCTA

C) SPECT

D) ETT

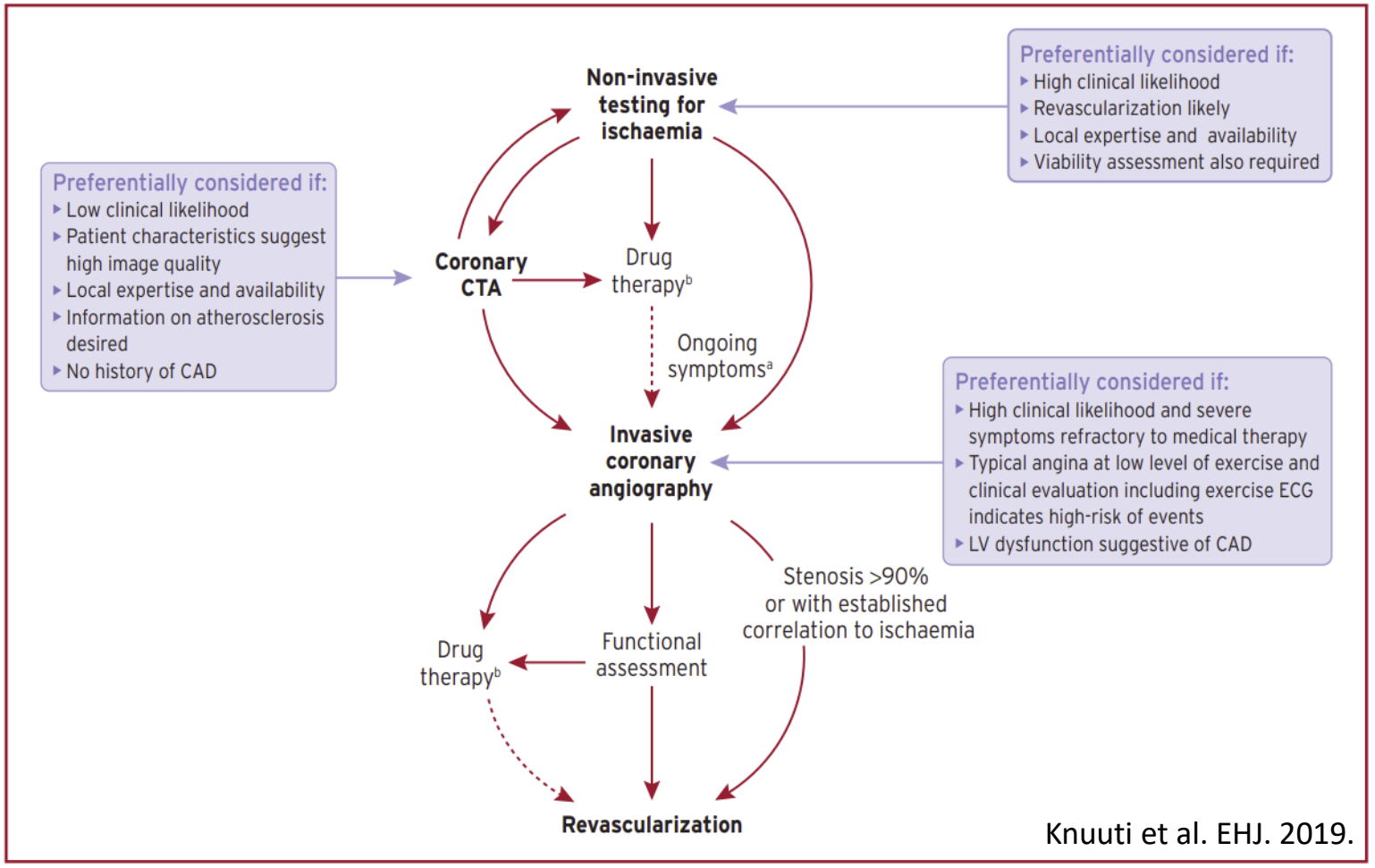
Diagnosing CAD



Gulati et al. JACC. 2021.

ST. MICHAEL'S
UNITY HEALTH TORONTO

Diagnosing CAD



Knuuti et al. EHJ. 2019.

ST. MICHAEL'S
UNITY HEALTH TORONTO

Diagnosing CAD

- Widely available in Ontario
  - ETT
  - Echo
  - SPECT
- Available at SMH
  - ETT
  - Echo
  - SPECT
  - *CTA
  - *CMR
  - PET (soon)

*Wait time

ST. MICHAEL'S
UNITY HEALTH TORONTO

Diagnosing CAD

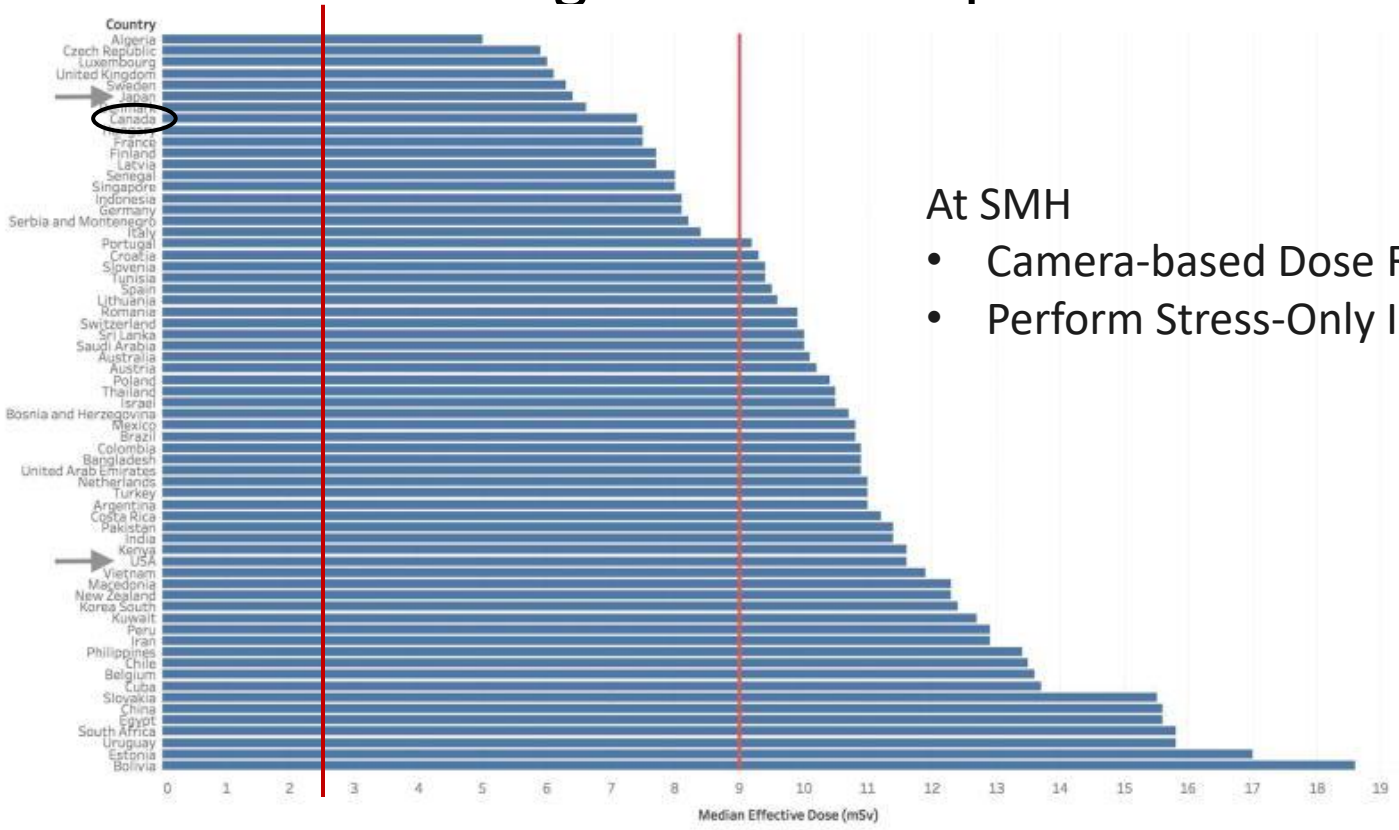
ETT	ECHO	CCTA	SPECT	CMR	PET
Low $	Exercise	Exercise -	Exercise	Exercise -	Exercise
No radiation	No radiation	Highest sensitivity / NPV		'Gold standard' LVEF + scar	Microvascular dz
				Microvascular dz	
				No radiation	
				Limited availability	Limited availability

$ $$$

ST. MICHAEL'S
UNITY HEALTH TORONTO

Updates in cardiac imaging

- SPECT: Reducing radiation exposure



At SMH

- Camera-based Dose Reduction Strategies
- Perform Stress-Only Imaging

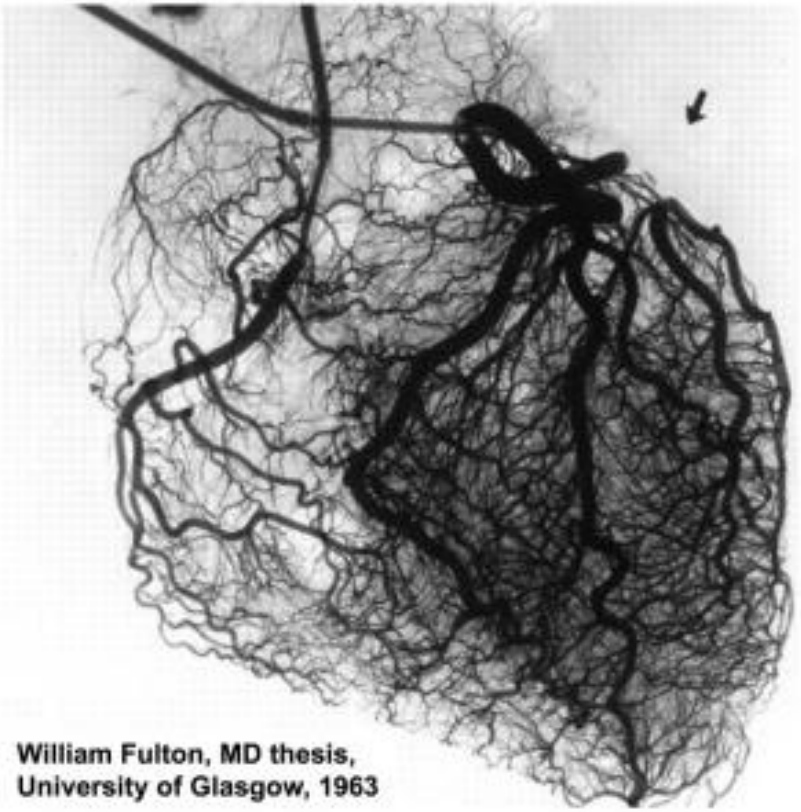
Gupta et al. JNC. 2020.

ST. MICHAEL'S
UNITY HEALTH TORONTO

Updates in cardiac imaging: microcirculation

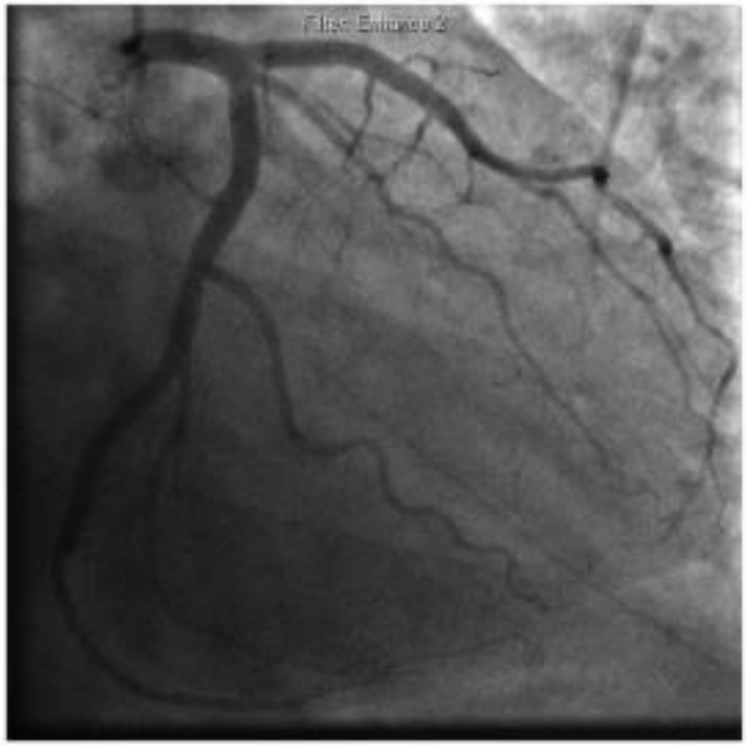
Imaging resolution

30 µm



William Fulton, MD thesis,
University of Glasgow, 1963

300 µm +



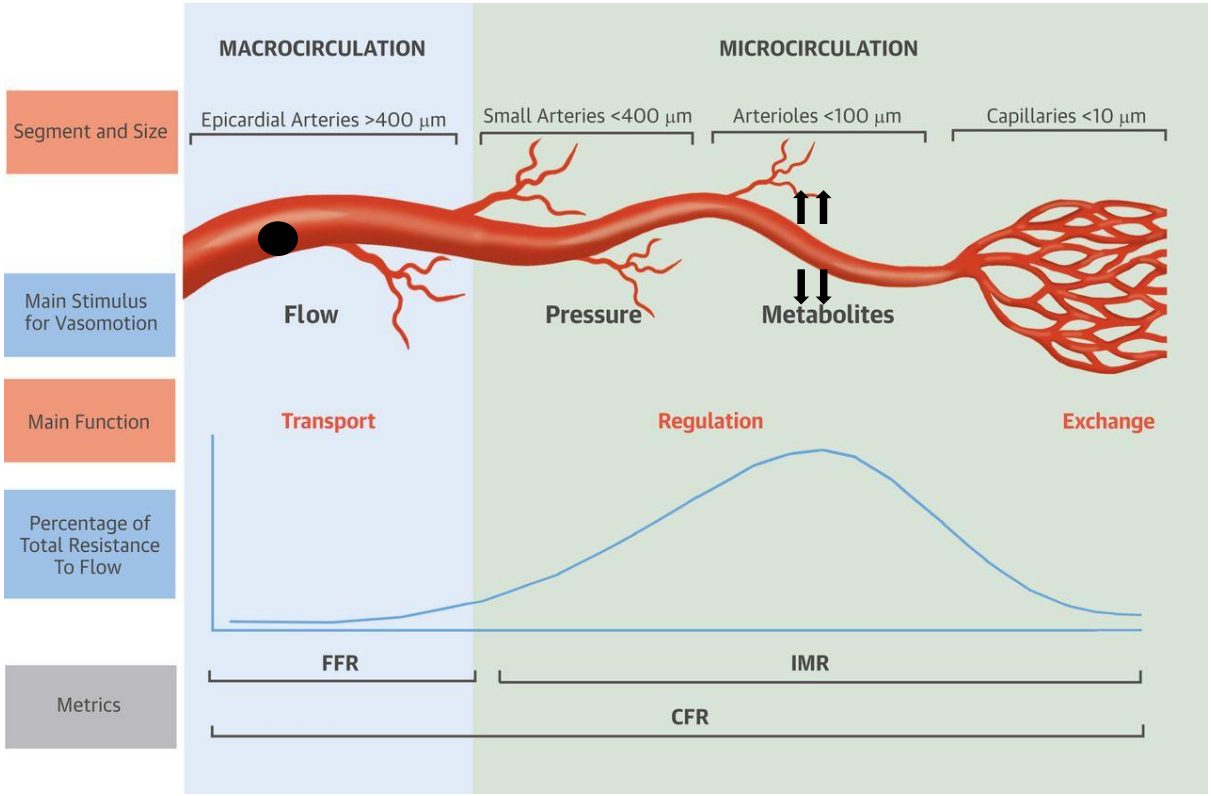
Ford et al. AHJ. 2018.

ST. MICHAEL'S
UNITY HEALTH TORONTO

Quantitative Myocardial Perfusion

- Coronary Flow Reserve (CFR)

  = Stress myocardial blood flow/Rest myocardial blood flow



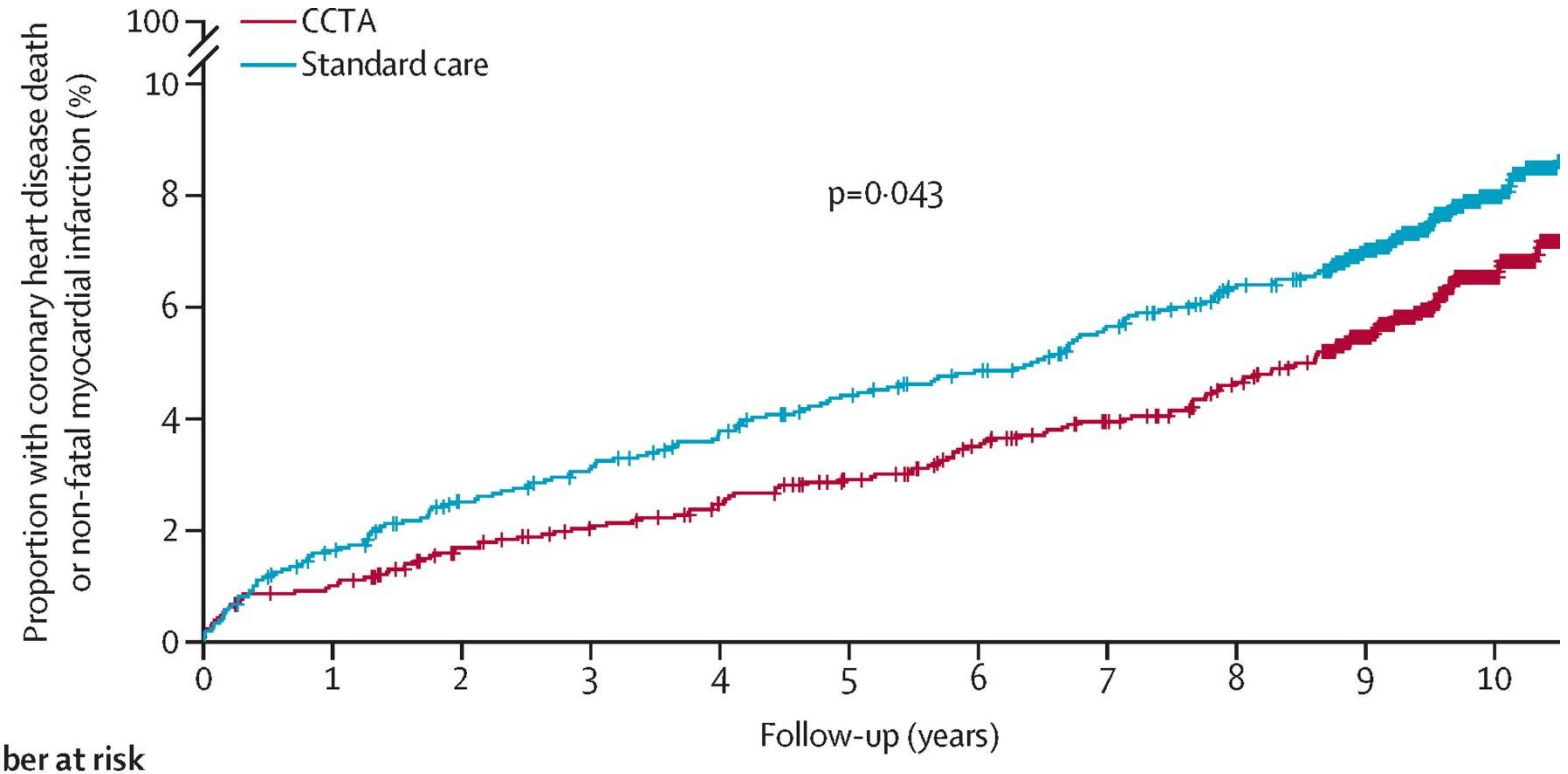
Abnormal

CFR < 2
Stress MBF <1.7

De Bruyne et al. JACC. 2016.

ST. MICHAEL'S
UNITY HEALTH TORONTO

Updates in cardiac imaging: atherosclerosis



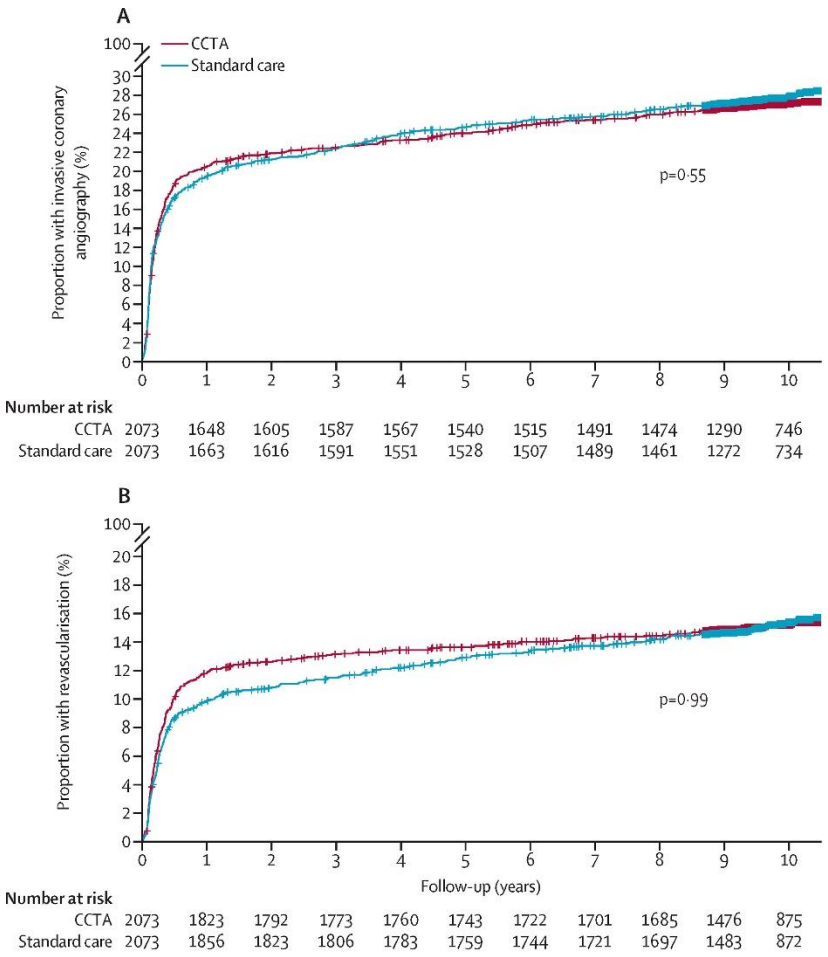
Number at risk

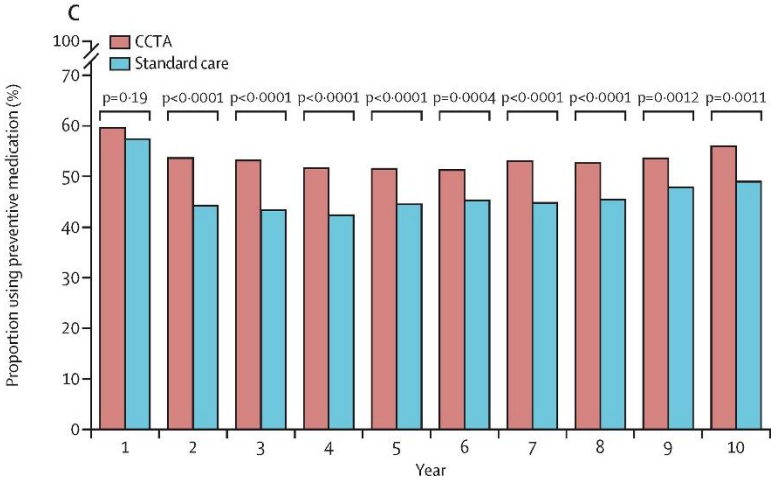
CCTA	2073	2050	2023	2008	1993	1974	1951	1930	1905	1668	993
Standard care	2073	2032	2002	1987	1967	1947	1932	1909	1880	1647	976

William et al. Lancet. 2025.

ST. MICHAEL'S
UNITY HEALTH TORONTO

Updates in cardiac imaging: atherosclerosis



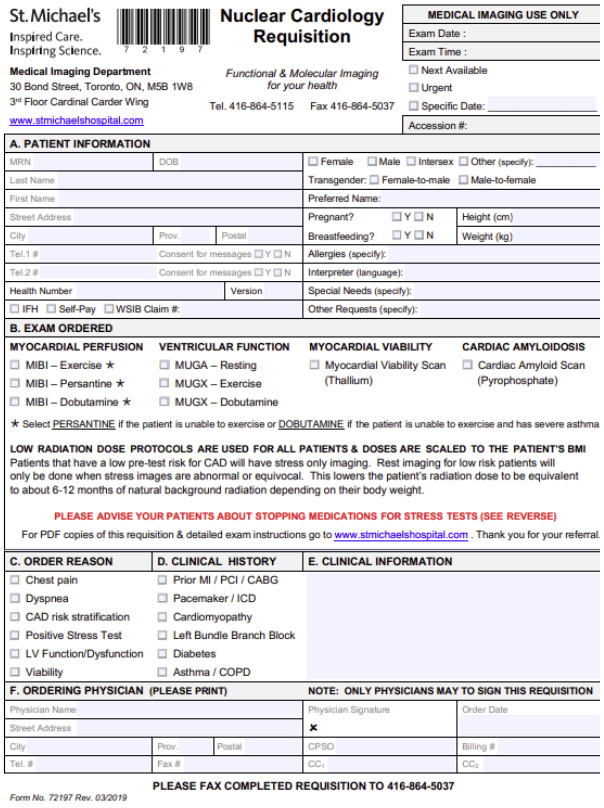


William et al. Lancet. 2025.

Key Messages

- Advances in non-invasive coronary testing enables interrogation of epicardial and microvascular function
- Patients at lower risk of CAD are favored to have CTA
  - Subclinical atherosclerosis
  - Change / intensification in medical therapy

ST. MICHAEL'S
UNITY HEALTH TORONTO



St. Michael's
Inspired Care.
Inspiring Science.

7 2 1 9 7

Nuclear Cardiology Requisition

Functional & Molecular Imaging for your health

Medical Imaging Department
30 Bond Street, Toronto, ON, M5B 1W8
3rd Floor Cardinal Carder Wing
www.stmichaelshospital.com

Tel. 416-864-5115 Fax 416-864-5037

MEDICAL IMAGING USE ONLY
Exam Date :
Exam Time :
☐ Next Available
☐ Urgent
☐ Specific Date:
Accession #:

A. PATIENT INFORMATION

MRN | DOB | ☐ Female ☐ Male ☐ Intersex ☐ Other (specify):
Last Name | Transgender: ☐ Female-to-male ☐ Male-to-female
First Name | Preferred Name:
Street Address | Pregnant? ☐ Y ☐ N | Height (cm)
City | Prov. | Postal | Breastfeeding? ☐ Y ☐ N | Weight (kg)
Tel.1 # | Consent for messages ☐ Y ☐ N | Allergies (specify):
Tel.2 # | Consent for messages ☐ Y ☐ N | Interpreter (language):
Health Number | Version | Special Needs (specify):
☐ IFH ☐ Self-Pay ☐ WSIB Claim #: | Other Requests (specify):

B. EXAM ORDERED

MYOCARDIAL PERFUSION	VENTRICULAR FUNCTION	MYOCARDIAL VIABILITY	CARDIAC AMYLOIDOSIS
☐ MIBI – Exercise ★	☐ MUGA – Resting	☐ Myocardial Viability Scan (Thallium)	☐ Cardiac Amyloid Scan (Pyrophosphate)
☐ MIBI – Persantine ★	☐ MUGX – Exercise		
☐ MIBI – Dobutamine ★	☐ MUGX – Dobutamine		

★ Select PERSANTINE if the patient is unable to exercise or DOBUTAMINE if the patient is unable to exercise and has severe asthma

LOW RADIATION DOSE PROTOCOLS ARE USED FOR ALL PATIENTS & DOSES ARE SCALED TO THE PATIENT'S BMI
Patients that have a low pre-test risk for CAD will have stress only imaging. Rest imaging for low risk patients will only be done when stress images are abnormal or equivocal. This lowers the patient's radiation dose to be equivalent to about 6-12 months of natural background radiation depending on their body weight.

PLEASE ADVISE YOUR PATIENTS ABOUT STOPPING MEDICATIONS FOR STRESS TESTS (SEE REVERSE)

For PDF copies of this requisition & detailed exam instructions go to www.stmichaelshospital.com . Thank you for your referral.

C. ORDER REASON	D. CLINICAL HISTORY	E. CLINICAL INFORMATION
☐ Chest pain	☐ Prior MI / PCI / CABG	
☐ Dyspnea	☐ Pacemaker / ICD	
☐ CAD risk stratification	☐ Cardiomyopathy	
☐ Positive Stress Test	☐ Left Bundle Branch Block	
☐ LV Function/Dysfunction	☐ Diabetes	
☐ Viability	☐ Asthma / COPD	

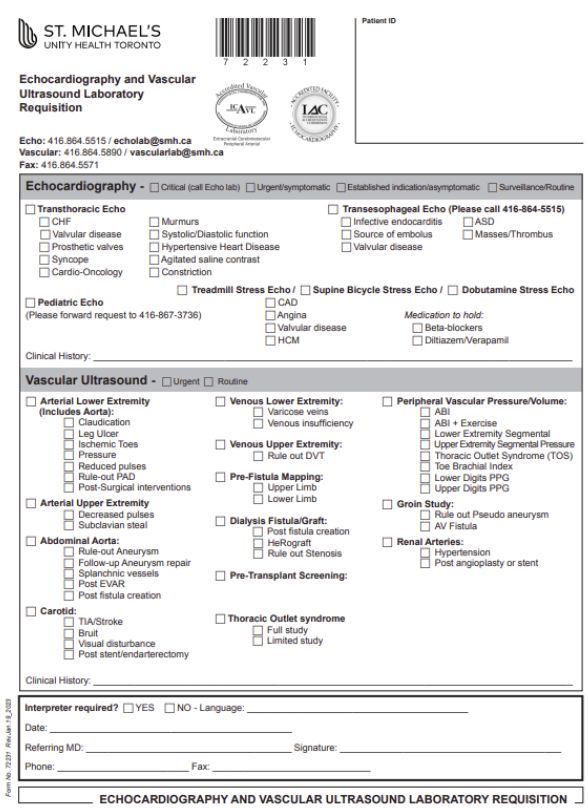
F. ORDERING PHYSICIAN (PLEASE PRINT) | **NOTE: ONLY PHYSICIANS MAY TO SIGN THIS REQUISITION**

Physician Name | Physician Signature | Order Date
Street Address | ✕
City | Prov. | Postal | CPSO | Billing #
Tel. # | Fax # | CC_1 | CC_2

PLEASE FAX COMPLETED REQUISITION TO 416-864-5037

Form No. 72197 Rev. 03/2019

https://unityhealth.to/wp-content/uploads/2021/02/72197-nuclear-cardiology-requisition.pdf



ST. MICHAEL'S
UNITY HEALTH TORONTO

7 2 2 3 1

Patient ID

Echocardiography and Vascular Ultrasound Laboratory Requisition

Echo: 416.864.5515 / **echolab@smh.ca**
Vascular: 416.864.5890 / **vascularlab@smh.ca**
Fax: 416.864.5571

Echocardiography - ☐ Critical (call Echo lab) ☐ Urgent/symptomatic ☐ Established indication/asymptomatic ☐ Surveillance/Routine

☐ **Transthoracic Echo**
- ☐ CHF
- ☐ Valvular disease
- ☐ Prosthetic valves
- ☐ Syncope
- ☐ Cardio-Oncology
- ☐ Murmurs
- ☐ Systolic/Diastolic function
- ☐ Hypertensive Heart Disease
- ☐ Agitated saline contrast
- ☐ Constriction

☐ **Transesophageal Echo (Please call 416-864-5515)**
- ☐ Infective endocarditis
- ☐ ASD
- ☐ Source of embolus
- ☐ Masses/Thrombus
- ☐ Valvular disease

☐ **Treadmill Stress Echo /** ☐ **Supine Bicycle Stress Echo /** ☐ **Dobutamine Stress Echo**

☐ **Pediatric Echo**
(Please forward request to 416-867-3736)
- ☐ CAD
- ☐ Angina
- ☐ Valvular disease
- ☐ HCM

Medication to hold:
- ☐ Beta-blockers
- ☐ Diltiazem/Verapamil

Clinical History: _____

Vascular Ultrasound - ☐ Urgent ☐ Routine

☐ **Arterial Lower Extremity (Includes Aorta):**
- ☐ Claudication
- ☐ Leg Ulcer
- ☐ Ischemic Toes
- ☐ Pressure
- ☐ Reduced pulses
- ☐ Rule-out PAD
- ☐ Post-Surgical interventions

☐ **Arterial Upper Extremity**
- ☐ Decreased pulses
- ☐ Subclavian steal

☐ **Abdominal Aorta:**
- ☐ Rule-out Aneurysm
- ☐ Follow-up Aneurysm repair
- ☐ Splanchnic vessels
- ☐ Post EVAR
- ☐ Post fistula creation

☐ **Carotid:**
- ☐ TIA/Stroke
- ☐ Bruit
- ☐ Visual disturbance
- ☐ Post stent/endarterectomy

☐ **Venous Lower Extremity:**
- ☐ Varicose veins
- ☐ Venous insufficiency

☐ **Venous Upper Extremity:**
- ☐ Rule out DVT

☐ **Pre-Fistula Mapping:**
- ☐ Upper Limb
- ☐ Lower Limb

☐ **Dialysis Fistula/Graft:**
- ☐ Post fistula creation
- ☐ HeiRograft
- ☐ Rule out Stenosis

☐ **Pre-Transplant Screening:**

☐ **Thoracic Outlet syndrome**
- ☐ Full study
- ☐ Limited study

☐ **Peripheral Vascular Pressure/Volume:**
- ☐ ABI
- ☐ ABI + Exercise
- ☐ Lower Extremity Segmental
- ☐ Upper Extremity Segmental Pressure
- ☐ Thoracic Outlet Syndrome (TOS)
- ☐ Toe Brachial Index
- ☐ Lower Digits PPG
- ☐ Upper Digits PPG

☐ **Groin Study:**
- ☐ Rule out Pseudo aneurysm
- ☐ AV Fistula

☐ **Renal Arteries:**
- ☐ Hypertension
- ☐ Post angioplasty or stent

Clinical History: _____

Interpreter required? ☐ YES ☐ NO - Language: _____

Date: _____

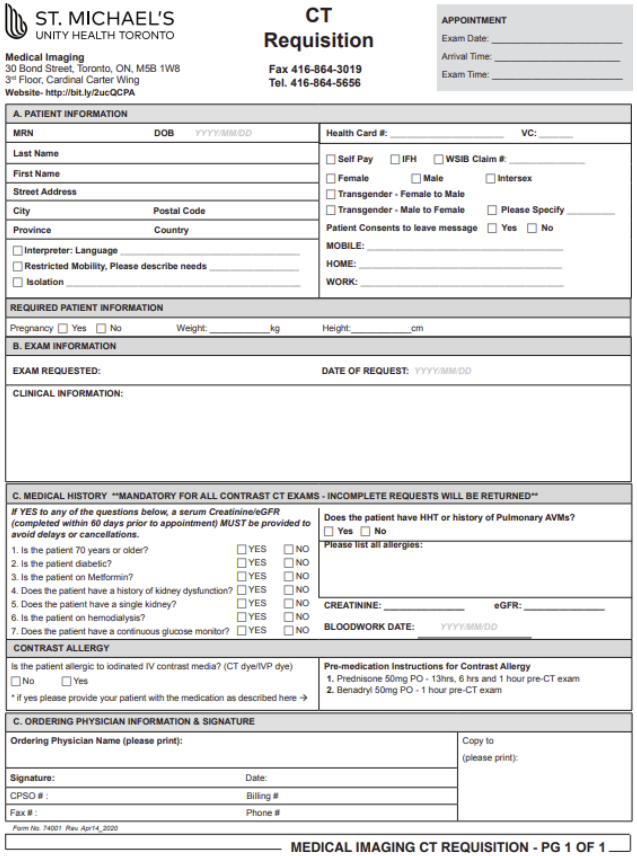
Referring MD: _____ Signature: _____

Phone: _____ Fax: _____

Form No. 72231 Rev.Jan 18_2020

ECHOCARDIOGRAPHY AND VASCULAR ULTRASOUND LABORATORY REQUISITION

https://unityhealth.to/wp-content/uploads/2021/05/Heart-and-Vascular_SMH_vascular-and-echo-requisition.pdf



ST. MICHAEL'S
UNITY HEALTH TORONTO

CT Requisition

Medical Imaging
30 Bond Street, Toronto, M5B 1W8
3rd Floor, Cardinal Carter Wing
Website- http://bit.ly/2ucQCPA

Fax 416-864-3019
Tel. 416-864-5656

APPOINTMENT
Exam Date: _____
Arrival Time: _____
Exam Time: _____

A. PATIENT INFORMATION

MRN | DOB YYYY/MM/DD | Health Card #: | VC:
Last Name | ☐ Self Pay ☐ IFH ☐ WSIB Claim #:
First Name | ☐ Female ☐ Male ☐ Intersex
Street Address | ☐ Transgender - Female to Male
City | Postal Code | ☐ Transgender - Male to Female ☐ Please Specify
Province | Country | Patient Consents to leave message ☐ Yes ☐ No
☐ Interpreter: Language | MOBILE:
☐ Restricted Mobility, Please describe needs | HOME:
☐ Isolation | WORK:

REQUIRED PATIENT INFORMATION

Pregnancy ☐ Yes ☐ No Weight: _____kg Height: _____cm

B. EXAM INFORMATION

EXAM REQUESTED: **DATE OF REQUEST:** YYYY/MM/DD

CLINICAL INFORMATION:

C. MEDICAL HISTORY **MANDATORY FOR ALL CONTRAST CT EXAMS - INCOMPLETE REQUESTS WILL BE RETURNED**

If YES to any of the questions below, a serum Creatinine/eGFR (completed within 60 days prior to appointment) MUST be provided to avoid delays or cancellations.

1. Is the patient 70 years or older?	☐ YES	☐ NO
2. Is the patient diabetic?	☐ YES	☐ NO
3. Is the patient on Metformin?	☐ YES	☐ NO
4. Does the patient have a history of kidney dysfunction?	☐ YES	☐ NO
5. Does the patient have a single kidney?	☐ YES	☐ NO
6. Is the patient on hemodialysis?	☐ YES	☐ NO
7. Does the patient have a continuous glucose monitor?	☐ YES	☐ NO

Does the patient have HHT or history of Pulmonary AVMs? ☐ Yes ☐ No

Please list all allergies:

CREATININE: _____ **eGFR:** _____

BLOODWORK DATE: YYYY/MM/DD

CONTRAST ALLERGY

Is the patient allergic to iodinated IV contrast media? (CT dye/IVP dye)
☐ No ☐ Yes
* if yes please provide your patient with the medication as described here →

Pre-medication Instructions for Contrast Allergy
1. Prednisone 50mg PO - 13hrs, 6 hrs and 1 hour pre-CT exam
2. Benadryl 50mg PO - 1 hour pre-CT exam

C. ORDERING PHYSICIAN INFORMATION & SIGNATURE

Ordering Physician Name (please print): | Copy to (please print):
Signature: | Date:
CPSO # : | Billing #
Fax # : | Phone #

Form No. 74001 Rev. Apr14_2020

MEDICAL IMAGING CT REQUISITION - PG 1 OF 1

https://unityhealth.to/wp-content/uploads/2021/05/Imaging_SMH_medical-imaging-ct-requisition.pdf

ST. MICHAEL'S
UNITY HEALTH TORONTO

Thank you