Redo-TAV
Challenges and solution

Vinayak Bapat, MD

Researcher, Valve Science Center, Minneapolis Heart Institute Foundation

Cardiac Surgeon and Chair of Cardiothoracic Surgery
Minneapolis Heart Institute®

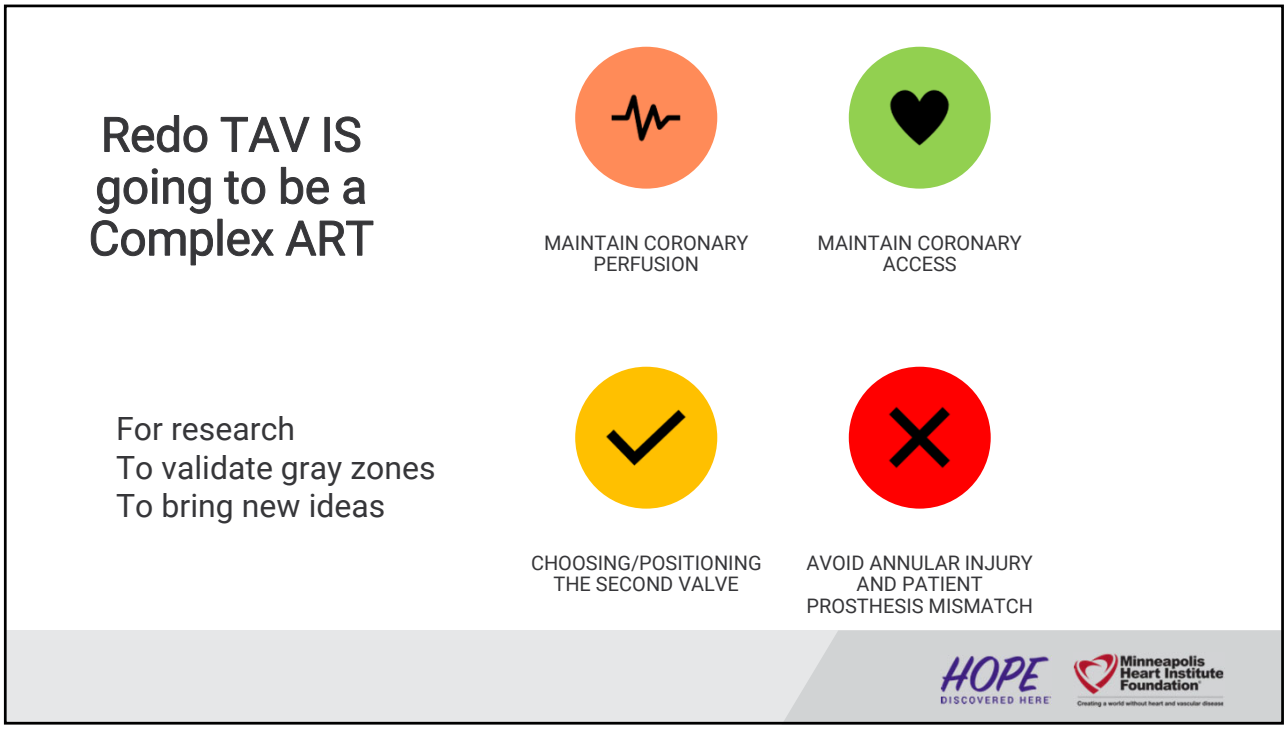
1

Disclosure Statement of Financial Interest

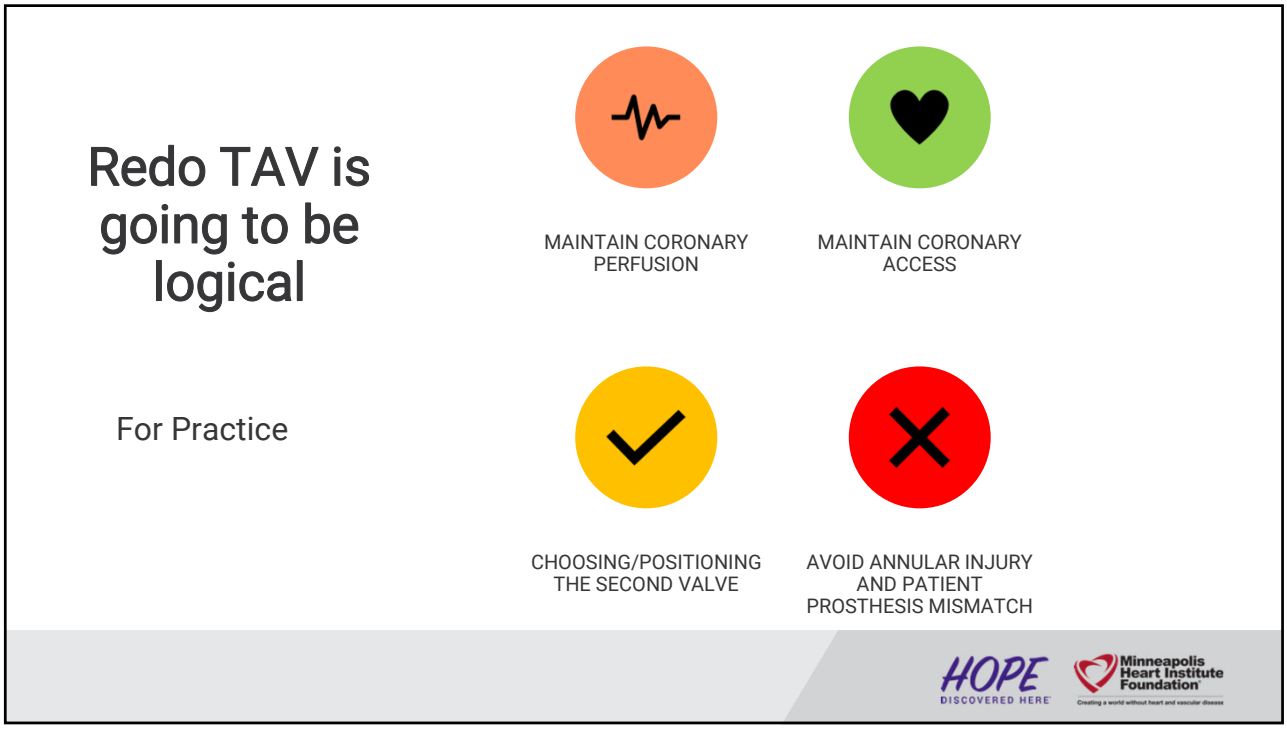
Within the past 12 months, I or my spouse/partner have had a financial interest/arrangement or affiliation with the organization(s) listed below.

Affiliation/Financial Relationship	Company
Consulting Fees/Honoraria	Medtronic Inc
Consulting Fees/Honoraria	Edwards Lifesciences
Consulting Fees/Honoraria	Abbott
Consulting Fees/Honoraria	Boston Scientific
Consulting Fees/Honoraria	Anteris
Consulting Fees/Honoraria	Meril

2


Redo TAV IS going to be a Complex ART
For research
To validate gray zones
To bring new ideas
MAINTAIN CORONARY PERFUSION
MAINTAIN CORONARY ACCESS
CHOOSING/POSITIONING THE SECOND VALVE
AVOID ANNULAR INJURY AND PATIENT PROSTHESIS MISMATCH
HOPE DISCOVERED HERE
Minneapolis Heart Institute Foundation

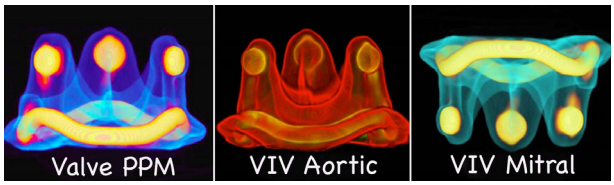
3

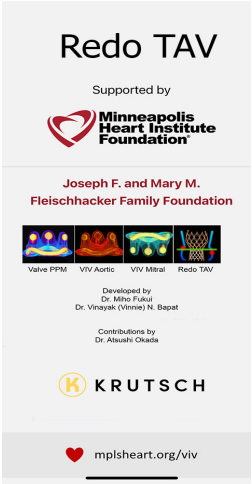

Redo TAV is going to be logical
For Practice
MAINTAIN CORONARY PERFUSION
MAINTAIN CORONARY ACCESS
CHOOSING/POSITIONING THE SECOND VALVE
AVOID ANNULAR INJURY AND PATIENT PROSTHESIS MISMATCH
HOPE DISCOVERED HERE
Minneapolis Heart Institute Foundation

4

Aortic VIV, Mitral VIV & Valve PPM App Usage

- July 2022 to June 2023
- APPs were used >350,000 times
- Countries: >150
- Contributions by physicians all over the world

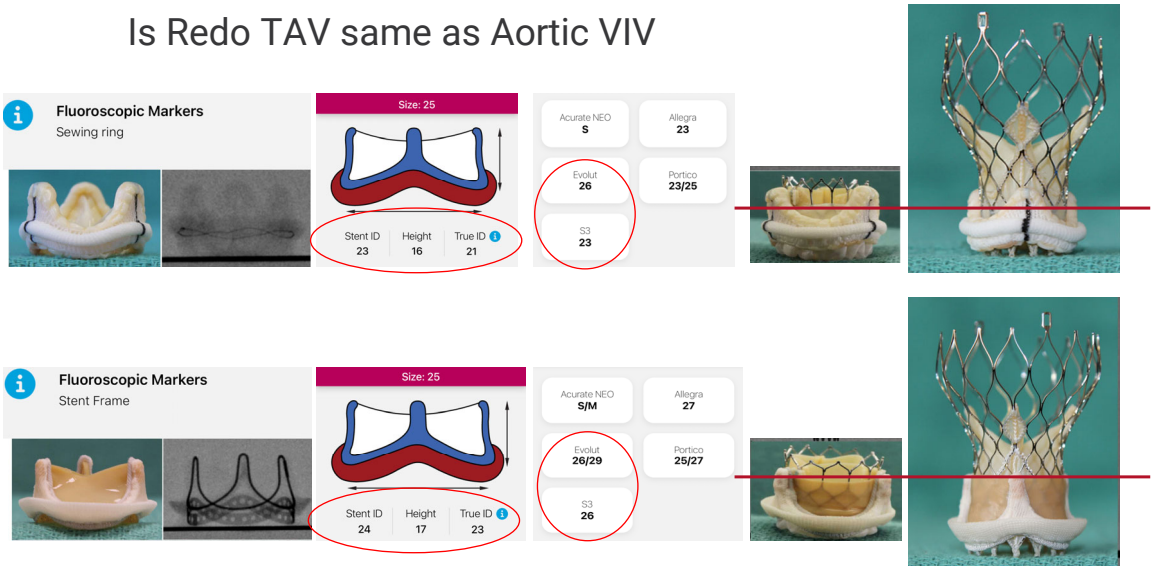




HOPE DISCOVERED HERE
Minneapolis Heart Institute Foundation

5

Is Redo TAV same as Aortic VIV

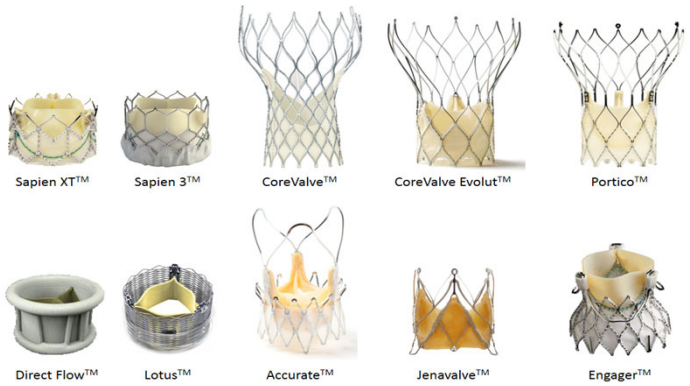


HOPE DISCOVERED HERE
Minneapolis Heart Institute Foundation

6

First challenge

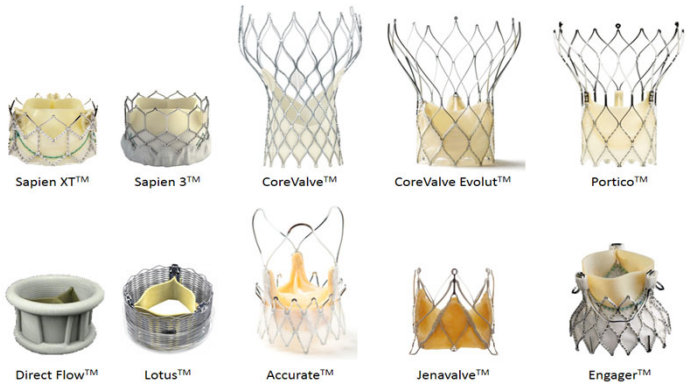
All valves have different design



7

Second challenge

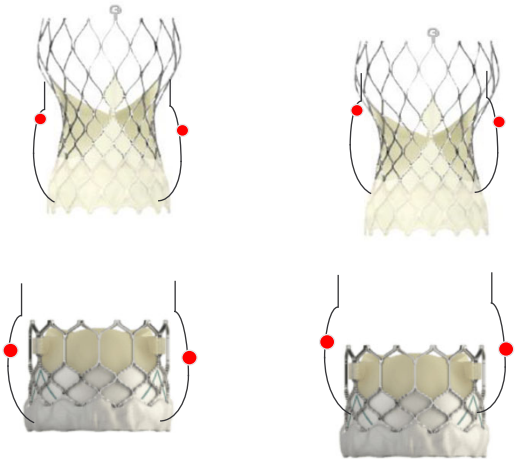
Valve Compatibility within each other is complex



8

Third challenge

Depth of TAV implant varies in each patient

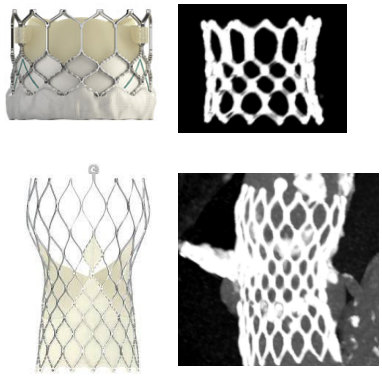


HOPE DISCOVERED HERE | Minneapolis Heart Institute Foundation

9

Fourth challenge

Most TAV are under expanded, hence dimensions are not constant



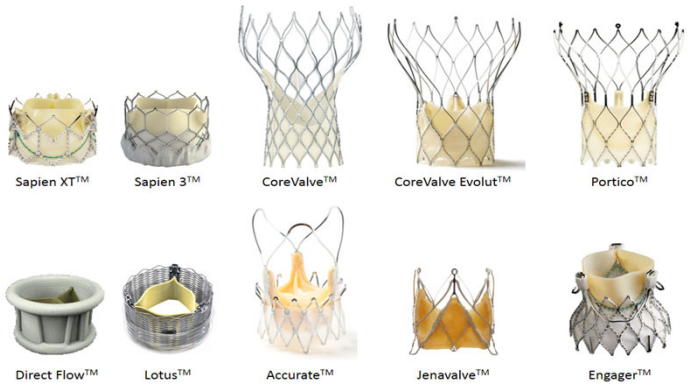
Using in-vitro Bench Sizing may lead to issues

HOPE DISCOVERED HERE | Minneapolis Heart Institute Foundation

10

Fifth challenge

Can we make a workflow Which accommodates all combinations?

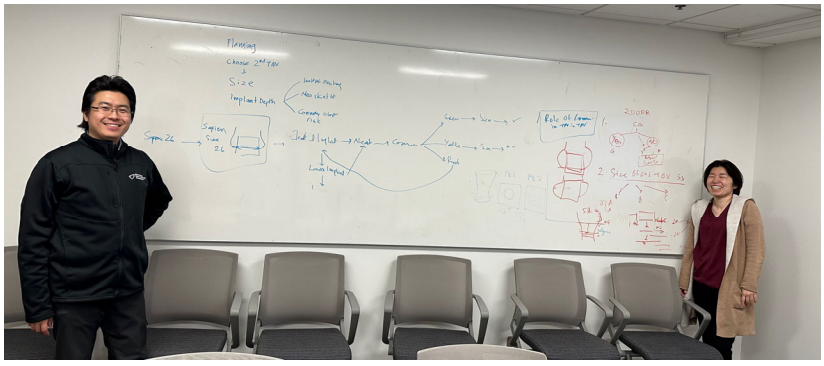


HOPE DISCOVERED HERE
Minneapolis Heart Institute Foundation

11

5 months of work
50+ different workflows
Beta-testing, Logo and Launch (Nov 15)

Dr. Atsushi Okada

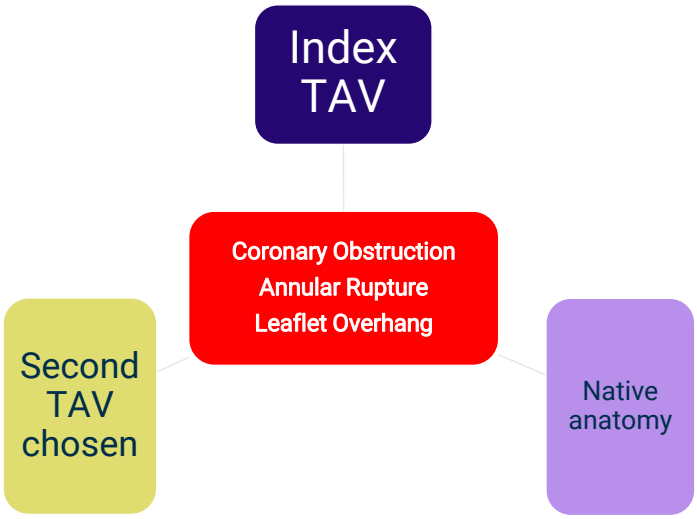


Dr. Miho Fukui

HOPE DISCOVERED HERE
Minneapolis Heart Institute Foundation

12

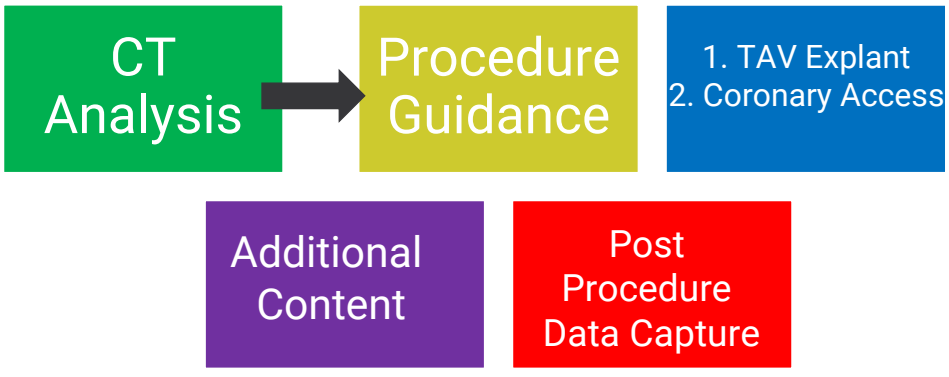
Main Concerns with Redo TAV



CT Analysis
1. may not be done by the implanter
2. may be done few days/weeks before the procedure
3. Second TAV may be from a different manufacturer

13

Content



14

Common Terminology and Nomenclature

- **Redo TAV or TAV in TAV ?** (TAV rather than TAVI or TAVR)
- **Index TAV and Second TAV**
- **Neoskirt:** Area of TAV combination covered with leaflets and/or inner skirt
- **Neoskirt plane:** Level of the Neoskirt for a given combination
- **Coronary risk plane:** Plane below the lowest coronary ostia

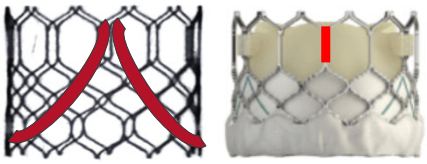
- **VTC:** Valve To Coronary distance
- **VTA:** Valve To Aorta distance
- **VTSTJ:** Valve to STJ distance

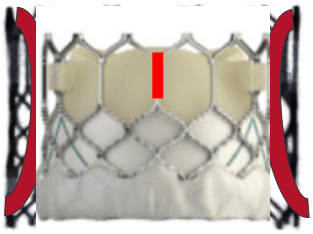
15

4 Redo TAV Combinations

16

1. What is Leaflet overhang and Leaflet deflection



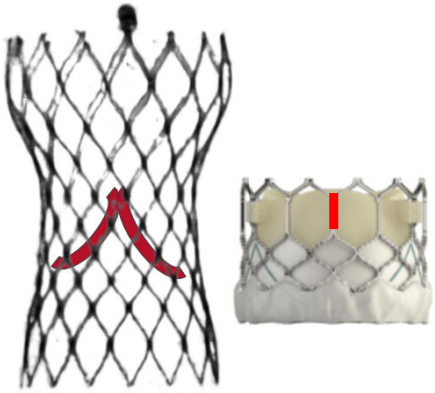


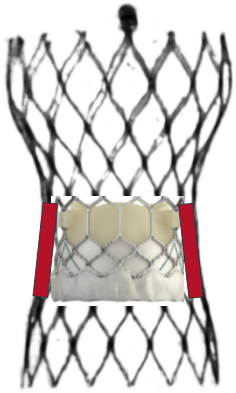
No Leaflet overhang

Leaflets deflected up to the top of the leaflet attachment

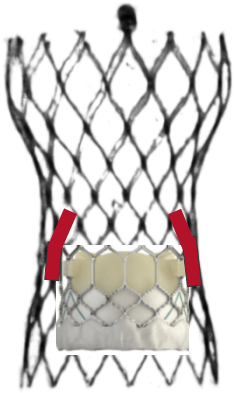
17

Leaflet overhang and Leaflet deflection





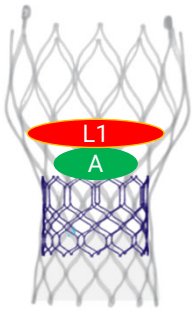
No Leaflet overhang



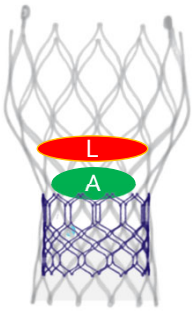
Leaflet overhang +

18

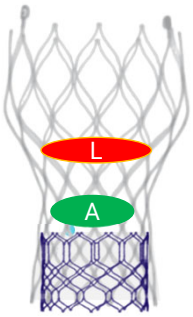
Example–ER26 and S3 23 (for illustration purpose only)



Node 6 Implant



Node 5 Implant



Node 4 Implant

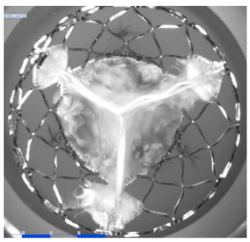
L should be more than A

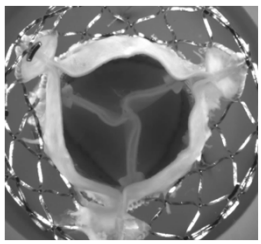
Area A: GOA/EOA of S3
Area L: GOA of leaflet overhang

19

Example–ER23 and S3 23

Node 5 implant



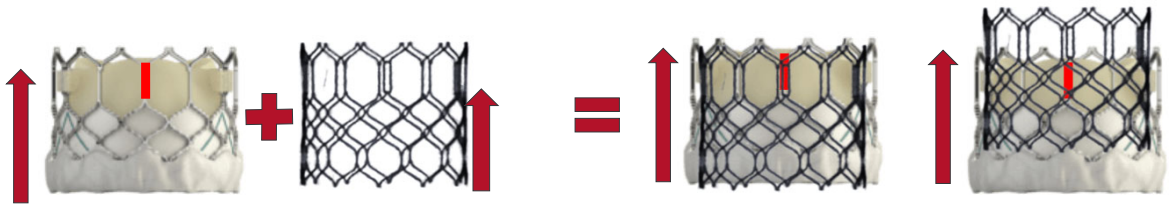


Dr. Sellers, Vancouver, TCT 2023

20

2. Neo skirt: Definition and meaning

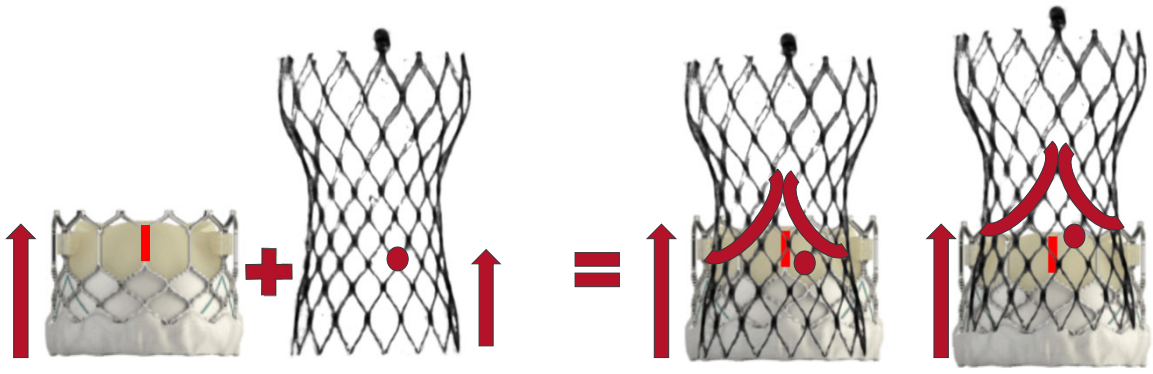
Combination of
Index TAV **Pinned** leaflets + Skirt of Second TAV



21

Neo skirt: Definition and meaning

Combination of
Index TAV **Pinned** leaflets + Skirt of Second TAV

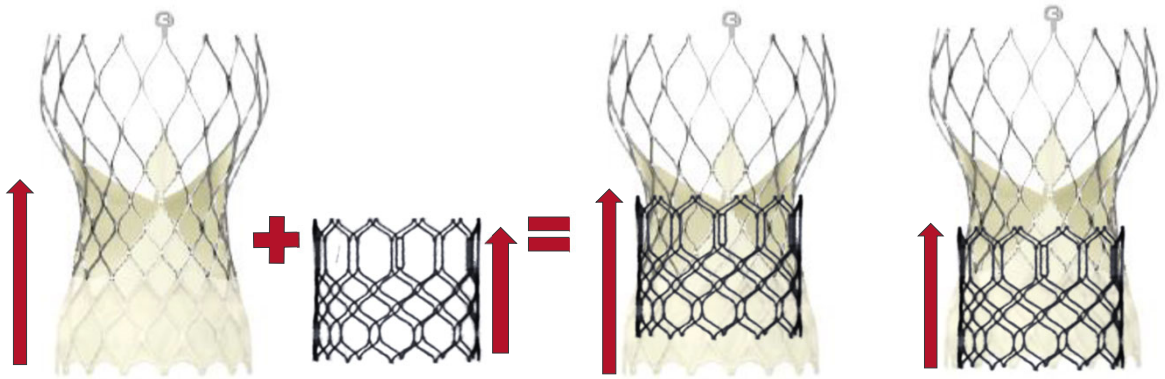


22

Neo skirt: Definition and meaning

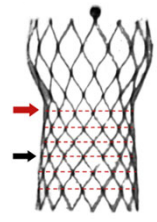
Combination of

Index TAV **Pinned** leaflets + Skirt of Second TAV

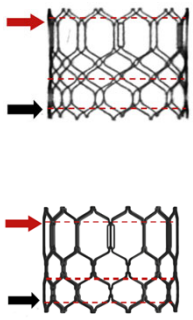


23

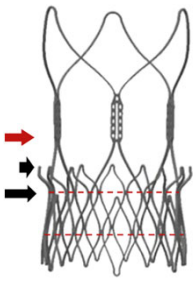
3. Each Valve has unique landmarks



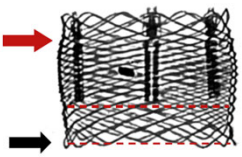
Nodes



Commissure Tab
Inflow



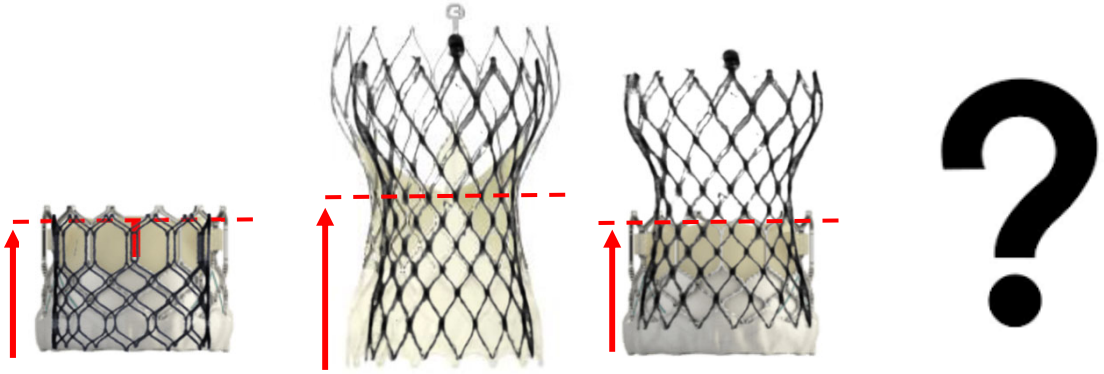
Commissure Tab
Top of Upper Crown
Bottom of Upper Crown



Tunning Fork
Inflow

24

4. Neoskirt and Neoskirt plane

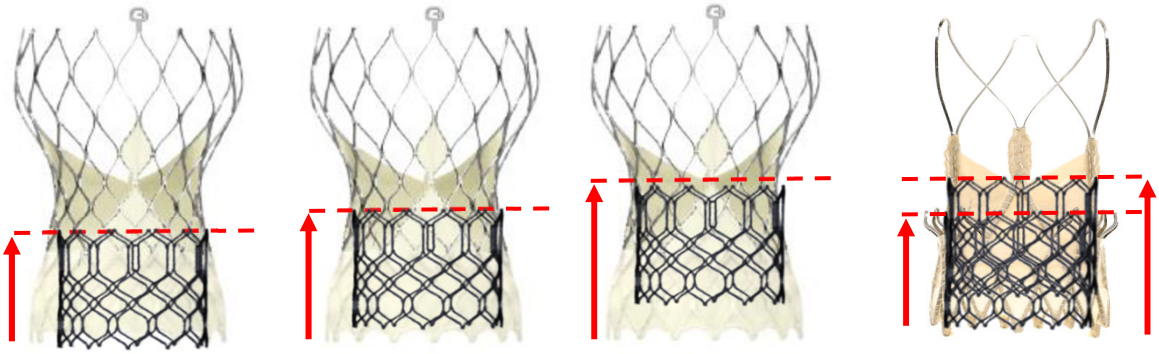


Short in Short | Tall in Tall | Tall in Short | Short in Tall

Single NSP

25

Neoskirt planes!

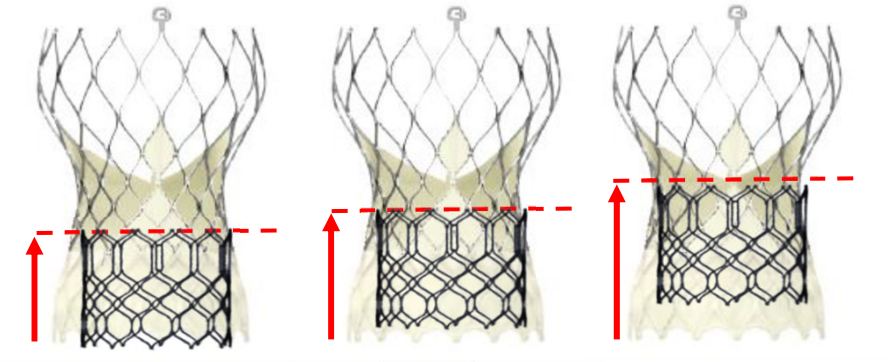


Node 4 | Node 5 | Node 6 | ACURATE neo2

Combination specific with lower and upper limit

26

5. Size of Second TAV before Coronary Analysis: Why?

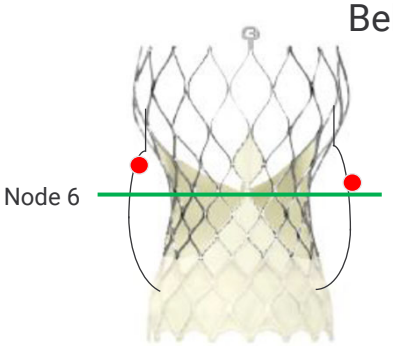


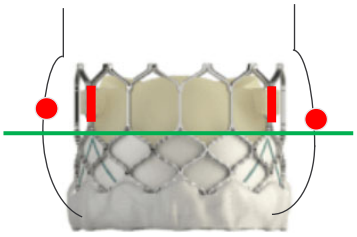
Sizing may change with
Level of implant

27

6. Coronary Risk Plane (CRP) & its relationship to Index TAV landmark

Below the lowest coronary ostia



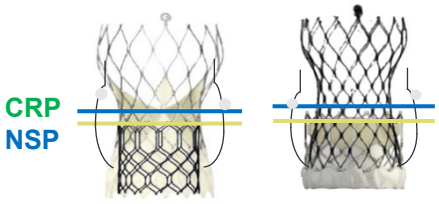


Below top of the
Commissure tab

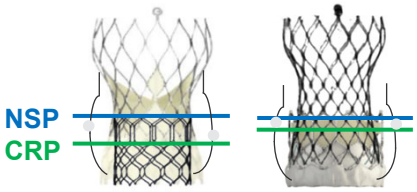
28

Relationship between CRP and NSP

CRP = Coronary risk plane
NSP = Neo skirt plane



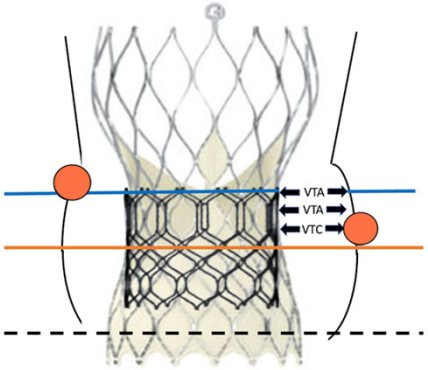
No/Minimal risk to coronaries
NSP below CRP



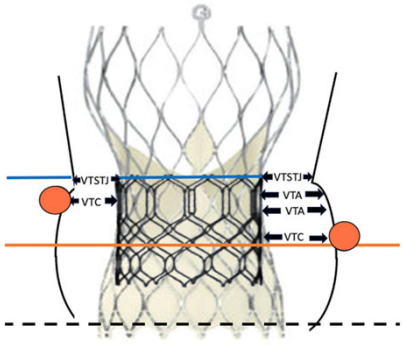
Risk to coronaries need assessment
NSP above CRP

29

7. Coronary Risk Analysis



NSP below STJ: VTA and VTC



NSP below STJ: VTSTJ, VTA and VTC

Risk based on NARROWEST MEASUREMENT

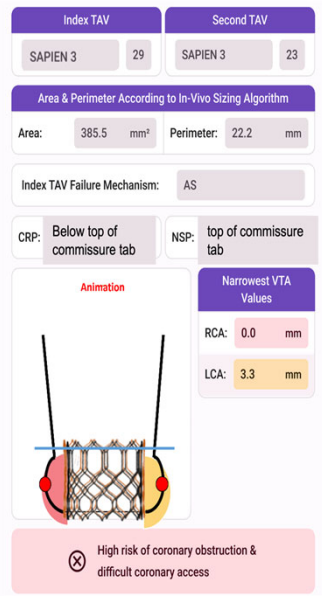
30

Risk classification

VTA >4	VTA 2-4	VTA <2
Minimal Risk of Coronary obstruction & good coronary access	Possible Risk of Coronary obstruction & difficult coronary access	Very high risk of Coronary obstruction & Difficult coronary access

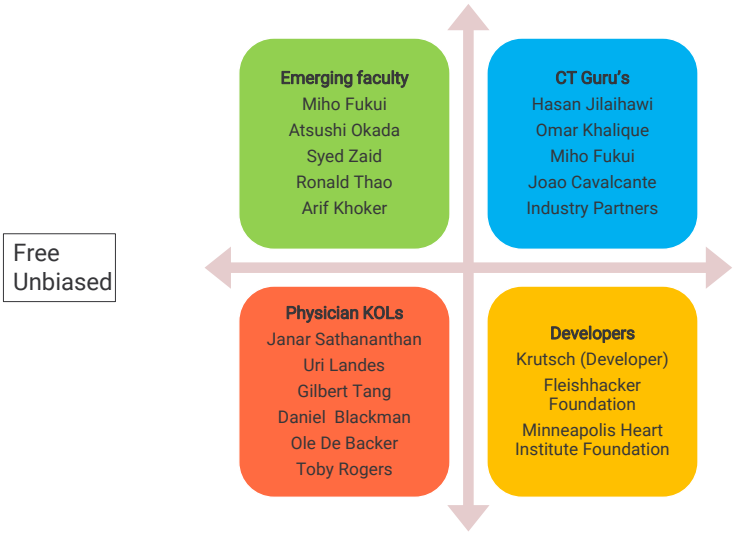
31

Summary Report



32

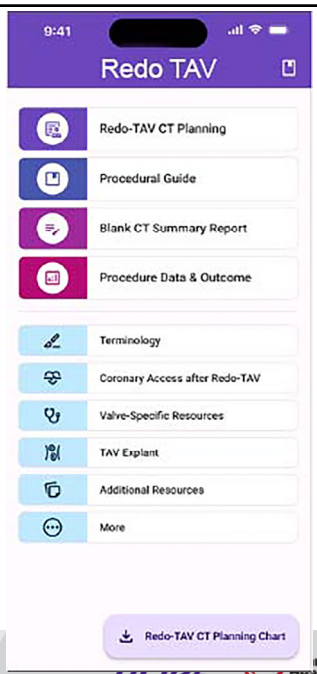
APP development



33

Home screen

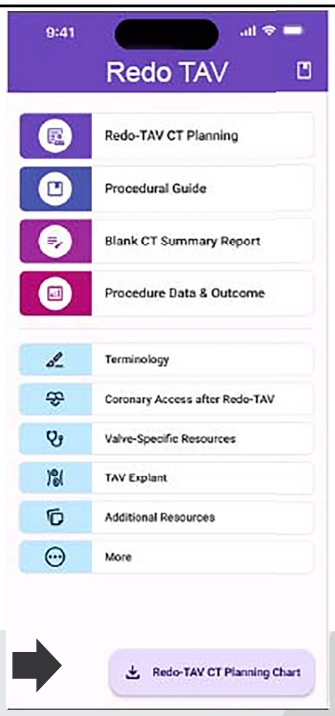
- Multiple links
- Top tabs – commonly used
- Bottom tabs – educational content

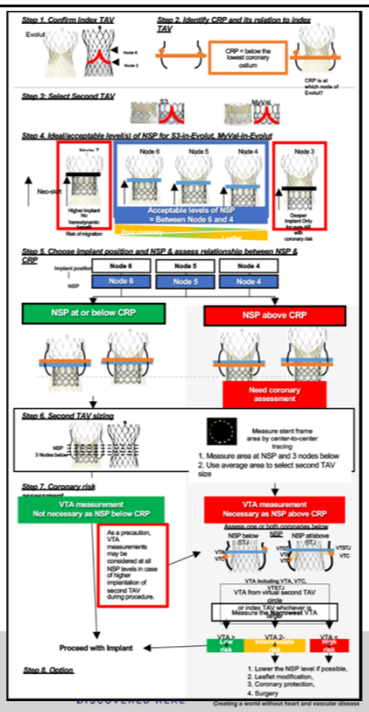


34

CT planning charts

Combination Specific
Downloadable PDF format





35

TAVR explant

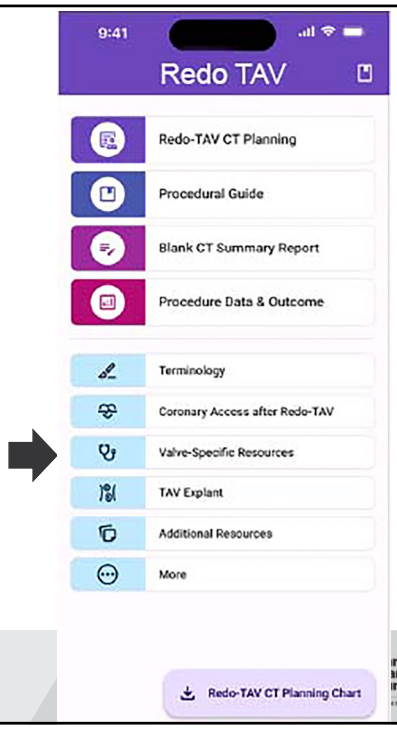
1. Planning
2. Techniques : subdivided into valve types
3. Expert discussions

36

Valve specific content

Deep dive in each design
Case examples
Bench testing data

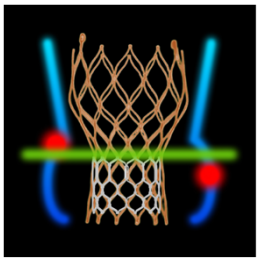
Developed with Industry partners



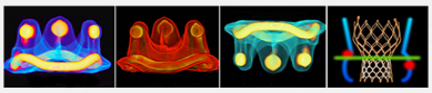
37

Publications, Presentations, Workshops

- Publications: 6 to 7 major publications
- Sessions and talks: All major Intervention meetings
- Redo-TAV CT analysis and APP use Course



Joseph F. and Mary M.
Fleischhacker Family Foundation



38

Minneapolis Heart Institute Foundation®

MINNEAPOLIS HEART INSTITUTE®

Prognosis of Excessive Trabeculation in the setting of normal ventricular function but prevalent significant risk factors.

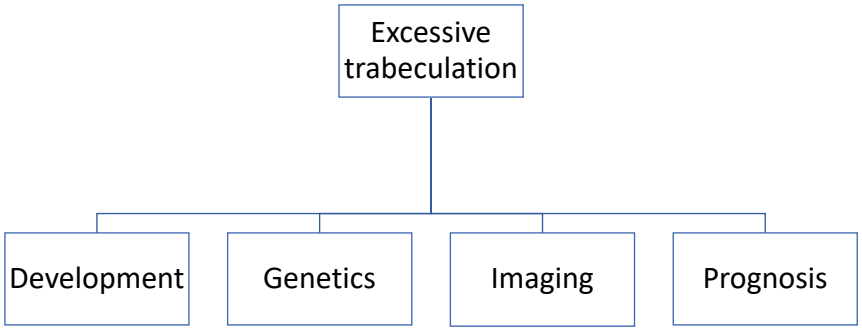
Ali Bahbah, MD.
International Research Scholar, Hear Rhythm Science Center.

39

ILOs

- Learn why non-compaction is not accurate and should be replaced with excessive trabeculation.
-Definition, Epidemiology and clinical picture.
-The prognosis of Excessive trabeculation in different populations.
-Suggested definition for Excessive Trabeculation.
-Algorithm for management of patients with Excessive trabeculations.

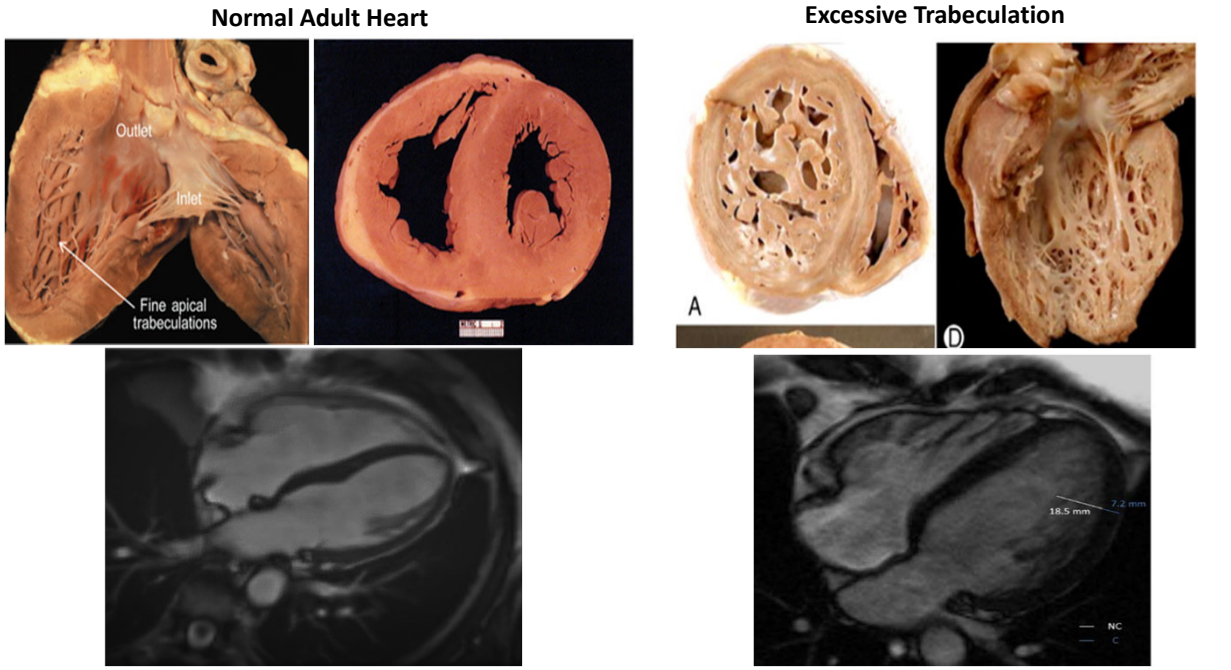
40



Old Definition

Left ventricular non-compaction (LVNC) is a very rare congenital cardiomyopathy. It is a disease of endomyocardial trabeculations that increase in number and prominence. This cardiomyopathy carries a high risk of malignant arrhythmias, thromboembolic phenomenon and left ventricular dysfunction.

41



42

Isolated Noncompaction of Left Ventricular Myocardium

A Study of Eight Cases

Thomas K. Chin, MD, Joseph K. Perloff, MD, Roberta G. Williams, MD, Kenneth Jue, MD, and Renee Mohrmann, MD

Isolated noncompaction of left ventricular myocardium is a rare disorder of endomyocardial morphogenesis characterized by numerous, excessively prominent ventricular trabeculations and deep intertrabecular recesses. This study comprised eight cases, including three at necropsy. Ages ranged from 11 months to 22.5 years, with follow-up as long as 5 years. Gross morphological severity ranged from moderately abnormal ventricular trabeculations to profoundly abnormal, loosely compacted trabeculations. Echocardiographic images were diagnostic and corresponded to the morphological appearances at necropsy. The depths of the intertrabecular recesses were assessed by a quantitative echocardiographic X-to-Y ratio and were significantly greater than in normal control subjects ($p<0.001$). Clinical manifestations of the disorder included depressed left ventricular systolic function in five patients, ventricular arrhythmias in five, systemic embolization in three, distinctive facial dysmorphism in three, and familial recurrence in four patients. We conclude that isolated noncompaction of left ventricular myocardium is a rare if not unique disorder with characteristic morphological features that can be identified by two-dimensional echocardiography. The incidence of cardiovascular complications is high. The disorder may be associated with facial dysmorphism and familial recurrence. (*Circulation* 1990;82:507–513)

Cardiovasc Intervent Radiol (1986) 9:127–131

CardioVascular and Interventional Radiology

© Springer-Verlag New York Inc.

Heart

Persisting Myocardial Sinusoids of Both Ventricles as an Isolated Anomaly: Echocardiographic, Angiographic, and Pathologic Anatomical Findings

Rolf Jenni,[1] Norbert Goebel,[2] Roberto Tartini,[1] Jakob Schneider,[3] Urs Arbenz,[4] and Oswald Oelz[1]

[1]Department of Internal Medicine, [2]Diagnostic Radiology, and [3]Pathology, University Hospital Zurich, and [4]Department of Cardiology, Children's University Hospital, Zurich, Switzerland

Identification of a Rare Congenital Anomaly of the Myocardium by Two-Dimensional Echocardiography: Persistence of Isolated Myocardial Sinusoids

ROLF ENGBERDING, MD
FRANZ BENDER, MD

The persistence of myocardial sinusoids has been reported in infants with atresia of semilunar valves and intact ventricular septum.[1-3] This complete right ventricular or left ventricular (LV) outflow tract obstruction induces high systolic ventricular pressure, thus prohibiting the regression of embryogenic myocardial sinusoids. To our knowledge, no other case of isolated persistent myocardial sinusoids, which resulted in a cardiac disease, has been previously published.

In a 33-year-old woman with exertional dyspnea and palpitations, a short systolic murmur was present over the apex. Otherwise, physical examination was normal. On chest radiograph, the heart was large and the pulmonary veins were congested. The electrocardiogram revealed complete left bundle branch block (QRS = 0.19 second), which was discovered when the patient was 15 years old, prolonged PQ interval (0.24 second) and ventricular extrasystoles and couplets. A 2-dimensional echocardiogram (Fig. 1) showed marked LV enlargement and LV wall thickening. The dimensions of the right side of the heart were normal. Within the LV wall, huge sinusoids were visualized. This diagnosis was confirmed by a left and right-sided cardiac catheterization and ventriculography (Fig. 2). Apparently, no communication existed between the sinusoids and coronary arteries or the right ventricle. Selective left and right coronary angiograms showed normal results. The intracardiac pressures (in mm Hg) were: pulmonary artery wedge mean, 18; pulmonary artery, 40/18; right ventricle, 40/5; right atrial mean, 5; left atrial mean, 18; left ventricle, 120/20; and aorta, 120/80. The oxygen saturation values (%) were: pulmonary artery, 67; right atrium, 67; and left atrium, 96.

Our case shows that diagnosis of persistent myocardial sinusoids can be established by 2-dimensional echocardiography and that this anomaly can occur as an isolated congenital anomaly.

From the University Hospital, Department of Cardiology-Angiology, Domagkstr. 3, 4400 Münster, Federal Republic of Germany. Manuscript received January 3, 1984; revised manuscript received February 27, 1984, accepted February 29, 1984.

References

1. **Davignon AL, Du Shane JW, Kincaid OW, Swan HJC.** Pulmonary atresia with intact ventricular septum. Report of two cases studied by selective angiocardiography and right heart catheterization. Am Heart J 1961;62:690–697.
2. **Elliott LP, Adams PJr, Edwards JE.** Pulmonary atresia with intact ventricular septum. Br Heart J 1963;25:489–501.
3. **Lauer RM, Fink HP, Petry EL, Dunn MI, Diehl AM.** Angiographic demonstration of intramyocardial sinusoids in pulmonary-valve atresia with intact ventricular septum and hypoplastic right ventricle. N Engl J Med 1964;271:68–72.

43

© 2021. Published by The Company of Biologists Ltd | Biology Open (2021) 10, bio057059. doi:10.1242/bio.057059

RESEARCH ARTICLE

Quantified growth of the human embryonic heart

Jaeike W. Faber, Jaco Hagoort, Antoon F. M. Moorman, Vincent M. Christoffels and Bjarke Jensen*

ABSTRACT
The size and growth patterns of the components of the human embryonic heart have remained largely undefined. To provide these data, three-dimensional heart models were generated from immunohistochemically stained sections of ten human embryonic hearts ranging from Carnegie stage 10 to 23. Fifty-eight key structures were annotated and volumetrically assessed. Sizes of the septal foramina and atrioventricular canal opening were also measured. The heart grows exponentially throughout embryonic development. There was consistently less left than right atrial myocardium, and less right than left ventricular myocardium. We observed a later onset of trabeculation in the left atrium compared to the right. Morphometry showed that the rightward expansion of the atrioventricular canal starts in week 5. The septal foramina are less than 0.1 mm² and are, therefore, much smaller than postnatal septal defects. This chronological, graphical atlas of the growth patterns of cardiac components in the human embryo provides quantified references for normal heart development. Thereby, this atlas may support early detection of cardiac malformations in the foetus.

poorly understood. Nevertheless, in recent years, immunohistochemical studies, regarding for example the development of the cardiac conduction system, have clarified some of the controversies emerging from purely anatomical descriptions (Sizarov et al., 2011a). But, for the single cell transcriptomic data of the developing heart, which is becoming available (e.g. Cui et al., 2019), more detailed knowledge regarding cardiac structures and their sizes may help to validate the assignment of cell identities and their anatomical positions.

The few publications that do address quantitative descriptions of embryonic cardiac growth mostly focus on a detailed point such as ventricular wall thickness (e.g. Goor et al., 1970) or ventricular myocardial volume (e.g. Wenink, 1992). But, most of what is known about quantitative morphology stems from non-human heart development, such as mouse (de Boer et al., 2012; Ishiwata et al., 2003) and chicken (Rana et al., 2007; Rychterová, 1971). No quantitative reference work exists on the growth of key structures of the human heart that can indicate whether cardiac development might be deviating from normal.

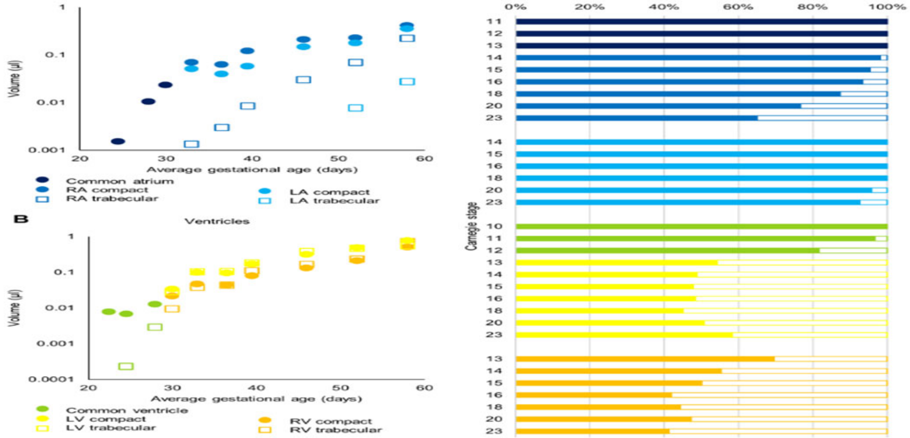
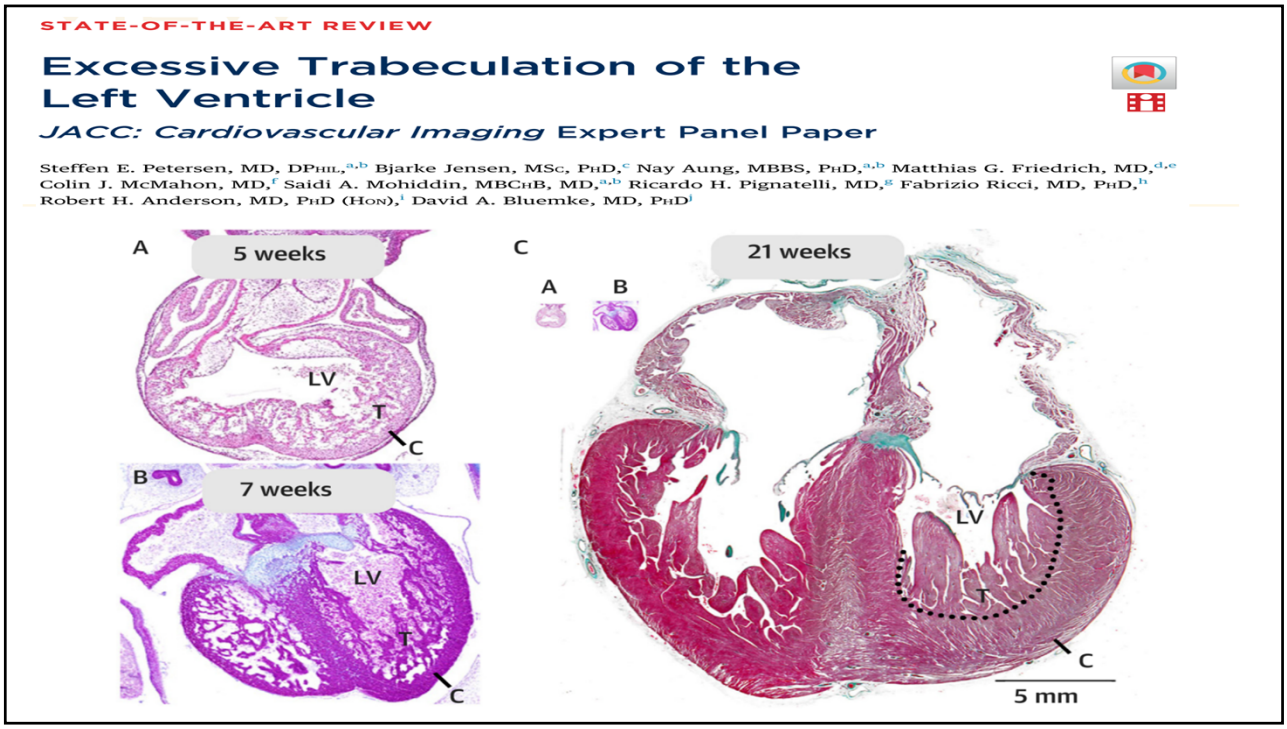
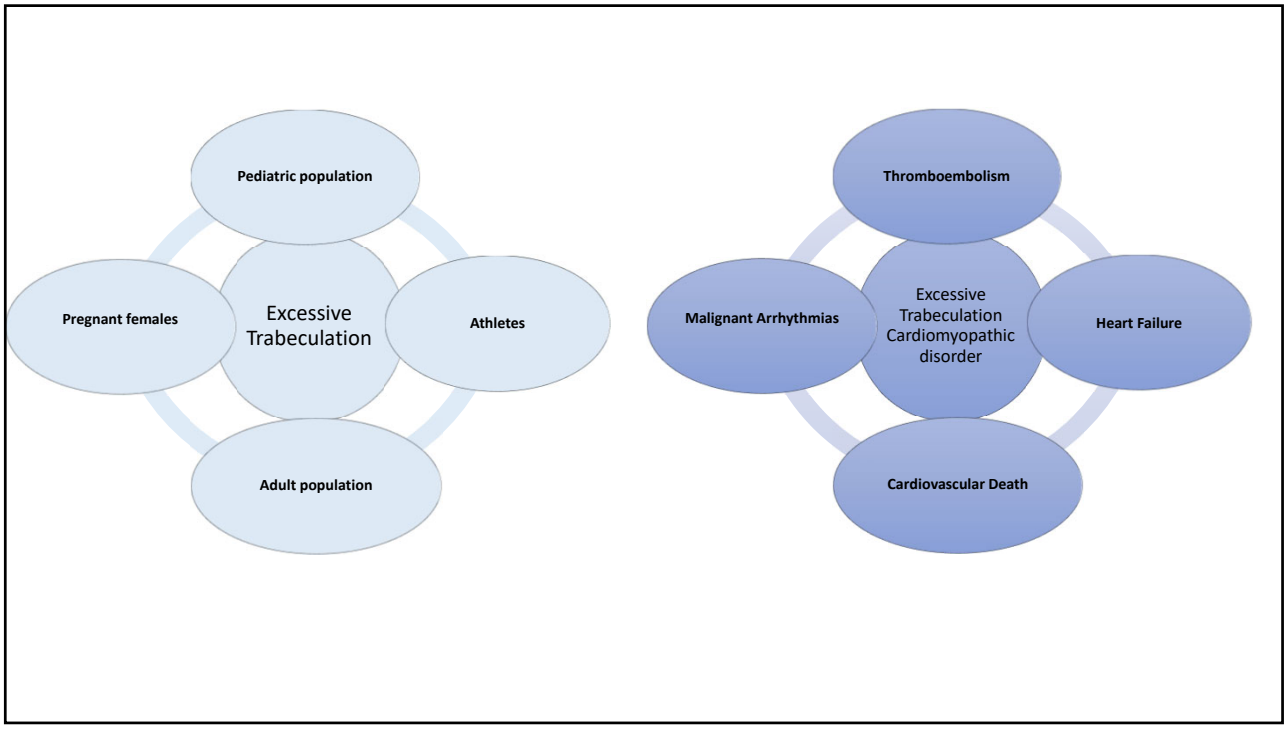


Fig. 5. Atrial and ventricular compact and trabecular myocardial growth. For the atria, distinction between outer myocardium and the trabecular pectinate muscles is made. For the ventricles the trabecular myocardium, including the papillary muscles, is segmented separated from the compact myocardium. Common atrium (includes *Atrial_myocardium*), right atrium (RA; compact includes *RA_myocardium*, *Inferior_rim_oval_fossa_myocardium* and *Secondary_atrial_septum_sulcus;* trabecular includes *RA_trabecular_myocardium* and *Septum_spurium_myocardium*), left atrium (LA; compact includes *LA_myocardium* and *Pulmonary_vein_myocardium*; trabecular includes *LA_trabecular_myocardium*), common ventricle (includes *Ventricular_myocardium* and *Ventricular_trabecular_myocardium*), left ventricle (LV; compact includes *LV_compact_myocardium*; trabecular includes *LV_trabecular_myocardium*), right ventricle (RV; compact includes *RV_compact_myocardium*; trabecular includes *RV_trabecular_myocardium*). *N*=1 for each time point, no statistical tests were performed.

44


STATE-OF-THE-ART REVIEW
Excessive Trabeculation of the Left Ventricle
JACC: Cardiovascular Imaging Expert Panel Paper
Steffen E. Petersen, MD, DPhil,[a,b] Bjarke Jensen, MSc, PhD,[c] Nay Aung, MBBS, PhD,[a,b] Matthias G. Friedrich, MD,[d,e] Colin J. McMahon, MD,[f] Saidi A. Mohiddin, MBChB, MD,[a,b] Ricardo H. Pignatelli, MD,[g] Fabrizio Ricci, MD, PhD,[h] Robert H. Anderson, MD, PhD (Hon),[i] David A. Bluemke, MD, PhD[j]
A
5 weeks
LV
T
C
B
7 weeks
LV
T
C
C
21 weeks
A
B
LV
T
C
5 mm

45


Pediatric population
Pregnant females
Excessive Trabeculation
Athletes
Adult population
Thromboembolism
Malignant Arrhythmias
Excessive Trabeculation Cardiomyopathic disorder
Heart Failure
Cardiovascular Death

46

Journal of the American College of Cardiology
© 2000 by the American College of Cardiology
Published by Elsevier Science Inc.

Vol. 36, No. 2, 2000
ISSN 0735-1097/00/$20.00
PII S0735-1097(00)00755-5

Long-Term Follow-up of 34 Adults With Isolated Left Ventricular Noncompaction: A Distinct Cardiomyopathy With Poor Prognosis

Erwin N. Oechslin, MD, Christine H. Attenhofer Jost, MD, Jerry R. Rojas, MD, Philipp A. Kaufmann, MD, Rolf Jenni, MD, MSEE
Zurich, Switzerland

OBJECTIVES We sought to describe characteristics and outcome in adults with isolated ventricular noncompaction (IVNC).

BACKGROUND Isolated ventricular noncompaction is an unclassified cardiomyopathy due to intrauterine arrest of compaction of the loose interwoven meshwork. Knowledge regarding diagnosis, morbidity and prognosis is limited.

METHODS Echocardiographic criteria for IVNC include—in the absence of significant heart lesions—segmental thickening of the left ventricular myocardial wall consisting of two layers: a thin, compacted epicardial and an extremely thickened endocardial layer with prominent trabeculations and deep recesses. Thirty-four adults (age ≥16 years, 25 men) fulfilled the diagnostic criteria and were followed prospectively.

RESULTS At diagnosis, mean age was 42 ± 17 years, and 12 patients (35%) were in New York Heart Association class III/IV. Left ventricular end-diastolic diameter was 65 ± 12 mm and ejection fraction 33 ± 13%. Apex and/or midventricular segments of both the inferior and lateral wall were involved in >80% of patients. Follow-up was 44 ± 40 months. Major complications were heart failure in 18 patients (53%), thromboembolic events in 8 patients (24%) and ventricular tachycardias in 14 patients (41%). There were 12 deaths: sudden in six, end-stage heart failure in four and other causes in two patients. Four patients underwent heart transplantation. Automated cardioverter/defibrillators were implanted in four patients.

CONCLUSIONS Diagnosis of IVNC by echocardiography using strict criteria is feasible. Its mortality and morbidity are high, including heart failure, thrombo-embolic events and ventricular arrhythmias. Risk stratification includes heart failure therapy, oral anticoagulation, heart transplantation and implantation of an automated defibrillator/cardioverter. As IVNC is a distinct entity, its classification as a specific cardiomyopathy seems to be more appropriate. (J Am Coll Cardiol 2000;36:493–500) © 2000 by the American College of Cardiology

Table 3. Long-Term Follow-up Data

	Number of Patients
Heart failure requiring hospitalization	18 (53%)
Deaths	12 (35%)
Heart failure	4 (33%)
Sudden cardiac death	6 (50%)
Others*	2 (17%)
Heart transplantation	4 (12%)
Syncope	6 (18%)
NYHA class at last follow-up or before heart transplantation or death	
Class I/II	18 (53%)
Class III/IV	16 (47%)
Ventricular tachycardia	14 (41%)
Thromboembolic events	8 (24%)
Cerebrovascular accident	1 (3%)
Transient ischemic attack	6 (18%)
Mesenteric infarction	1 (3%)
Pulmonary embolism	3 (9%)

*Two other deaths included pulmonary embolism and arrhythmic, nonsudden death.
NYHA = New York Heart Association.

Oechslin et al. Isolated Ventricular Noncompaction

47

The Relationship of Left Ventricular Trabeculation to Ventricular Function and Structure Over a 9.5-Year Follow-Up

The MESA Study

Filip Zemrak, MD,* Mark A. Ahlman, MD,† Gabriella Captur, MD, MSc,‡ Saidi A. Mohiddin, MBChB, MD,* Nadine Kawel-Boehm, MD,§ Martin R. Prince, MD, PhD,‖ James C. Moon, MBBCh, MD,‡ William G. Hundley, MD,¶ João A.C. Lima, MD,# David A. Bluemke, MD, PhD,† Steffen E. Petersen, MD, DPhil, MPH*

ABSTRACT

BACKGROUND Left ventricular (LV) trabeculation is highly variable among individuals and is increased in some diseases (e.g., congenital heart disease or cardiomyopathies), but its significance in population-representative individuals is unknown.

OBJECTIVES The goal of this study was to determine if excessive LV trabeculation in population-representative individuals is associated with preceding changes in cardiac volumes and function.

METHODS For technical reasons, the extent of trabeculation, which is expressed as the ratio of noncompacted to compacted (NC/C) myocardium, was measured on cardiac magnetic resonance (CMR) long-axis cine images in 2,742 participants in the MESA (Multi-Ethnic Study of Atherosclerosis) (mean age 68.7 years; 52.3% women; 56.4% with hypertension; 16.8% with diabetes) at examination 5. These were considered in quintiles of trabeculation extent; the NC/C ratio of quintile 5 was 2.46 to 5.41. We determined the relationship between the maximal NC/C ratio and the preceding change (9.5 years between examinations 1 and 5) in end-systolic volume indexed (ESVi) to body surface area. Secondary analyses assessed the associations between the maximal NC/C ratio and preceding changes in end-diastolic volume indexed (EDVi) to body surface area and the ejection fraction (EF).

RESULTS Over 9.5 years, the ESVi decreased by 1.3 ml/m², the EDVi decreased by 5.1 ml/m², and the EF decreased by 0.6% ($p < 0.0001$). Even in subjects with excessive trabeculation, there were no clinically relevant differences in LV volumes and systolic function changes among the quintiles of trabeculation extent.

CONCLUSIONS Greater extent of, and even excessive, LV trabeculation measured in end-diastole in asymptomatic population-representative individuals appeared benign and was not associated with deterioration in LV volumes or function during an almost 10-year period. (J Am Coll Cardiol 2014;64:1971–80) © 2014 by the American College of Cardiology Foundation.

TABLE 2 Demographic and CMR Data at MESA Examination 5

	All (n = 2,742)	Quintile 1 NC/C: 0-1.41 (n = 549)	Quintile 2 NC/C: 1.42-1.71 (n = 548)	Quintile 3 NC/C: 1.72-2.00 (n = 548)	Quintile 4 2.01-2.45 (n = 548)	Quintile 5 2.46-5.41 (n = 549)

TABLE 3 Cardiovascular Adverse Outcomes in Relation to the Extent of LV Trabeculations

	All	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Atrial fibrillation	24	10 (1.9)	7 (1.3)	1 (0.2)	3 (0.6)	3 (0.6)
Congestive heart failure	22	4 (0.7)	5 (0.9)	5 (0.9)	4 (0.7)	4 (0.7)
Stroke	28	4 (0.7)	8 (1.5)	10 (1.9)	2 (0.4)	4 (0.7)
Transient ischemic attack	17	4 (0.7)	3 (0.6)	4 (0.7)	4 (0.7)	2 (0.4)
Myocardial infarction	41	15 (2.8)	2 (0.4)	8 (1.5)	9 (1.7)	7 (1.3)
Hard cardiovascular endpoints	68	19 (3.6)	10 (1.9)	18 (3.4)	11 (2.0)	10 (1.9)
All cardiovascular endpoints	121	31 (6.0)	21 (4.0)	25 (4.8)	20 (3.8)	24 (4.6)

Values are n or n (%). The incidence of cardiovascular adverse outcomes in the whole studied cohort and quintiles of maximal NC/C ratio are shown. Hard cardiovascular endpoints included myocardial infarction, resuscitated cardiac arrest, and stroke. All cardiovascular endpoints include hard cardiovascular endpoints plus definite angina, probable angina followed by coronary revascularization.
Abbreviations as in Table 2.

EXTENT OF NC/C RATIO IN QUINTILES	Quintile 1 (0 to 1.41)	Quintile 2 (1.42 to 1.72)	Quintile 3 (1.73 to 2.01)	Quintile 4 (2.02 to 2.45)	Quintile 5 (2.46 to 5.41)	p Value
CHANGE IN ESVi (ML/M²)	-1.3 ± 8.0	-2.1 ± 7.1	-1.4 ± 7.5	-0.9 ± 7.4	-1.0 ± 7.2	0.08
CHANGE IN EDVi (ML/M²)	-6.5 ± 13.1	-6.0 ± 12.4	-5.1 ± 12.1	-4.4 ± 12.3	-3.6 ± 11.3	<0.001
CHANGE IN EF (%)	-1.4 ± 8.2	-0.1 ± 7.6	-0.4 ± 8.0	-0.8 ± 7.5	-0.3 ± 7.9	0.053

Zemrak, F., et al., J Am Coll Cardiol. 2014; 64(19):1971–80.

CENTRAL ILLUSTRATION Changes Over a 9.5-Year Period in the ESVi, EDVi, and EF

The changes over this time period in the end-systolic volume index (ESVi) and ejection fraction (EF) were not different among the quintiles of maximal noncompaction to compaction ratio (NC/C), even in participants in whom the current "normal value" (<2.3) was exceeded. The decrease in the end-diastolic volume index (EDVi) was smaller with an increasing extent of trabeculation; significant differences were seen between quintiles 1 and 4 ($p < 0.05$), between quintiles 1 and 5 ($p < 0.001$), and between quintiles 2 and 5 ($p < 0.01$), but these changes were clinically insignificant.

Zemrak et al. LV Trabeculation and Function in MESA

48

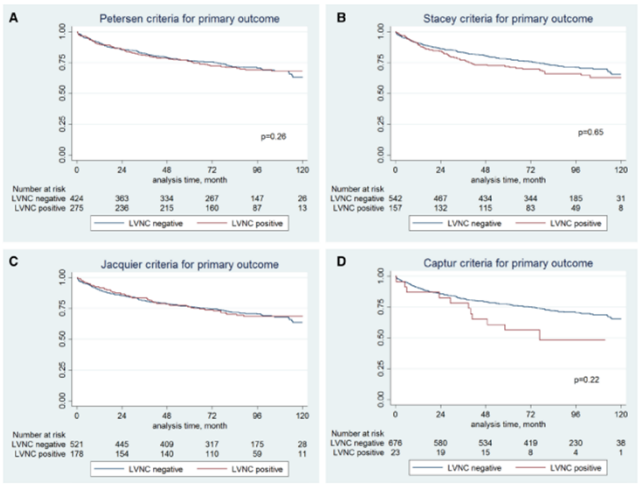
Magnetic Resonance Imaging

Prevalence and Prognostic Significance of Left Ventricular Noncompaction in Patients Referred for Cardiac Magnetic Resonance Imaging

Alexander Ivanov, MD; Devindra S. Dabiesingh, DO, MPH; Geetha P. Bhumireddy, MD; Ambreen Mohamed, MD; Ahmed Asfour, MD; William M. Briggs, PhD, MS; Jean Ho, BS; Saadat A. Khan, MD; Alexandra Grossman, BS; Igor Klem, MD; Terrence J. Sacchi, MD; John F. Heitner, MD

Background—Presence of prominent left ventricular trabeculation satisfying criteria for left ventricular noncompaction (LVNC) on routine cardiac magnetic resonance examination is frequently encountered; however, the clinical and prognostic significance of these findings remain elusive. This registry aimed to assess LVNC prevalence by 4 current criteria and to prospectively evaluate an association between diagnosis of LVNC by these criteria and adverse events.

Methods and Results—There were 700 patients referred for cardiac magnetic resonance: 42% were women, median age was 70 years (range, 45–71 years), mean left ventricular ejection fraction was 51% (±17%), and 32% had late gadolinium enhancement on cardiac magnetic resonance. The cohort underwent diagnostic assessment for LVNC by 4 separate imaging criteria—referenced by their authors as Petersen, Stacey, Jacquier, and Captur, with LVNC prevalence of 39%, 23%, 25% and 3%, respectively. Primary clinical outcome was combined end point of time to death, ischemic stroke, ventricular tachycardia/ventricular fibrillation, and heart failure hospitalization. Secondary clinical outcomes were (1) all-cause mortality and (2) time to the first occurrence of any of the following events: cardiac death, ischemic stroke, ventricular tachycardia/ventricular fibrillation, or heart failure hospitalization. During a median follow-up of 7 years, there were no statistically significant differences in assessed outcomes noted between patients with and without LVNC irrespective of the applied criteria.



Ivanov et al. LVNC in Patients Referred for CMR

49

Genetics, Clinical Features, and Long-Term Outcome of Noncompaction Cardiomyopathy

Jaap I. van Waning, MD,[a] Kadir Caliskan, MD, PhD,[b] Yvonne M. Hoedemaekers, MD, PhD,[c] Karin Y. van Spaendonck-Zwarts, MD, PhD,[d] Annette F. Baas, MD, PhD,[e] S. Matthijs Boekholdt, MD, PhD,[f] Joost P. van Melle, MD,[g] Arco J. Teske, MD, PhD,[h] Folkert W. Asselbergs, MD, PhD,[h] Ad P.C.M. Backx, MD,[i] Gideon J. du Marchie Sarvaas, MD,[j] Michiel Dalinghaus, MD, PhD,[k] Johannes M.P.J. Breur, MD, PhD,[l] Marijke P.M. Linschoten, MSc,[b] Laura A. Verlooij, MD,[c] Isabella Kardys, MD, PhD,[b] Dennis Dooijes, PhD,[e] Ronald H. Lekanne Deprez, PhD,[d] Arne S. IJpma, PhD,[a] Maarten P. van den Berg, MD, PhD,[g] Robert M.W. Hofstra, PhD,[a] Marjon A. van Slegtenhorst, PhD,[a] Jan D.H. Jongbloed, PhD,[c] Danielle Majoor-Krakauer, MD, PhD[a]

ABSTRACT

BACKGROUND The clinical outcomes of noncompaction cardiomyopathy (NCCM) range from asymptomatic to heart failure, arrhythmias, and sudden cardiac death. Genetics play an important role in NCCM.

OBJECTIVES This study investigated the correlations among genetics, clinical features, and outcomes in adults and children diagnosed with NCCM.

METHODS A retrospective multicenter study from 4 cardiogenetic centers in the Netherlands classified 327 unrelated NCCM patients into 3 categories: 1) genetic, with a mutation in 32% (81 adults; 23 children) of patients; 2) probably genetic, familial cardiomyopathy without a mutation in 16% (45 adults; 8 children) of patients; or 3) sporadic, no family history, without mutation in 52% (149 adults; 21 children) of patients. Clinical features and major adverse cardiac events (MACE) during follow-up were compared across the children and adults.

RESULTS *MYH7*, *MYBPC3*, and *TTN* mutations were the most common mutations (71%) found in genetic NCCM. The risk of having reduced left ventricular (LV) systolic dysfunction was higher for genetic patients compared with the probably genetic and sporadic cases ($p = 0.024$), with the highest risk in patients with multiple mutations and *TTN* mutations. Mutations were more frequent in children ($p = 0.04$) and were associated with MACE ($p = 0.025$). Adults were more likely to have sporadic NCCM. High risk for cardiac events in children and adults was related to LV systolic dysfunction in mutation carriers, but not in sporadic cases. Patients with *MYH7* mutations had low risk for MACE ($p = 0.03$).

CONCLUSIONS NCCM is a heterogeneous condition, and genetic stratification has a role in clinical care. Distinguishing genetic from nongenetic NCCM complements prediction of outcome and may lead to management and follow-up tailored to genetic status. (J Am Coll Cardiol 2018;71:711–22) © 2018 by the American College of Cardiology Foundation.

TABLE 2 Clinical Features at Long-Term Follow-Up of Pediatric and Adult Patients With NCCM

	Children (n = 52)				Adults n = 275				
		No Mutation (n = 29) (55%)				No Mutation (n = 194) (70%)			
	Mutation (n = 23) (45%)	Familial (n = 8) (15%)	Not Familial (n = 21) (40%)		Mutation (n = 81) (30%)	Familial (n = 45) (16%)	Not Familial n = 149 (54%)		
	Genetic	Probably Genetic	Sporadic	Total	Genetic	Probably Genetic	Sporadic	Total	p Value
Median follow-up, months	81 (13-114)	24 (1-102)	40 (19-120)	60 (18-113)	26 (6-69)	29 (10-71)	22 (4-49)	25 (4-58)	
Heart failure									
Heart failure requiring hospitalization	9 (39)	3 (38)	1 (5)	13 (25)	20 (25)	9 (20)	30 (20)	59 (21)	
Thromboembolic events									
TIA					2 (2)	1 (2)	5 (3)	8 (3)	
Stroke	1 (4)			1 (2)	1 (2)	4 (9)	12 (8)	17 (6)	
Peripheral thromboembolism	1 (4)			1 (2)	4 (5)	1 (2)	6 (4)	11 (4)	
Arrhythmias									
Atrial fibrillation	3 (13)	1 (13)	1 (5)	5 (10)	15 (19)	8 (18)	21 (14)	44 (16)	
Sustained VT/VF	1 (4)	2 (25)	1 (5)	3 (6)	3 (4)	2 (4)	11 (7)	16 (6)	
ICD	5 (22)	2 (25)	2 (10)	9 (17)*	34 (42)	15 (33)	57 (38)	106 (39)	0.004
Secondary prevention (% of ICD)		1 (50)		1 (11)	3 (9)	2 (13)	5 (9)	12 (4)	
Appropriate shock (% of ICD)					1 (3)	3 (20)	6 (11)	10 (9)	
LVAD	1 (4)			1 (2)	2 (2)		1 (1)	3 (1)	
Heart transplantation	4 (17)			4 (8)	2 (2)	2 (4)	2 (1)	6 (2)	
Death	4 (17)	3 (38)	1 (5)	8 (16)	3 (4)	5 (11)	8 (5)	16 (6)	
MACE in patients with LV systolic dysfunction	8 (35)	3 (38)	0 (0)	11 (21)	12 (15)	6 (13)	18 (12)	36 (13)	
MACE in patients with normal LV function	1 (4)	1 (13)	1 (5)	3 (6)	1 (1)	5 (11)	16 (11)	22 (8)	0.027

Values are n (interquartile range) or n (%). *Significant for children versus adults. †Significant for mutation carriers versus no mutation.
ICD = implantable cardioverter-defibrillator; LVAD = LV assist device; MACE = major adverse cardiac events; RV = right ventricular; TIA = transient ischemic attack; VF = ventricular fibrillation;

Van Waning et al. Noncompaction Cardiomyopathy Features and Genetics

50

1.Baseline Characteristics of patients with Excessive trabeculation, preserved EF and ICD implanted. (N=20)	
Gender Female.	10 (50)
Age at diagnosis (yrs).	39 (27,54)
LVEF at presentation (%)	*57.5 (7.5)
Follow up time (yrs)	13 (9,15)
2.Risk factors for SCD and VAs	
Family history of SCD/Genetic cardiomyopathy.	7(35)
History of Syncope Prior to ICD implant.	8(40)
History of NSVT Prior to ICD implant.	7(35)
LV morphological or Functional abnormality on CMR.	8(40)
3.Device Characteristics	
Age at ICD implantation (yrs).	41.1 (29,56)
Time from device Implantation to appropriate therapy	2.1 (2.4,6)
Type of device implanted	Single chamber 10 (50%) Dual chamber 8 (40%) Biventricular 2 (10%)
4.Adverse Outcomes	
Composite outcome	9 (45)
Appropriate ICD Therapy	5 (25)
Stroke	2 (10)
Development of Cardiomyopathy	2 (10)
Death	0 (0)

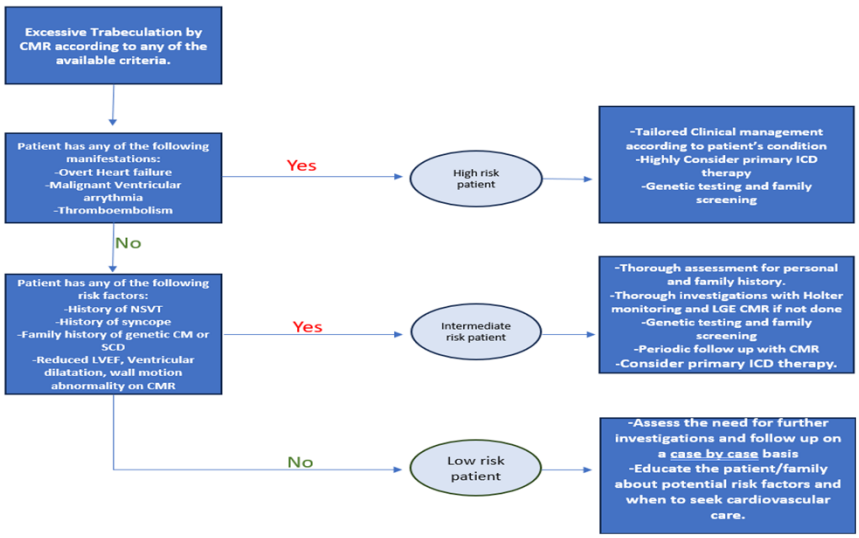
ICD, Implantable Cardiac Defibrillator; LVEF, Left Ventricular Ejection Fraction; SCD, Sudden Cardiac Death; VAs, Ventricular Arrythmias; CMR, Cardiac Magnetic Resonance.
Numerical variables Median (IQR). Categorical variables; N (%).
*LVEF, Mean (SD).

Bahbah et al. ICD implantation in patients with Excessive Trabeculation and preserved Ejection fraction.

51

Definition

Excessive trabeculation is a deviation from the conventional developmental process of the human structural myocardium, which in the presence of certain genetic, familial and clinical factors can give rise to a Cardiomyopathic disorder with potentially fatal outcomes.



52

Diversity and discrimination against physicians in interventional cardiology

Athanasios Rempakos, MD

Center for Coronary Artery Disease (CCAD), Minneapolis Heart Institute Foundation

Minneapolis Heart Institute Foundation | Center for Coronary Artery Disease

Allina Health MINNEAPOLIS HEART INSTITUTE

53

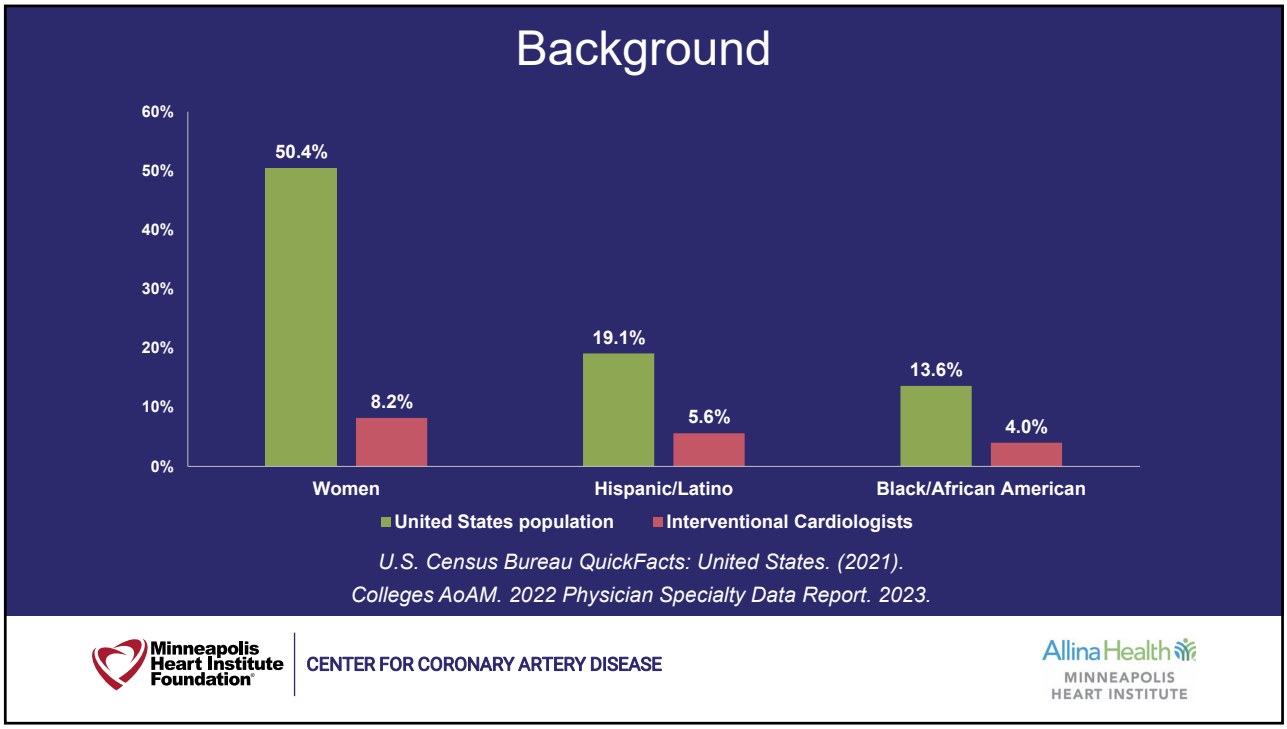
Disclosure of Relevant Financial Relationships

I, Athanasios Rempakos DO NOT have any relevant financial relationships to disclose.

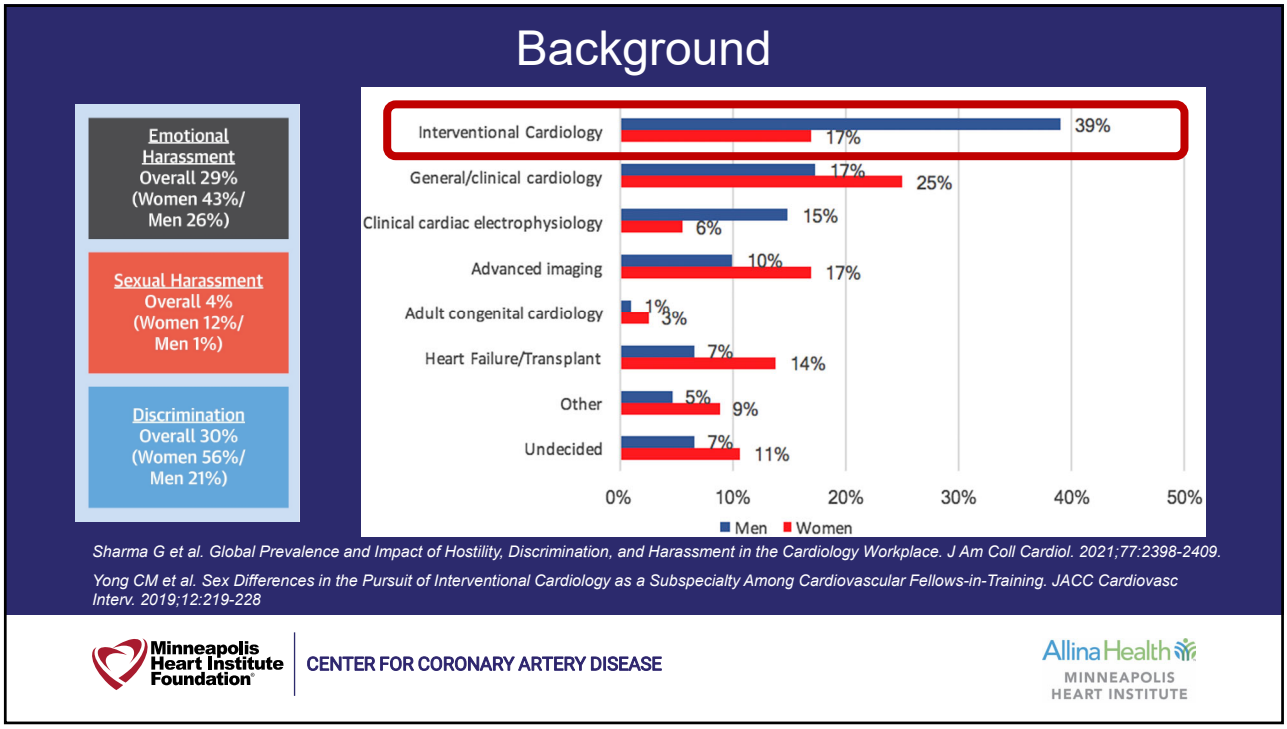
Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

54

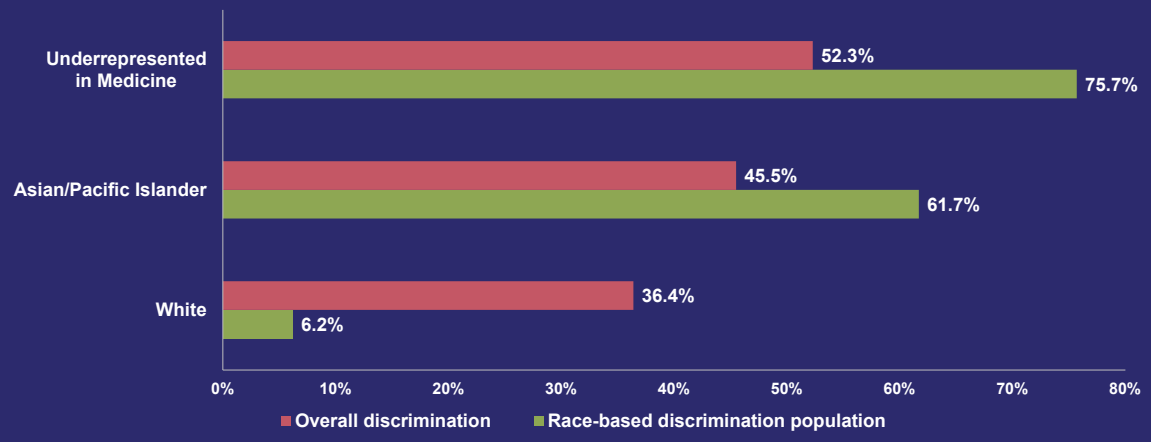

Background
60%
50%
40%
30%
20%
10%
0%
50.4%
8.2%
19.1%
5.6%
13.6%
4.0%
Women
Hispanic/Latino
Black/African American
United States population
Interventional Cardiologists
U.S. Census Bureau QuickFacts: United States. (2021).
Colleges AoAM. 2022 Physician Specialty Data Report. 2023.
Minneapolis Heart Institute Foundation
CENTER FOR CORONARY ARTERY DISEASE
Allina Health
MINNEAPOLIS HEART INSTITUTE

55


Background
Emotional Harassment
Overall 29%
(Women 43%/
Men 26%)
Sexual Harassment
Overall 4%
(Women 12%/
Men 1%)
Discrimination
Overall 30%
(Women 56%/
Men 21%)
Interventional Cardiology
39%
17%
General/clinical cardiology
17%
25%
Clinical cardiac electrophysiology
15%
6%
Advanced imaging
10%
17%
Adult congenital cardiology
1%
3%
Heart Failure/Transplant
7%
14%
Other
5%
9%
Undecided
7%
11%
0%
10%
20%
30%
40%
50%
Men
Women
Sharma G et al. Global Prevalence and Impact of Hostility, Discrimination, and Harassment in the Cardiology Workplace. J Am Coll Cardiol. 2021;77:2398-2409.
Yong CM et al. Sex Differences in the Pursuit of Interventional Cardiology as a Subspecialty Among Cardiovascular Fellows-in-Training. JACC Cardiovasc Interv. 2019;12:219-228
Minneapolis Heart Institute Foundation
CENTER FOR CORONARY ARTERY DISEASE
Allina Health
MINNEAPOLIS HEART INSTITUTE

56

Background



Thomas KL et al.; ACC Diversity & Inclusion Task Force and ACC Women in Cardiology Section. Perspectives of Racially and Ethnically Diverse U.S. Cardiologists: Insights From the ACC Professional Life Survey. J Am Coll Cardiol. 2021 Oct 26;78(17):1746-1750.

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

57

Background

Non-evidence-based DEI initiatives

- Impede the identification and resolution of discrimination directed towards "disadvantaged" groups
- Generate uncertainties regarding the competence and attributions of individuals belonging to "disadvantaged" groups
- Increase sensitivity of discrimination against "advantaged" groups
- Evoke feelings of threat and victimization among "advantaged" groups

Dover TL, Kaiser CR, Major B. Mixed Signals: The Unintended Effects of Diversity Initiatives. 2020;14:152-181.

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

58

Goal

- **Conduct a global, web-based survey of interventional cardiology (IC) fellows and attendings to:**
  - Assess gender and racial/ethnic diversity of physicians in the field of IC
  - Evaluate discrimination against physicians in the IC workplace

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

59

Methods

- Final survey consisted of **48 questions:**

a) Demographic information → b) Discrimination against physicians → c) Gender Diversity → d) Race/ethnicity diversity

- Distributed to IC attendings and fellows via social media and email lists

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

60

Definitions

- Participant group labeled “non-white” included:
  - American Indian/Alaska Native
  - Asian
  - Black/African-American
  - Native Hawaiian/Pacific Islander
  - Hispanic white
- Comparison populations:

Non-white vs non-Hispanic white	➡	Participants practicing in the United States
Native vs non-native English speakers	➡	Participants practicing in the English-speaking countries

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

61

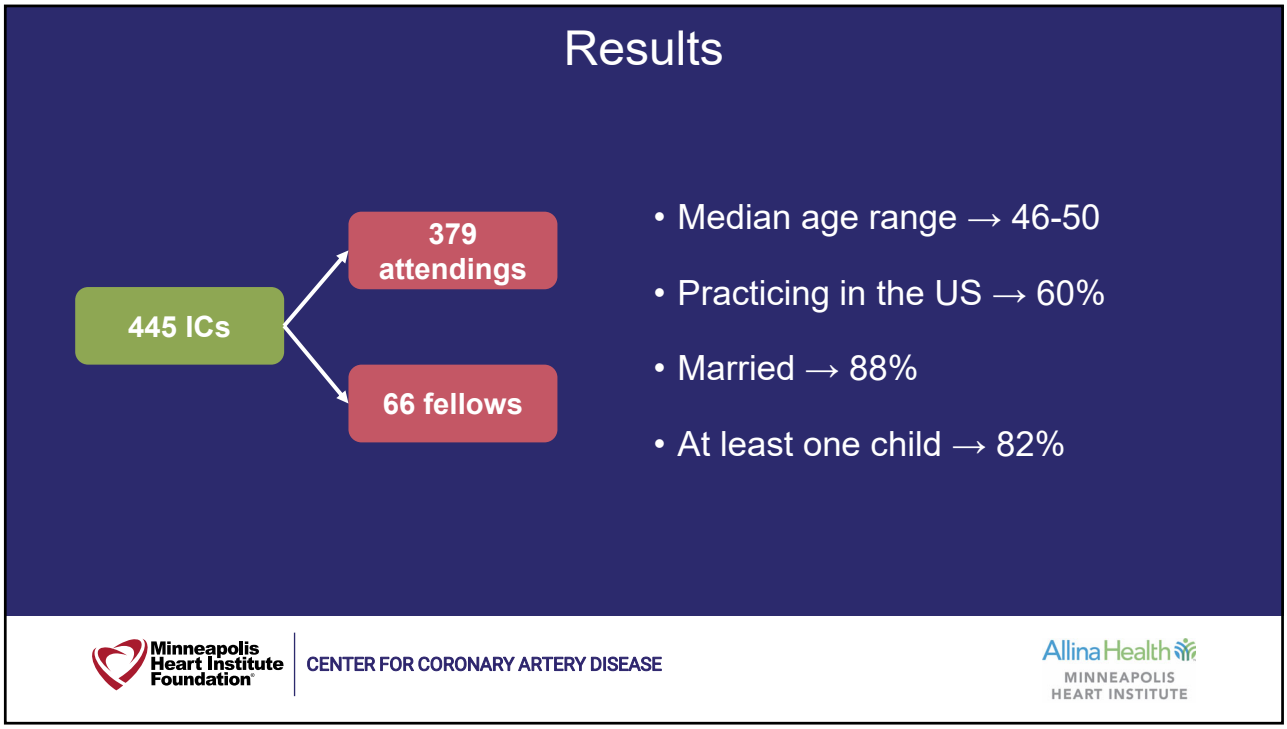
Statistical analysis

- Categorical variables: presented as percentages and compared using Pearson’s chi-square test or Fisher’s exact test
- Continuous variables: presented as mean ± SD or as median (interquartile range [IQR]) and compared using the Student’s t-test and the Mann-Whitney U test
- A 2-sided p value <0.05 was considered to indicate statistical significance

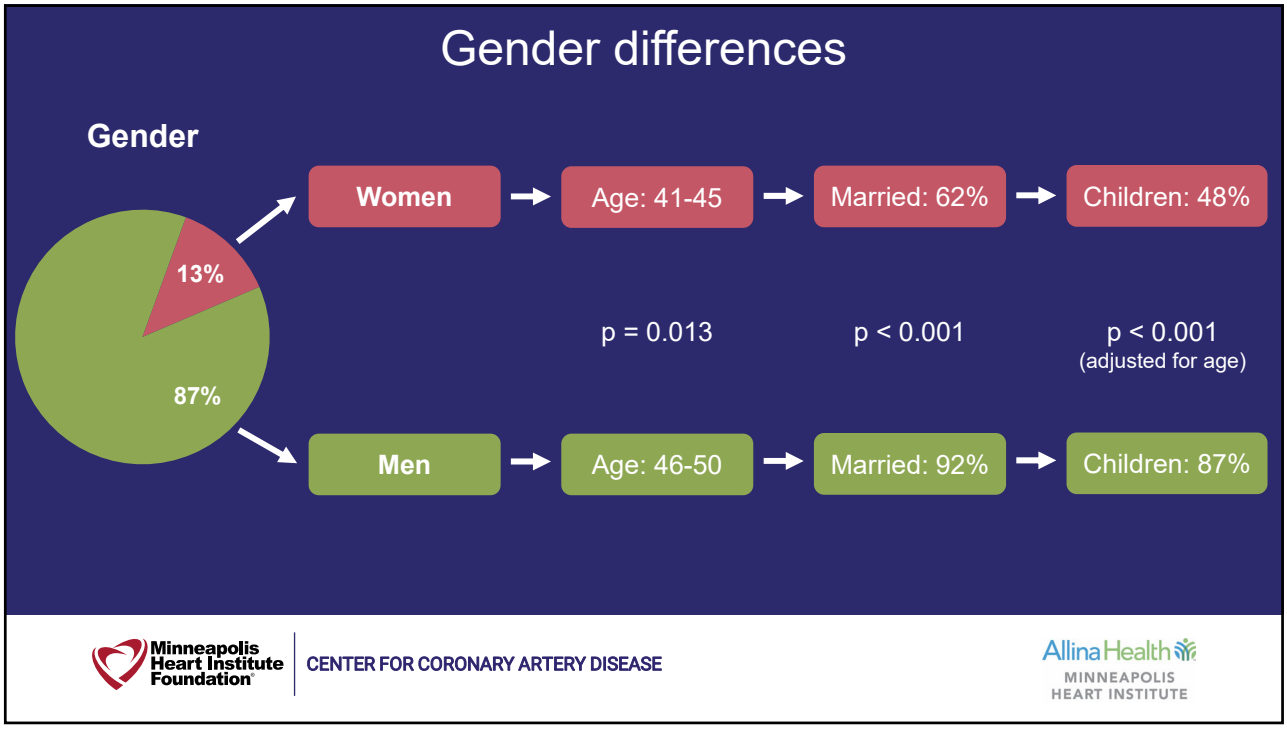
Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

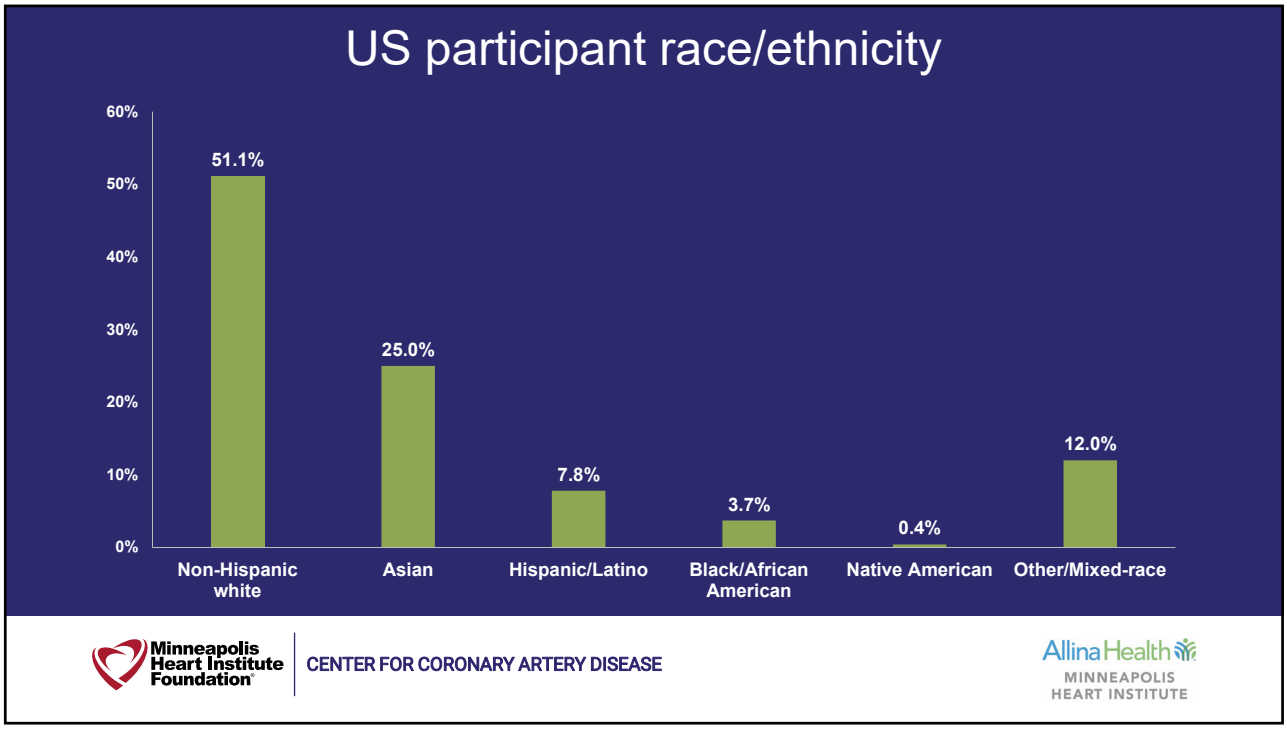
62


Results
379 attendings
445 ICs
66 fellows
• Median age range → 46-50
• Practicing in the US → 60%
• Married → 88%
• At least one child → 82%
Minneapolis Heart Institute Foundation
CENTER FOR CORONARY ARTERY DISEASE
Allina Health
MINNEAPOLIS HEART INSTITUTE

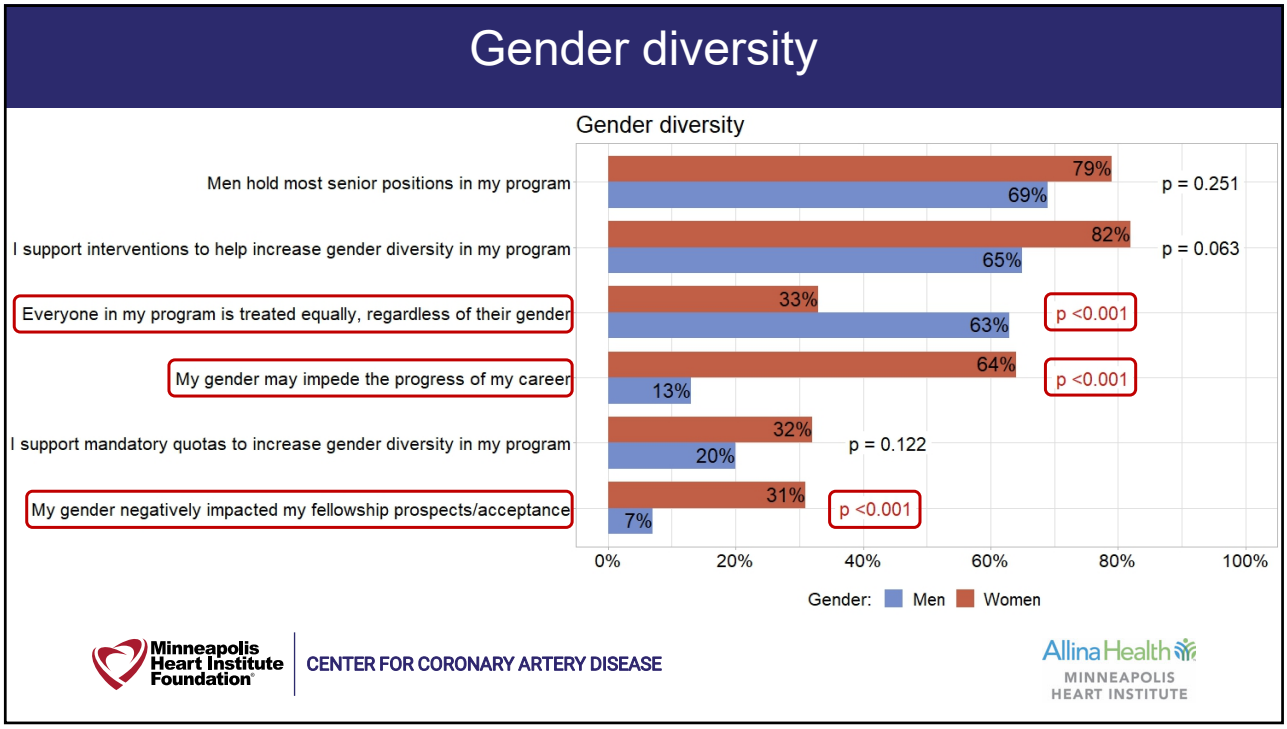
63


Gender differences
Gender
13%
87%
Women
Age: 41-45
Married: 62%
Children: 48%
p = 0.013
p < 0.001
p < 0.001
(adjusted for age)
Men
Age: 46-50
Married: 92%
Children: 87%
Minneapolis Heart Institute Foundation
CENTER FOR CORONARY ARTERY DISEASE
Allina Health
MINNEAPOLIS HEART INSTITUTE

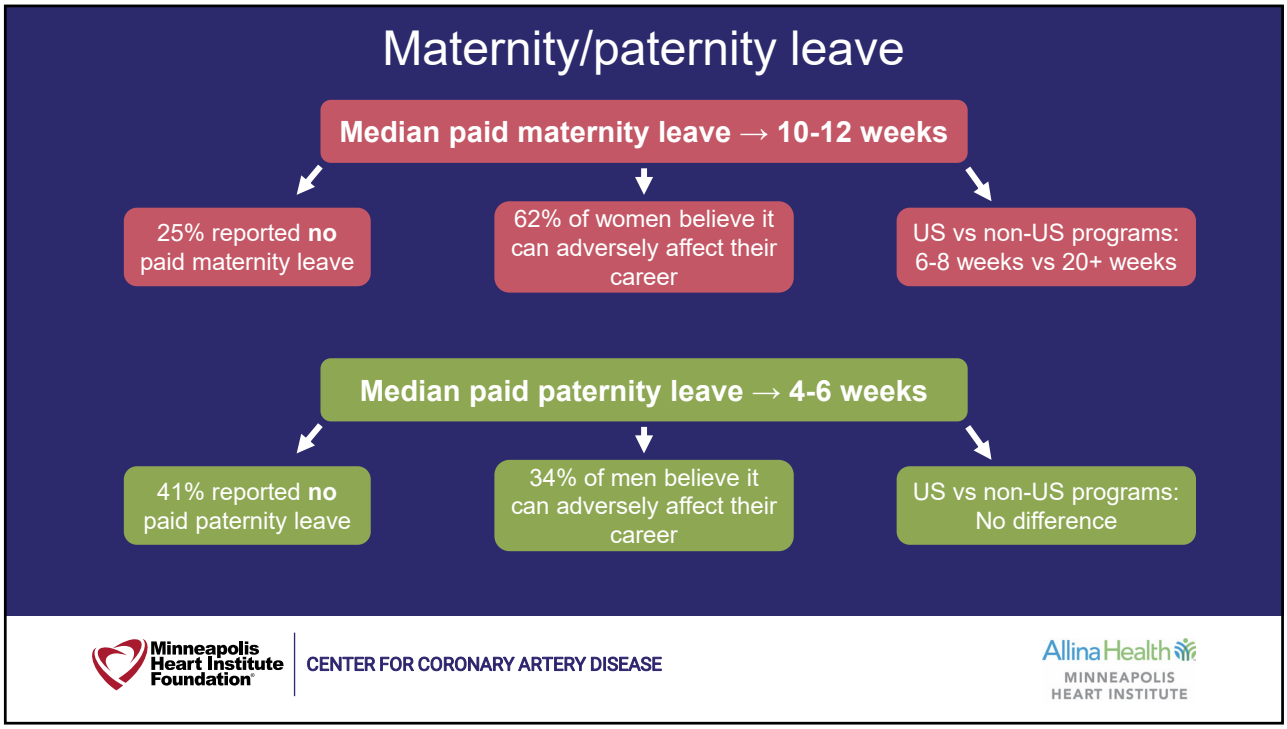
64


US participant race/ethnicity
60%
50%
40%
30%
20%
10%
0%
51.1%
25.0%
7.8%
3.7%
0.4%
12.0%
Non-Hispanic white
Asian
Hispanic/Latino
Black/African American
Native American
Other/Mixed-race
Minneapolis Heart Institute Foundation
CENTER FOR CORONARY ARTERY DISEASE
Allina Health
MINNEAPOLIS HEART INSTITUTE

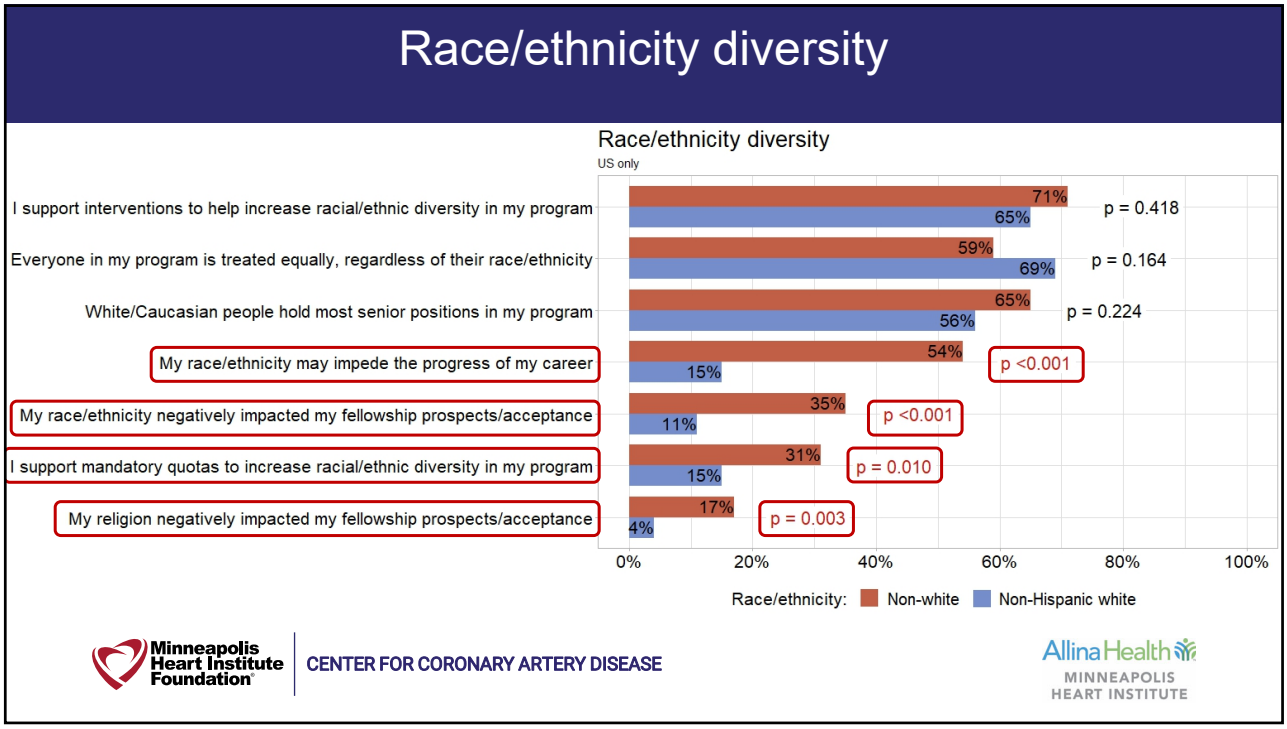
65


Gender diversity
Gender diversity
Men hold most senior positions in my program
79%
69%
p = 0.251
I support interventions to help increase gender diversity in my program
82%
65%
p = 0.063
Everyone in my program is treated equally, regardless of their gender
33%
63%
p <0.001
My gender may impede the progress of my career
64%
13%
p <0.001
I support mandatory quotas to increase gender diversity in my program
32%
20%
p = 0.122
My gender negatively impacted my fellowship prospects/acceptance
31%
7%
p <0.001
0%
20%
40%
60%
80%
100%
Gender: Men Women
Minneapolis Heart Institute Foundation
CENTER FOR CORONARY ARTERY DISEASE
Allina Health
MINNEAPOLIS HEART INSTITUTE

66

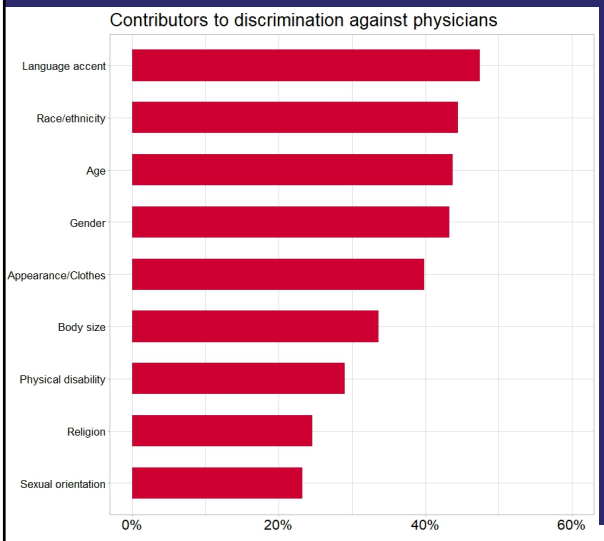

Maternity/paternity leave
Median paid maternity leave → 10-12 weeks
25% reported no paid maternity leave
62% of women believe it can adversely affect their career
US vs non-US programs: 6-8 weeks vs 20+ weeks
Median paid paternity leave → 4-6 weeks
41% reported no paid paternity leave
34% of men believe it can adversely affect their career
US vs non-US programs: No difference
Minneapolis Heart Institute Foundation
CENTER FOR CORONARY ARTERY DISEASE
Allina Health
MINNEAPOLIS HEART INSTITUTE

67


Race/ethnicity diversity
Race/ethnicity diversity
US only
I support interventions to help increase racial/ethnic diversity in my program
71%
65%
p = 0.418
Everyone in my program is treated equally, regardless of their race/ethnicity
59%
69%
p = 0.164
White/Caucasian people hold most senior positions in my program
65%
56%
p = 0.224
My race/ethnicity may impede the progress of my career
54%
15%
p <0.001
My race/ethnicity negatively impacted my fellowship prospects/acceptance
35%
11%
p <0.001
I support mandatory quotas to increase racial/ethnic diversity in my program
31%
15%
p = 0.010
My religion negatively impacted my fellowship prospects/acceptance
17%
4%
p = 0.003
0%
20%
40%
60%
80%
100%
Race/ethnicity: Non-white Non-Hispanic white
Minneapolis Heart Institute Foundation
CENTER FOR CORONARY ARTERY DISEASE
Allina Health
MINNEAPOLIS HEART INSTITUTE

68

Discrimination against physicians



42 participants (9%) reported incidents of discrimination to their organization

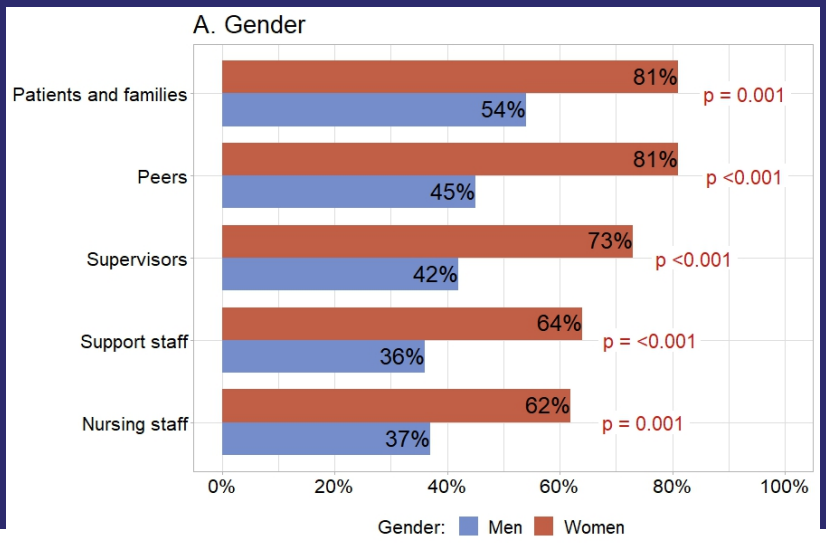
8 participants (19%) expressed satisfaction with the response received

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

69

Discrimination sources - Gender

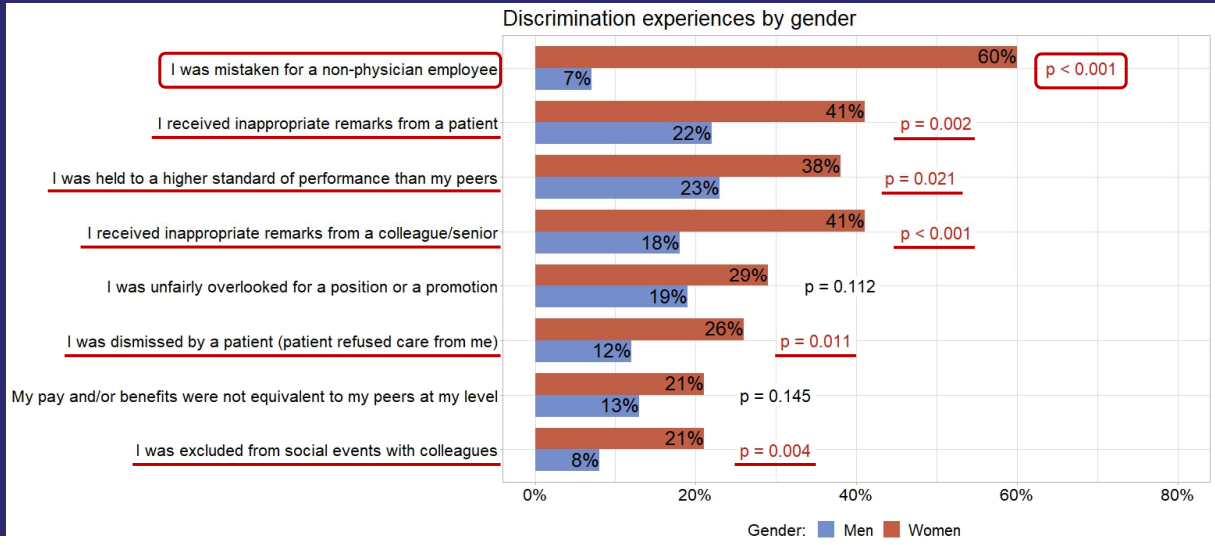


Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

70

Discrimination experiences - Gender

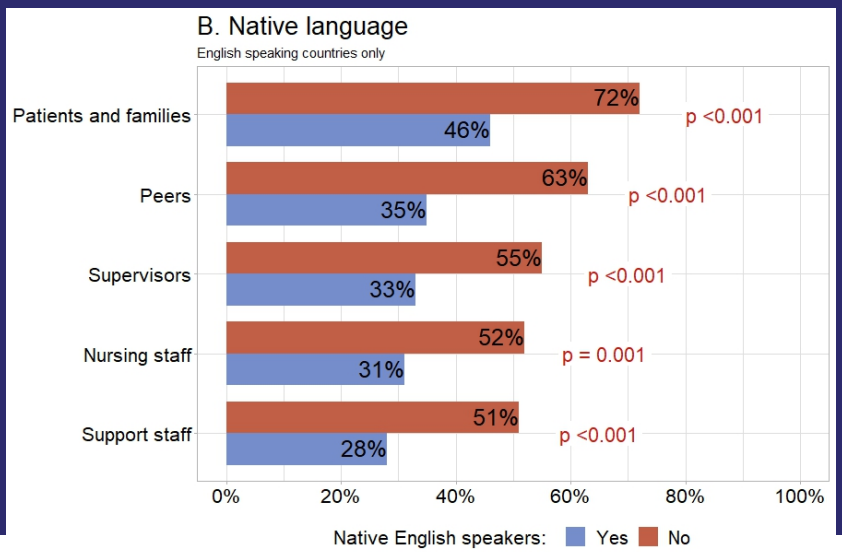


Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

71

Discrimination experiences - Language

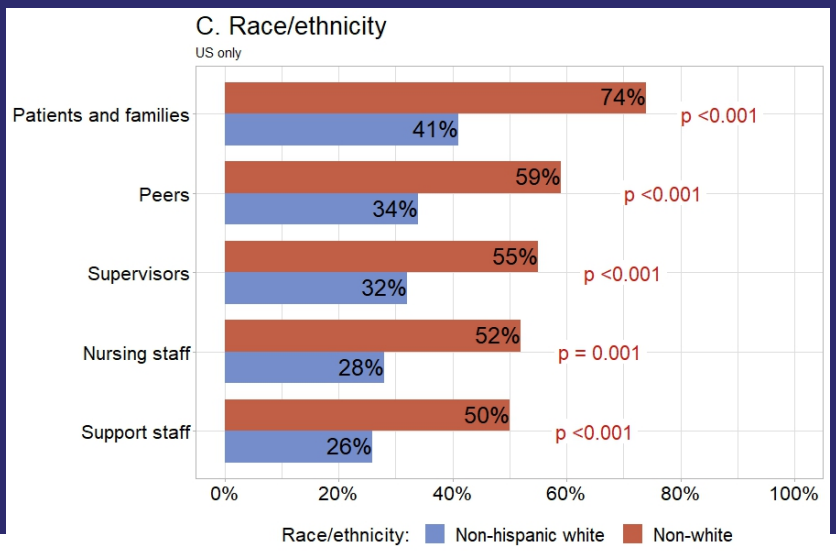


Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

72

Discrimination experiences – Race/ethnicity



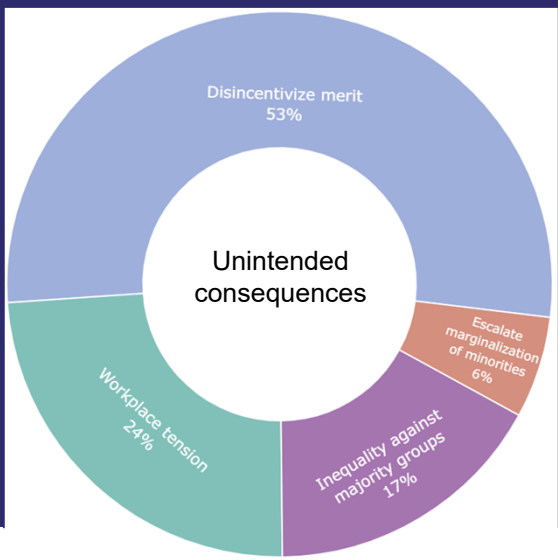
Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

73

Unintended consequences

41% of participants were concerned about unintended consequences of DEI interventions



29% women
Vs
43% men
(p = 0.102)

46% non-white
Vs
58% non-Hispanic white
(p = 0.077)

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

74

Limitations

- Participants might be more interested in diversity and discrimination than non-responders, which might result in selection bias
- Email lists and social media for participant recruitment may introduce additional selection bias
- Disparities in cultural norms, expectations, and linguistic barriers could influence the interpretation of "discrimination" across different regions

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

75

Conclusions

- Women practicing IC are **less likely** to be **married** or **have children**
- **Women** and **non-white individuals** encounter obstacles in **career advancement**
- **Women**, **non-native English speakers**, and **non-white individuals** have a **higher** likelihood of experiencing discrimination from **patients and families**, **peers**, **supervisors**, **support staff**, and **nursing staff**
- A portion of the participants (41%) expressed concerns that **DEI initiatives** might result in **unintended consequences**

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

76

Discrimination against physicians in interventional cardiology

Athanasios Rempakos, MD[1]; Michaella Alexandrou, MD[1]; Bahadir Simsek, MD[1]; Spyridon Kostantinis, MD[1]; Judit Karacsonyi, MD, PhD[1]; Allison Hall, MD[2]; Arnold H. Seto, MD[3]; Barbara Danek, MD[4]; Binita Shah, MD[5]; Courtney Baechler, MD, MS[1]; Delaine Thomas, MPH[1]; James W. Choi, MD[6]; Jeremy Rier, DO[7]; Kathleen E. Kearney, MD[4]; Ki Park, MD, MS[8]; Mosi Bennett, MD, PhD[1]; Santiago Garcia, MD[9]; Thao Duong, MD[10]; Jimmy Kerrigan, MD[11]; Bavana V. Rangan, BDS, MPH[1]; Olga C. Mastrodemos, BA[1]; Salman S. Allana, MD[1]; Yader Sandoval, MD[1]; M. Nicholas Burke, MD[1]; Emmanouil S. Brilakis, MD, PhD[1]

[1]Minneapolis Heart Institute and Minneapolis Heart Institute Foundation, Abbott Northwestern Hospital, Minneapolis, Minnesota, USA. [2]Eastern Health, Memorial University of Newfoundland, St. John's, Newfoundland, Canada. [3]Long Beach VA Health Care System, Long Beach, California, USA [4]Division of Cardiology, University of Washington, Seattle, Washington, USA. [5]Division of Cardiology, Department of Medicine, NYU Grossman School of Medicine, New York, New York [6]Texas Health Presbyterian Hospital, Dallas, TX, USA [7]WellSpan York Hospital, York, Pennsylvania, USA [8]Cardiovascular Medicine, University of Florida College of Medicine, Gainesville, Florida, USA. [9]The Christ Hospital, Cincinnati, Ohio, USA. [10]HCA Midwest Health, Overland Park, Kansas, USA. [11] Division of Cardiology, Ascension Saint Thomas Heart, Nashville, Tennessee, USA.

BACKGROUND

Data on discrimination against physicians in the field of interventional cardiology are limited.

METHODS

We performed an online, anonymous, international survey of interventional cardiologists.

RESULTS

A total of 445 interventional cardiologists participated in the survey. Median age was 46-50 years and most (61%) practice in the United States. Among the participants, 13% were women and 13% belonged to underrepresented minority groups. Participants were asked to discern which characteristics contribute to discrimination against physicians in their workplace. Several characteristics were identified (Figure): language accent (48%), race/ethnicity (44%), age (44%), gender (43%), and appearance/clothing (40%). Women were more likely to have experienced discrimination by patients and families (81% vs 54%; p<0.001), peers (81% vs 45%; p<0.001), supervisors (73% vs 43%; p<0.001), support staff (64% vs 36%; p<0.001), and nursing staff (63% vs 37%; p=0.001), compared with men. Similarly, among participants who practice in the US, UK, Canada, and Australia (n=296), physicians whose first language was not English were more likely to have experienced discrimination from patients and families (73% vs 46%; p<0.001), peers (63% vs 35%; p<0.001), supervisors (56% vs 33%; p<0.001), support staff (51% vs 28%; p<0.001), and nursing staff (52% vs 31%; p=0.001), compared with native English speakers. Both women (60% vs 7%; p<0.001) and underrepresented minority groups (28% vs 12%; p=0.003) were more likely to be mistaken for a non-physician employee, compared with men and non-underrepresented minority groups respectively. While 9% (n=42) of the total participants reported incidents of discrimination to their respective organizations, only 19% of those (n=8) expressed satisfaction with the response received.

CONCLUSION

Our survey provides a snapshot of the current status of discrimination faced by interventional cardiologists.

Minneapolis Heart Institute Foundation
Creating a world without heart and vascular disease

Allina Health
MINNEAPOLIS HEART INSTITUTE

The leading factors contributing to discrimination against interventional cardiologists were: language accent (48%), race/ethnicity (44%), age (44%), gender (43%), and appearance/clothing (40%).

For more information, scan the QR code to go to *progresscto.org*, or email *thanrempakos@gmail.com*

Acknowledgements: The authors are grateful for the philanthropic support of our generous Anonymous donors(2), and the philanthropic support of Frank J and Eleanor A. Maslowski Charitable Trust; Drs. Mary Ann and Donald A Sens; Mr. Raymond Ames and Ms. Barbara Thorndike; Joseph F and Mary M Fleischhacker Family Foundation; Mrs. Diane and Dr. Cline Hickok; Mrs. Marilyn and Mr. William Ryerse; Mr. Greg and Mrs. Rhoda Olsen; Mrs. Wilma and Mr. Dale Johnson; Mrs. Charlotte and Mr. Jerry Golinvaux Family Fund; the Roehl Family Foundation; the Joseph Durda Foundation.

FIGURES

Figure 1: Contributors leading to discrimination against interventional cardiologists.

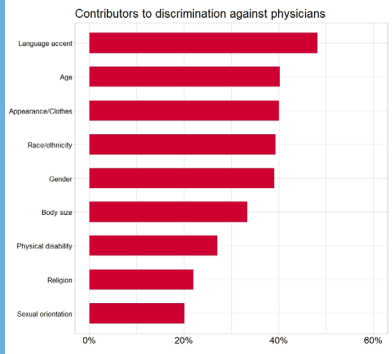
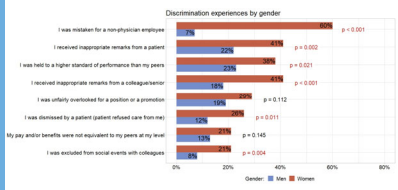


Figure 2: Forms of discrimination in women vs men.



Disclosures: Dr. Hall: speaker honoraria from Medtronic, OpSens Medical, and the Cardiovascular Innovations Foundation. Dr. Seto: research grants from Philips and ACIST; honoraria from Getinge, General Electric, and Terumo, and equity in Frond Medical. Dr. Shah: advisory boards for Philips Volcano and Horizon Therapeutics and is a consultant for Terumo Medical. Dr. Choi: Medtronic advisory board. Dr. Garcia: institutional research grants from Edwards Lifesciences, Abbott Vascular, BSCI, and Biotronik; is a consultant for NeoChord, Medtronic, BSCI, and Abbott Vascular; and is a proctor for Edwards Lifesciences. Dr. Brilakis: consulting/speaker honoraria from Abbott Vascular, American Heart Association (associate editor Circulation), Amgen, Asahi Intecc, Biotronik, Boston Scientific, Cardiovascular Innovations Foundation (Board of Directors), CSI, Elsevier, GE Healthcare, IMDS, Medicure, Medtronic, Siemens, Teleflex, and Terumo; research support: Boston Scientific, GE Healthcare (owner, Hippocrates LLC; shareholder, MHI Ventures, Cleerly Health, Stellion Medical.

77

Thank you!

Athanasios Rempakos, MD
thanrempakos@gmail.com

Rempakos A, Alexandrou M, Simsek B, Kostantinis S, Karacsonyi J, Mutlu D, Hall A, Seto AH, Danek B, Shah B, Baechler C, Thomas D, Choi JW, Rier J, Kearney KE, Park K, Bennett M, Garcia S, Duong T, Kerrigan J, Al-Ogaili A, Rangan BV, Mastrodemos OC, Allana SS, Sandoval Y, Burke MN, Brilakis ES

Acknowledgements

The authors are grateful for the philanthropic support of our generous Anonymous donors(2), and the philanthropic support of Drs. Mary Ann and Donald A Sens; Mr. Raymond Ames and Ms. Barbara Thorndike; Frank J and Eleanor A. Maslowski Charitable Trust; Joseph F and Mary M Fleischhacker Family Foundation; Mrs. Diane and Dr. Cline Hickok; Mrs. Marilyn and Mr. William Ryerse; Mr. Greg and Mrs. Rhoda Olsen; Mrs. Wilma and Mr. Dale Johnson; Mrs. Charlotte and Mr. Jerry Golinvaux Family Fund; the Roehl Family Foundation; the Joseph Durda Foundation.

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

78

Cardiologist Well-Being and Burnout

Michaella Alexandrou, MD
Center for Coronary Artery Disease

Minneapolis Heart Institute Foundation | Center for Coronary Artery Disease
Allina Health MINNEAPOLIS HEART INSTITUTE

79

Disclosure of Relevant Financial Relationships

I, Michaella Alexandrou DO NOT have any relevant financial relationships to disclose.

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE
Allina Health MINNEAPOLIS HEART INSTITUTE

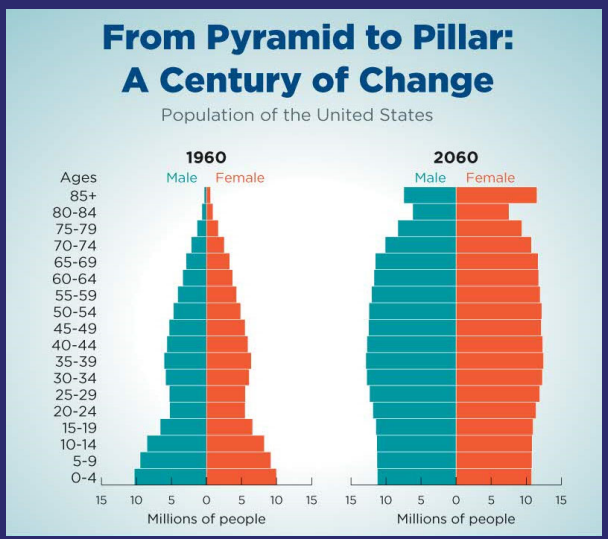
80

Seeing the Big Picture: The Significance of Burnout

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

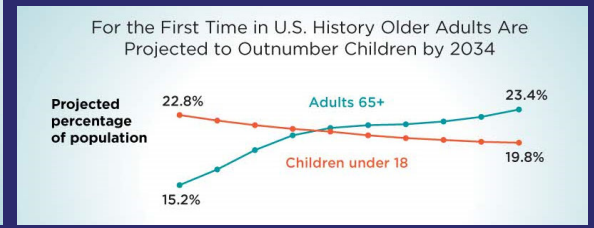
Allina Health MINNEAPOLIS HEART INSTITUTE

81



Aging population

Multimorbidity



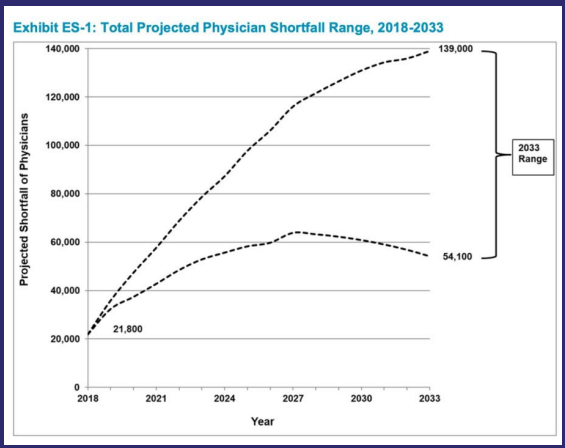
National Population Projections, U.S Department of Commerce, U.S. Census Bureau, 2017

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

82

A critical shortage of physicians



Association of American Medical Colleges, The Complexities of Physician Supply and Demand: Projections From 2018 to 2033, 2020

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

83

Will the Provider Workforce Be Adequate?

By 2030

40%

of the U.S. population will have clinically evident cardiovascular disease

The current number of cardiologists would need to double by 2050 to erase the expected shortage

Heidenreich P.A., Trogdon J.G., Khavjou O.A., et al. "Forecasting the future of cardiovascular disease in the United States: a policy statement from the American Heart Association". Circulation 2011;123:8: 933-944. 10.1161/CIR.0b013e31820a55f5.

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

84

Burnout consequences

Coronary heart disease

Type 2 diabetes

Mortality ≤ 45 years

Gastrointestinal issues

Hypercholesterolemia

Headaches

Psychological ill-health symptoms

Musculoskeletal pain

Insomnia

Prolonged fatigue

Use of psychotropic & antidepressant medications

Depressive symptoms

Absenteeism

Job dissatisfaction

New disability pension

Salvagioni DAJ, Melanda FN, Mesas AE, González AD, Gabani FL, Andrade SM. Physical, psychological and occupational consequences of job burnout: A systematic review of prospective studies. PLoS One. 2017 Oct 4;12(10):e0185781. doi: 10.1371/journal.pone.0185781. PMID: 28977041; PMCID: PMC5627926.

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

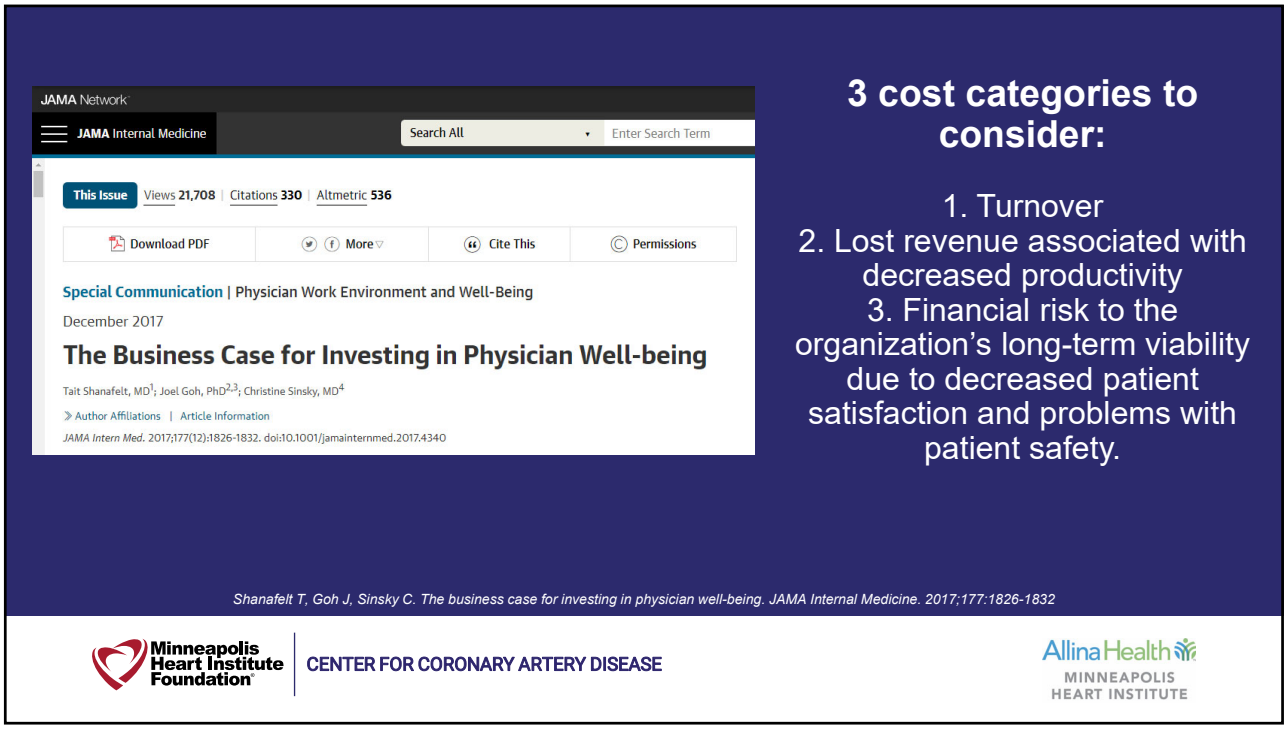
Allina Health MINNEAPOLIS HEART INSTITUTE

85

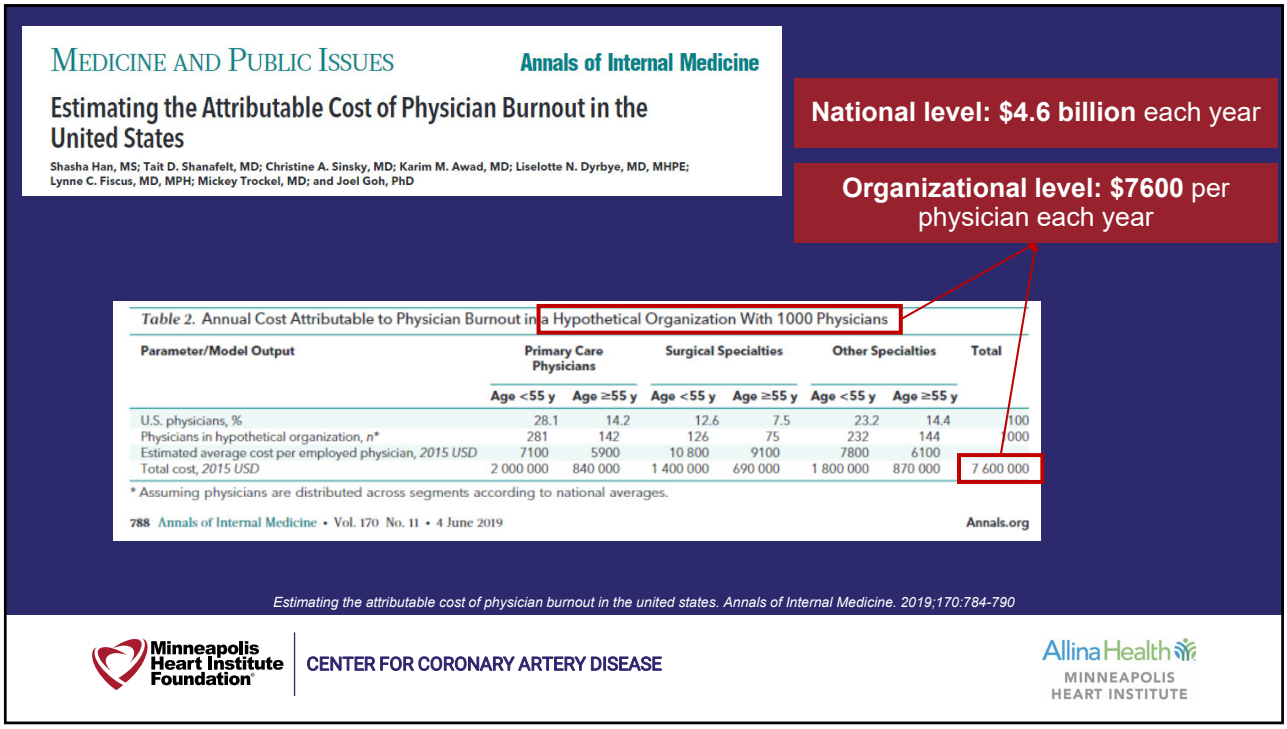
Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

86


JAMA Network
JAMA Internal Medicine
Search All
Enter Search Term
This Issue
Views 21,708 | Citations 330 | Altmetric 536
Download PDF
More
Cite This
Permissions
Special Communication | Physician Work Environment and Well-Being
December 2017
The Business Case for Investing in Physician Well-being
Tait Shanafelt, MD[1]; Joel Goh, PhD[2,3]; Christine Sinsky, MD[4]
Author Affiliations | Article Information
JAMA Intern Med. 2017;177(12):1826-1832. doi:10.1001/jamainternmed.2017.4340
3 cost categories to consider:
1. Turnover
2. Lost revenue associated with decreased productivity
3. Financial risk to the organization's long-term viability due to decreased patient satisfaction and problems with patient safety.
Shanafelt T, Goh J, Sinsky C. The business case for investing in physician well-being. JAMA Internal Medicine. 2017;177:1826-1832
Minneapolis Heart Institute Foundation
CENTER FOR CORONARY ARTERY DISEASE
Allina Health
MINNEAPOLIS HEART INSTITUTE

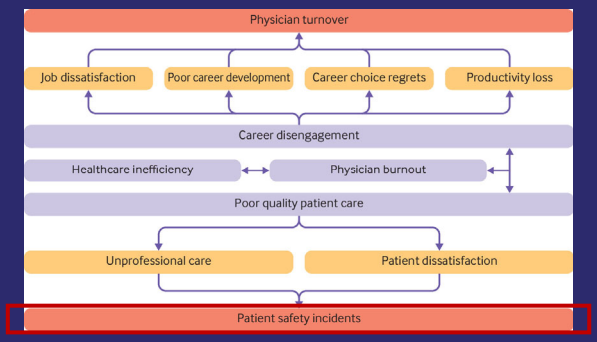
87


MEDICINE AND PUBLIC ISSUES
Annals of Internal Medicine
Estimating the Attributable Cost of Physician Burnout in the United States
Shasha Han, MS; Tait D. Shanafelt, MD; Christine A. Sinsky, MD; Karim M. Awad, MD; Liselotte N. Dyrbye, MD, MHPE; Lynne C. Fiscus, MD, MPH; Mickey Trockel, MD; and Joel Goh, PhD
National level: $4.6 billion each year
Organizational level: $7600 per physician each year
Table 2. Annual Cost Attributable to Physician Burnout in a Hypothetical Organization With 1000 Physicians
Parameter/Model Output
Primary Care Physicians
Surgical Specialties
Other Specialties
Total
Age <55 y
Age ≥55 y
U.S. physicians, %
28.1
14.2
12.6
7.5
23.2
14.4
Physicians in hypothetical organization, n*
281
142
126
75
232
144
1000
Estimated average cost per employed physician, 2015 USD
7100
5900
10 800
9100
7800
6100
Total cost, 2015 USD
2 000 000
840 000
1 400 000
690 000
1 800 000
870 000
7 600 000
* Assuming physicians are distributed across segments according to national averages.
788 Annals of Internal Medicine • Vol. 170 No. 11 • 4 June 2019
Annals.org
Estimating the attributable cost of physician burnout in the united states. Annals of Internal Medicine. 2019;170:784-790
Minneapolis Heart Institute Foundation
CENTER FOR CORONARY ARTERY DISEASE
Allina Health
MINNEAPOLIS HEART INSTITUTE

88

Patient safety

170 observational studies of
239,246 physicians



Hodkinson A, Zhou, A, Johnson J, Geraghty K, Riley R, Zhou A et al. Associations of physician burnout with career engagement and quality of patient care: systematic review and meta-analysis BMJ 2022; 378 :e070442

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

89

Patient dissatisfaction

569,776 patients and 409 general practitioners (GPs)

Patients were more likely to change GPs who had higher occupational distress (burnout and low job satisfaction)

Nørøxe KB, Vedsted P, Bro F, Carlsen AH, Pedersen AF. Mental well-being and job satisfaction in general practitioners in denmark and their patients' change of general practitioner: A cohort study combining survey data and register data. BMJ Open. 2019;9:e030142

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

90

What is burnout?

A syndrome conceptualized as resulting from chronic workplace stress that has not been successfully managed.

3 dimensions:

- feelings of energy depletion or exhaustion
- ↑ mental distance from one's job, or feelings of negativism or cynicism related to one's job
- ↓ professional efficacy

WHO definition

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

91

How many cardiologists are burnout?

The prevalence of burnout varies according to definition

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

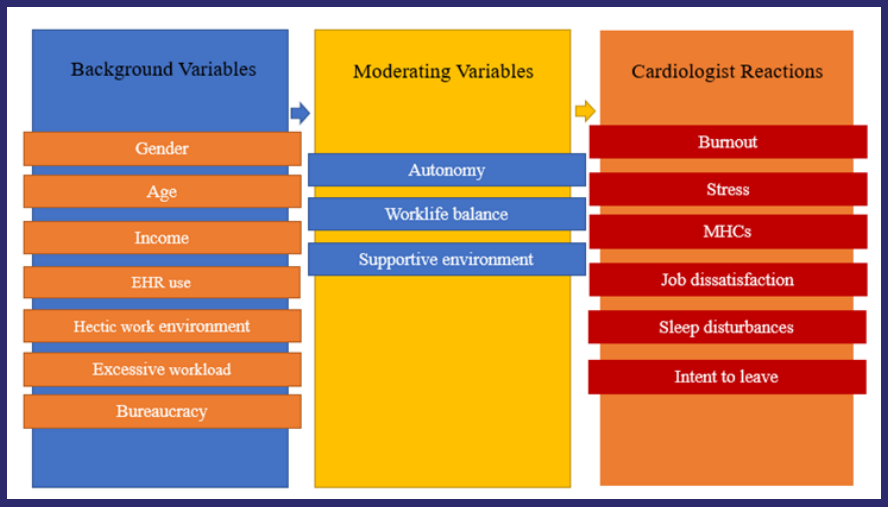
92

Author (publication year)	Country	Participants (n)	How was burnout assessed	Main Results
Mehta, L.S. et al. (2019)	USA	Cardiologists (2,274)	Mini-Z survey	26.8% reported burnout symptoms
Lobo, A.S. et al. (2019)	USA	Cardiovascular workers (481) [70% interventional cardiologists]	"Do you feel burnout?"	56.5% reported burnout
Shah, S. et al. (2020)	USA	IC, structural, CHIP, and peripheral vascular fellows (135)	Not applicable	65% reported significant stress at work and at home because of the COVID-19 pandemic
Cullen, M.W. et al. (2021)	USA	Cardiovascular Diseases Fellowship Program Directors (141)	Mini-Z survey	21% reported symptoms of burnout
Joshi, S.S. et al. (2022)	International	Cardiac imaging specialists (125)	Not reported	58% reported burnout (64% reported worsening during the COVID-19 pandemic)
Sharma, G. et al. (2023)	International	Cardiologists (5,890)	Not applicable	28% reported any self-reported MHC, of which 76.1% reported psychological distress
Simsek, B. et al. (2023)	International	Attending IC (1,159) and IC fellows (192)	"Rate the impact of your burnout on your life"	69% of the interventional cardiologists are affected by burnout
Koval, M.L. (2023)	USA	Cardiologists (367)	"Do you feel burnout/and or depressed?"	43% felt burned out (29%) or both burned out and depressed (14%)
Simsek, B. et al. (2023)	USA/Canada	First-year IC fellows (111)	Not applicable	84% considered the interventional cardiology fellowship somewhat (62%) or very stressful (22%)
Bogerd, R. et al (2023)	Netherlands	Cardiologists (382)	Not applicable	3.85/5 on professional fulfillment, 2.25/ 5 on work exhaustion and 2.04/5 interpersonal disengagement

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

93



Conceptual model of burnout and related symptoms in cardiologists. *Adapted and used with permission from: Linzer M, et al. Working conditions in primary care: physician reactions and care quality. Ann Intern Med. 2009; 151:28–36.*

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

94

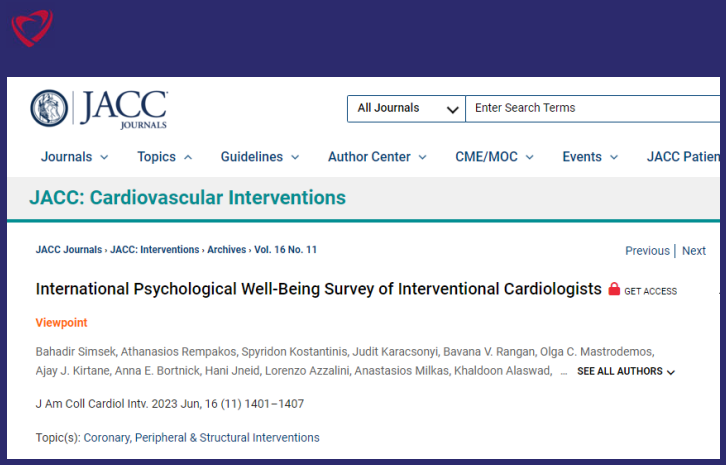
Are we superheroes?

No

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

95



Impact of burnout on IC physicians

I felt lonely in the past year (84%)
I am working too hard (78%)
I am emotionally exhausted (64%)
I am frustrated by work (58%)
My enthusiasm towards work decreased in the past year (44%)
I considered quitting my job in the past year (41%)
I am achieving less than I think I should ≥3/week (40%)
I feel overwhelmed ≥3/week (33%)
I am considering to leave my job (32%)
I am not physically healthy (30%)
I am not happy with my life (28%)

1,159 IC attendings and 192 IC fellows

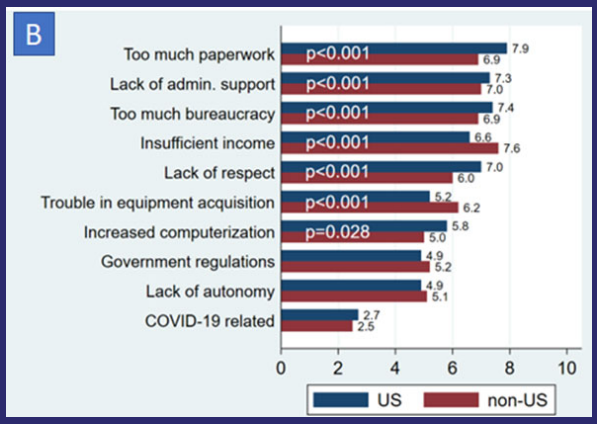
Simsek , B., Konstantinis, S., et al. International psychological well-being survey of interventional cardiologists. JACC Cardiovasc Interv. 2023

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

96

Contributors to burnout



Simsek, B., Konstantinis, S., et al. International psychological well-being survey of interventional cardiologists. JACC Cardiovasc Interv. 2023

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

97

Sex Differences in the Well-being of Interventional Cardiologists

Michaella Alexandrou, MD[1]; Bahadir Simsek, MD[1]; Athanasios Rempakos, MD[1]; Spyridon Kostantinis, MD[1]; Judit Karacsonyi, MD, PhD[1]; Bavana V. Rangan, BDS, MPH[1]; Olga C. Mastrodemos, BA[1]; Ajay J. Kirtane, MD, SM[2]; Anna E. Bortnick, MD, MS[3]; Hani Jneid, MD[4]; Lorenzo Azzalini, MD, PhD, MSc[5]; Anastasios Milkas, MD[6]; Khaldoon Alaswad, MD[7]; Mark Linzer, MD[8]; Mohaned Egred, MD[9]; Sunil V. Rao, MD[10]; Salman S. Allana, MD[11]; Yader Sandoval, MD[11]; Emmanouil S. Brilakis, MD, PhD[1]

[1]Minneapolis Heart Institute and Minneapolis Heart Institute Foundation, Minneapolis, MN, USA
[2]Division of Cardiology, Columbia University Irving Medical Center/NewYork-Presbyterian Hospital, New York, NY, USA
[3]Department of Medicine, Montefiore-Medical Center/Albert Einstein College of Medicine, Bronx, NY, USA
[4]Department of Medicine, Division of Cardiology, Baylor College of Medicine, Houston, TX, USA
[5]Division of Cardiology, Department of Medicine, University of Washington, Seattle, WA, USA
[6]Department of Cardiology, Athens Naval Hospital, Athens, Greece
[7]Division of Cardiology, Henry Ford Hospital, Detroit, MI, USA
[8]Institute for Professional Worklife, Hennepin Healthcare, Minneapolis, MN, USA
[9]Department of Cardiology, Freeman Hospital, Newcastle upon Tyne, UK/ Newcastle University Translational and Clinical Research Institute, Newcastle upon Tyne, UK
[10]Department of Medicine, Division of Cardiology, New York University Grossman School of Medicine, New York, NY, USA

BACKGROUND

Sex differences in the well-being of interventional cardiologists have received limited study.

METHODS

We conducted an international, anonymous, online survey exploring sex-based differences in the well-being of interventional cardiologists.

RESULTS

Of 1,251 survey participants, 121 (9.7%) were women. Women were more likely to be under 50 years old and single and were more commonly practicing at academic institutions or hospitals with academic affiliation. There was no difference in the self-reported overall burnout between women and men. On a scale of 0-10, men reported more often too much paperwork (6.9±2.5 vs 6.2±2.7, p=0.013) and government regulations (4.8±3.1 vs 3.6±2.8, p<0.001) as contributors to burnout. Women reported less often getting well along with colleagues (7.0±2.9 vs 7.5±2.1, p=0.047) and more often feeling lonely during the prior year (5.5±3.1 vs 4.3±3.2, p<0.001). Men more commonly chose exercise as a coping mechanism for burnout, while women more often chose talking with family/friends. Women prioritize additional paid time off (7.5±2.5 vs 6.9±2.7, p=0.041) as the most preferable wellness-related action and asked more often for respect/recognition from administration, opportunities for professional growth and mentorship opportunities. Almost half (44.3%) of women IC attendings considered leaving their job during the prior year (vs 40.6% men, p=0.572) and 45.5% reported decreased enthusiasm towards work, compared with the prior year (vs 44.2% men, p=0.590). Almost 1 in 10 (9.1%) reported suicidal ideation in the last year (vs 6.1% men, p=0.387). Seventy-five % of women IC attendings reported thinking they are achieving less than they think they should at least twice a week (vs 56.1% men, p=0.001). One-third (28.7%) of women IC attendings reported not having access to mental health support if needed through their hospital/practice (vs 36.9% men, p=0.167).

CONCLUSION

Our survey shows sex differences in contributors and coping mechanisms to burnout in the field of interventional cardiology. Better communication with administration and access to career development opportunities might be especially valuable for reducing the risk of burnout in women.

Minneapolis Heart Institute Foundation
Creating a world without heart and vascular disease

Allina Health MINNEAPOLIS HEART INSTITUTE

Among 1,251 interventional cardiologists and fellows:

Women (9.7%) asked more often for

★ Respect/recognition from the administration (7.9 vs 7.2, p=0.016)

★ Opportunities for professional growth (7.9 vs 7.2, p=0.017)

★ Mentorship opportunities (7.5 vs 6.4, p=0.002)

For more information, email *alexmichaella@gmail.com*

Acknowledgements: The authors are grateful for the philanthropic support of our generous Anonymous donors(2), and the philanthropic support of Frank J and Eleanor A. Maslowski Charitable Trust; Drs. Mary Ann and Donald A Sens, Mr. Raymond Ames and Ms. Barbara Thorndike; Joseph F. and Mary M Fleischhacker Family Foundation; Mrs. Diane and Dr. Cline Hickok; Mrs. Marilyn and Mr. William Ryerse; Mr. Greg and Mrs. Rhoda Olson; Mrs. Wilma and Mr. Dale Johnson; Mrs. Charlotte and Mr. Jerry Golnesus Family Fund; the Roehl Family Foundation, the Joseph Durda Foundation. The generous gifts of these donors to the Minneapolis Heart Institute Foundation's Science Center for Coronary Artery Disease (CCAD) helped support this research project.

FIGURES

Figure 1: Comparison of the baseline characteristics of women vs men interventional cardiologists and fellows.

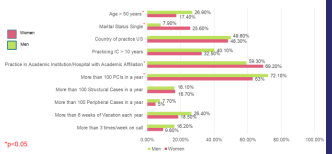


Figure 2: Burnout in women vs men interventional cardiologists and fellows.

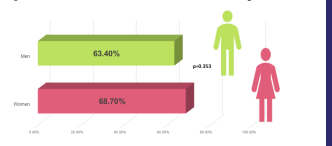
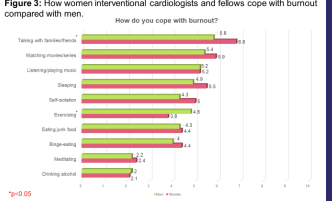


Figure 3: How women interventional cardiologists and fellows cope with burnout compared with men.



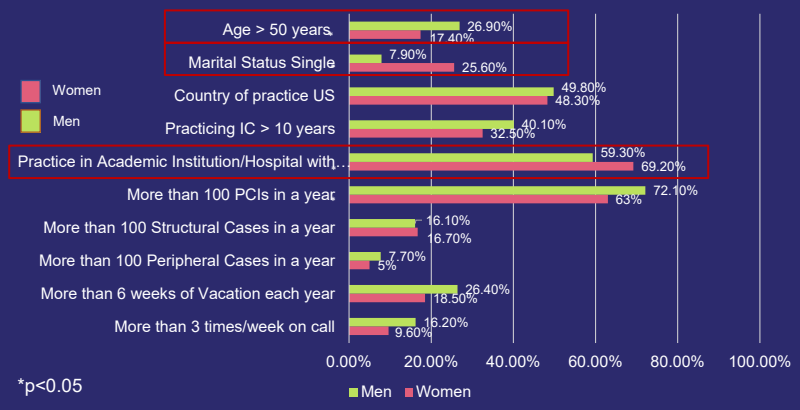
Conflict of interest statement: The authors report no financial relationships or conflicts of interest regarding the content herein.

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

98

Women vs men IC attendings/fellows



*p<0.05

Alexandrou, M., Simsek, B., Rempakos, A., et al. (2023). Sex Differences in the Well-being of Interventional Cardiologists. Journal of Invasive Cardiology (accepted)

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

99

Women asked more often for

Respect/recognition from the administration
(7.9 vs 7.2, p=0.016)

Opportunities for professional growth
(7.9 vs 7.2, p=0.017)

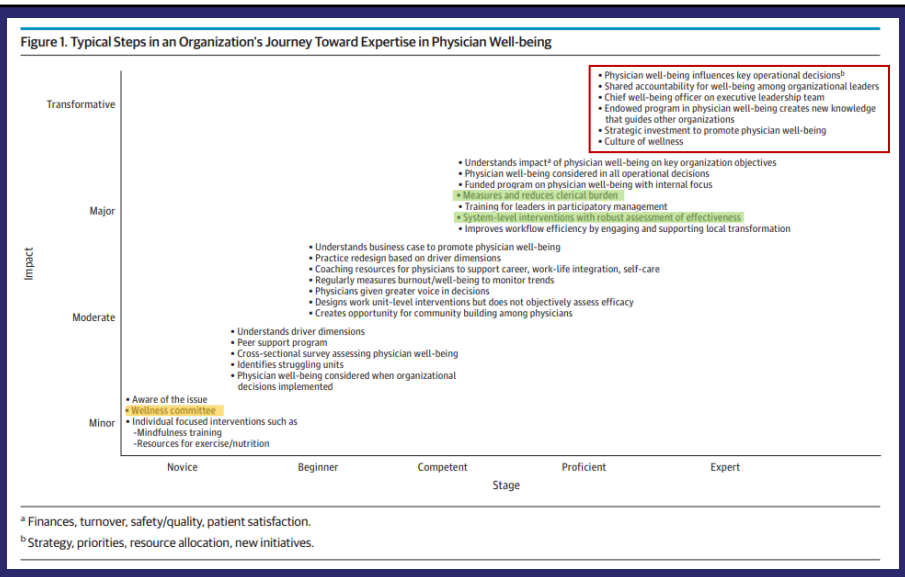
Mentorship opportunities
(7.5 vs 6.4, p=0.002)

Alexandrou, M., Simsek, B., Rempakos, A., et al. (2023). Sex Differences in the Well-being of Interventional Cardiologists. Journal of Invasive Cardiology (accepted)

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

100



Shanafelt T, Goh J, Sinsky C. The business case for investing in physician well-being. JAMA Internal Medicine. 2017;177:1826-1832

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

101

MAYO CLINIC

"When individually focused offerings are not coupled with sincere efforts to address the system-based issues contributing to burnout, this approach is typically met with skepticism and resistance by physicians ("they are implying I am the problem")".

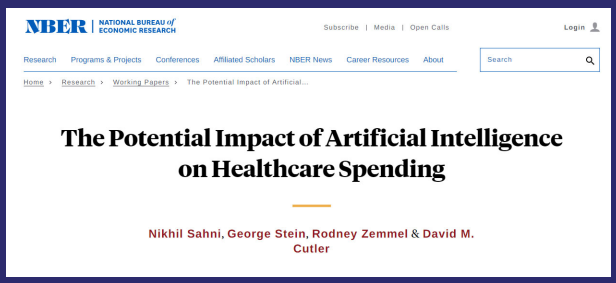
Shanafelt TD, Noseworthy JH. Executive leadership and physician well-being: Nine organizational strategies to promote engagement and reduce burnout. Mayo Clin Proc. 2017;92:129-146

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

102

AI adoption could alleviate the workload burden


NBER | NATIONAL BUREAU of ECONOMIC RESEARCH

Subscribe | Media | Open Calls | Login

Research | Programs & Projects | Conferences | Affiliated Scholars | NBER News | Career Resources | About | Search

Home › Research › Working Papers › The Potential Impact of Artificial...

The Potential Impact of Artificial Intelligence on Healthcare Spending

Nikhil Sahni, George Stein, Rodney Zemmel & David M. Cutler

"We estimate that wider adoption of AI could lead to savings of 5 to 10 percent in US healthcare spending—**roughly $200 billion to $360 billion annually in 2019 dollars.**"

Non direct financial benefits:

- **improved healthcare quality**
- **increased access**
- **better patient experience**
- **and greater clinician satisfaction**

Sahni NaS, George and Zemmel, Rodney and Cutler, David M. The potential impact of artificial intelligence on healthcare spending. 2023;30857

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

103

Currently enrolling at MHI

STRAIN study

*(**STR**ess **A**ssessment of **IN**terventional cardiology fellows and attendings)*

Interventional cardiology attendings/fellows

Wearables

POLAR H1O Chest strap

WHOOP wearable

Intraoperative stress assessment based on heart rate variability (HRV)

Reporting also:

- Burnout assessed by the Mini-Z survey
- Subjective stress assessed by the STAI-short version survey

Does intraoperative stress accumulate?
Which procedures are more stressful?
When do IC attendings/fellows recover?
Does stress decrease with training?

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

104

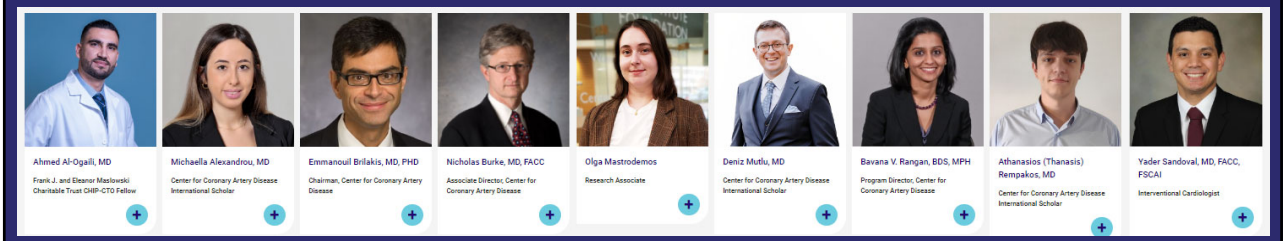
Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

105

Michaella Alexandrou, MD
michaella.alexandrou@allina.com

Thank you!



Acknowledgments: The authors are grateful for the philanthropic support of our generous Anonymous donors(2), and the philanthropic support of Drs. Mary Ann and Donald A Sens; Mr. Raymond Ames and Ms. Barbara Thorndike; Frank J and Eleanor A. Maslowski Charitable Trust; Joseph F and Mary M Fleischhacker Family Foundation; Mrs. Diane and Dr. Cline Hickok; Mrs. Marilyn and Mr. William Ryerse; Mr. Greg and Mrs. Rhoda Olsen; Mrs. Wilma and Mr. Dale Johnson; Mrs. Charlotte and Mr. Jerry Golinvaux Family Fund; the Roehl Family Foundation; the Joseph Durda Foundation.

Minneapolis Heart Institute Foundation | CENTER FOR CORONARY ARTERY DISEASE

Allina Health MINNEAPOLIS HEART INSTITUTE

106

Causes of Long-Term Mortality in Patients with Microvascular Obstruction Following ST-segment Elevation Myocardial Infarction

Giselle Fisher, Bethany White, Brynn Okeson, Evan Walser- Kunz,
Jay H Traverse

Minneapolis Heart Institute Foundation
Minneapolis Heart Institute at Abbott Northwestern Hospital
University of Minnesota School of Medicine, Cardiovascular Division

107

Microvascular Obstruction (MVO)

- Observed on cMRI in 40 -70% of STEMI patients.
- Manifested as persistent ST-elevation on EKG or as No-Reflow following PCI.
- Likely diverse etiologies including:
  - Distal athero-embolic debris and platelet and WBC clumping
  - Microvascular dysfunction secondary to I / R injury.
  - Extrinsic compression of micro-vessels due to edema.
  - Destruction of vascular integrity and intramyocardial hemorrhage (IMH).

108

Historical Observations of MVO *(no-reflow)*

- First observed in the Brain !
- First described in the heart by Kloner et al (JCI, 1974) " The no-reflow phenomenon after temporary coronary occlusion in the dog".

-40 min LAD coronary occlusion = normal reperfusion following release of occlusion.
-90 min occlusion = impaired blood flow following release of occlusion.

<u>Histopathology (electron microscopy):</u>
- Sig capillary damage in subendocardium with swollen endothelium and intra-luminal endothelial protrusion.
- Intraluminal platelets and fibrin thrombi.
- Interstitial and intramyocardial edema (extrinsic compression)

109

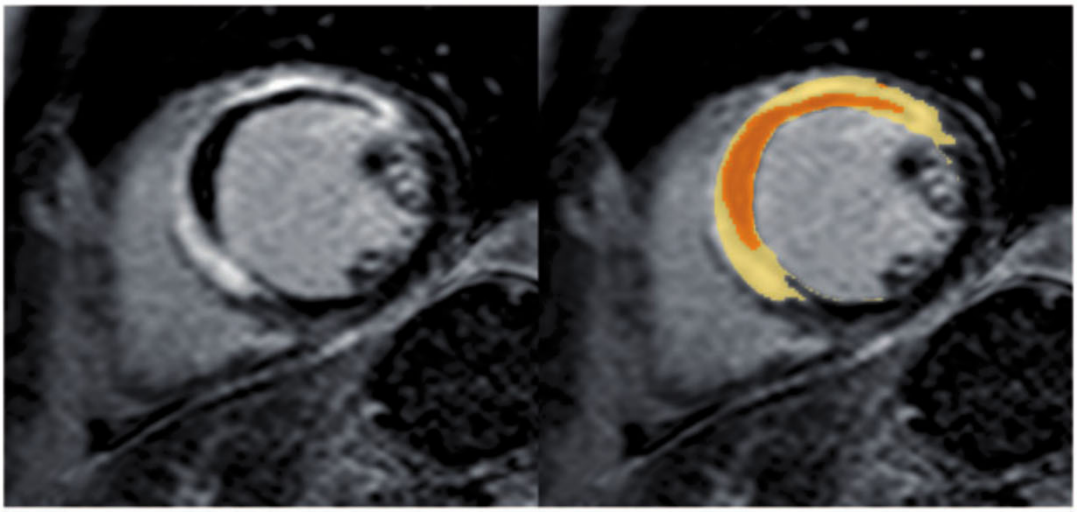
Historical Observations of MVO

- Increases with Ischemic duration.
- No-Reflow area increases over time (process, not an event).
- Cell contracture may contribute to microvascular compression
- Platelet and leukocyte depletion may reduce extent of no-reflow.
- Confined to region of myocardial infarction

Kloner R, et al. JCI 1974

110

MVO is represented by hypo-enhanced (orange) region inside the hyper-enhanced (yellow) infarct region



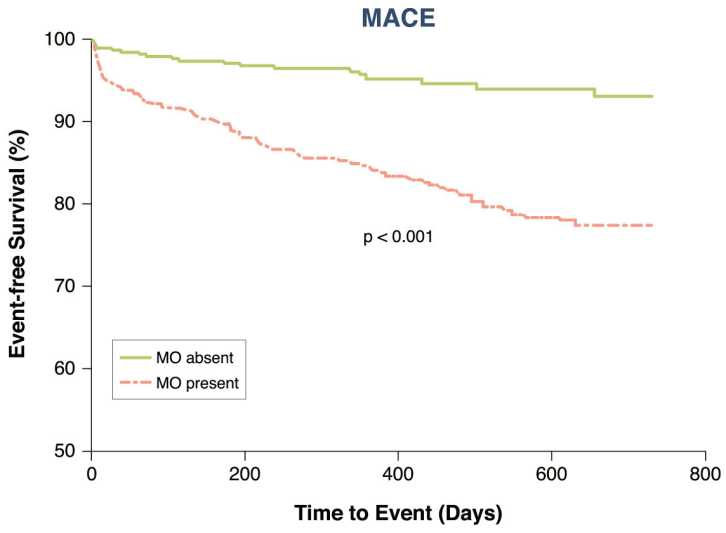
De Waha S., et al. Eur Heart J 2017

111

1025 STEMI Patients From 8 PCI trials who received primary PCI

Freedom from cardiac death CHF, recurrent MI.

MVO more powerful predictor than Infarct size

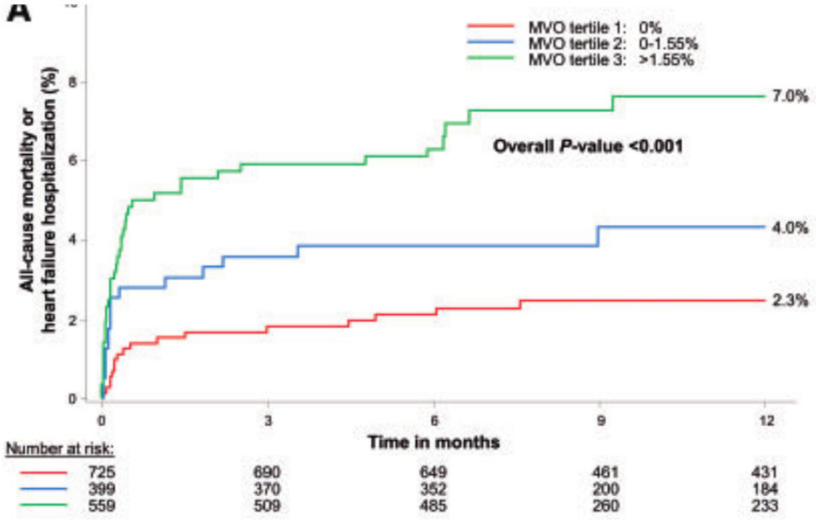


Number at Risk					
MO absent	447	293	161	119	93
MO present	566	379	256	168	114

Van Kranenburg M, et al. JACC Imag. 2014

112

Increasing amounts of MVO are Associated with Increased All-cause Mortality and Heart Failure Admissions over 1-Year



Data pooled from 7 Randomized Primary PCI Trials where MVO was Measured by cMRI Within 7 days of STEMI. MVO occurred in 57% of All Patients

De Waha S., et al. Eur Heart J 2017

113

The Presence of MVO as Powerful as Infarct Size or LV function in Predicting Event-Free Survival

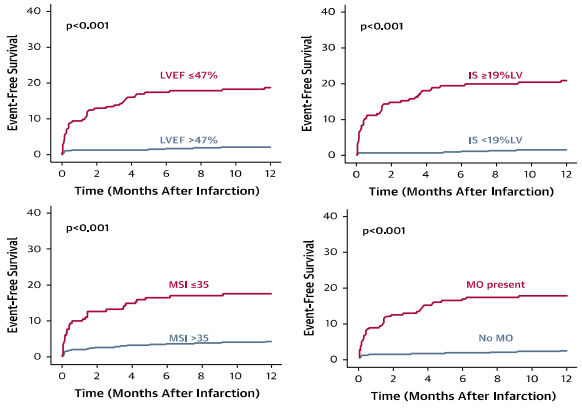


FIGURE 4 Event-Free Survival According to IS, Myocardial Salvage Index, LVEF, and MO

Kaplan-Meier curves showing the risk of cardiac events, stratified by the size of the infarct (IS), the myocardial salvage index (MSI), left ventricular ejection fraction (LVEF), and the presence of microvascular obstruction (MO). LV = left ventricle.

Multicenter Study from Germany Of 738 STEMI patients

Eitel, et al. JACC 2014

114

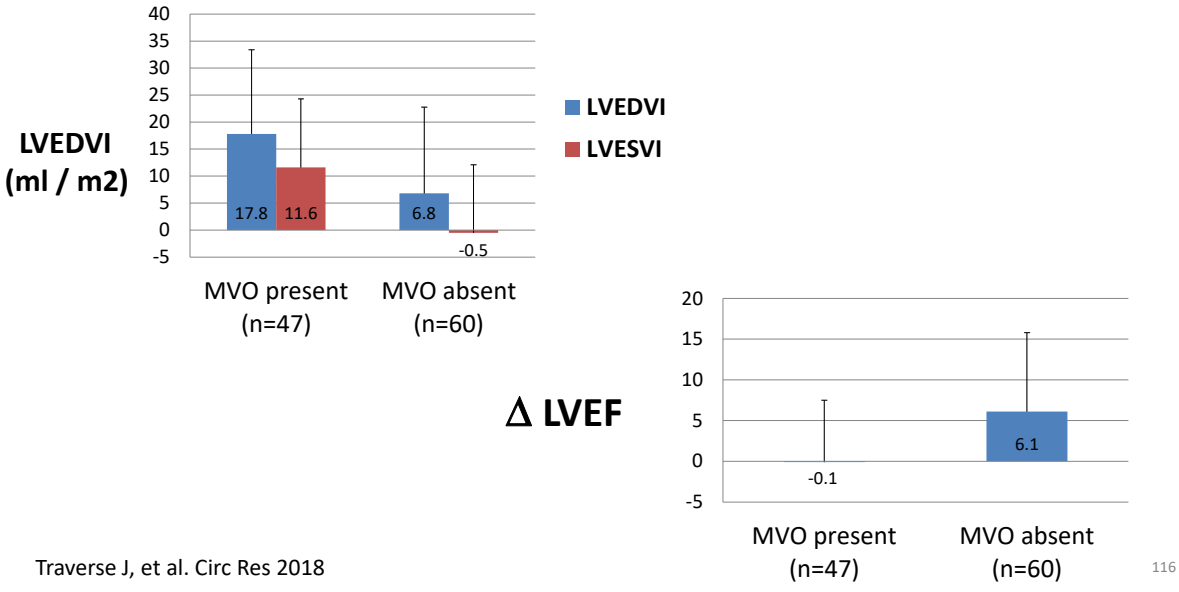
The NHLBI TIME Trial:
Role of Microvascular Obstruction in 2-Year Clinical and MRI Follow-up

Jay H. Traverse, MD
Principal Investigator, TIME Study
Minneapolis Heart Institute at Abbott Northwestern Hospital
University of Minnesota Medical School
Cardiovascular Cell Therapy Research Network (CCTRN)

2016 Scientific Sessions of the AHA

115

Effect of MVO on Changes in LVEF and Volumes at 6-months



Traverse J, et al. Circ Res 2018

116

116

Long-Term Causes of Mortality in Patients with MVO Following STEMI – Rationale and Methodology

Rationale: The long-term natural history and mortality is not known in patients with MVO following STEMI beyond 2 years.

- We analyzed the long-term follow-up and cardiac MRIs of 475 patients admitted through the Level 1 Program (Mean age = 60 years, 76% male) for the presence (n=337) or absence (n=138) of MVO following STEMI and successful reperfusion with PCI between 2007 -2017.
- Causes of death were determined from the patient's electronic medical record or death certificate.

117

Long-Term Causes of Mortality in Patients with MVO Following STEMI – RESULTS

- Patients with MVO had greater ischemic times (159 vs. 141 mins; p = 0.012) and were more likely to have TIMI 0 flow on presentation (71 vs 54%; p <0.002).
- Patients with MVO had greater infarct size by cardiac enzymes resulting in greater LV end-diastolic volume index (LVEDVI) (80 vs.75 ml/m2) and LV end-systolic volume index (LVESVI) (39 vs 30 ml/m2) LV mass (146 vs 134 g) and reduced LVEF (48 vs 58 %; all p < 0.01) by cardiac MRI performed 1-3 days following STEMI and PCI.
- During long-term follow-up a total of 56 patients with MVO died compared to 18 patients without MVO.
- Patients with MVO died sooner after STEMI (5.9 vs 7.8 years) and were more likely to die from cardiovascular causes such as progressive heart failure or sudden cardiac death (Table). LVEF before death was lower in the MVO group (46 vs 52%).

118

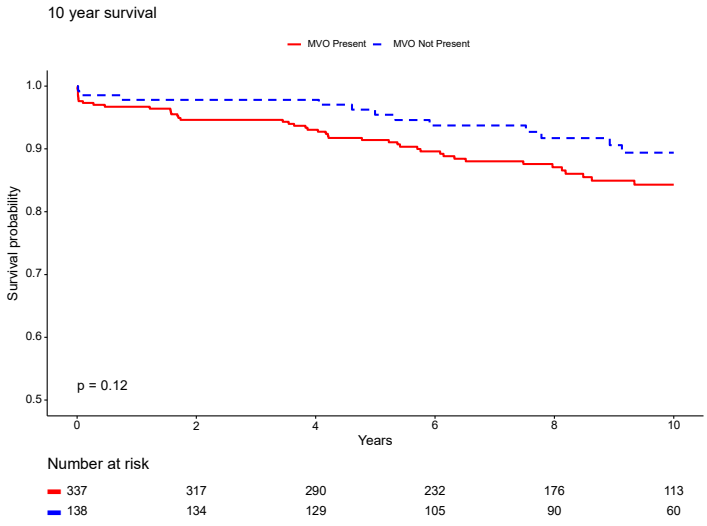
Long-Term Mortality of STEMI Patients who have MVO on cardiac MRI

Cause of Death	Cardiovascular - CHF - Cardiac arrest - MI	Neurological - Dementia - Stroke - ICH	Sepsis	Pulmonary -pneumonia -respiratory failure - COVID-ARDS	Cancer	Natural Causes	Time from STEMI to death (years)
MVO + (n=56)	22*	8	6	7	9	4	5.9 ± 4
MVO – (n=18)	1	1	0	3	7	7	7.8 ± 4

* P < 0.004 Fishers Exact Test

119

Kaplan-Meier Mortality Curve over 10-Years



120

CONCLUSIONS

- There is significant long-term mortality associated with MVO following STEMI with the majority of patients dying from cardiovascular causes. In contrast, patients with STEMI without MVO rarely died from a cardiac etiology but from cancer and natural causes.

These findings may suggest that MVO acts as a surrogate marker for greater underlying atherosclerosis, microvascular dysfunction or other unknown co-morbidities that enhances Long-term cardiovascular mortality.

121