Redo-TAV Challenges and solution

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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.

<table>
<thead>
<tr>
<th>Affiliation/Financial Relationship</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consulting Fees/Honoraria</td>
<td>Medtronic Inc</td>
</tr>
<tr>
<td>Consulting Fees/Honoraria</td>
<td>Edwards Lifesciences</td>
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</tr>
<tr>
<td>Consulting Fees/Honoraria</td>
<td>Meril</td>
</tr>
</tbody>
</table>
Redo TAV is going to be a Complex ART

For research
To validate gray zones
To bring new ideas

CHOOSING/POSITIONING THE SECOND VALVE

AVOID ANNULAR INJURY AND PATIENT PROSTHESIS MISMATCH

MAINTAIN CORONARY PERFUSION

MAINTAIN CORONARY ACCESS

Redo TAV is going to be logical

For Practice

CHOOSING/POSITIONING THE SECOND VALVE

AVOID ANNULAR INJURY AND PATIENT PROSTHESIS MISMATCH

MAINTAIN CORONARY PERFUSION

MAINTAIN CORONARY ACCESS
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

Is Redo TAV same as Aortic VIV

Fluoscopic Markers
Sewing ring

Fluoscopic Markers
Stent Frame
First challenge

All valves have different design

Second challenge

Valve Compatibility within each other is complex
Third challenge

Depth of TAV implant varies in each patient

Fourth challenge

Most TAV are under expanded, hence dimensions are not constant

Using in-vitro Bench Sizing may lead to issues
Fifth challenge

Can we make a workflow which accommodates all combinations?

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

Dr. Atsushi Okada

Dr. Miho Fukui
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

Content

- **CT Analysis**
- **Procedure Guidance**
  1. TAV Explant
  2. Coronary Access
- **Additional Content**
- **Post Procedure Data Capture**
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

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4 Redo TAV Combinations

- **Short in Short**
- **Short in Tall**
- **Tall in Short**
- **Tall in Tall**
1. What is Leaflet overhang and Leaflet deflection

Leaflets deflected up to the top of the leaflet attachment

No Leaflet overhang

Leaflet overhang and Leaflet deflection

No Leaflet overhang

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

Node 6 Implant

Node 5 Implant

Node 4 Implant

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

L should be more than A

Example–ER23 and S3 23

Node 5 implant

Dr. Sellers, Vancouver, TCT 2023
2. Neo skirt: Definition and meaning

Combination of
Index TAV Pinned leaflets + Skirt of Second TAV
Neo skirt: Definition and meaning
Combination of
Index TAV Pinned leaflets + Skirt of Second TAV

3. Each Valve has unique landmarks
4. Neoskirt and Neoskirt plane

- Short in Short
- Tall in Tall
- Tall in Short
- Short in Tall

Single NSP

Neoskirt planes!

- Node 4
- Node 5
- Node 6
- ACURATE neo2

Combination specific with lower and upper limit
5. Size of Second TAV before Coronary Analysis: Why?

Node 4

Node 5

Node 6

Sizing may change with Level of implant

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

Below the lowest coronary ostia

Node 6

Below top of the Commissure tab
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

7. Coronary Risk Analysis

- **NSP below STJ**: VTA and VTC
- **NSP below STJ**: VTSTJ, VTA and VTC

**Risk based on NARROWEST MEASUREMENT**
**Risk classification**

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

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**Summary Report**

- Index TIVA: SAPEN 3
- Second TIVA: SAPEN 3
- Area: 385.5 mm²
- Perimeter: 22.2 mm
- Index TIVA Failure Mechanism: A5
- Opi: Below top of commissure tab
- NPP: Top of commissure tab

- LCA: 0.9 mm
- RCA: 3.3 mm

High risk of coronary obstruction & difficult coronary access
APP development

Emerging faculty
- Miho Fukui
- Atsushi Okada
- Syed Zaid
- Ronald Thao
- Arif Khoker

CT Guru's
- Hasan Jilaihawi
- Omar Khalique
- Miho Fukui
- Joao Cavalcante
- Industry Partners

Physician KOLs
- Janar Sathananthan
- Uri Landes
- Gilbert Tang
- Daniel Blackman
- Ole De Backer
- Toby Rogers

Developers
- Krutsch (Developer)
- Fleishhacker Foundation
- Minneapolis Heart Institute Foundation

Free
Unbiased

Home screen

- Multiple links
- Top tabs – commonly used
- Bottom tabs – educational content
CT planning charts
Combination Specific
Downloadable PDF format

TAVR explant
1. Planning
2. Techniques: subdivided into valve types
3. Expert discussions
Valve specific content

Deep dive in each design
Case examples
Bench testing data

Developed with Industry partners

Publications, Presentations, Workshops

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

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.
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.
Isolated Noncompaction of Left Ventricular Myocardium
A Study of Eight Cases

Thomas K. Chio, MD, Joseph K. Purkoff, MD, Robert G. Williams, MD,
Kenneth Roe, MD, and Renee Miesen, MD

Isolated noncompaction of left ventricular myocardium is a rare disorder of embryonic cardiac development. It is characterized by the persistence of deep endocardial furrows and myocardial trabeculations in the left ventricular myocardium. These furrows and trabeculations may cause ventricular tachycardia and other arrhythmias. The condition is often associated with other congenital heart defects, such as patent ductus arteriosus and coarctation of the aorta. The mechanism of ventricular tachycardia is not fully understood but is thought to be related to the presence of abnormal myocardial trabeculations.

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

Rolf Jensen, Norbert Gaedel, Roberto Tartini, Jakob Schneider, Urs Arbour, and Oswald Goll

Department of Internal Medicine, Diagnostic Radiology, and Pathology, University Hospital Zürich, and Department of Cardiology, Children's University Hospital, Zürich, Switzerland

Heart

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

Rolf Jensen, Norbert Gaedel, Roberto Tartini, Jakob Schneider, Urs Arbour, and Oswald Goll

Department of Internal Medicine, Diagnostic Radiology, and Pathology, University Hospital Zürich, and Department of Cardiology, Children's University Hospital, Zürich, Switzerland

Quantified growth of the human embryonic heart

Jacques W. Feller, Jean Huguenin, Antonin M. Mooser, Vincent E. Stover, and Jacques Jensen

Embryonic heart development is a complex process that involves the formation of the heart tube, its segmentation, and the differentiation of myocardial cells. The process is regulated by a variety of genes, including those that control cell proliferation, apoptosis, and differentiation. The growth of the heart is influenced by factors such as hormones, growth factors, and mechanical forces. The understanding of heart development is crucial for the treatment of congenital heart defects and for the development of new therapeutic strategies.

References

Excessive Trabeculation of the Left Ventricle

JACC: Cardiovascular Imaging Expert Panel Paper

Steffen E. Petersen, MD, DPsa, DB; Bjarke Jenseen, MSc, PhD; Nury Aung, MBBS, PhD; Matthias G. Friedrich, MD, PhD; Colin J. McMahon, MD; Saidi A. Mohiddin, MBChB, MD, PhD; Ricardo R. Pignatelli, MD; Fabrizio Ricci, MD, PhD; Robert H. Anderson, MD, PhD (Hon); David A. Bluemke, MD, PhD

Pediatric population
Excessive Trabeculation
Athletes

Pregnant females
Adult population

Thromboembolism
Malignant Arrhythmias
Excessive Trabeculation Cardiomyopathic disorder
Heart Failure
Cardiovascular Death

State-of-the-Art Review

45

46
Long-Term Follow-up of 34 Adults With Isolated Left Ventricular Noncompaction: A Distinct Cardiomyopathy With Poor Prognosis

Erwine N. Oechslin, MD, Christine H. Amthauer June, MD, Jerry B. Rofsky, MD, Philipp A. Kaufmann, MD, Rolf Jerns, MD, MSE

Zurich, Switzerland

Oechslin et al. Isolated Ventricular Noncompaction

Table 3. Long-Term Follow-up Data

<table>
<thead>
<tr>
<th>Number of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart failure requiring hospitalization</td>
</tr>
<tr>
<td>Deaths</td>
</tr>
<tr>
<td>Heart failure</td>
</tr>
<tr>
<td>Sudden cardiac death</td>
</tr>
<tr>
<td>Others*</td>
</tr>
<tr>
<td>Heart transplantation</td>
</tr>
<tr>
<td>Syncope</td>
</tr>
<tr>
<td>NYHA class at last follow-up or before heart transplantation or death</td>
</tr>
<tr>
<td>Class I/II</td>
</tr>
<tr>
<td>Class III/IV</td>
</tr>
<tr>
<td>Ventricular tachycardia</td>
</tr>
<tr>
<td>Thromboembolic events</td>
</tr>
<tr>
<td>Cerebrovascular accident</td>
</tr>
<tr>
<td>Transient ischemic attack</td>
</tr>
<tr>
<td>Mesenteric infarction</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
</tr>
</tbody>
</table>

*Two other deaths included pulmonary embolism and arrhythmia, nonsudden death. NYHA = New York Heart Association.
Magnetic Resonance Imaging

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

Alexander Ivanov, MD; Devidas S. Dab NULL, DO; MPH; Geetha R. BhumVARADA, MD; Andrei Moharan, MD; Akhil Anoor, MD; William M. Briggs, MD, PhD; Jean Hu, BS; Saeed A. Kazmi, MD; ALESSANDRA AL-

IVANOV, MD; New York Weill Cornell Medical College, New York, NY; Van Waning et al. Noncompaction Cardiomyopathy Features and Genetics

Van Waning et al. Noncompaction Cardiomyopathy Features and Genetics
1. Baseline Characteristics of patients with Excessive trabeculation, preserved EF and ICD implanted. (N=20)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender Female</td>
<td>10 (50)</td>
</tr>
<tr>
<td>Age at diagnosis (yrs)</td>
<td>39 (27-54)</td>
</tr>
<tr>
<td>LVEF at presentation (%)</td>
<td>57.5 (7.5)</td>
</tr>
<tr>
<td>Follow up time (yrs)</td>
<td>15 (5-15)</td>
</tr>
</tbody>
</table>

2. Risk factors for SCD and VAs

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family History of SCD/Genetic cardiomyopathy</td>
<td>7 (35)</td>
</tr>
<tr>
<td>History of Syncope Prior to ICD implant.</td>
<td>8 (40)</td>
</tr>
<tr>
<td>History of NSVT Prior to ICD implant.</td>
<td>7 (35)</td>
</tr>
<tr>
<td>LV morphological or Functional abnormality on CMR.</td>
<td>8 (40)</td>
</tr>
</tbody>
</table>

3. Device Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at ICD implantation (yrs)</td>
<td>41.1 (29.5-56)</td>
</tr>
<tr>
<td>Time from device implantation to appropriate therapy</td>
<td>2.1 (2.4-4.8)</td>
</tr>
<tr>
<td>Type of device implanted</td>
<td></td>
</tr>
<tr>
<td>Single chamber</td>
<td>10 (50%)</td>
</tr>
<tr>
<td>Dual chamber</td>
<td>8 (40%)</td>
</tr>
<tr>
<td>Biventricular</td>
<td>2 (10%)</td>
</tr>
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4. Adverse Outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite outcome</td>
<td>9 (45)</td>
</tr>
<tr>
<td>Appropriate ICD Therapy</td>
<td>5 (25)</td>
</tr>
<tr>
<td>Stroke</td>
<td>2 (10)</td>
</tr>
<tr>
<td>Development of Cardiomyopathy</td>
<td>2 (10)</td>
</tr>
<tr>
<td>Death</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

ICD, Implantable Cardiac Defibrillator; LVEF, Left Ventricular Ejection Fraction; SCD, Sudden Cardiac Death; VAs, Ventricular Arrhythmias; CMR, Cardiac Magnetic Resonance.

*LVEF, Mean (SD).

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

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.

Excessive Trabeculation by CMR according to any of the available criteria.

- Tailored Clinical management according to patient’s condition
- Highly Consider primary ICD therapy
- Genetic testing and family counseling

Thorough assessment for personal and family history
- Through investigations with Holter monitoring and LGE CMR if not done previously, testing and family counseling
- Periodic follow up with CMR.
- Consider primary ICD therapy.

Assess the need for further investigations and follow up on a case by case basis.
- Educate the patient/family about potential risk factors and when to seek cardiovascular care.
Diversity and discrimination against physicians in interventional cardiology

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

Disclosure of Relevant Financial Relationships

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


**Background**

- **Underrepresented in Medicine**
  - Overall discrimination: 75.7%
  - Race-based discrimination population: 52.3%

- **Asian/Pacific Islander**
  - Overall discrimination: 61.7%
  - Race-based discrimination population: 45.5%

- **White**
  - Overall discrimination: 36.4%
  - Race-based discrimination population: 6.2%

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**Background**

- **Non-evidence-based DEI initiatives**
  - Impede the identification and resolution of discrimination directed towards “disadvantaged” groups
  - Increase sensitivity of discrimination against “advantaged” groups
  - Generate uncertainties regarding the competence and attributions of individuals belonging to “disadvantaged” groups
  - Evoke feelings of threat and victimization among “advantaged” groups

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**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

**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
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
  - Native vs non-native English speakers

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
Results

- Median age range → 46-50
- Practicing in the US → 60%
- Married → 88%
- At least one child → 82%

Gender differences

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age</th>
<th>Married</th>
<th>Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women</td>
<td>Age: 41-45</td>
<td>62%</td>
<td>48%</td>
</tr>
<tr>
<td>Men</td>
<td>Age: 46-50</td>
<td>92%</td>
<td>87%</td>
</tr>
</tbody>
</table>

- Men: 87% Married, 87% Children
- Women: 62% Married, 48% Children

p = 0.013  p < 0.001  p < 0.001 (adjusted for age)
US participant race/ethnicity

- Non-Hispanic white: 51.1%
- Asian: 25.0%
- Hispanic/Latino: 7.8%
- Black/African American: 3.7%
- Native American: 0.4%
- Other/Mixed-race: 12.0%

Gender diversity

- Men hold most senior positions in my program: 69% (79% p = 0.251)
- I support interventions to help increase gender diversity in my program: 65% (82% 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: 13% (64% p < 0.001)
- I support mandatory quotas to increase gender diversity in my program: 20% (32% p = 0.122)
- My gender negatively impacted my fellowship prospects/acceptance: 7% (31% p < 0.001)
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

Race/ethnicity diversity

- I support interventions to help increase racial/ethnic diversity in my program
- Everyone in my program is treated equally, regardless of their race/ethnicity
- White/Caucasian people hold most senior positions in my program
- My race/ethnicity may impede the progress of my career
- My race/ethnicity negatively impacted my fellowship prospects/acceptance
- I support mandatory quotas to increase racial/ethnic diversity in my program
- My religion negatively impacted my fellowship prospects/acceptance

Race/ethnicity: Non-white, Non-Hispanic white

- p = 0.418
- p = 0.164
- p = 0.224
- p < 0.001
- p = 0.010
- p = 0.003
42 participants (9%) reported incidents of discrimination to their organization.

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

**Discrimination sources - Gender**

<table>
<thead>
<tr>
<th>Category</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients and families</td>
<td>54%</td>
<td>81%</td>
</tr>
<tr>
<td>Peers</td>
<td>45%</td>
<td>81%</td>
</tr>
<tr>
<td>Supervisors</td>
<td>42%</td>
<td>73%</td>
</tr>
<tr>
<td>Support staff</td>
<td>36%</td>
<td>64%</td>
</tr>
<tr>
<td>Nursing staff</td>
<td>37%</td>
<td>62%</td>
</tr>
</tbody>
</table>

P-values: p < 0.001 (significant differences).
### Discrimination experiences - Gender

#### Discrimination experiences by gender

- **I was mistaken for a non-physician employee**
  - Men: 7%
  - Women: 41%
  - P < 0.001

- **I received inappropriate remarks from a patient**
  - Men: 22%
  - Women: 41%
  - P = 0.002

- **I was held to a higher standard of performance than my peers**
  - Men: 23%
  - Women: 38%
  - P = 0.021

- **I received inappropriate remarks from a colleague/senior**
  - Men: 18%
  - Women: 41%
  - P < 0.001

- **I was unfairly overlooked for a position or a promotion**
  - Men: 19%
  - Women: 29%
  - P = 0.112

- **I was dismissed by a patient (patient refused care from me)**
  - Men: 12%
  - Women: 26%
  - P = 0.011

- **My pay and/or benefits were not equivalent to my peers at my level**
  - Men: 13%
  - Women: 21%
  - P = 0.145

- **I was excluded from social events with colleagues**
  - Men: 8%
  - Women: 21%
  - P = 0.004

### Discrimination experiences - Language

#### B. Native language

- **Patients and families**
  - English speaking: 72%
  - Non-English speaking: 46%
  - P < 0.001

- **Peers**
  - English speaking: 63%
  - Non-English speaking: 35%
  - P < 0.001

- **Supervisors**
  - English speaking: 55%
  - Non-English speaking: 33%
  - P < 0.001

- **Nursing staff**
  - English speaking: 52%
  - Non-English speaking: 31%
  - P = 0.001

- **Support staff**
  - English speaking: 51%
  - Non-English speaking: 28%
  - P < 0.001
Discrimination experiences – Race/ethnicity

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)
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

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
Discrimination against physicians in interventional cardiology

**BACKGROUND**

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

**METHODS**

The authors 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 identify factors that contribute to discrimination in their workplace. Several characteristics were identified (Figure): language accent (48%), race/ethnicity (44%), age (44%), gender (43%), and appearance/clothing (40%).

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

**CONCLUSION**

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

**Disclosures:** The authors declare that they have no competing financial interests.

**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 Thomdike; 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.
Cardiologist Well-Being and Burnout

Michaella Alexandrou, MD
Center for Coronary Artery Disease

Disclosure of Relevant Financial Relationships

I, Michaella Alexandrou DO NOT have any relevant financial relationships to disclose.
Seeing the Big Picture: The Significance of Burnout

Aging population
Multimorbidity

From Pyramid to Pillar: A Century of Change
Population of the United States


For the First Time in U.S. History Older Adults Are Projected to Outnumber Children by 2034
A critical shortage of physicians

![Graph showing projected physician shortfall from 2018 to 2033]

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

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


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

It’s all about money
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

**Patient safety**

170 observational studies of 239,246 physicians


doi:10.1136/bmj-2022-070442

**Patient dissatisfaction**

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

569,776 patients and 409 general practitioners (GPs)

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

How many cardiologists are burnout?

The prevalence of burnout varies according to definition
### Main Results

<table>
<thead>
<tr>
<th>Author (publication year)</th>
<th>Country</th>
<th>Participants (n)</th>
<th>How was burnout assessed</th>
<th>Main Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mehta, L.S. et al. (2019)</td>
<td>USA</td>
<td>Cardiologists (2,274)</td>
<td>Mini-Z survey</td>
<td>26.8% reported burnout symptoms</td>
</tr>
<tr>
<td>Lebo, A.S. et al. (2019)</td>
<td>USA</td>
<td>Cardiovascular workers (481) [70% interventional cardiologists]</td>
<td>“Do you feel burnout?”</td>
<td>56.5% reported burnout</td>
</tr>
<tr>
<td>Shah, S. et al. (2020)</td>
<td>USA</td>
<td>IC, structural, CHIP, and peripheral vascular fellows (135)</td>
<td>Not applicable</td>
<td>66% reported significant stress at work and at home because of the COVID-19 pandemic</td>
</tr>
<tr>
<td>Cullen, M.W. et al. (2021)</td>
<td>USA</td>
<td>Cardiovascular Diseases Fellowship Program Directors (141)</td>
<td>Mini-Z survey</td>
<td>21% reported symptoms of burnout</td>
</tr>
<tr>
<td>Joshi, S.S. et al. (2022)</td>
<td>International</td>
<td>Cardiac imaging specialists (125)</td>
<td>Not reported</td>
<td>58% reported burnout (64% reported worsening during the COVID-19 pandemic)</td>
</tr>
<tr>
<td>Sharma, G. et al. (2023)</td>
<td>International</td>
<td>Cardiologists (5,890)</td>
<td>Not applicable</td>
<td>28% reported any self-reported MHC, of which 76.1% reported psychological distress</td>
</tr>
<tr>
<td>Simsek, B. et al. (2023)</td>
<td>International</td>
<td>Attending IC (1,159) and IC fellows (192)</td>
<td>“Rate the impact of your burnout on your life”</td>
<td>89% of the interventional cardiologists are affected by burnout</td>
</tr>
<tr>
<td>Koval, M.L. (2023)</td>
<td>USA</td>
<td>Cardiologists (367)</td>
<td>“Do you feel burnt out and depressed?”</td>
<td>43% felt burnt out (29%) or both burnt out and depressed (14%)</td>
</tr>
<tr>
<td>Simsek, B. et al. (2023)</td>
<td>USA/Canada</td>
<td>First-year IC fellows (111)</td>
<td>Not applicable</td>
<td>94% considered the interventional cardiology fellowship somewhat (62%) or very stressful (22%)</td>
</tr>
<tr>
<td>Begerd, R et al. (2023)</td>
<td>Netherlands</td>
<td>Cardiologists (382)</td>
<td>Not applicable</td>
<td>3.85/5 on professional fulfillment, 2.25/5 on work exhaustion and 2.04/5 interpersonal disengagement</td>
</tr>
</tbody>
</table>

### Conceptual model of burnout and related symptoms in cardiologists

- **Background Variables**
  - Gender
  - Age
  - Income
  - EHR use
  - Hectic work environment
  - Excessive workload
  - Bureaucracy

- **Moderating Variables**
  - Autonomy
  - Work-life balance
  - Supportive environment

- **Cardiologist Reactions**
  - Burnout
  - Stress
  - MHCs
  - Job dissatisfaction
  - Sleep disturbances
  - Intent to leave

Are we superheroes?

No

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

Contributors to burnout


Sex Differences in the Well-being of Interventional Cardiologists

Among 1,251 interventional cardiologists and fellows:

Women (9.7%) asked more often for

- Respect/recognition from the administration (7.4 vs 7.2, p<0.001)
- Opportunities for professional growth (7.4 vs 7.2, p<0.001)
- Mentorship opportunities (7.5 vs 6.4, p<0.001)

Our survey shows sex differences in collaboration and cooperation. Women tend to report lower levels of collaboration and cooperation, which might be especially valuable for reducing the rate of burnout or stress.

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

Figure 2: Burnout varies in men international cardiologists and fellows.

Figure 3: How women international cardiologists and fellows cope with burnout compared to men.
MHIF Cardiovascular Grand Rounds | November 6, 2023

Women vs men IC attendings/fellows

- Age > 50 years
- Marital Status Single
- Country of practice US
- Practicing IC > 10 years
- Practice in Academic Institution/Hospital with...
- More than 100 PCIs in a year
- More than 100 Structural Cases in a year
- More than 100 Peripheral Cases in a year
- More than 8 weeks of Vacation each year
- More than 3 times/week on call

*Women vs men, *p<0.05


Women asked more often for

- Respect/recognition from the administration (7.9 vs 7.2, p=0.018)
- Opportunities for professional growth (7.9 vs 7.2, p=0.017)
- Mentorship opportunities (7.5 vs 6.4, p=0.002)

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").
AI adoption could alleviate the workload burden

“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

STRAIN study
(STress Assessment of INterventional cardiology fellows and attendings)

Wearables

Interventional cardiology attendings/fellows

Polar H10 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 STAIi-short version survey

Does intraoperative stress accumulate?
Which procedures are more stressful?
When do IC attendings/fellows recover?
Does stress decrease with training?
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. Sersen; 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; Mrs. Wilma and Mr. Dale Johnson; Mrs. Charlotte and Mr. Jerry Golinvaux Family Fund; the Roehl Family Foundation; the Joseph Durda Foundation.
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

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).
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.

**Histopathology (electron microscopy):**
- Significant capillary damage in subendocardium with swollen endothelium and intraluminal endothelial protrusion.
- Intraluminal platelets and fibrin thrombi.
- Interstitial and intramyocardial edema (extrinsic compression)

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


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

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


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

Multicenter Study from Germany Of 738 STEMI patients

Eitel, et al. JACC 2014
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

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

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.

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

<table>
<thead>
<tr>
<th>Cause of Death</th>
<th>Cardiovascular</th>
<th>Neurological</th>
<th>Sepsis</th>
<th>Pulmonary</th>
<th>Cancer</th>
<th>Natural Causes</th>
<th>Time from STEMI to death (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVO + (n=56)</td>
<td>22*</td>
<td>8</td>
<td>6</td>
<td>7</td>
<td>9</td>
<td>4</td>
<td>5.9 ± 4</td>
</tr>
<tr>
<td>MVO – (n=18)</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>7</td>
<td>7</td>
<td>7.8 ± 4</td>
</tr>
</tbody>
</table>

* P < 0.004 Fishers Exact Test

Kaplan-Meier Mortality Curve over 10-Years
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.