Management of Valvular Heart Disease
2016

Robert O. Bonow, MD, MS
Northwestern University Feinberg School of Medicine
Bluhm Cardiovascular Institute
Northwestern Memorial Hospital

No Relationships to Disclose
Evidence-based guidelines?  
The majority of recommendations are Level of Evidence C
### Stages of Valvular Heart Disease

<table>
<thead>
<tr>
<th>Stage</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Risk of valve disease</td>
</tr>
<tr>
<td>B</td>
<td>Mild - moderate asymptomatic disease</td>
</tr>
</tbody>
</table>
| C     | Severe valve disease but asymptomatic  
  C1: Normal LV function  
  C2: Depressed LV function |
| D     | Severe, symptomatic valve disease |
Mitral regurgitation

Degenerative MR: primary valve disease
Functional MR: primary myocardial disease
Mitral regurgitation

Primary mitral regurgitation
Secondary mitral regurgitation
Mitral regurgitation

Primary mitral regurgitation

Secondary
Chronic Mitral Regurgitation

56 year old healthy man

Echo findings:
- Dilated left ventricle
- Normal LV systolic function
- Myxomatous leaflets with MVP
- Dilated left atrium
- Normal pulmonary artery pressure
- Severe mitral regurgitation
Chronic Mitral Regurgitation

56 year old healthy man

Issues:
• Surgery?
• Medical therapy?
• Transcatheter repair?
Mitral regurgitation

Indications for mitral valve surgery for severe primary MR?

- Symptomatic patients
- Asymptomatic patients
  - LV systolic dysfunction
  - Pulmonary hypertension
  - Atrial fibrillation
  - *Normal LV function, repair feasible?*

- class I
- class I
- class IIa
- class IIa

?
Mitral regurgitation

Indications for mitral valve surgery for severe primary MR?

- Symptomatic patients
- Asymptomatic patients
  - LV systolic dysfunction
  - Pulmonary hypertension
  - Atrial fibrillation
  - Normal LV function, repair feasible?

MV repair to improve survival? What is the natural history?
Mitral regurgitation

Indications for mitral valve surgery for severe primary MR?

• Symptomatic patients
• Asymptomatic patients
  • LV systolic dysfunction
  • Pulmonary hypertension
  • Atrial fibrillation
  • Normal LV function, repair feasible?

Asymptomatic severe primary MR:
66% come to surgery in 5 years because of symptoms, LV dysfunction, pulmonary hypertension or AF
Mitral regurgitation

Indications for mitral valve surgery for severe primary MR?

- Symptomatic patients
- Asymptomatic patients
  - LV systolic dysfunction
  - Pulmonary hypertension
  - Atrial fibrillation
  - *Normal LV function, repair feasible?*

**Severe primary MR:**
Long-term postoperative survival is worse if surgery is performed after patients become symptomatic
Surgery for Acquired Cardiovascular Disease

Late outcome: Implications for patients

Tirone E. David, MD
Joan Ivanov, PhD
Susan Armstrong, MS
Harry Rakowski, MD

Mitral Regurgitation
Survival After Mitral Valve Surgery

Survival (percent)

Time (years)

Expected

n=488

64%

p<0.001

David et al, J Thorac Cardiovasc Surg 2003;126:1143-1152
Mitral Regurgitation
Survival After Mitral Valve Surgery

Survival (percent)

Time (years)

FC I-II
81%
n=488
p<0.001
FC III-IV
58%

Late Outcomes of Mitral Valve Repair for Mitral Regurgitation Due to Degenerative Disease

Tirone E. David, MD; Susan Armstrong, MSc; Brian W. McCrindle MD; Cedric Manlhiot, BSc

**Background**—The pathology predisposing to mitral regurgitation (MR) is broad, and there are numerous degrees of severity and pathologies. This study examined survival after mitral valve repair (MVR) for degenerative MR.

**Methods and Results**—All patients (n=840) were prospectively followed with median follow-up of 10.4 years. Clinical, hemodynamic, and echocardiographic variables were collected. Survival was assessed as a function of the degree of MR, with severity of MR being a strong predictor of survival. Patients with severe MR had significantly lower survival rates compared to those with mild or moderate MR. The degree of myxomatous change, which is associated with increased MR severity, was also a significant predictor of survival. Patients with severe MR and severe myxomatous change had the poorest survival rates.

**Conclusions**—MV repair for degenerative MR is a feasible and safe procedure, and it is associated with excellent long-term survival. Patients with severe MR and severe myxomatous change have a higher risk of recurrent MR.

Mitral regurgitation

Indications for MV repair for asymptomatic primary MR:

- Chronic severe MR
- Preserved LV function
- Experienced surgical center
- Likelihood of durable repair without residual MR > 95%

- Repair better than mitral valve replacement
- Patients should be referred to centers experienced in repair

class IIa

class I
EDITORIAL COMMENT

The Time Has Come to Define Centers of Excellence in Mitral Valve Repair

Robert O. Bonow, MD, MS, David H. Adams, MD

J Am Coll Cardiol 2016;67:499-501

Center of Excellence in Mitral Valve Repair
Criteria include:
1) Mitral valve surgery volume requirement (center and surgeon)
2) Expert periprocedural imaging capabilities
3) Transparency regarding outcomes, including:
   Repair rates, mortality rates, stroke rates, and repair durability
Mitral regurgitation

Primary mitral regurgitation

Secondary mitral regurgitation

• Diagnostic dilemmas
• Therapeutic dilemmas
Imprecision in grading severity of secondary MR

Defining “Severe” Secondary Mitral Regurgitation
Emphasizing an Integrated Approach

Paul A. Grayburn, MD, Blasé Carabello, MD, Judy Hung, MD, Linda D. Gillam, MD, David Liang, MD, Michael J. Mack, MD, Patrick M. McCarthy, MD, D. Craig Miller, MD, Alfredo Trento, MD, Robert J. Siegel, MD

J Am Coll Cardiol 2014;54:2792-2801

What is “severe” secondary MR?
Ischemic Mitral Regurgitation
Long-Term Outcome and Prognostic Implications With Quantitative Doppler Assessment

Francesco Grigioni, MD; Maurice Enriquez-Sarano, MD; Kenton J. Zehr, MD; Kent R. Bailey, PhD; A. Jamil Tajik, MD


**Survival After MI**

- **MI without MR**: 61%
- **ERO 1-19**: 47%
- **ERO ≥20**: 29%

*p<0.001*

Grigioni et al. *Circulation* 2001;103:1759-1764
Valvular Heart Disease

Influence of Mitral Regurgitation Repair on Survival in the Surgical Treatment for Ischemic Heart Failure Trial

Marek A. Deja, Paul A. Grayburn, Benjamin Sun, Vivek Rao, Lilin She, Michal Krejca, Anil R. Jain, Yeow Leng Chua, Richard Daly, Michele Senni, Krzysztof Mokrzycki, Lorenzo Menicanti, Jae K. Oh, Robert Michler, Krzysztof Wrobel, Andre Lamy, Eric J. Velazquez, Kerry L. Lee and Robert H. Jones

*Circulation. 2012;125:2639-2648*

Ischemic Cardiomyopathy

- **No MR**: 30%
- **Mild MR**: 47%
- **Mod-Severe MR**: 55%

*p<0.001*

Deja et al. *Circulation* 2012;125:2639-2648
## Prevalence of MR in Patients with LV Dysfunction

<table>
<thead>
<tr>
<th>Study</th>
<th>Journal</th>
<th>N</th>
<th>MR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yiu et al</td>
<td>Circulation 2000</td>
<td>128</td>
<td>63%</td>
</tr>
<tr>
<td>Grigioni et al</td>
<td>Circulation 2001</td>
<td>303</td>
<td>64%</td>
</tr>
<tr>
<td>Koelling et al</td>
<td>Am Heart J 2002</td>
<td>1436</td>
<td>49%</td>
</tr>
<tr>
<td>Trichon et al</td>
<td>Am J Cardiol 2003</td>
<td>2057</td>
<td>56%</td>
</tr>
<tr>
<td>Robbins et al</td>
<td>Am J Cardiol 2003</td>
<td>221</td>
<td>59%</td>
</tr>
<tr>
<td>Cleland et al</td>
<td>N Engl J Med 2004</td>
<td>605</td>
<td>50%</td>
</tr>
<tr>
<td>Grayburn et al</td>
<td>J Am Coll Cardiol 2005</td>
<td>336</td>
<td>77%</td>
</tr>
<tr>
<td>Bursi et al</td>
<td>Circulation 2005</td>
<td>303</td>
<td>50%</td>
</tr>
<tr>
<td>Acker et al</td>
<td>J Thorac CV Surg 2006</td>
<td>300</td>
<td>66%</td>
</tr>
<tr>
<td>Di Mauro et al</td>
<td>Ann Thorac Surg 2006</td>
<td>239</td>
<td>75%</td>
</tr>
<tr>
<td>Rossi et al</td>
<td>Heart 2011</td>
<td>1300</td>
<td>74%</td>
</tr>
<tr>
<td>Deja et al</td>
<td>Circulation 2012</td>
<td>599</td>
<td>63%</td>
</tr>
<tr>
<td>Onishi et al</td>
<td>Circ Heart Fail 2013</td>
<td>277</td>
<td>48%</td>
</tr>
</tbody>
</table>

*Patients with moderate to severe MR*
Secondary mitral regurgitation:
...a marker of a sicker LV
- or -
...a contributor to a sicker LV?
Secondary mitral regurgitation:
...a marker of a sicker LV
- or -
...a therapeutic target?

Therapies that produce beneficial reverse remodeling also reduce severity of functional MR
Secondary mitral regurgitation can be repaired. But should it be repaired? ... or replaced?

Unlike repair of myxomatous MR, repair of secondary MR is often not durable.
Mitral-Valve Repair versus Replacement for Severe Ischemic Mitral Regurgitation


Recurrent MR at 12 months
MV repair: 33%
MV replacement: 2%

Death (%)

HR=0.79 (95% CI 0.72, 1.47)
p=0.45

MV replacement (n=125)
MV repair (n=126)

Time (months)

Mitral-Valve Repair versus Replacement for Severe Ischemic Mitral Regurgitation

Two-Year Outcomes of Surgical Treatment of Severe Ischemic Mitral Regurgitation


HR=0.79 (95% CI 0.46, 1.35) p=0.39

Death (%) vs Time (months)

MV replacement (n=125)
MV repair (n=126)

Two-Year Outcomes of Surgical Treatment of Severe Ischemic Mitral Regurgitation

<table>
<thead>
<tr>
<th>Time</th>
<th>Repair (No MR)</th>
<th>Repair (Recurrence)</th>
<th>Replace (No MR)</th>
<th>Replace (Recurrence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 days</td>
<td>30%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>38%</td>
<td>5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 months</td>
<td>45%</td>
<td>9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 months</td>
<td>46%</td>
<td>12%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Death
- No MR
- MR
- Recurrence

Percent of Patients.
Correction of Mitral Regurgitation in Nonresponders to Cardiac Resynchronization Therapy by MitraClip Improves Symptoms and Promotes Reverse Remodeling

Angelo Auricchio, MD, PhD,* Wolfgang Schillinger, MD,† Sven Meyer, MD,‡ Francesco Maisano, MD,§ Rainer Hoffmann, MD,|| Gian Paolo Ussia, MD,¶ Giovanni B. Pedrazzini, MD,* Jan van der Heyden, MD,# Simona Fratini, MD, P. Catherine Klersy, MD, MSc,†† Jan Komtebedde, DVM,* Olaf Franzen, MD,‡ on behalf of the PERMIT-CARE Investigators

Lugano, Switzerland; Göttingen, Hamburg, and Aachen, Germany; Milan, Catania, L’Aquila, and Pavia, Italy; and Nieuwegein, the Netherlands

J Am Coll Cardiol 2011;58:2183–9
Indications for mitral valve surgery:

• Patients with severe MR, persistent symptoms despite optimal medical therapy, including CRT
  class IIa

• Severe MR, persistent symptoms despite optimal medical therapy, including CRT
  class IIb

• Patients with moderate MR undergoing CABG or AVR
  class IIb

Secondary mitral regurgitation

Guideline-directed medical therapy for heart failure, including CRT

Guideline-
directed medical therapy for heart failure, including CRT
Prevalence of Heart Failure
United States

Source: NHANES, CDC, and American Heart Association
Atrial Fibrillation: Prevalence with Aging
The ATRIA Study

The ATRIA Study

Age Group (years)

Prevalence (percent)

Men
Women

n=17,974

Go et al, *JAMA* 2001;285:2370-2375
Evidence of Atrial Functional Mitral Regurgitation Due to Atrial Fibrillation
Reversal With Arrhythmia Control

Zachary M. Gertz, MD,* Amresh Raina, MD,* Laszlo Saghy, MD,† Erica S. Zado, PA-C,* David J. Callans, MD,* Francis E. Marchlinski, MD,* Martin G. Keane, MD,* Frank E. Silvestry, MD*
Philadelphia, Pennsylvania; and Szeged, Hungary

J Am Coll Cardiol 2011;58:1474–81

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Follow-up</th>
</tr>
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<tbody>
<tr>
<td>Recurrent AF</td>
<td>36%</td>
<td>18%</td>
</tr>
<tr>
<td>Sinus rhythm</td>
<td>29%</td>
<td>19%</td>
</tr>
<tr>
<td>Recurrent AF</td>
<td>64%</td>
<td>64%</td>
</tr>
<tr>
<td>Sinus rhythm</td>
<td>71%</td>
<td>57%</td>
</tr>
</tbody>
</table>

Percent of Patients

Severe
Moderate
Mild
Trace/none
Burden of valvular heart diseases: a population-based study

Vuyisile T Nkomo, Julius M Gardin

Moderate-Severe Mitral Valve Disease

28,412 subjects

Percent

ARIC, CHS, CARDIA (n=11,911)
Olmstead County (n=16,501)

Age

<45 45-54 55-64 65-74 ≥75

Nkomo et al, Lancet 2006;368:1005-1011
Burden of valvular heart diseases: a population-based study

Vuyisile T Nkomo, Julius M Gardin

Moderate-Severe Aortic Valve Disease

ARIC, CHS, CARDIA (n=11,911)
Olmstead County (n=16,501)

28,412 subjects

Percent

Age

<45 45-54 55-64 65-74 ≥75

Nkomo et al, Lancet 2006;368:1005-1011
Aortic Stenosis

Age >60

- All patients: 47%
- Men: 51%

Roberts and Ko, *Circulation* 2005;111:920-925

from Otto and Bonow, Valvular Heart Disease
*Braunwald’s Heart Disease*, 10th ed, 2014
## Stages of Aortic Stenosis

<table>
<thead>
<tr>
<th>Stage</th>
<th>Definition</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Risk of valve disease</td>
<td>BAV, RHD, CVD risk</td>
</tr>
<tr>
<td>B</td>
<td>Mild - moderate asymptomatic disease</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Severe valve disease but asymptomatic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C1: Normal LV function</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C2: Depressed LV function</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Severe, symptomatic valve disease</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D1: High gradient AS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D2: Low gradient, LV dysfunction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D3: Low gradient, normal LV function</td>
<td></td>
</tr>
</tbody>
</table>
Aortic-Valve Stenosis — From Patients at Risk to Severe Valve Obstruction

Catherine M. Otto, M.D., and Bernard Prendergast, D.M.

The advent of corrective operations for various forms of heart disease has placed increasing emphasis upon the need for accurate information concerning the natural history of patients with potentially correctible lesions. An understanding of the natural course assumes particular importance in the case of aortic stenosis because of the significant incidence of sudden death associated with this disease and the grave prognosis that appears to accompany the onset of certain symptoms, patients with isolated valvular aortic stenosis of rheumatic etiology and patients without a history of rheumatic fever who have isolated calcific aortic stenosis; many of the latter patients are now considered to have developed calcification and stenosis of a congenitally bicuspid valve. The review will focus primarily on the prognostic significance of three major symptoms—angina pectoris, syncope, and symptoms related to left ventricular failure.
Aortic Stenosis

By John Ross, Jr., M.D. and Eugene Braunwald, M.D.

The advent of corrective operations for various forms of heart disease has placed increasing emphasis upon the need for accurate information concerning the natural history of patients with potentially correctible lesions. An understanding of aortic stenosis assumes particular importance in patients with isolated valvular aortic stenosis of rheumatic etiology and patients without a history of rheumatic fever who have isolated calcific aortic stenosis; many of the latter patients are now considered to have developed disease and the grave prognosis to accompany the onset of symptoms.

From the Cardiology Branch, National Heart Institute, Bethesda, Maryland.

Supplement V to Circulation, Vol. XXXVI

Ross and Braunwald, Am J Circulation 1968;38:V-61
Evaluation of Patients With Severe Symptomatic Aortic Stenosis Who Do Not Undergo Aortic Valve Replacement

The Potential Role of Subjectively Overestimated Operative Risk

David S. Bach, MD; Derrick Siao, MD; Steven E. Girard, MD, PhD; Claire Duvernoy, MD; Benjamin C. Smith, MD; William H. Liberman, MD; Daniel L. Breyman, MD; Mark S. Hachamovitch, MD; Stephen J. Ellenbogen, MD; Eric J. Topol, MD

Aortic Stenosis
Survival of Symptomatic Patients

Survival (percent)

Time (months)

Bach et al, Circ Cardiovasc Qual Outcomes 2009;2:533-539
Aortic Stenosis

Indications for AVR

- Symptomatic patients with severe AS

class I
Aortic Stenosis

Management challenges:

• The asymptomatic patient with severe AS
• Low-flow, low gradient severe AS
• Indications for TAVR
Aortic Stenosis

Management challenges:

• The asymptomatic patient with severe AS
• Low-flow, low gradient severe AS
• Indications for TAVR
Aortic stenosis

Indications for valve replacement

**Exercise test results:**

- Symptoms (class I)
- Hypotension (class IIa)

Should *asymptomatic* patients with severe AS undergo AVR? 
...when they are *really* asymptomatic?
Aortic Stenosis

84 year old man with severe AS

- Watchful waiting?
- More data (more testing)?
- Aortic valve replacement?
Natural History of Severe Asymptomatic AS

Pellikka et al. Circulation 2005;111:3290-2395
Stewart et al. Eur Heart J 2010;31:2216-2222

Vmax > 4.0 m/s
Natural History of Severe Asymptomatic AS

Natural History of Severe Asymptomatic AS

![Graph showing event-free survival over time for different Vmax values.

Vmax 4.0 – 5.0 m/s
Vmax 5.0 – 5.5 m/s
Vmax >5.5 m/s

n=198
p<0.001

Rosenhek et al. Circulation 2010;121:151-156]
Aortic Stenosis

Management challenges:

• The asymptomatic patient with severe AS
• Low-flow, low gradient severe AS

Indications for TAVR

What is the risk of death while waiting for symptoms to trigger AVR?
Natural History of Severe Asymptomatic AS

Survival (%)

Time (years)

Kang et al. Circulation 2010;121:1502-1509
Nistri et al. Am J Cardiol 2012;109;718-723
Average hospital mortality: 8.8%

- Low volume centers: 13.0%
- High volume centers: 6.0%


31% of patients who developed symptoms did not have AVR → 17 deaths
Aortic stenosis

Indications for valve replacement in asymptomatic patients:

- Very severe AS: \( V_{\text{max}} \geq 5 \text{ m/s} \) (class IIa)
- Rapid progression and low surgical risk (class IIb)
Aortic stenosis

The ACC/AHA guidelines have lowered the threshold for surgery in asymptomatic patients with AS

- Severity of AS
- Severity of calcification
- Left ventricular function
- Exercise response
- BNP?
Aortic stenosis

The ACC/AHA guidelines have lowered the threshold for surgery in asymptomatic patients with AS...but there needs to be renewed emphasis on the class I indications for surgery in *symptomatic* patients with severe AS.
Aortic stenosis

Management challenges:

• The asymptomatic patient with severe AS
• Low-flow, low gradient severe AS
• Indications for TAVR
Diastole

- Normal Flow
  - High Gradient
  - Normal LV Function

- Low Flow
  - Low Gradient
  - LV Dysfunction

Systole

- Low Flow
  - Low Gradient
  - Normal LV Function

- Dobutamine echocardiography

- Clinical skillset
  - Valve calcification
  - Myocardial strain
  - Myocardial fibrosis
Inconsistent grading of aortic valve stenosis by current guidelines: haemodynamic studies in patients with apparently normal left ventricular function

Jan Minners, Martin Allgeier, Christa Gohlke-Baerwolf, Rolf-Peter Kienzle, Franz-Josef Neumann, Nikolaus Jander

Heart 2010;96:1463–1468
Low-Flow, Low-Gradient Aortic Stenosis With Normal and Depressed Left Ventricular Ejection Fraction

Philippe Pibarat, DVM, PtId, Jean G. Dumesnil, MD
Québec City, Québec, Canada

Clavel et al, J Am Coll Cardiol 2013;62:2239-2238
Ozkan et al, Nat Review Cardiol 2011;8:494-501
Herrmann et al, J Am Coll Cardiol 2011;58:402-412
Low Flow, Low Gradient Aortic Stenosis

Indications for valve replacement:

• Normal EF, if clinical, hemodynamic and anatomic data support severe AS

class IIa
Aortic stenosis

Management challenges:

• The asymptomatic patient with severe AS
• Low-flow, low gradient severe AS
• Indications for TAVR
Indications for TAVR vs surgical AVR:

- Evaluation by a Heart Team
- Surgical AVR for patients at low or intermediate risk
- TAVR for patients with prohibitive surgical risk and life expectancy >12 months
- TAVR alternative for patients at high surgical risk
Indications for TAVR vs surgical AVR:

- Evaluation by a Heart Team (class I)
- Surgical AVR for patients at low or intermediate risk (class I)
- TAVR for patients with prohibitive surgical risk and life expectancy >12 months (class I)
- TAVR alternative for patients at high surgical risk (class IIa)
- TAVR as alternative? (class I?)
AVR mortality
STS Database
n=141,905

TAVR mortality
Clinical Trials
n=3532

High Risk
Intermediate Risk
Low Risk

30-Day Mortality (percent)


PARTNER A
PARTNER II S3 High Risk
CoreValve High Risk
PARTNER IIa S3 Intermed Risk
CoreValve Intermed Risk
NOTION
Aortic Valve Replacement
Hospital Mortality

Medicare 1999-2011

30 Day AVR Mortality (percent)

Year

1999 2001 2003 2005 2007 2009 2011

N=24,900 N=33,441

7.6% 4.2%

Barreto-Filho et al, JAMA 2013;210:2078-2085
Aortic Valve Replacement
Hospital Mortality

Medicare 1999-2011

30 Day AVR Mortality (percent)

Year

1999 2001 2003 2005 2007 2009 2011

Age ≥85
12.3%
5.8%

Age 75-84
5.9%

Age 65-74
3.3%

Barreto-Filho et al, JAMA 2013;210:2078-2085
TAVR Now

- TAVR has been truly transformative
- Surgical AVR remains the standard with proven durability and safety for most patients
- TAVR provides treatment options for patients who previously had no options other than a predictably very poor short term outcome
- TAVR is an alternative to SAVR in patients at high surgical risk
- The threshold for TAVR is declining in clinical trials, registries and clinical practice
- All patients want this
TAVR in the Future

- Guidelines will need to adapt to the rapidly evolving TAVR evidence base

**TAVR in intermediate and low risk surgical patients**

- Availability of TAVR is likely to inform new indications for valve replacement
  - Moderate AS in primary cardiomyopathy
  - Asymptomatic severe AS?

- Judgment of the Heart Team remains essential in patient selection for TAVR

- Appropriate use criteria and performance measures are needed to define quality
Aortic stenosis is a simple mechanical fault which, if severe enough, imposes a heavy burden on the left ventricle and sooner or later overcomes it.