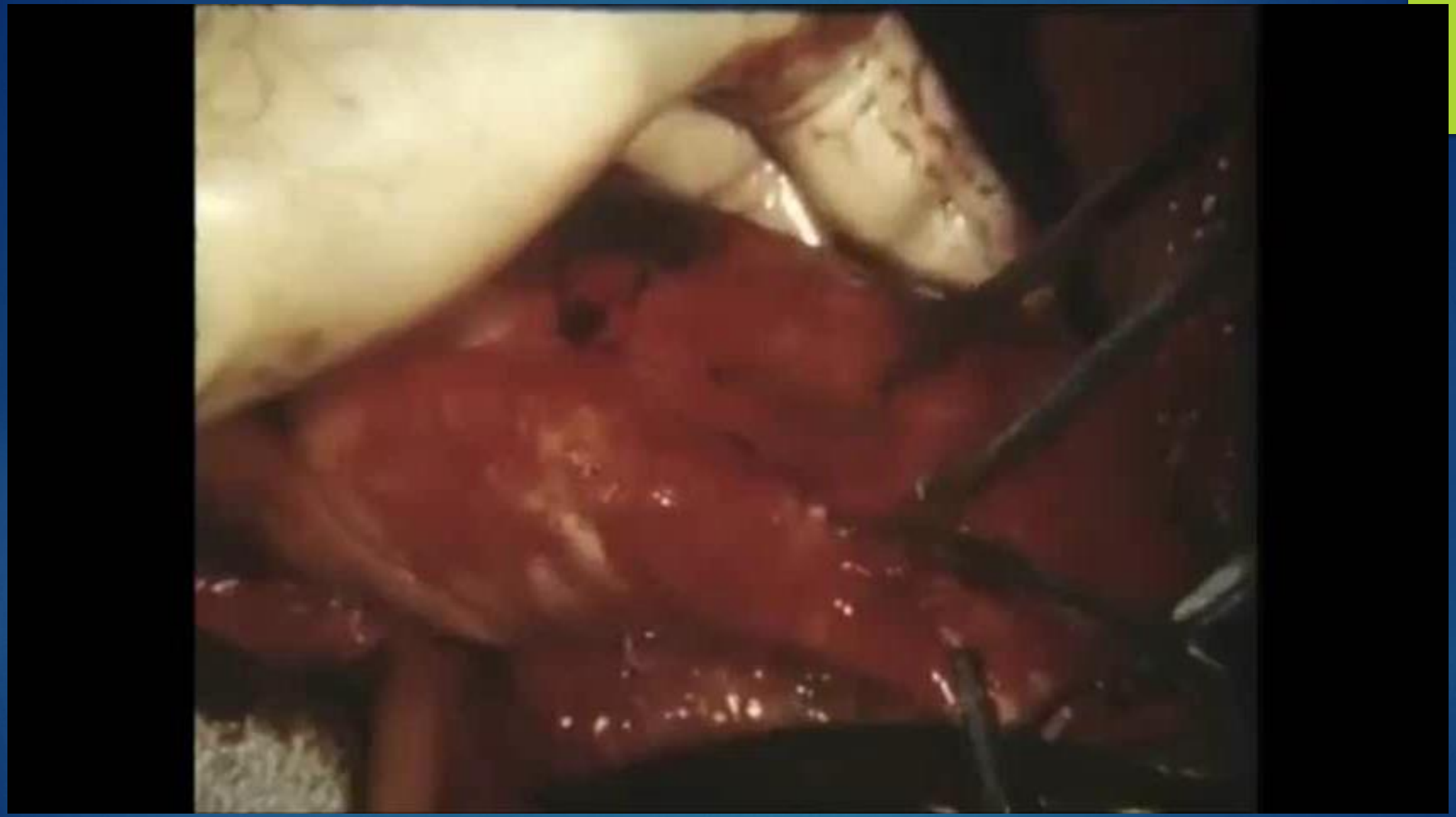
말기 심부전의 수술적 치료

성균관의대 삼성서울병원
부교수 조양현



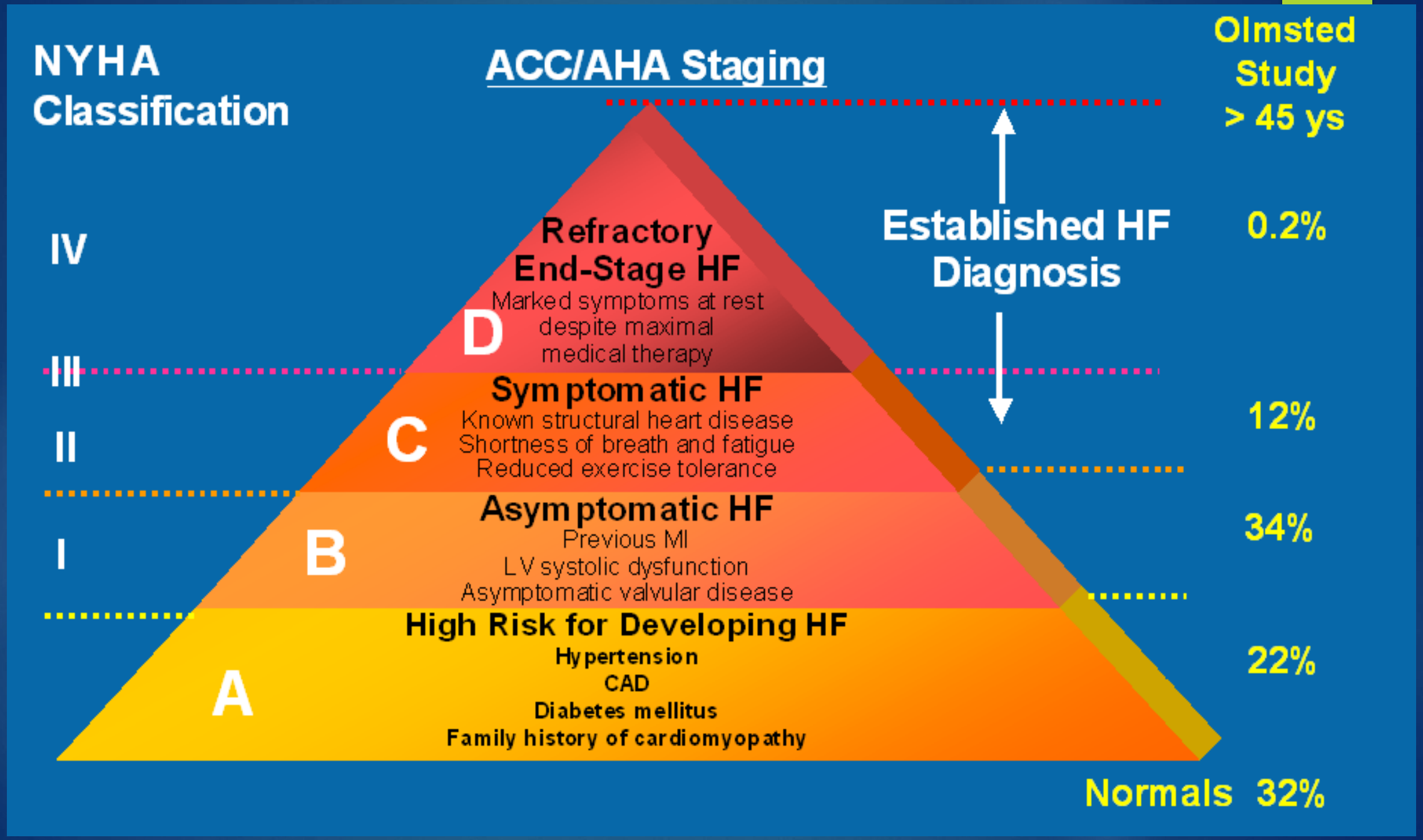
April 4, 1969

Heart Transplantation

7.4.6. Cardiac Transplantation: Recommendation

Class I

1. **Evaluation for cardiac transplantation is indicated for carefully selected patients with stage D HF despite GDMT, device, and surgical management.**[680] ***(Level of Evidence: C)***


NYHA Classification
ACC/AHA Staging
Olmsted Study > 45 ys
IV
III
II
I
Established HF Diagnosis
D
Refractory End-Stage HF
Marked symptoms at rest despite maximal medical therapy
0.2%
C
Symptomatic HF
Known structural heart disease
Shortness of breath and fatigue
Reduced exercise tolerance
12%
B
Asymptomatic HF
Previous MI
LV systolic dysfunction
Asymptomatic valvular disease
34%
A
High Risk for Developing HF
Hypertension
CAD
Diabetes mellitus
Family history of cardiomyopathy
22%
Normals 32%

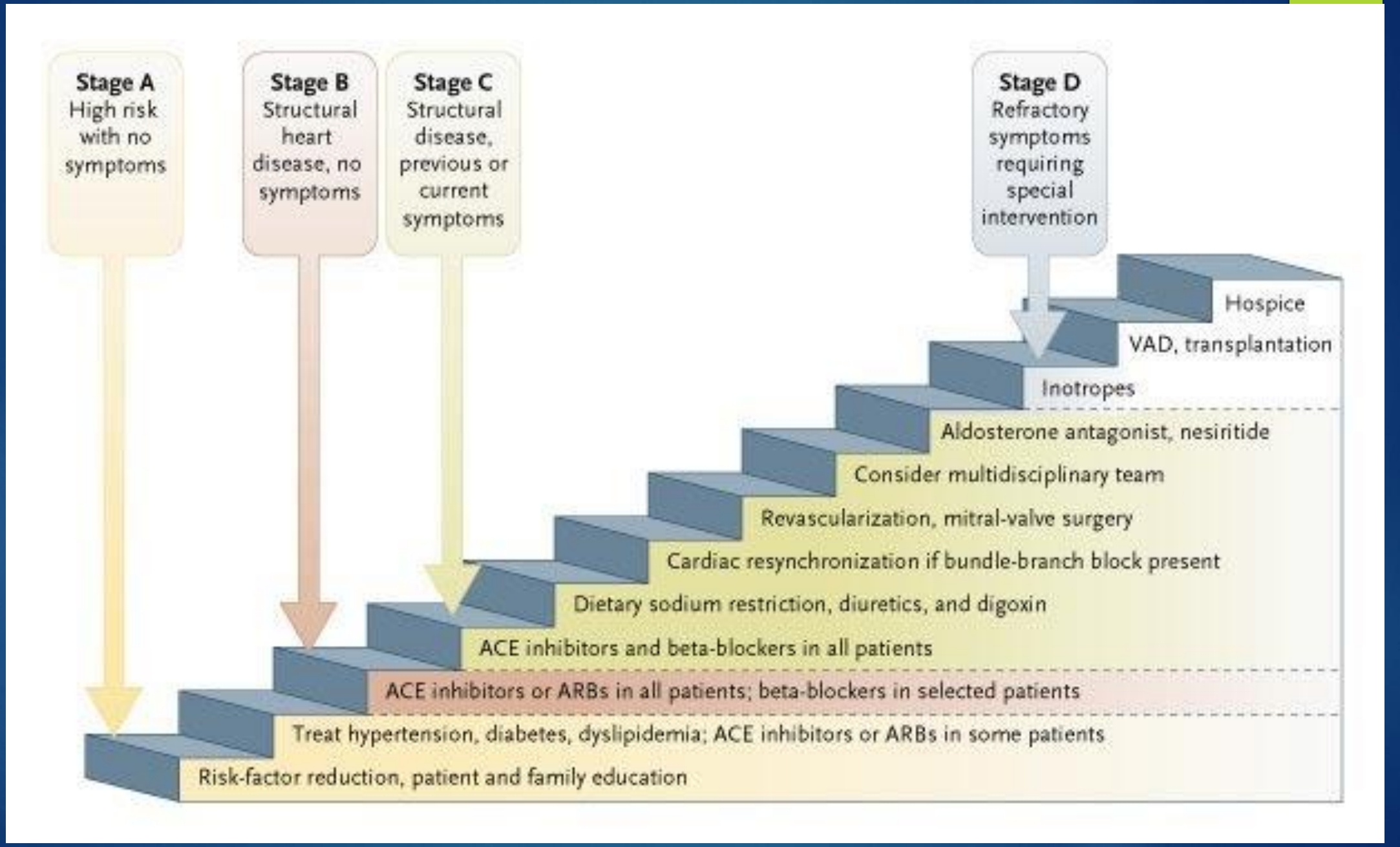

Stage A
High risk with no symptoms
Stage B
Structural heart disease, no symptoms
Stage C
Structural disease, previous or current symptoms
Stage D
Refractory symptoms requiring special intervention
Hospice
VAD, transplantation
Inotropes
Aldosterone antagonist, nesiritide
Consider multidisciplinary team
Revascularization, mitral-valve surgery
Cardiac resynchronization if bundle-branch block present
Dietary sodium restriction, diuretics, and digoxin
ACE inhibitors and beta-blockers in all patients
ACE inhibitors or ARBs in all patients; beta-blockers in selected patients
Treat hypertension, diabetes, dyslipidemia; ACE inhibitors or ARBs in some patients
Risk-factor reduction, patient and family education

Table 23. ESC Definition of Advanced HF

1. Severe symptoms of HF with dyspnea and/or fatigue at rest or with minimal exertion (NYHA class III or IV)
2. Episodes of fluid retention (pulmonary and/or systemic congestion, peripheral edema) and/or reduced cardiac output at rest (peripheral hypoperfusion)
3. Objective evidence of severe cardiac dysfunction shown by at least 1 of the following:
   a. LVEF <30%
   b. Pseudonormal or restrictive mitral inflow pattern
   c. Mean PCWP >16 mm Hg and/or RAP >12 mm Hg by PA catheterization
   d. High BNP or NT-proBNP plasma levels in the absence of noncardiac causes
4. Severe impairment of functional capacity shown by 1 of the following:
   a. Inability to exercise
   b. 6-Minute walk distance ≤300 m
   c. Peak $\dot{V}o_2$ <12 to 14 mL/kg/min
5. History of ≥1 HF hospitalization in past 6 mo
6. Presence of all the previous features despite "attempts to optimize" therapy, including diuretics and GDMT, unless these are poorly tolerated or contraindicated, and CRT when indicated

Table 24. Clinical Events and Findings Useful for Identifying Patients With Advanced HF

Repeated (≥2) hospitalizations or ED visits for HF in the past year
Progressive deterioration in renal function (eg, rise in BUN and creatinine)
Weight loss without other cause (eg, cardiac cachexia)
Intolerance to ACE inhibitors due to hypotension and/or worsening renal function
Intolerance to beta blockers due to worsening HF or hypotension
Frequent systolic blood pressure <90 mm Hg
Persistent dyspnea with dressing or bathing requiring rest
Inability to walk 1 block on the level ground due to dyspnea or fatigue
Recent need to escalate diuretics to maintain volume status, often reaching daily furosemide equivalent dose >160 mg/d and/or use of supplemental metolazone therapy
Progressive decline in serum sodium, usually to <133 mEq/L
Frequent ICD shocks

BOX 98-2 Recipient Contraindications to Heart Transplantation

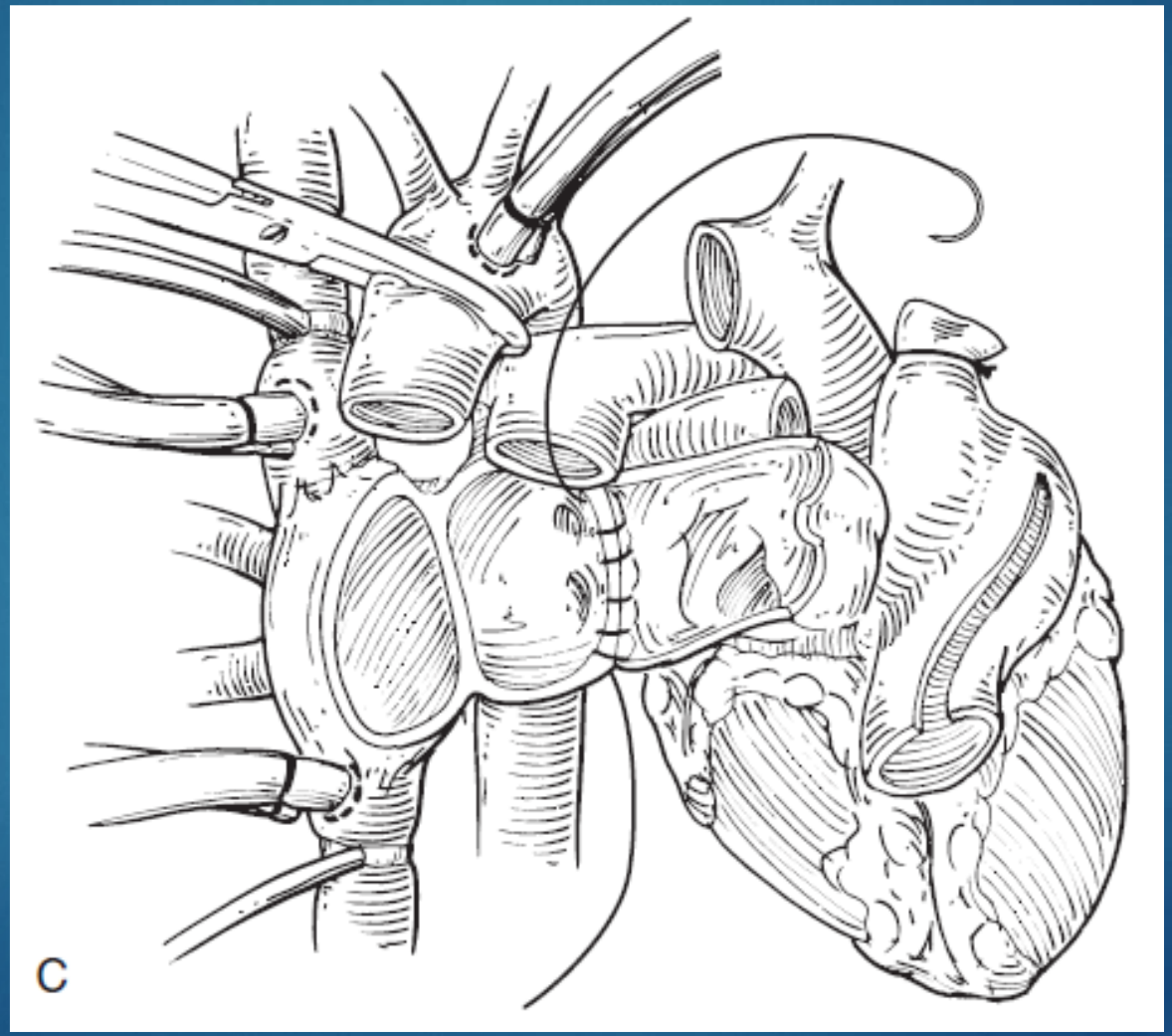
Absolute Contraindications

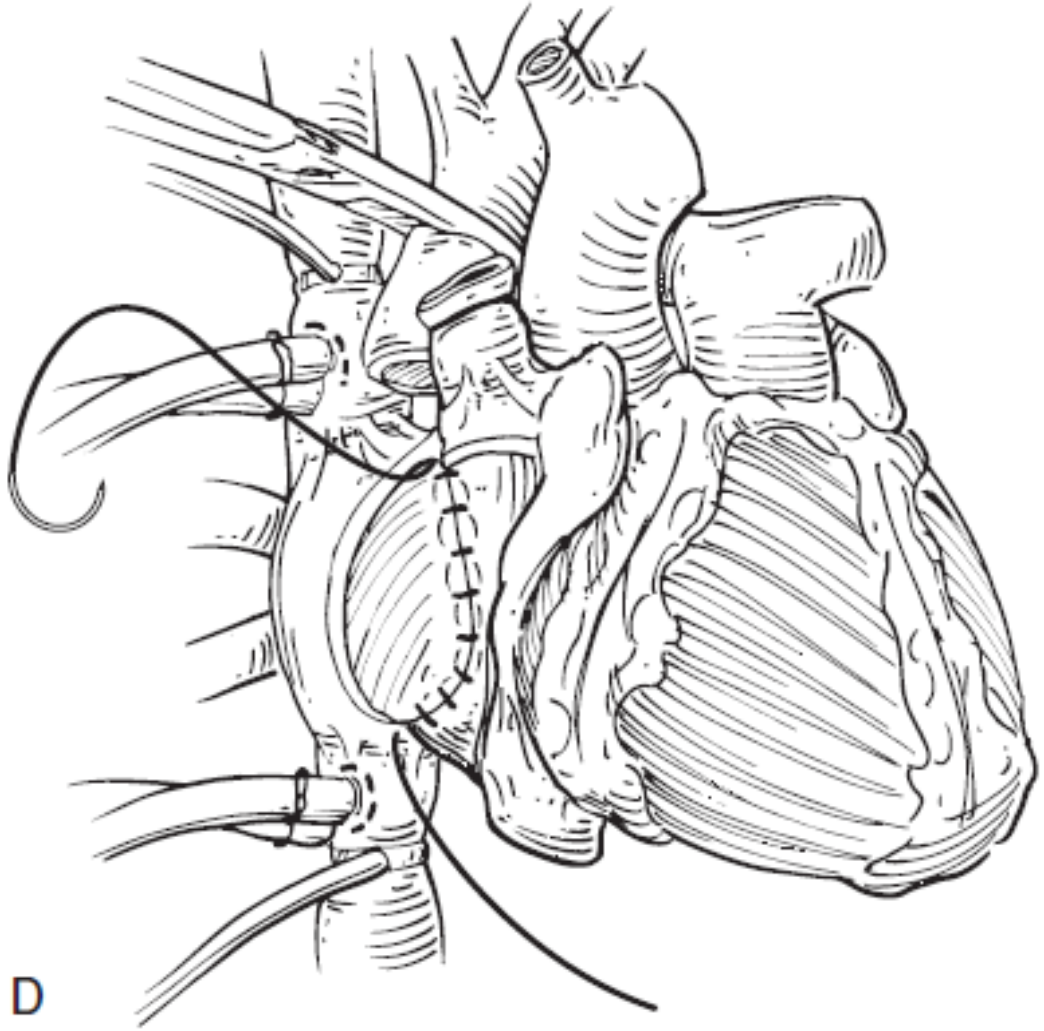
- Pulmonary hypertension (PVR > 6 Wood units despite maximal therapy)
- Significant irreversible renal dysfunction (e.g., creatinine clearance < 50 mg/mL/min)
- Significant irreversible hepatic dysfunction (e.g., bilirubin > 3.0 mg/dL)
- Active malignancy

Relative Contraindications

- Active infection (except in the setting of severe device complication, which is a status 1A criterion)
- Age older than 65 years
- Peripheral vascular disease not amenable to surgical or percutaneous therapy
- Diabetes mellitus with secondary organ damage
- Severe lung disease
- Uncorrected abdominal aortic aneurysm greater than 4 to 6 cm
- Systemic infection with immune suppression risk (human immunodeficiency virus, hepatitis B virus, cytomegalovirus)
- Obesity
- Osteoporosis
- Active peptic ulcer disease
- Substance abuse
- Psychiatric disorder
- Noncompliance with medical care

심장이식 수술





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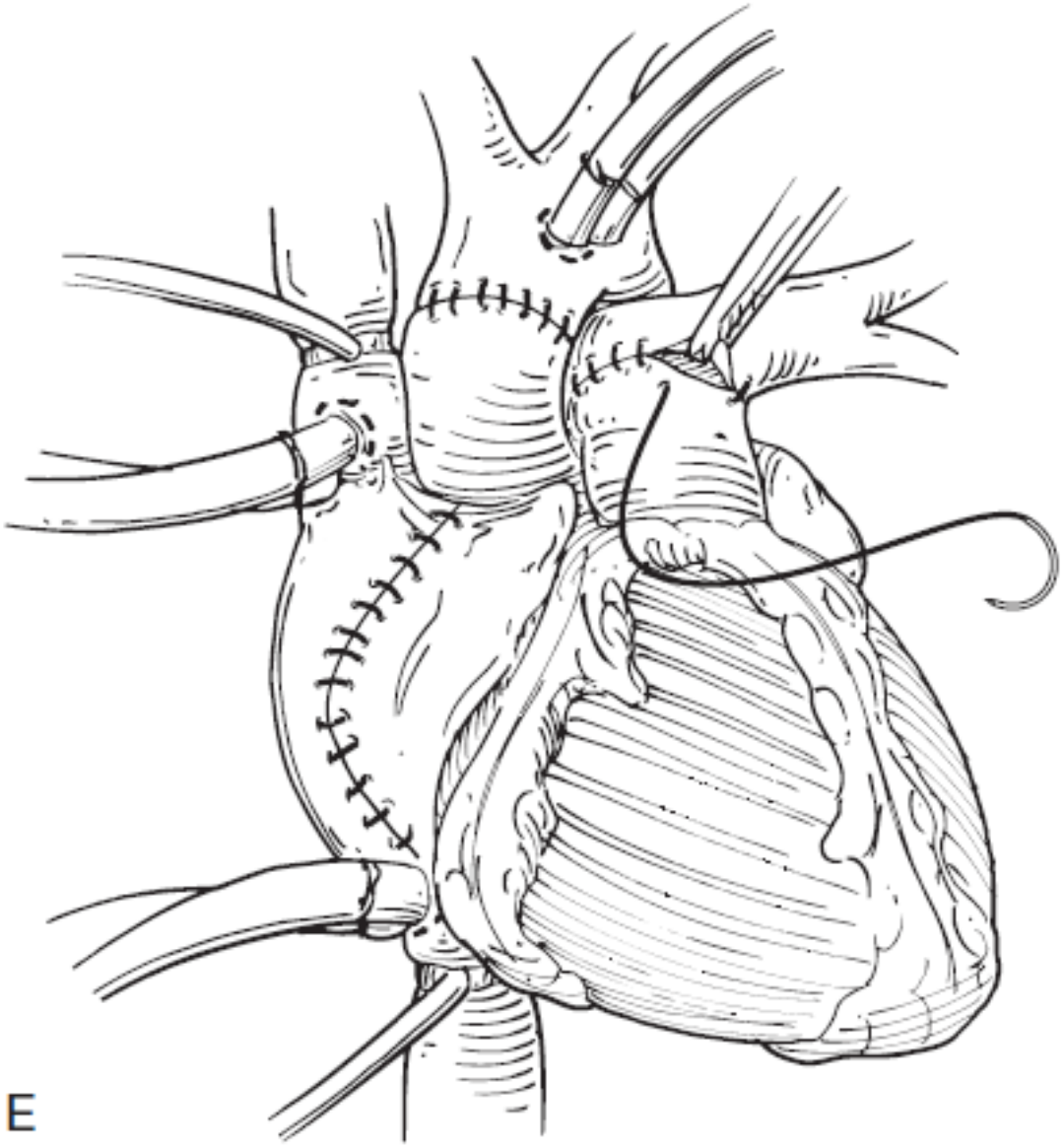

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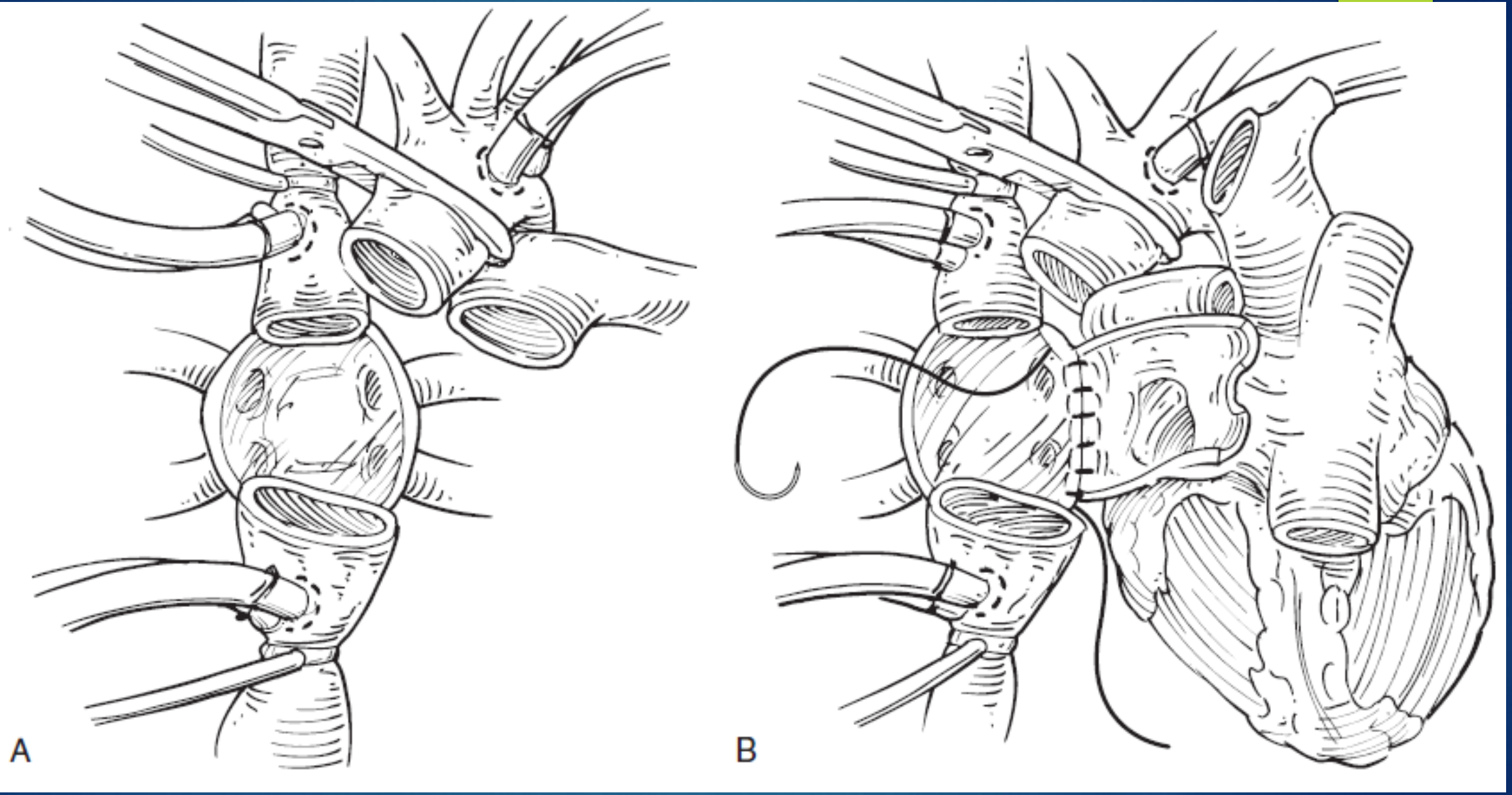
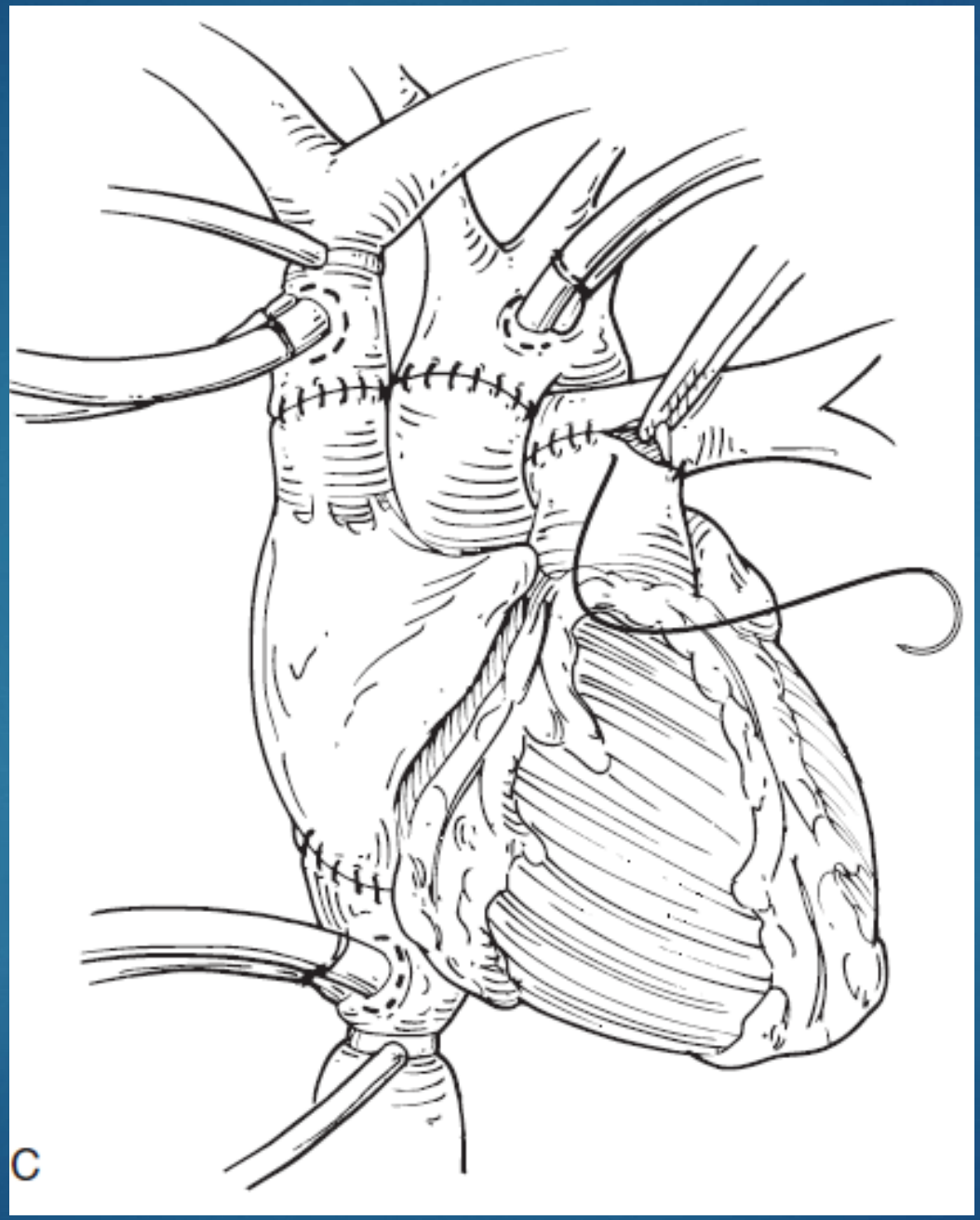
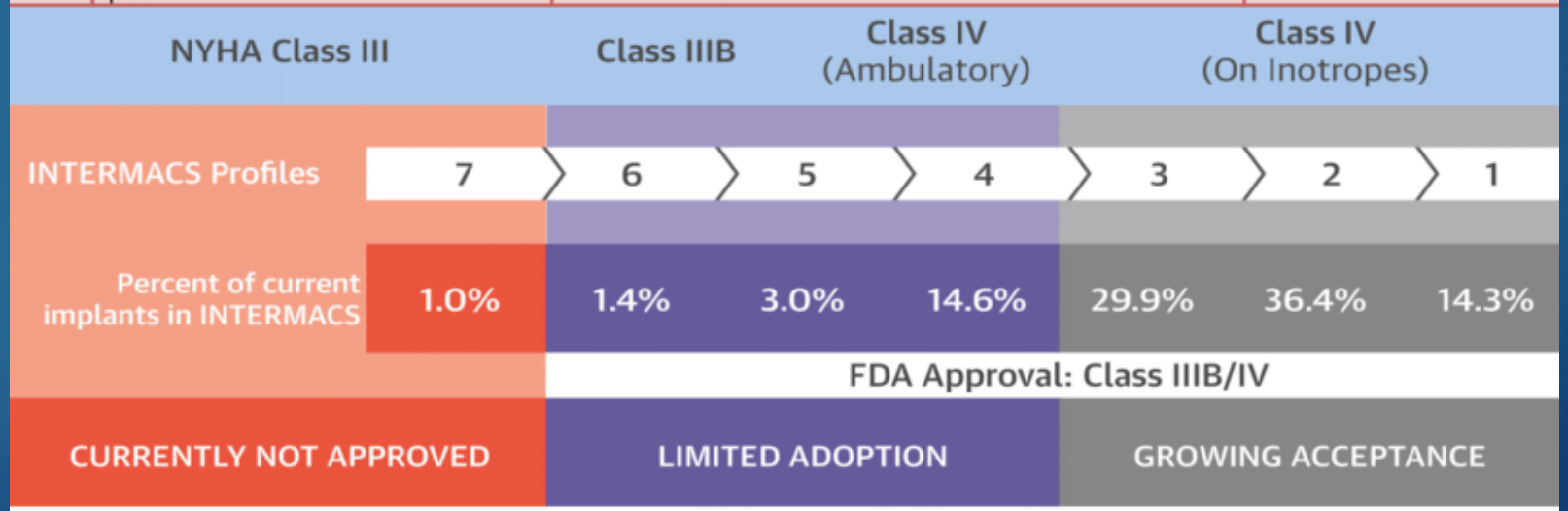

A
B


C

Durable Mechanical Circulatory Support

Level	Description	Hemodynamic Status	Time Frame for Intervention
1	Critical cardiogenic shock, "crash and burn"	Persistent hypotension despite rapidly escalating inotropic support and eventually IABP, and critical organ hypoperfusion	Within hours
2	Progressive decline on inotropic support, "sliding on inotropes"	Intravenous inotropic support with acceptable values of blood pressure and continuing deterioration in nutrition, renal function, or fluid retention	Within days
3	Stable but inotrope dependent, "dependent stability"	Stability reached with mild to moderate doses of inotropes but demonstrating failure to wean from them because of hypotension, worsening symptoms, or progressive renal dysfunction	Elective over weeks to months
4	Resting symptoms, "frequent flyer"	Possible weaning of inotropes but experiencing recurrent relapses, usually fluid retention	Elective over weeks to months
5	Exertion intolerant, housebound	Severe limited tolerance for activity, comfortable at rest with some volume overload and often with some renal dysfunction	Variable urgency, dependent on nutrition and organ function
6	Exertion limited, "walking wounded"	Less severe limited tolerance for activity and lack of volume overload, fatigue easily	Variable urgency, dependent on nutrition and organ function
7	Advanced NYHA III "symptoms, placeholder"	Patient without current or recent unstable fluid balance, NYHA class II or III	Not currently indicated



INTERMACS indicates Interagency Registry for Mechanically Assisted Circulatory Support; IABP, intra-aortic balloon pump; and NYHA, New York Heart Association.

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VOLUME 345 NOVEMBER 15, 2001 NUMBER 20

LONG-TERM USE OF A LEFT VENTRICULAR ASSIST DEVICE FOR END-STAGE HEART FAILURE

ERIC A. ROSE, M.D., ANNETINE C. GELIJNS, PH.D., ALAN J. MOSKOWITZ, M.D., DANIEL F. HEITJAN, PH.D., LYNNE W. STEVENSON, M.D., WALTER DEMBITSKY, M.D., JAMES W. LONG, M.D., PH.D., DEBORAH D. ASCHEIM, M.D., ANITA R. TIERNEY, M.P.H., RONALD G. LEVITAN, M.SC., JOHN T. WATSON, PH.D., AND PAUL MEIER, PH.D., FOR THE RANDOMIZED EVALUATION OF MECHANICAL ASSISTANCE FOR THE TREATMENT OF CONGESTIVE HEART FAILURE (REMATCH) STUDY GROUP*

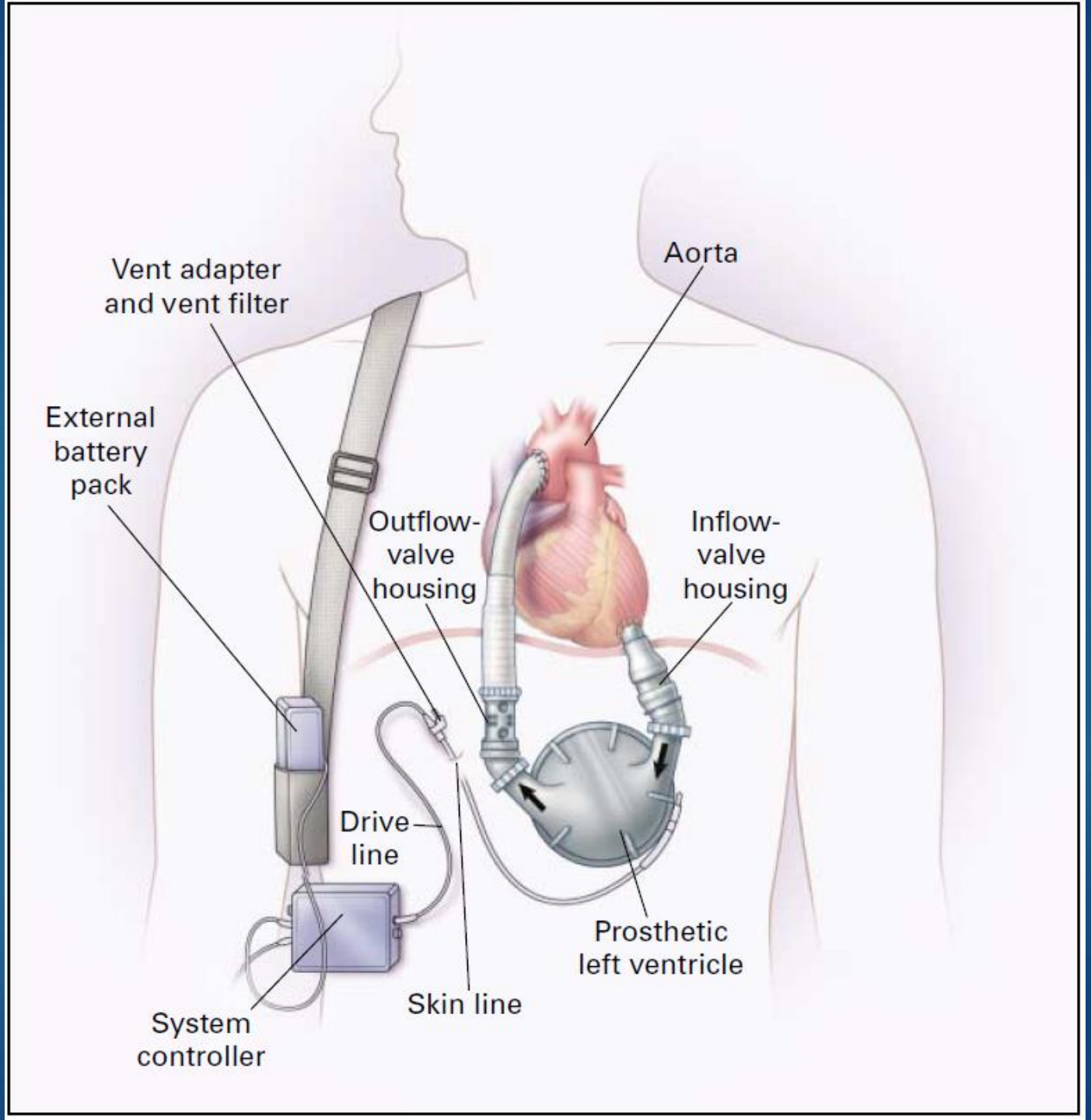
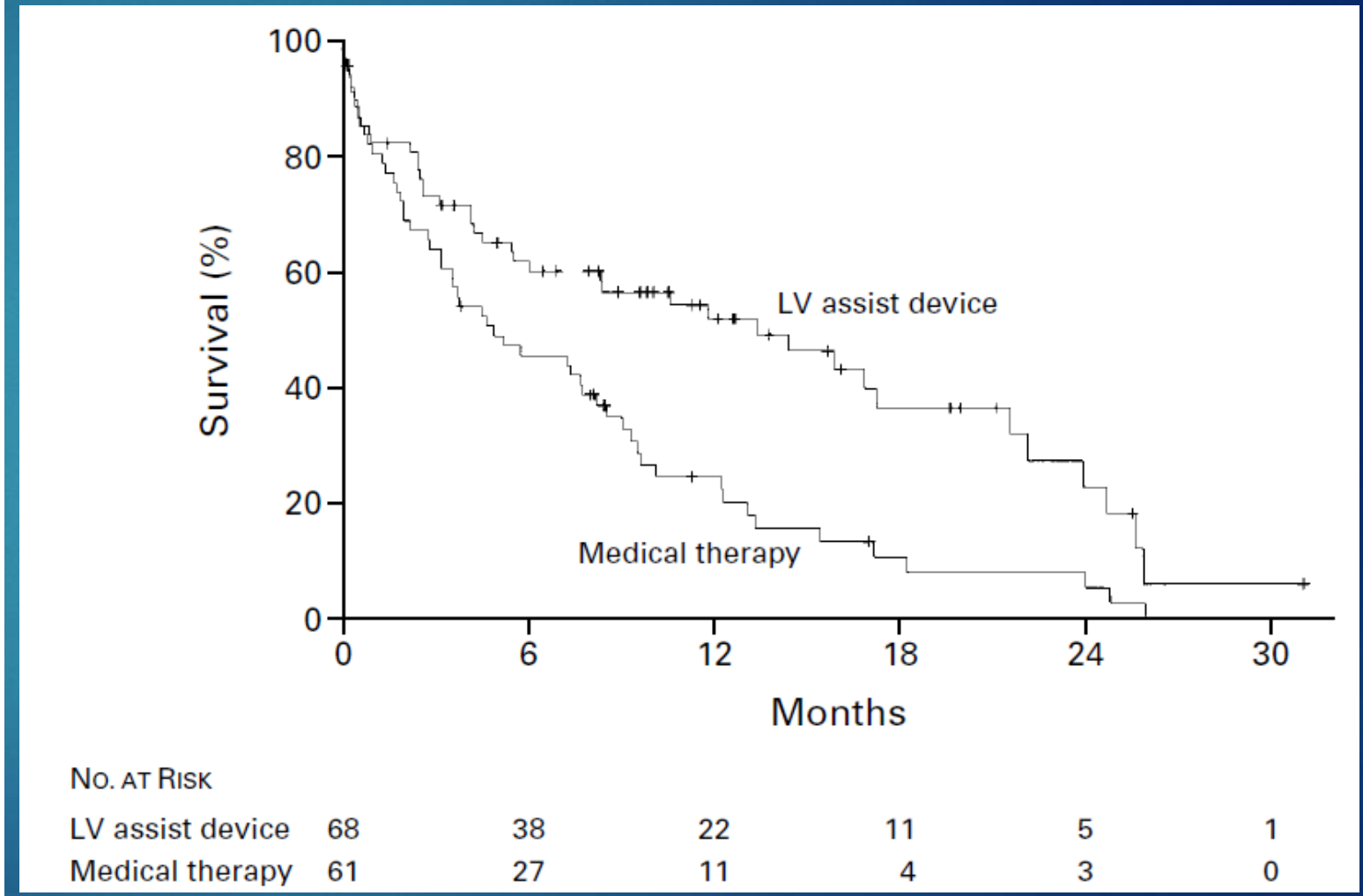
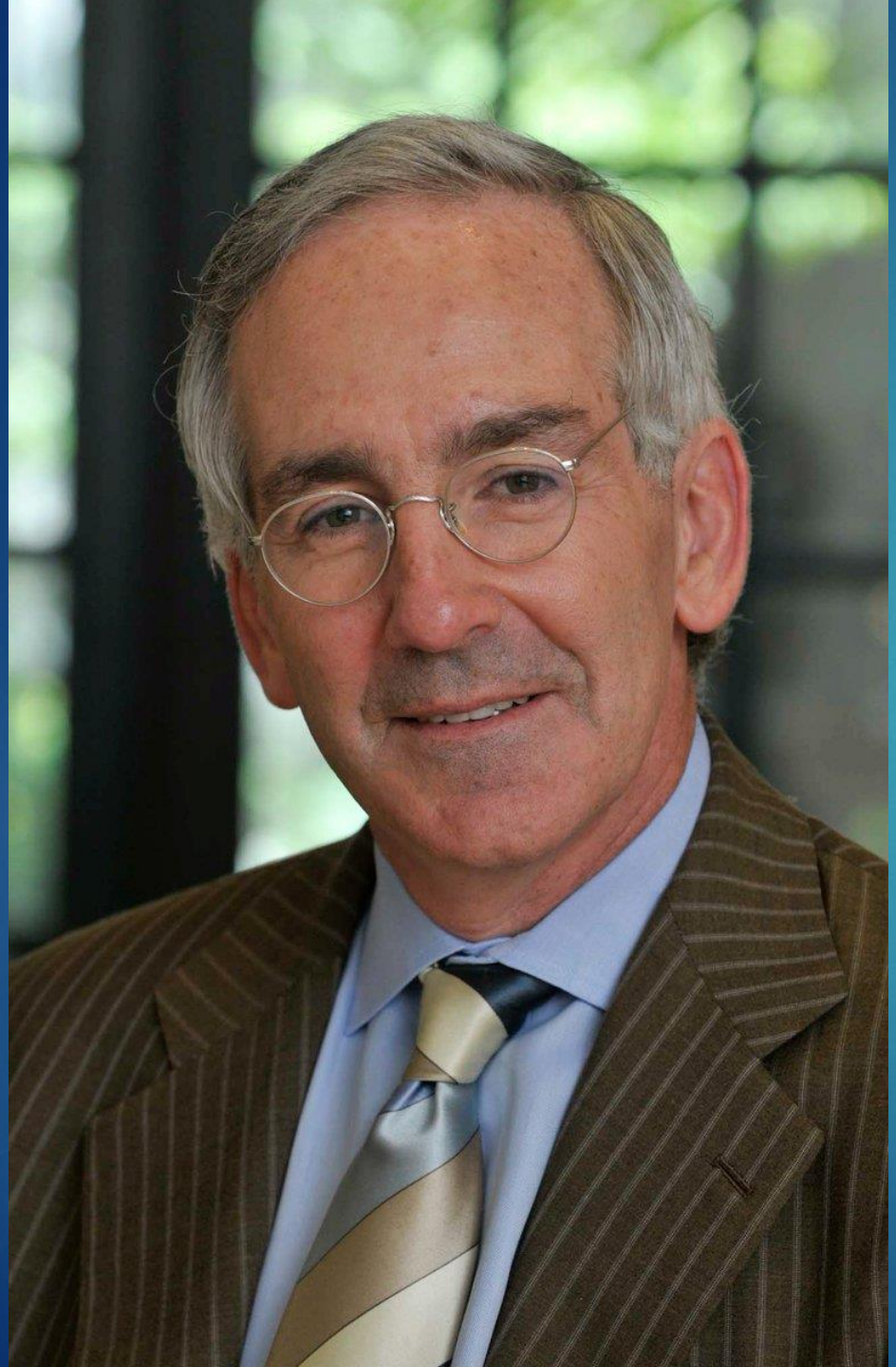

Vent adapter
and vent filter
Aorta
External
battery
pack
Outflow-
valve
housing
Inflow-
valve
housing
Drive
line
Prosthetic
left ventricle
Skin line
System
controller

TABLE 1. BASE-LINE CHARACTERISTICS OF THE PATIENTS.*

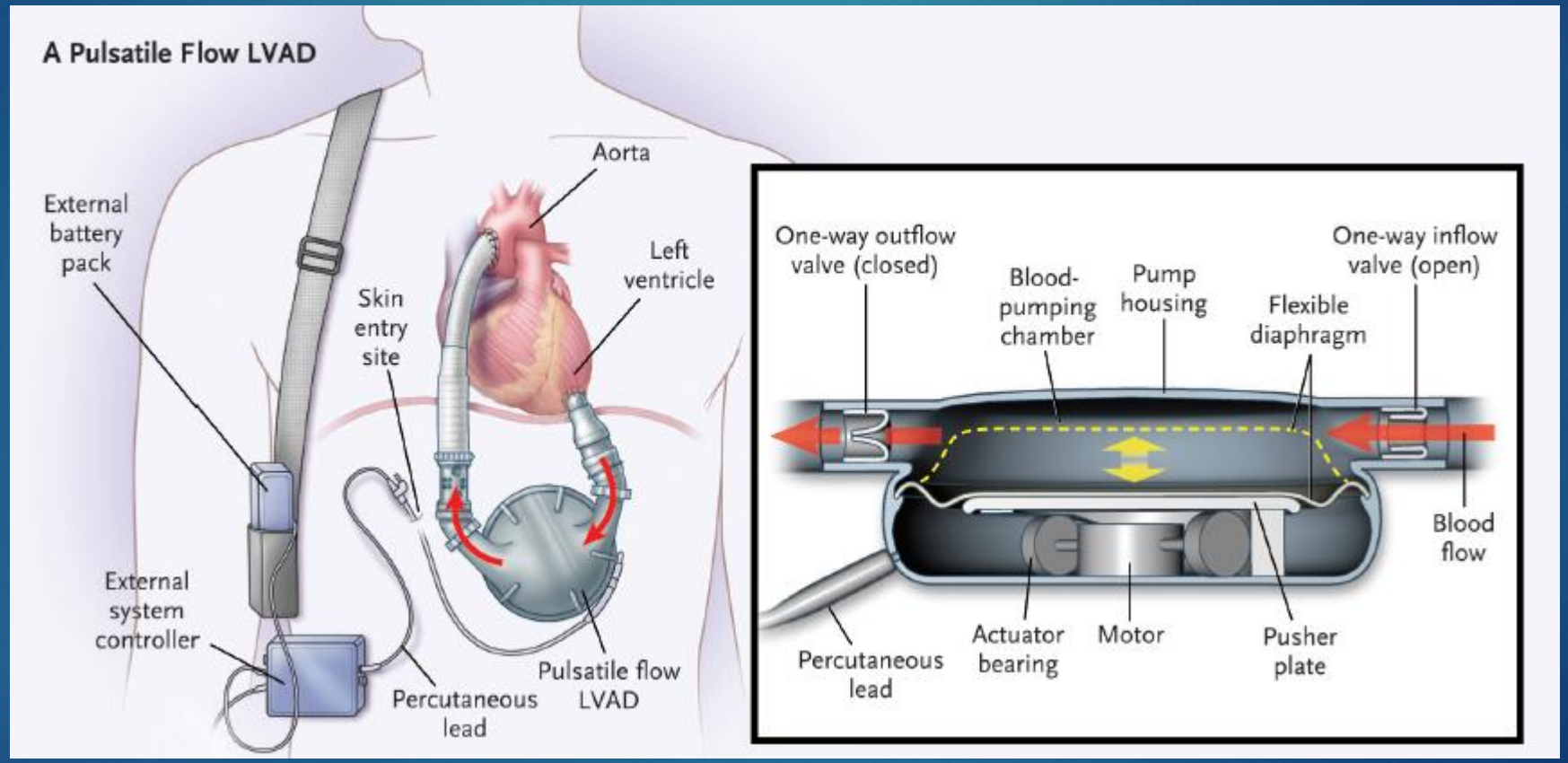
CHARACTERISTIC	MEDICAL-THERAPY GROUP (N=61)	LVAD GROUP (N=68)
Age (yr)	68±8.2	66±9.1
Male sex (%)	82	78
Ischemic cause of heart failure (%)	69	78
Left ventricular ejection fraction (%)	17±4.5	17±5.2
Blood pressure (mm Hg)		
Systolic	103±17	101±15
Diastolic	62±11	61±10
Pulmonary-capillary wedge pressure (mm Hg)	24±7.4	25±9.9
Cardiac index (liters/min/m²)	2±0.61	1.9±0.99
Heart rate (beats/min)	84±15	84±16
Pulmonary vascular resistance (Wood units)	3.2±1.8	3.4±1.8
Serum sodium (mmol/liter)	135±5.8	135±5.4
Serum creatinine (mg/dl)†	1.8±0.66	1.7±0.65
Concomitant medications (%)		
Digoxin	85	87
Loop diuretics	97	96
Spironolactone	39	34
ACE inhibitors	51	62
A-II antagonists	18	10
Amiodarone	46	45
Beta-blockers	20	24
Intravenous inotropic agents	72	65
NYHA class	IV	IV
Quality of life‡		
Minnesota Living with Heart Failure score	75±17	75±18
SF-36		
Physical function	18±19	19±19
Emotional role	25±38	33±42
Beck Depression Inventory	16±8	19±9





https://en.wikipedia.org/wiki/Eric_Rose

심실보조장치
Left ventricular assist device



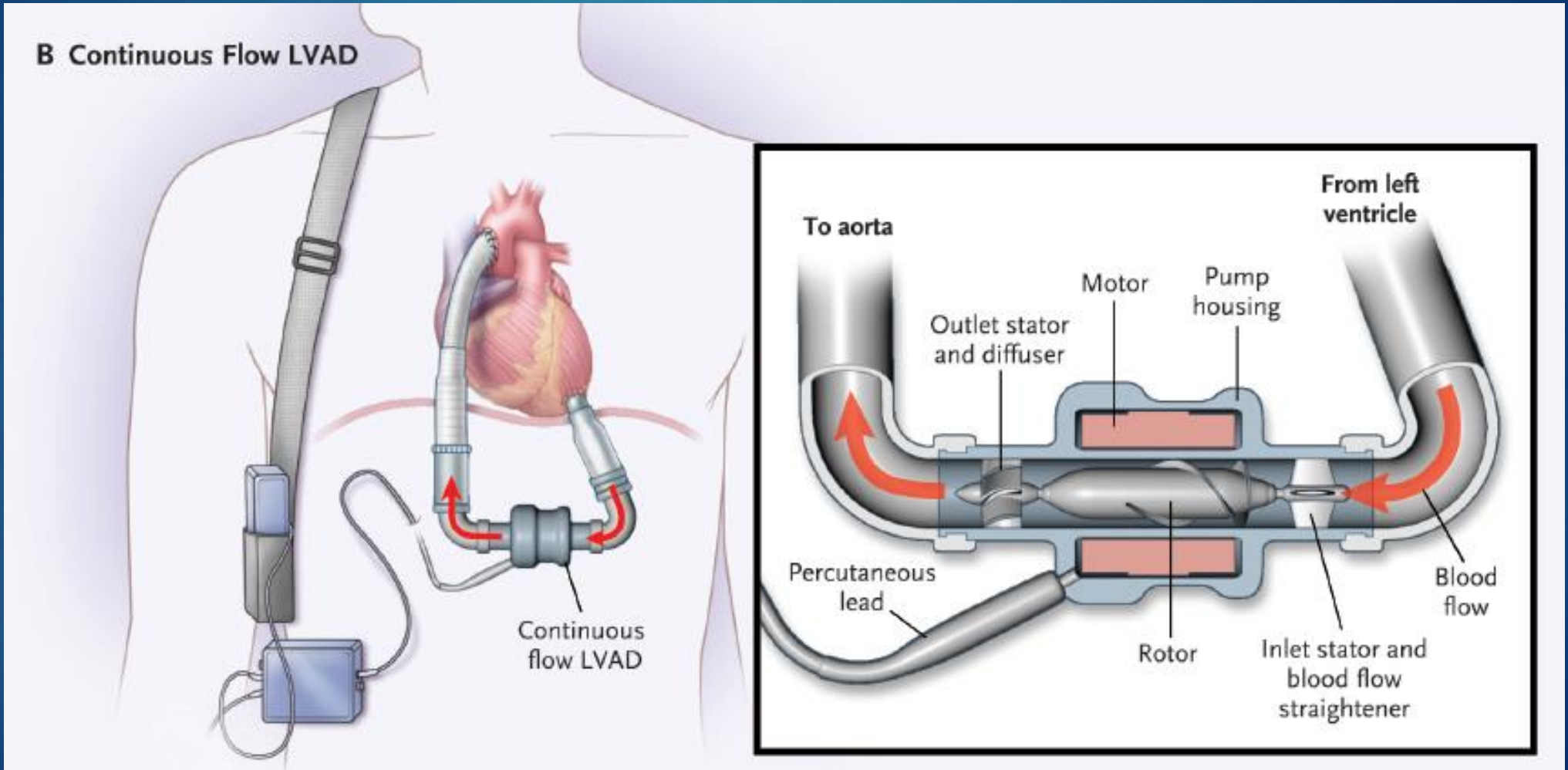
The NEW ENGLAND JOURNAL of MEDICINE

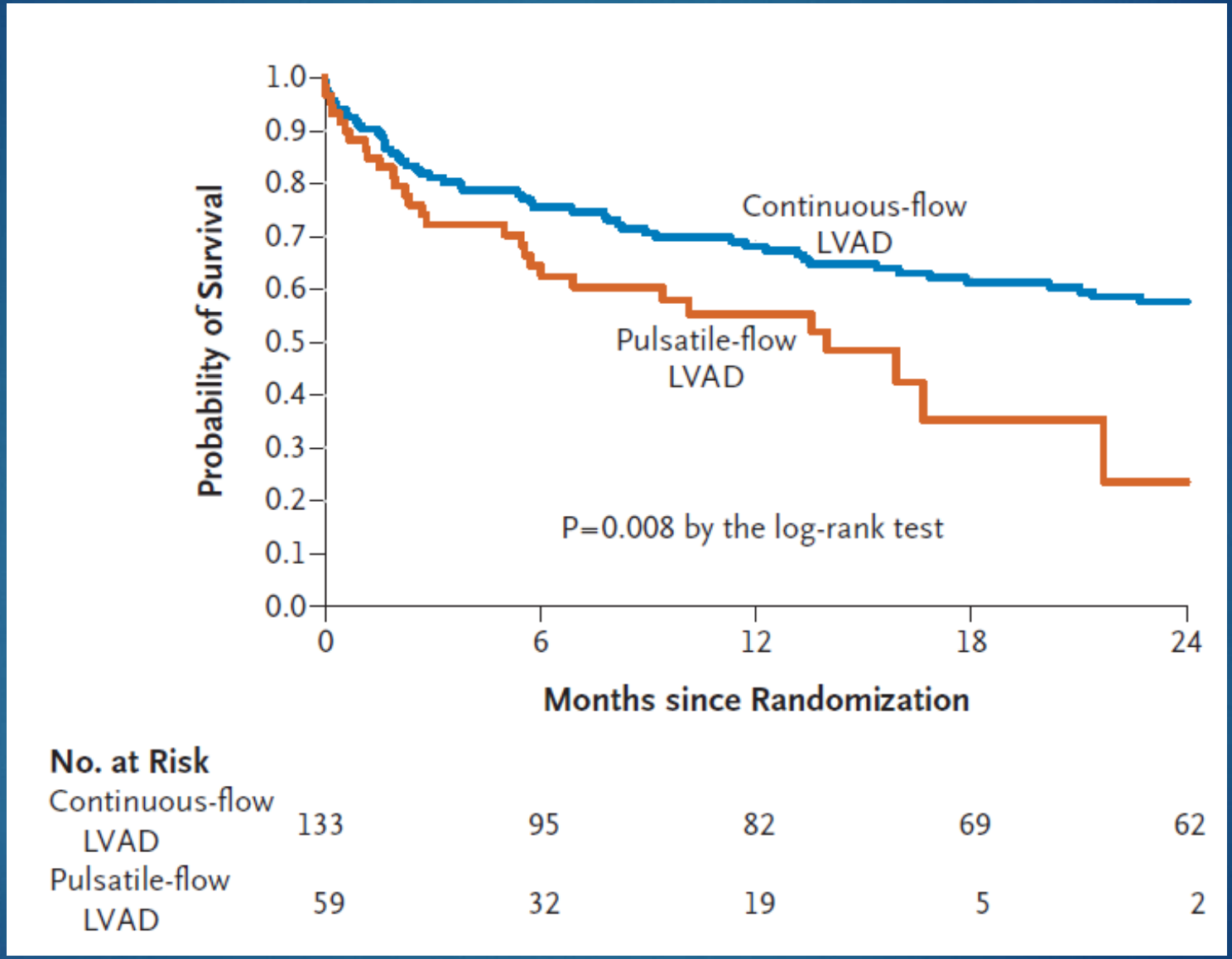
ORIGINAL ARTICLE

Advanced Heart Failure Treated with Continuous-Flow Left Ventricular Assist Device

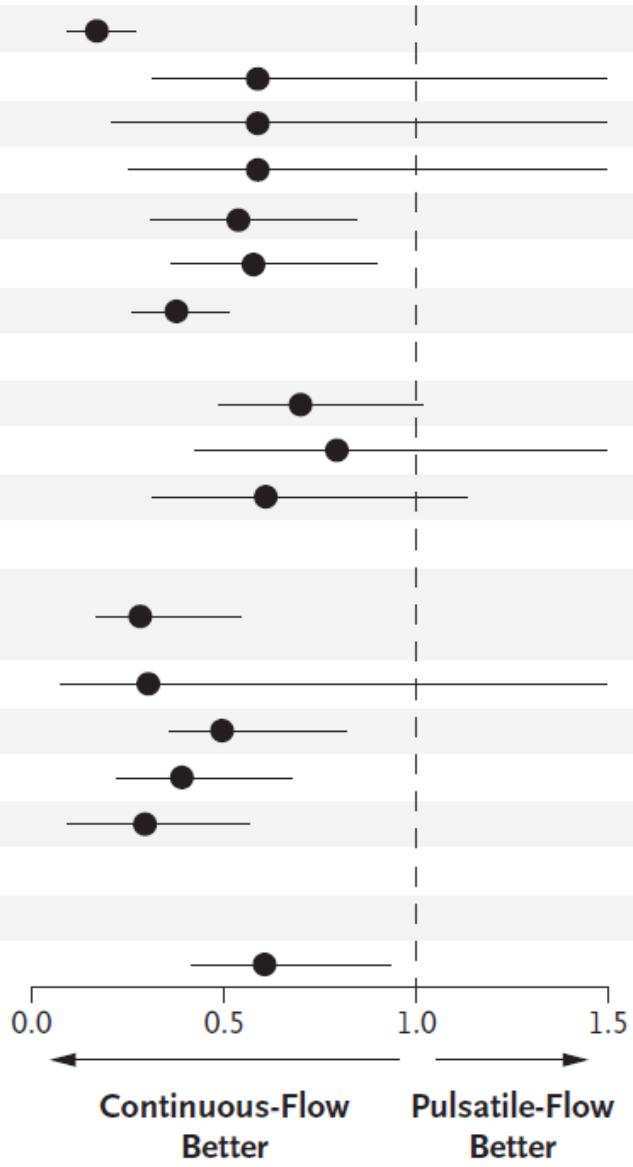
Mark S. Slaughter, M.D., Joseph G. Rogers, M.D., Carmelo A. Milano, M.D., Stuart D. Russell, M.D., John V. Conte, M.D., David Feldman, M.D., Ph.D., Benjamin Sun, M.D., Antone J. Tatooles, M.D., Reynolds M. Delgado, III, M.D., James W. Long, M.D., Ph.D., Thomas C. Wozniak, M.D., Waqas Ghumman, M.D., David J. Farrar, Ph.D., and O. Howard Frazier, M.D., for the HeartMate II Investigators*

2세대 심실보조장치


B Continuous Flow LVAD
Continuous flow LVAD
To aorta
From left ventricle
Motor
Pump housing
Outlet stator and diffuser
Percutaneous lead
Rotor
Inlet stator and blood flow straightener
Blood flow


Probability of Survival
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Continuous-flow LVAD
Pulsatile-flow LVAD
P=0.008 by the log-rank test
0
6
12
18
24
Months since Randomization
No. at Risk
Continuous-flow LVAD 133 95 82 69 62
Pulsatile-flow LVAD 59 32 19 5 2

Subgroup	Continuous-Flow LVAD (N=133) (211 patient-yr) no. (%)	no. of Events/ Patient-Yr	Pulsatile-Flow LVAD (N=59) (41 patient-yr) no. (%)	no. of Events/ Patient-Yr	Relative Risk (95% CI)	P Value for Interaction
Pump replacement	12 (9)	0.06	20 (34)	0.51		<0.001
Stroke	24 (18)	0.13	8 (14)	0.22		0.21
Ischemic	11 (8)	0.06	4 (7)	0.10		0.38
Hemorrhagic	15 (11)	0.07	5 (8)	0.12		0.33
LVAD-related infection	47 (35)	0.48	21 (36)	0.90		0.01
Local non-LVAD infection	65 (49)	0.76	27 (46)	1.33		0.02
Sepsis	48 (36)	0.39	26 (44)	1.11		<0.001
Bleeding						
Bleeding requiring PRBC	108 (81)	1.66	45 (76)	2.45		0.06
Bleeding requiring surgery	40 (30)	0.23	9 (15)	0.29		0.57
Other neurologic event	29 (22)	0.17	10 (17)	0.29		0.14
Right heart failure						
Managed with extended use of inotropes	27 (20)	0.14	16 (27)	0.46		<0.001
Managed with RVAD	5 (4)	0.02	3 (5)	0.07		0.12
Cardiac arrhythmia	75 (56)	0.69	35 (59)	1.31		0.006
Respiratory failure	50 (38)	0.31	24 (41)	0.80		<0.001
Renal failure	21 (16)	0.10	14 (24)	0.34		<0.001
Hepatic dysfunction	3 (2)	0.01	0	0.00		
LVAD thrombosis	5 (4)	0.02	0	0.00		
Rehospitalization	107 (94)	2.64	42 (96)	4.25		0.02

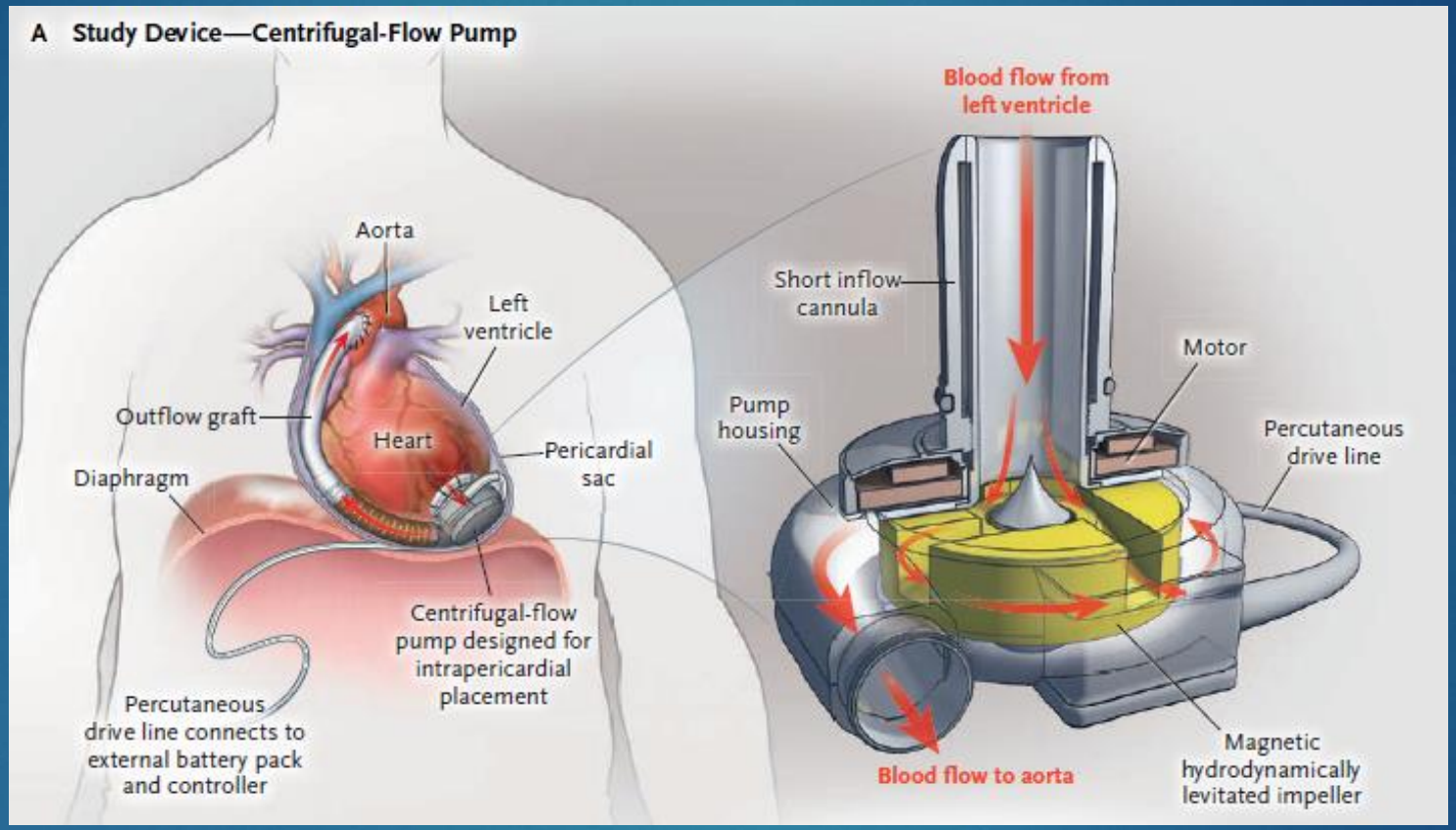


The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

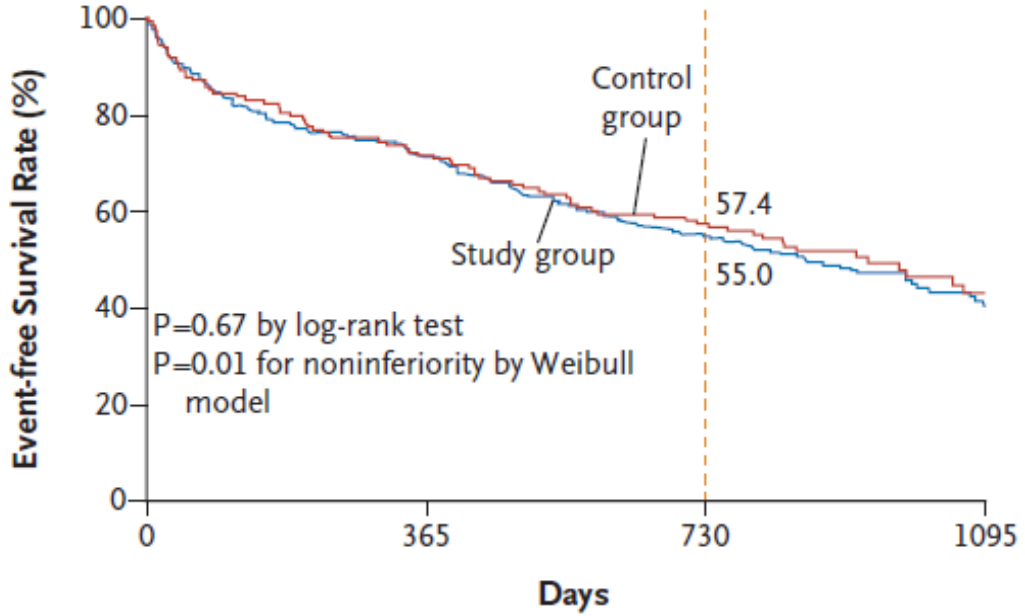
Intrapericardial Left Ventricular Assist Device for Advanced Heart Failure

Joseph G. Rogers, M.D., Francis D. Pagani, M.D., Ph.D., Antone J. Tatooles, M.D., Geetha Bhat, M.D., Mark S. Slaughter, M.D., Emma J. Birks, M.B., B.S., Ph.D., Steven W. Boyce, M.D., Samer S. Najjar, M.D., Valluvan Jeevanandam, M.D., Allen S. Anderson, M.D., Igor D. Gregoric, M.D., Hari Mallidi, M.D., Katrin Leadley, M.D., Keith D. Aaronson, M.D., O.H. Frazier, M.D., and Carmelo A. Milano, M.D.


A Study Device—Centrifugal-Flow Pump
Aorta
Left ventricle
Outflow graft
Heart
Pericardial sac
Diaphragm
Centrifugal-flow pump designed for intrapericardial placement
Percutaneous drive line connects to external battery pack and controller
Blood flow from left ventricle
Short inflow cannula
Motor
Pump housing
Percutaneous drive line
Blood flow to aorta
Magnetic hydrodynamically levitated impeller

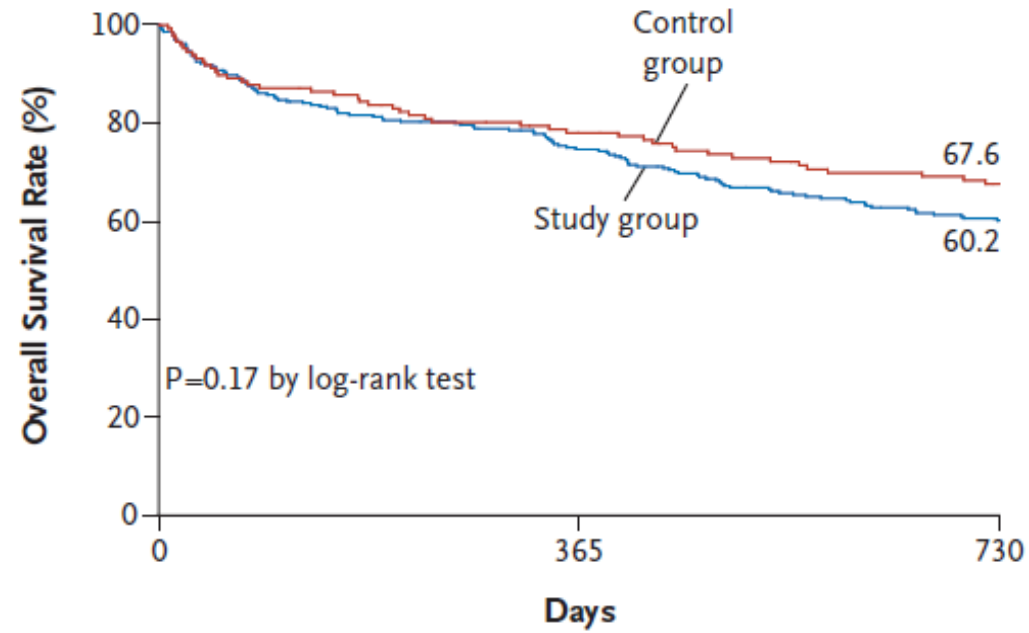
3세대 심실보조장치

A



No. at Risk				
Study group	297	211	159	33
Control group	148	106	82	19

B



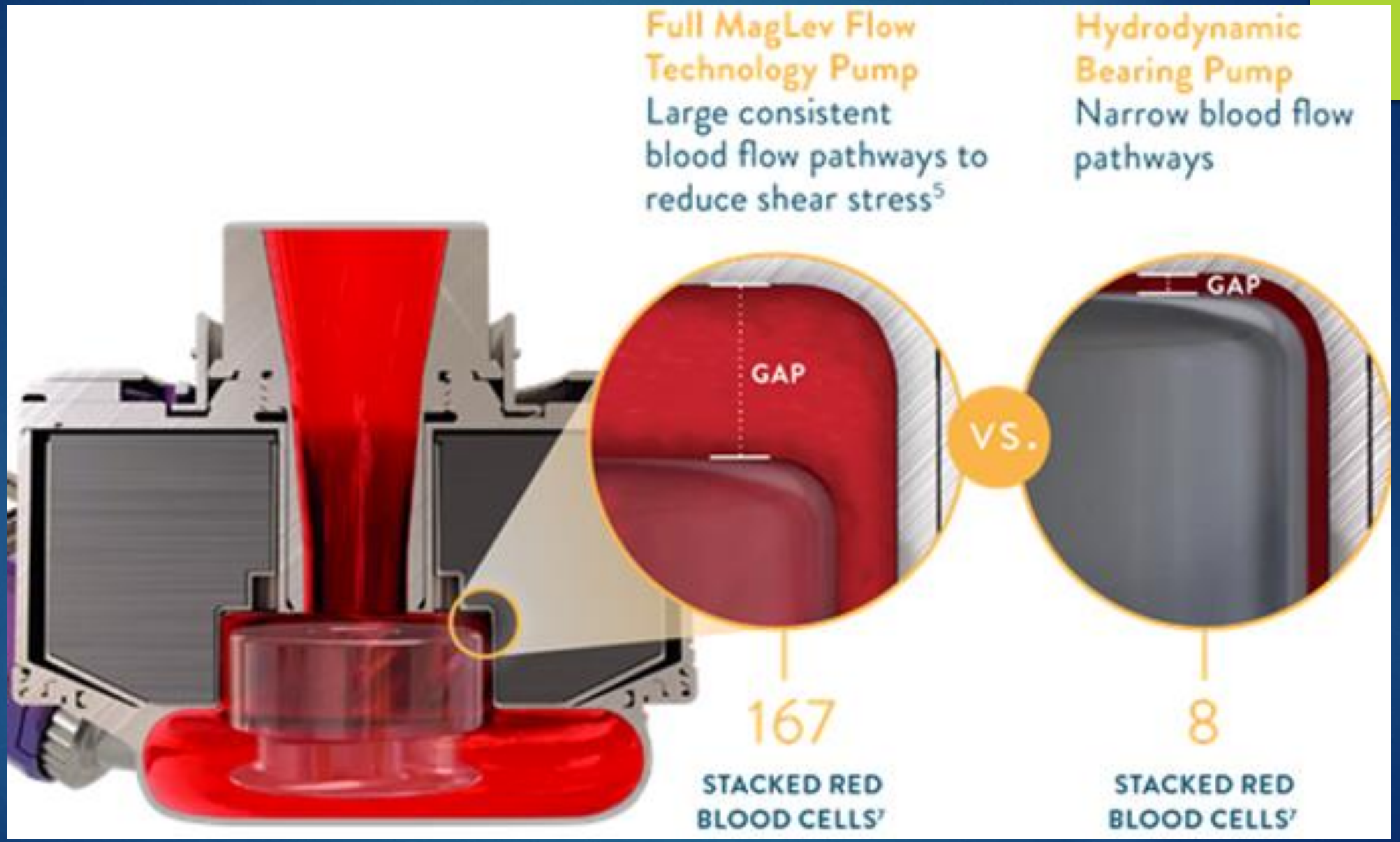
No. at Risk			
Study group	296	213	161
Control group	149	109	88

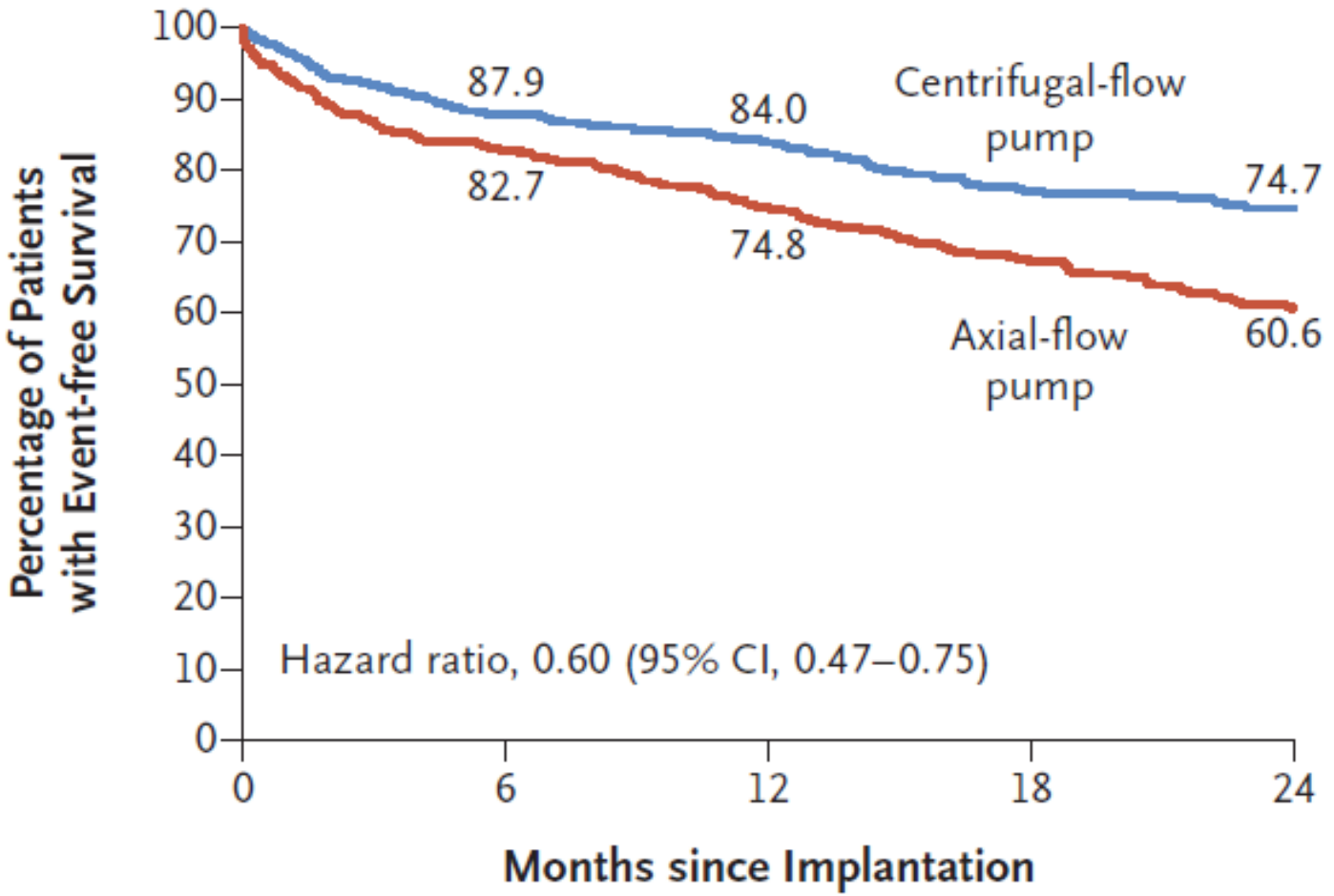
The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

A Fully Magnetically Levitated Left Ventricular Assist Device — Final Report

M.R. Mehra, N. Uriel, Y. Naka, J.C. Cleveland, Jr., M. Yuzefpolskaya, C.T. Salerno, M.N. Walsh, C.A. Milano, C.B. Patel, S.W. Hutchins, J. Ransom, G.A. Ewald, A. Itoh, N.Y. Raval, S.C. Silvestry, R. Cogswell, R. John, A. Bhimaraj, B.A. Bruckner, B.D. Lowes, J.Y. Um, V. Jeevanandam, G. Sayer, A.A. Mangi, E.J. Molina, F. Sheikh, K. Aaronson, F.D. Pagani, W.G. Cotts, A.J. Tatooles, A. Babu, D. Chomsky, J.N. Katz, P.B. Tessmann, D. Dean, A. Krishnamoorthy, J. Chuang, I. Topuria, P. Sood, and D.J. Goldstein, for the MOMENTUM 3 Investigators*


Full MagLev Flow Technology Pump
Large consistent blood flow pathways to reduce shear stress[5]
Hydrodynamic Bearing Pump
Narrow blood flow pathways
GAP
VS.
GAP
167
STACKED RED BLOOD CELLS[7]
8
STACKED RED BLOOD CELLS[7]



No. at Risk

Centrifugal-flow pump	516	438	373	313	280
Axial-flow pump	512	401	321	264	223

Total artificial heart

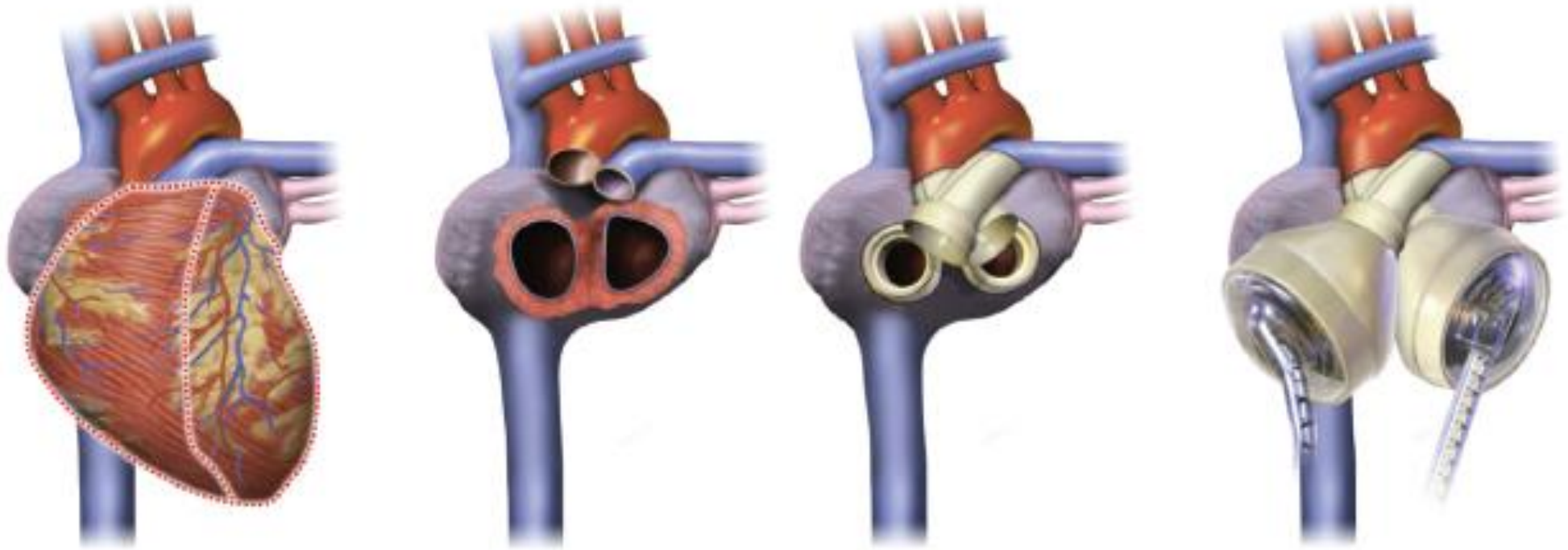
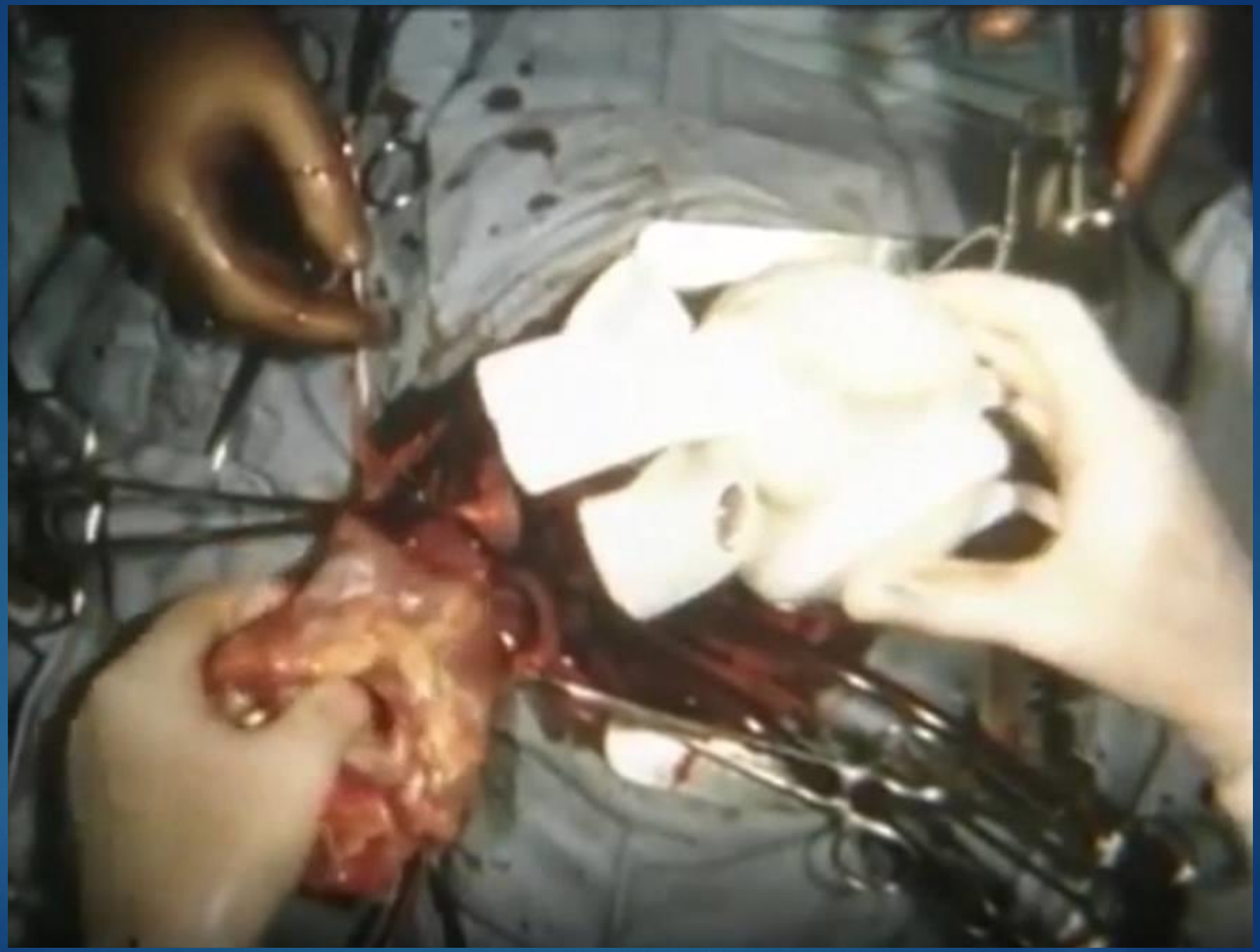
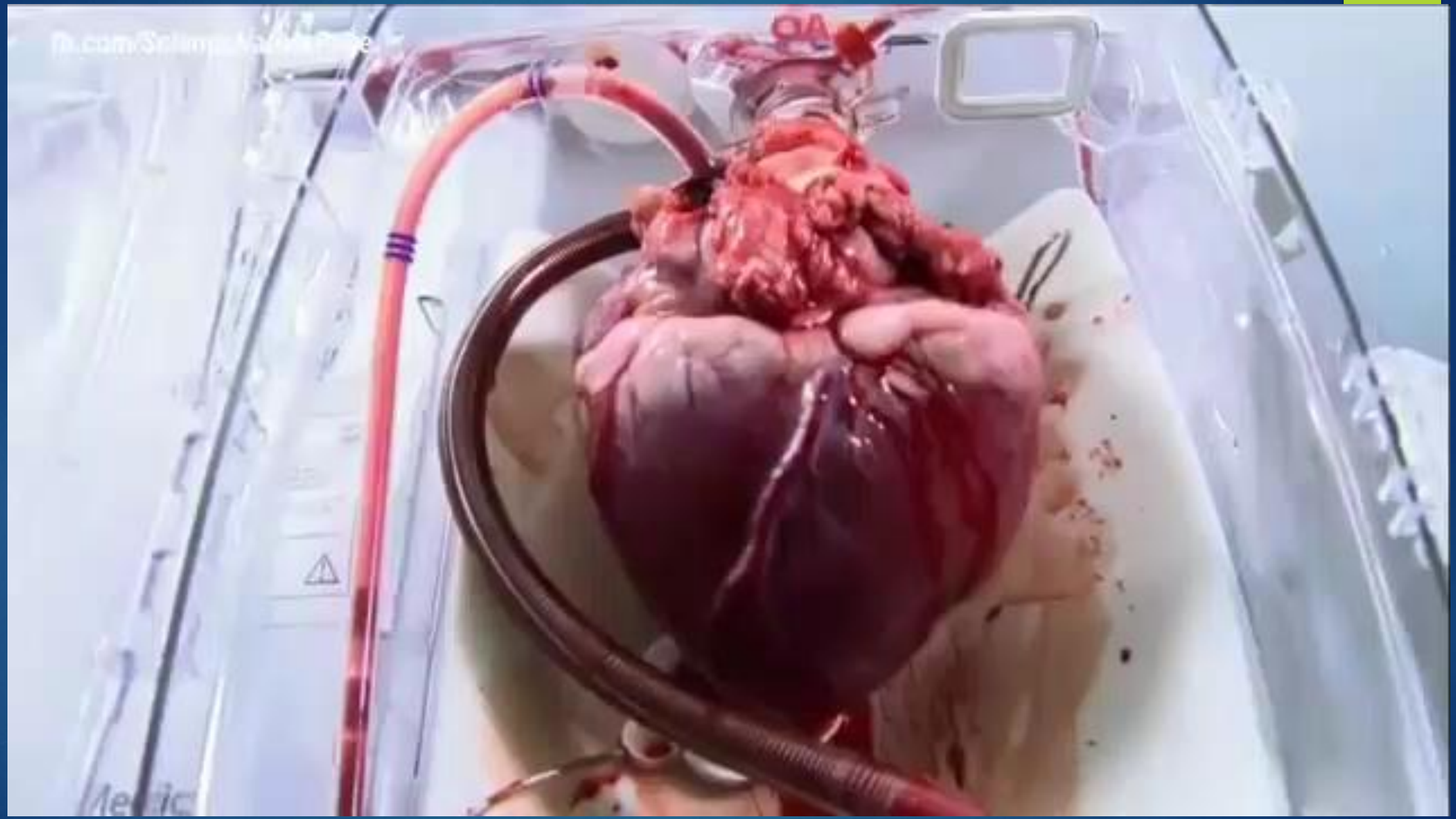


FIGURE 97-17 ■ SynCardia total artificial heart. (Reproduced with permission from SynCardia Systems, Inc.)





요약

- 말기 심부전의 정의: stage D heart failure, INTERMACS profile
- 수술적 치료
  - 심장 이식: 수술적 기법들
  - 장기적 기계 순환 보조
- Durable Mechanical Circulatory Support
  - LVAD, TAH
- LVAD
  - Pulsatile, Continuous flow
  - Axial, Centrifugal


감사합니다.