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Acute Aortic Syndromes: State of the Art

Kim A. Eagle, MD

Director
Samuel & Jean Frankel Cardiovascular Center
University of Michigan

keagle@umich.edu
@keaglemd

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Disclosures: Kim A. Eagle

Registry

IRAD

International Registry of Aortic Dissection

Role: *Founder*

GenTAC

Genetically Triggered Aortic Conditions

Role: *Program Leader*

Research Grants

- Gore (Major Sponsor)
- Mardigian Foundation
- Hewlett Foundation
- Medtronic
- Robert & Anne Aikens
- Terumo
- Varbedian Fund
- University of Michigan (Founding Sponsor)
- Marfan Foundation (GenTAC Alliance)

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Lecture Outline

- **Where have we been?**
  - Epidemiology
  - Classification
  - Clinical Presentation/ECG/Chest X-Ray
  - Static Imaging
  - Treatments
    - Medical
    - Non-Medical
- **Where are we headed?**
  - Genetics
  - Biomarkers
  - Dynamic Imaging
  - Survivorship
- **Reflections**

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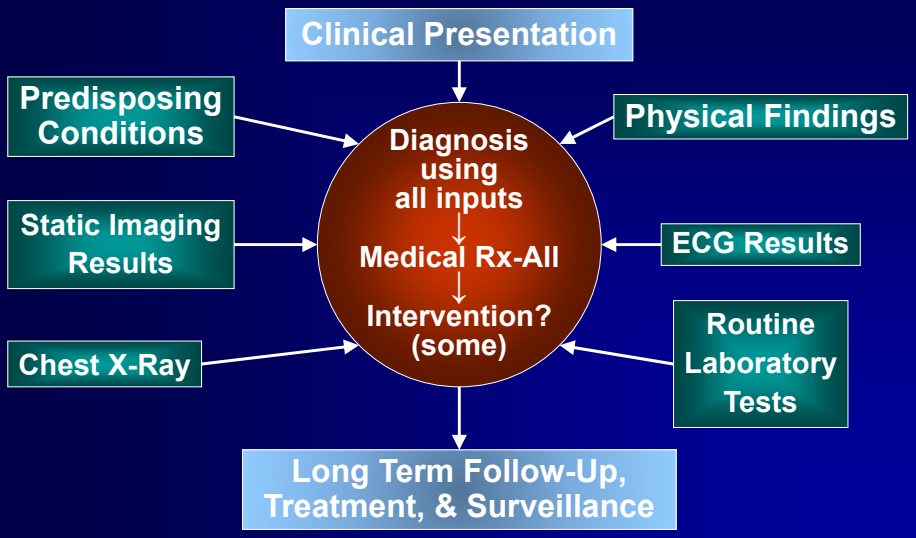
Understanding Acute Aortic Syndromes... Where Have We Been?



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Epidemiology: Aortic Dissection Community Study

- 52 incident dissections (**6/100,000/yr**)
- Risk factors
  - **HTN – 67%**
  - **Smoking – 62%**
  - **BP poorly controlled** pre-AoD
    56% BP's > 140/90;
- 33/52 died, **18 (>50%) at home**
- Hospital survivors: 5yr. survival
  Type A – 86%
  Type B – 83%

Circulation 2013;127:2031-37.

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Familiar Faces Lost or Affected by Aortic Dissections

- **John Ritter:** Beloved actor, died suddenly from an aortic dissection (2003)
- **Flo Hyman:** U.S. Olympic volleyball player, died from an aortic dissection at 31 (1986)
- **Grant Wahl:** Respected journalist, collapsed at the FIFA World Cup in Qatar; due to an aortic dissection (2022)
- **Lucille Ball**: Comedian, actress, and producer; aortic dissection at 77, died shortly after from other aorta issues (1989)
- **James Donaldson**: 14 seasons NBA player for Seattle Sonics and the Dallas Mavericks, aortic dissection survivor
- **Richie Faulkner:** Judas Priest guitarist, survived an on-stage aortic dissection during a 2021 concert

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The John Ritter Foundation for Aortic Health

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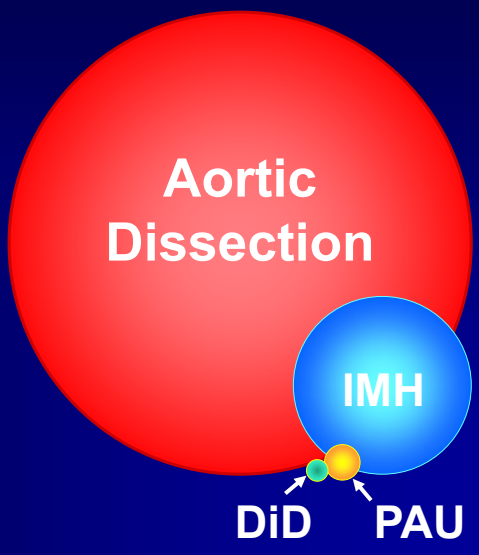
"Acute Aortic Syndromes"

- Classic Aortic Dissection
- Intramural Hematoma
- Penetrating Aortic Ulcer
- Discrete Aortic Dissection (DiD)



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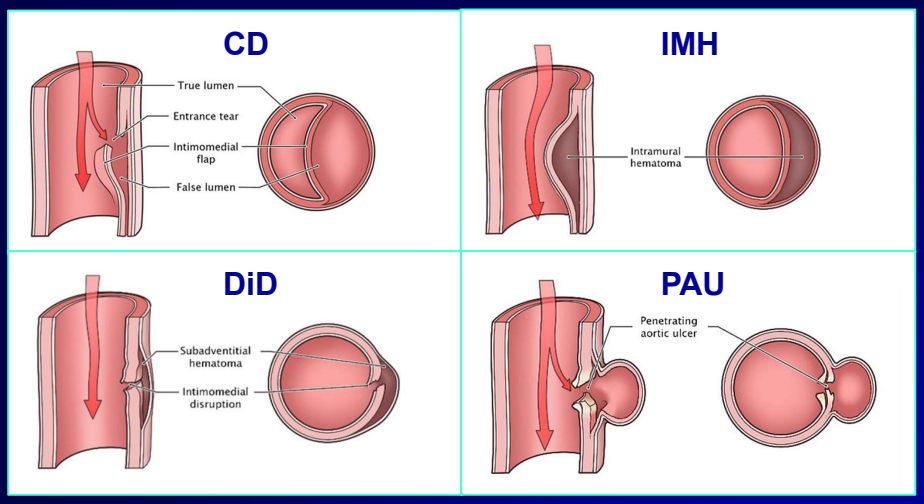
Types of Acute Aortic Syndromes



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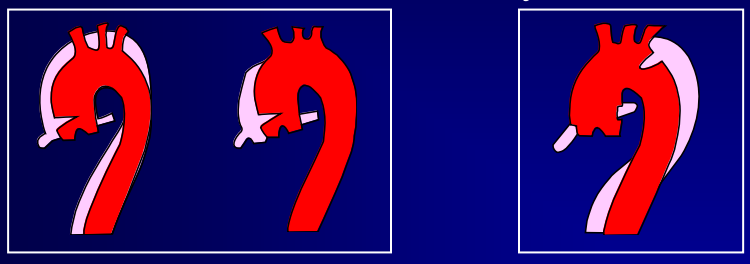
Historical Classification by Time From Symptom Onset - Outdated

Acute AoD

- Presentation within 14 days of onset



Stanford Type A
Involves the ascending aorta with or without descending aorta

Stanford Type B
Confined to descending aorta

Treasure T, et al. *J Heart Valve Dis* 1996;5:623-29.

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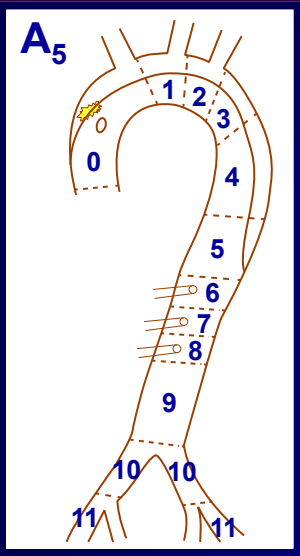
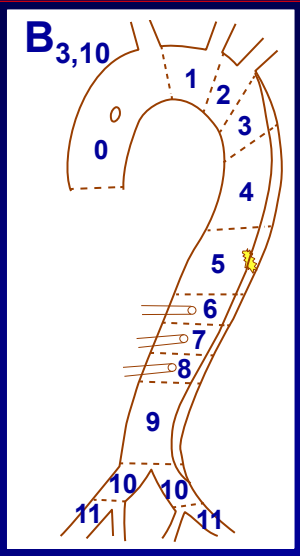
Current Anatomic Classification Scheme





Lombard JV, et al. *J Vasc Surg.* 2020;71:723-747.

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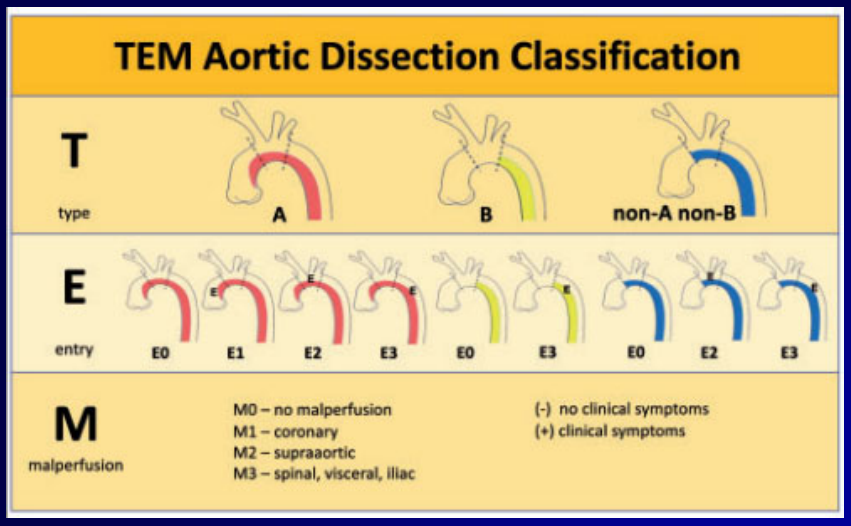
TEM Classification



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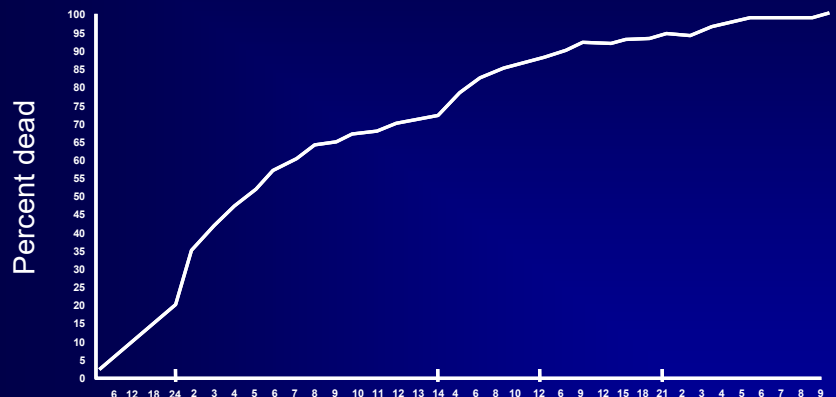
Aortic Dissection:
Mortality vs. Time from Symptom Onset



Mortality rate ….425 Cases

Hirst, Johns, and Kime; *Medicine* 1958;37:217-279.

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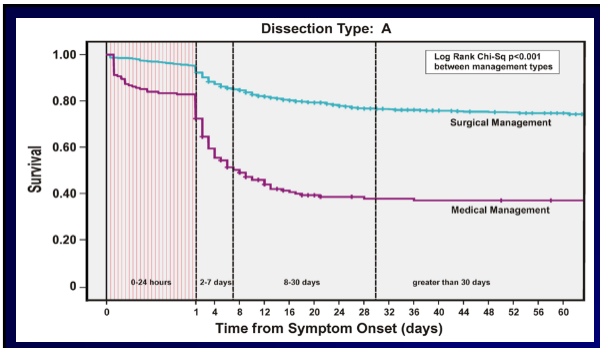
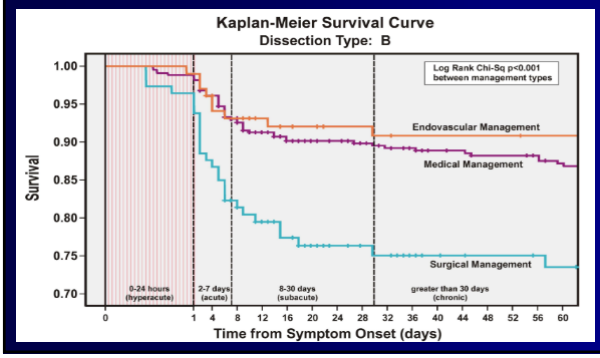


Booher AM et al. *Am J Med* 2013;126:730.e19-24.



AAD vs. TIME

ESC

Acute (≤14 days)

Sub-acute (2-6 weeks)

Chronic (>6 weeks)

IRAD

Hyperacute (<24 hours)

Acute (2-7 days)

Sub-acute (8-30 days)

Chronic (>30 days)

Booher AM, et al. *Am J Cardiol 2011;107:315.*

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Demographics and Past History

Variable	All	Type A	Type B	p-value
	(n=12725)	*(n=8610)*	*(n=4115)*	
Age (yrs)	61.9	61.3	63.0	<0.0001
Male	65.6%	65.7%	65.4%	NS
HTN	79.9%	77.6%	84.4%	<0.0001
Marfan	3.9%	3.4%	4.9%	0.0002
Prior Heart Surgery	**15.9%**	**13.5%**	**20.7%**	**<0.0001**
Iatrogenic	2.4%	2.8%	1.7%	0.0002
Family History	9.7%	8.9%	11.5%	0.0003

IRAD Investigators.

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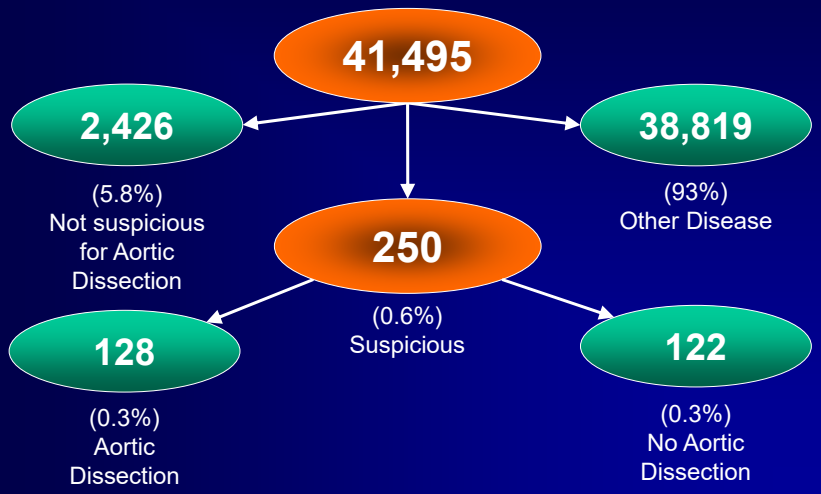
How Common is Aortic Dissection in ED Patients with Thoracic Pain?



Von Kodolitsch et al. *Arch Intern Med* 2000;160:2977-2982.

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Pain attending the splitting of the aortic wall is usually excruciating and extensive, radiating from midthorax front or back through the chest, down the back, and even into the thighs or up into the neck. The pain in the thorax or back comes suddenly at its maximum and is often prostrating, inducing a state of shock or even death.

- Paul Dudley White, 1944

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IRAD
Presenting Symptoms

Variable	All	Type A	Type B	p-value
• ***Pain***	94.8%	94.4%	95.7%	0.0036
Abrupt	**82.4%**	**81.4%**	**84.5%**	**0.0001**
Anterior	87.7%	91.4%	78.8%	<0.0001
Back	54.7%	45.7%	71.5%	<0.0001
Abdominal	32.2%	26.2%	43.9%	<0.0001
Sharp	45.5%	43.3%	55.9%	<0.0001
Tearing	27.4%	25.6%	30.9%	0.0001
• ***Syncope***	12.8%	17.0%	3.8%	<0.0001

(n=12725)

IRAD Investigators.

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IRAD Physical Exam

Variable	All	Type A	Type B	p-value
High BP	40.9%	29.9%	63.3%	<0.0001
Low BP	11.5%	15.4%	3.6%	<0.0001
Shock/Tamponade	8.0%	11.3%	1.2%	<0.0001
Murmur AI	**19.8%**	**26.4%**	**7.1%**	**<0.0001**
Pulse Deficit	**31.3%**	**35.0%**	**24.8%**	**<0.0001**
Stroke	5.5%	7.6%	1.4%	<0.0001

(n=12725)

IRAD Investigators.

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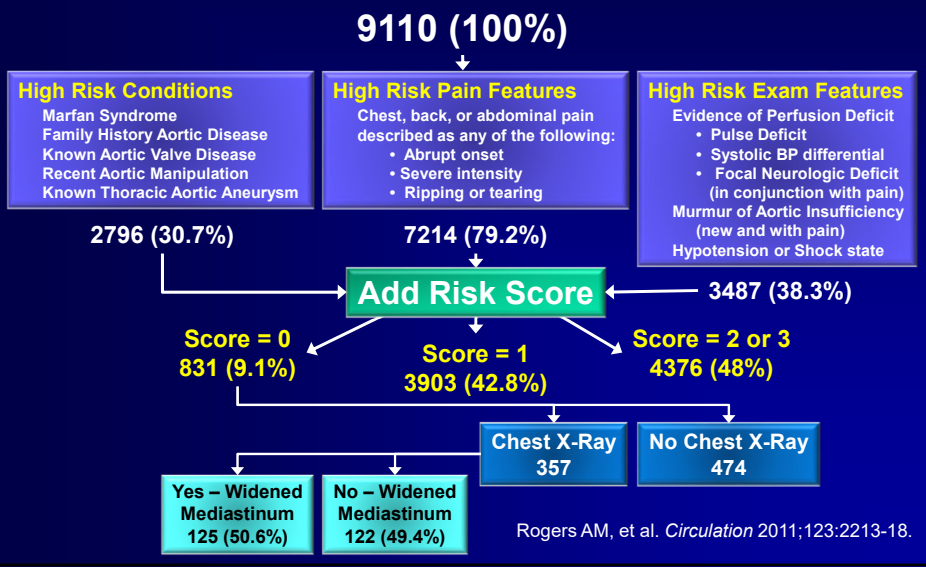
Sensitivity of ACC/AHA Guidelines for Acute Aortic Dissection



Rogers AM, et al. *Circulation* 2011;123:2213-18.

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IRAD
EKG & CXR

Variable	All	Type A	Type B	p-value
• *CXR*				
Normal	30.0%	30.6%	29.0%	NS
Wide Mediast. or Aorta	69.9%	69.9%	69.9%	NS
PL. Effusion	14.8%	12.4%	18.4%	<0.001
• *EKG*				
Normal	37.1%	36.4%	38.3%	NS
NSST-T △'s	46.6%	45.4%	49.1%	0.014
Ischemia	14.3%	16.9%	9.1%	<0.001
New MI	8.1%	10.3%	3.7%	<0.001

(n=9110)

IRAD Investigators.

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How Many U.S. Adults have Enlarged Aortas?

4.2 – 4.4cm	3.8 Million
4.5 – 4.9cm	1.6 Million
≥ 5.0cm	0.2 Million

- R. Devereux

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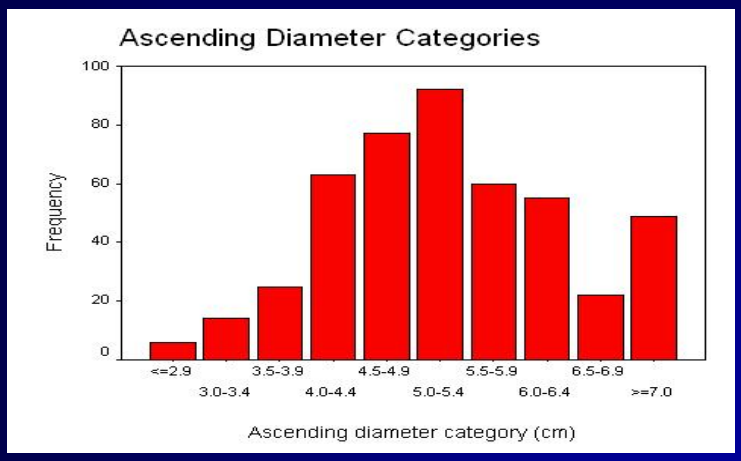
Maximum Aorta Diameter: Type A Dissection

(59% < 5.5 cm)



Pape LA, et al. *Circulation* 2007;116:1120-27.

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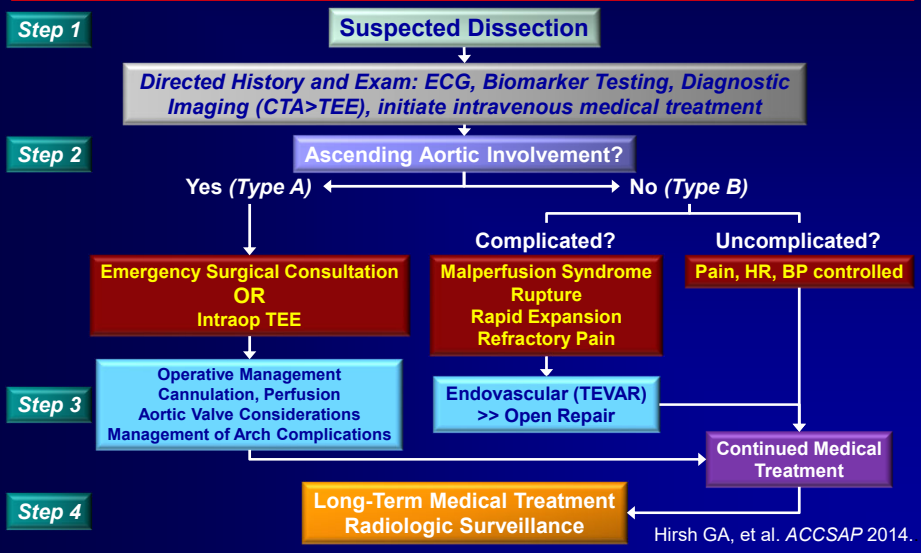
One Proposed Management Pathway for Acute Aortic Dissection



Hirsh GA, et al. *ACCSAP* 2014.

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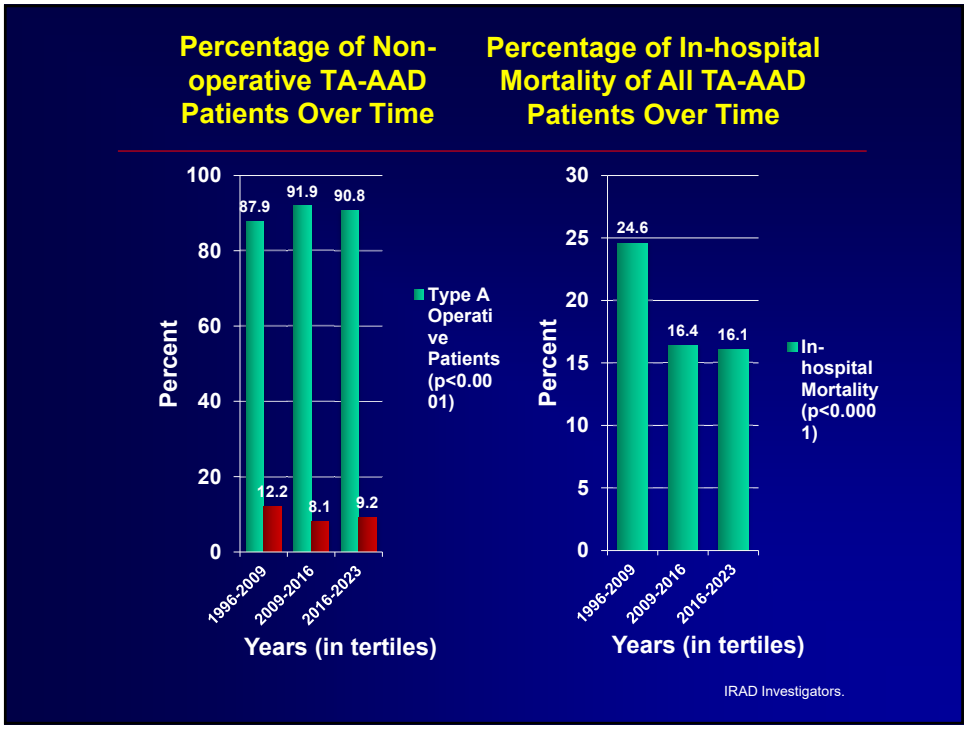
Percentage of Non-operative TA-AAD Patients Over Time
Percentage of In-hospital Mortality of All TA-AAD Patients Over Time
Percent
100
80
60
40
20
0
87.9
91.9
90.8
12.2
8.1
9.2
1996-2009
2009-2016
2016-2023
Years (in tertiles)
Type A Operative Patients (p<0.0001)
Percent
30
25
20
15
10
5
0
24.6
16.4
16.1
1996-2009
2009-2016
2016-2023
Years (in tertiles)
In-hospital Mortality (p<0.0001)
IRAD Investigators.

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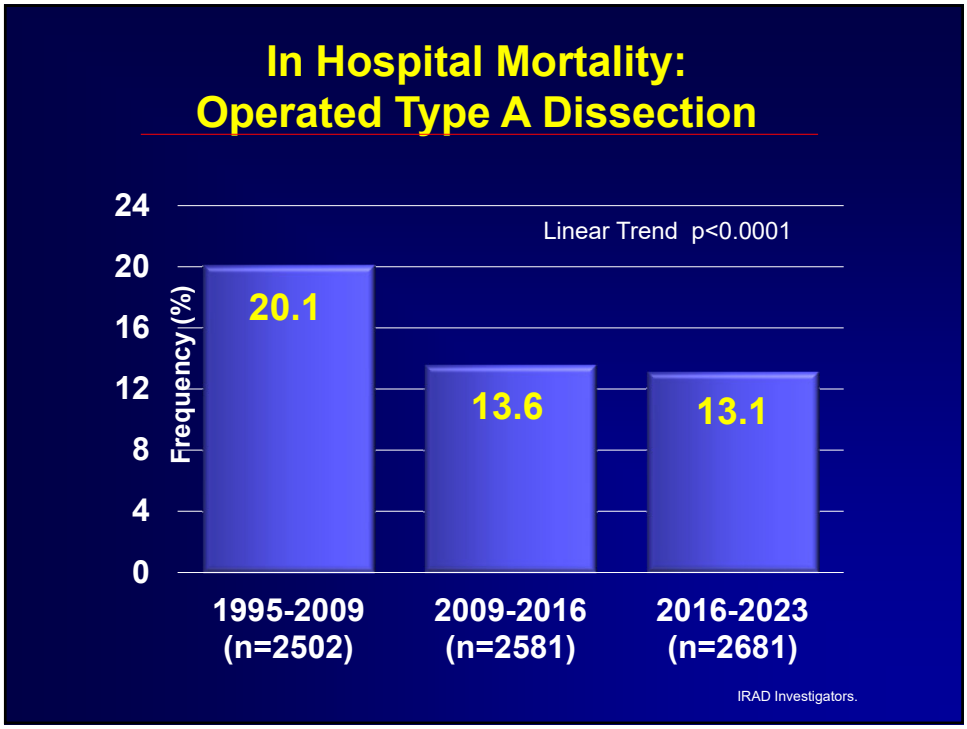
In Hospital Mortality:
Operated Type A Dissection
Linear Trend p<0.0001
Frequency (%)
24
20
16
12
8
4
0
20.1
13.6
13.1
1995-2009
(n=2502)
2009-2016
(n=2581)
2016-2023
(n=2681)
IRAD Investigators.

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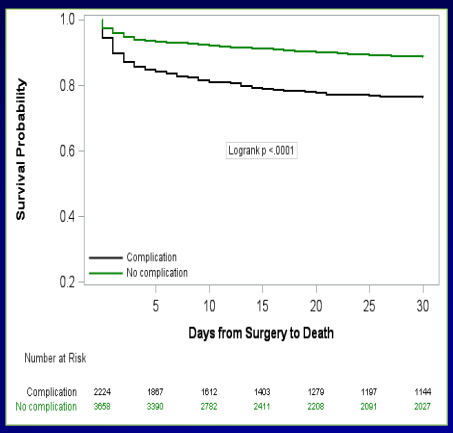
Index Hospitalization Mortality

Complication Type	Denominator	Mortality (%)
No Complication	3657	411 (11.2)
Any Complication	2241	536 (23.9)
Coronary Malperfusion	812	213 (26.2)
Coma	501	164 (32.7)
Neurological Deficit	619	132 (21.3)
Visceral Malperfusion	149	59 (39.6)
Lower Extremity Ischemia	928	227 (24.5)

Patients without concomitant complications had the lowest mortality rate (11%); patients with visceral ischemia had the highest mortality rate (40%)

Kaplan-Meier Survival



30-day survival following surgery is lower in patients with any complication

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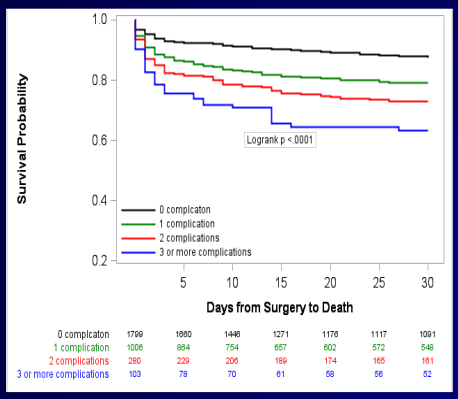
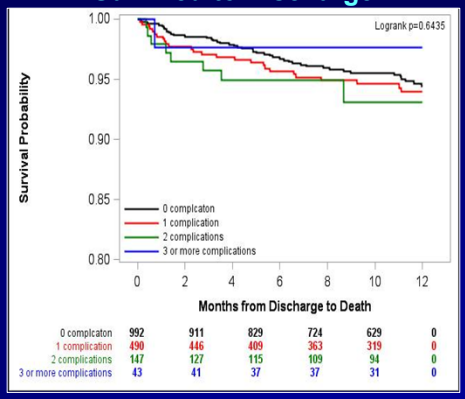
Kaplan-Meier Stratified by Number of Complications

30-Day Survival



30-day survival decreases as the number of concomitant complications increases

1-Year Survival in Patients who Survived to Discharge



One-year survival is similar between cohorts in patients who survive index hospitalization

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Type B Aortic Dissection Acuity

Uncomplicated
- No rupture
- No malperfusion
- No high-risk features

High Risk
- Refractory pain
- Refractory hypertension
- Bloody pleural effusion
- Aortic diameter >40mm
- Radiographic only malperfusion
- Readmission
- Entry tear: lesser curve location
- False lumen diameter >22mm

Complicated
- Rupture
- Malperfusion

Lombardi JV, et al. *J Vasc Surg* 2020;71:723-47.

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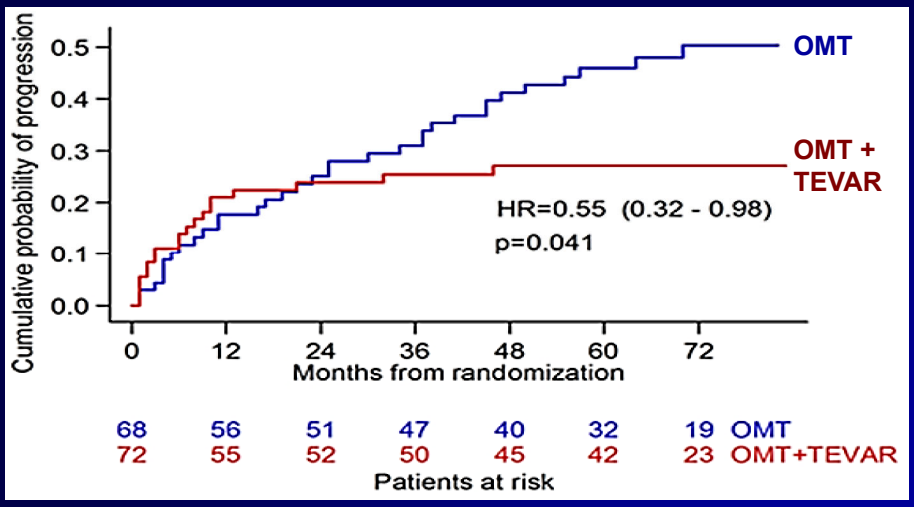
INSTEAD XL – Trial: Kaplan-Meier Estimates of Aortic Progression and Adverse Events



Nienaber C, et al. *Circ Cardiovasc Interv* 2013:6;407-416.

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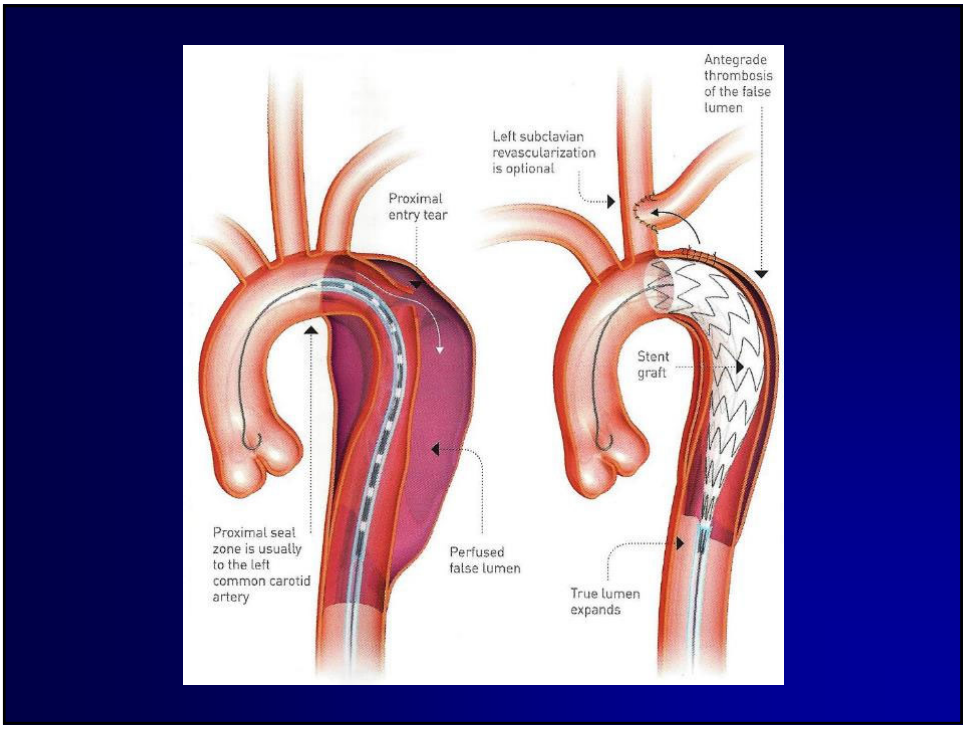

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INSTEAD XL – Trial Results

	OMT (n=68)	OMT + TEVAR (n=72)	
5 year follow-up			
Maximum aortic diameter	56.4±6.8	44.5±11.5	<0.0001
True lumen diameter at level A	18.7±6.7	32.6±5.5	<0.0001
False lumen diameter at level A	37.1±9.1	10.4±13.2	<0.0001
True lumen diameter at level B	16.9±7.2	28.6±6.4	<0.0001
False lumen diameter at level B	31.2±11.9	13.4±13.1	<0.0001
False lumen thrombosis at 5 year			
Complete, number (%)	11/50 (22.0)	48/53 (90.6)	<0.0001
Partial, number (%)	6/50 (12.0)	5/53 (9.4)	0.76

Nienaber C, et al. *Circ Cardiovasc Interv* 2013:6;407-416.

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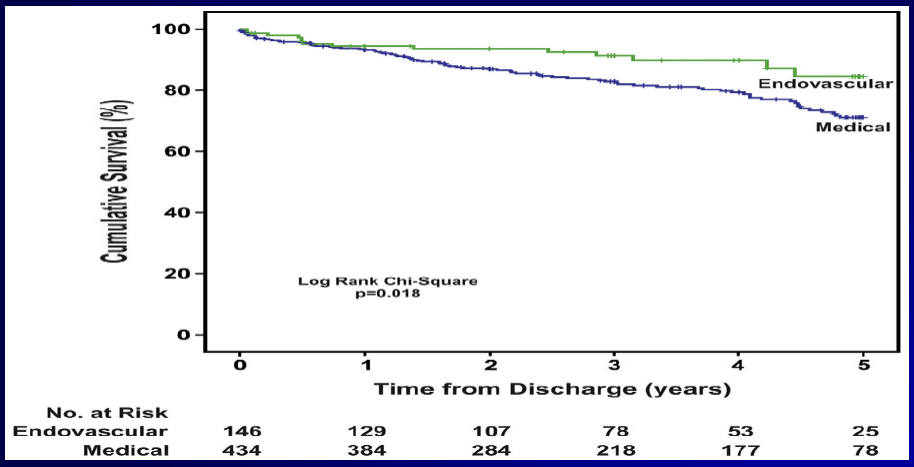
Comparison of Medical Therapy to Endovascular Treatment in Type B Dissection: *Long Term Follow-Up*



Fattori R, et al. *J Am Coll Cardiol Inv* 2013:6:876-82.

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Randomized Trials of Stent-Graft Therapy for Acute Stable Type B Aortic Dissection

Name	Country	Target Enrollment	Duration
Improve – AD	USA	1,100	7 Years
Sunday	Denmark	554	5 Years
Earnest	UK	470	5 Years

Ref.

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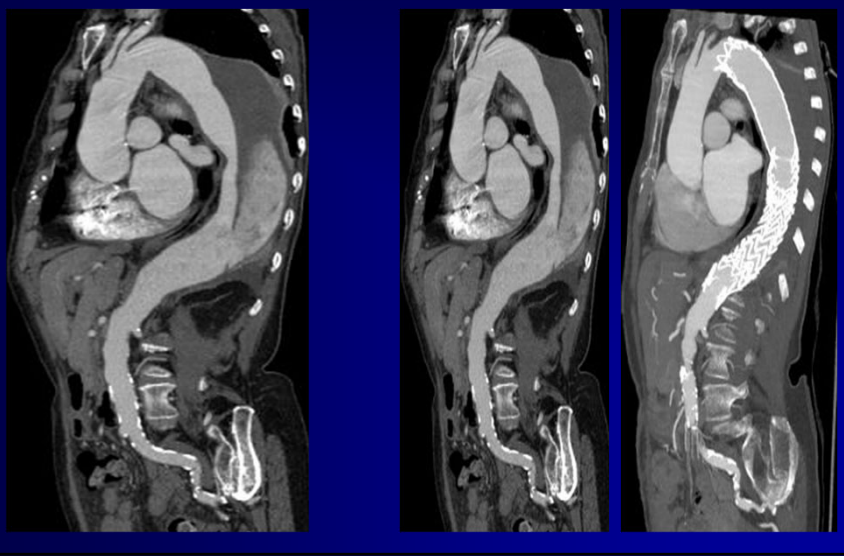
False Lumen Expansion is the Main Complication of Chronic Type B Dissection

Treatment with Stent Graft



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How to Follow?

1. Treatment
2. Surveillance
3. Patient Education

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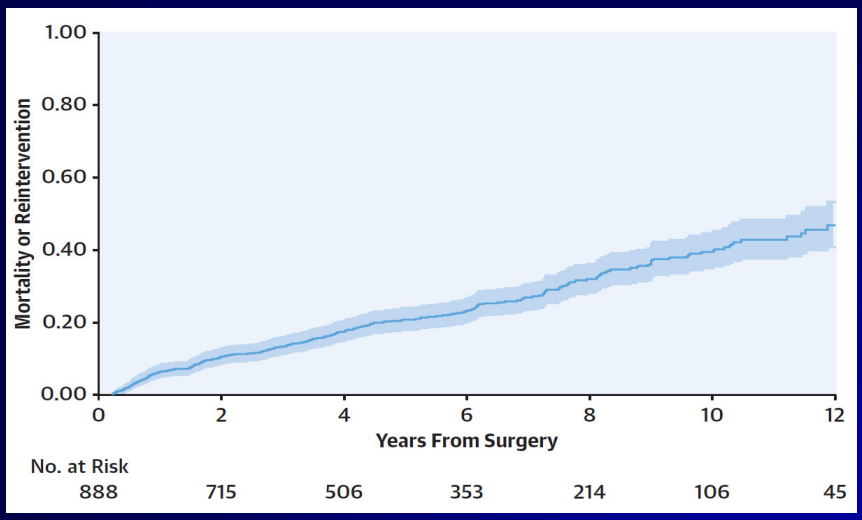
Probability of Reintervention or Death After Type A Dissection Surgery



An KR, et al. *J Am Coll Cardiol* 2021;78:1863-71.

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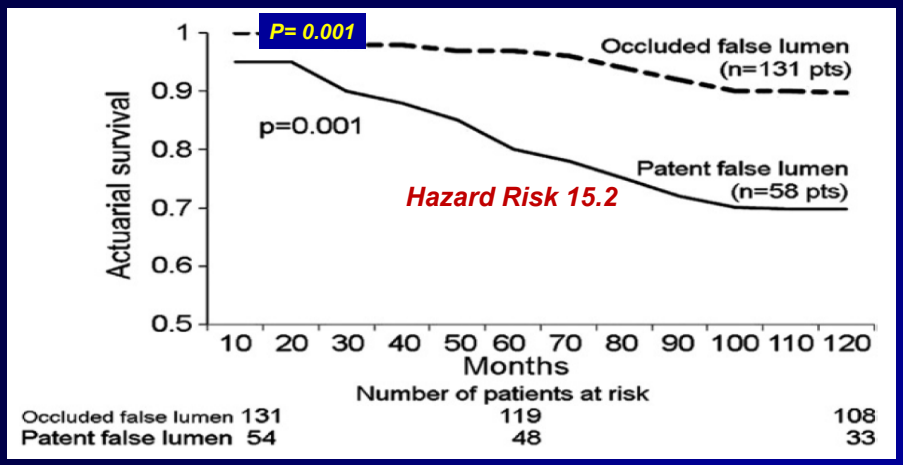
Survival After Type A Dissection: False Lumen



Fattouch, Ann *Thorac Surg* 2009.
224 pts acute DeBakey I dissection (early death 16%)
189 survivors followed, 48 with Marfan syndrome

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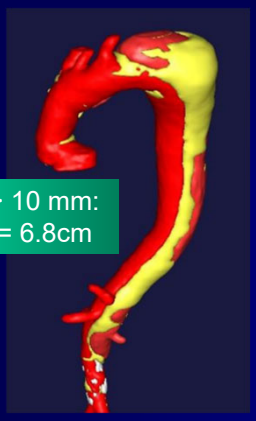
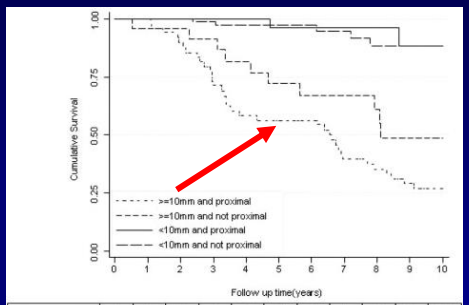
Type B Large Entry Tear: Bad!? Entry Tear Size and Proximal Location





	0	1	2	3	4	5	6	7	8	9	10
≥10mm prox	49	49	43	34	28	27	27	19	17	13	12
≥10mm not prox	23	22	21	19	17	14	12	12	10	8	8
<10mm prox	38	38	35	31	29	24	20	15	12	11	10
<10mm not prox	74	74	66	58	54	48	41	34	28	27	24

Cumulative survival free from sudden death and surgical/endovascular treatment by entry tear pattern (size and location). Prox indicates proximal.

Evangelista A, et al. *Circulation* 2012;125:3133-3141.

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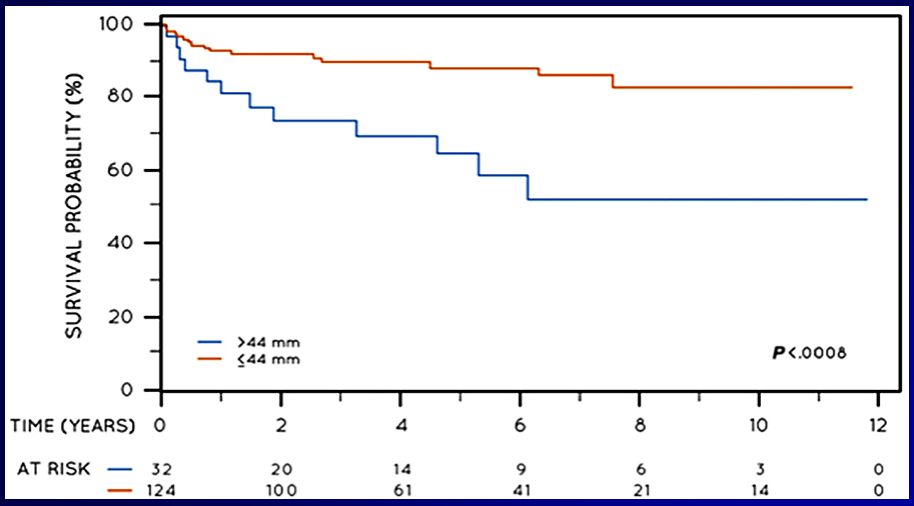
Large Diameter: Bad !? Type B Survival Related to Total Aortic Diameter



Ray HM, et al. *J Vasc Surg* 2016;64:1560-68.

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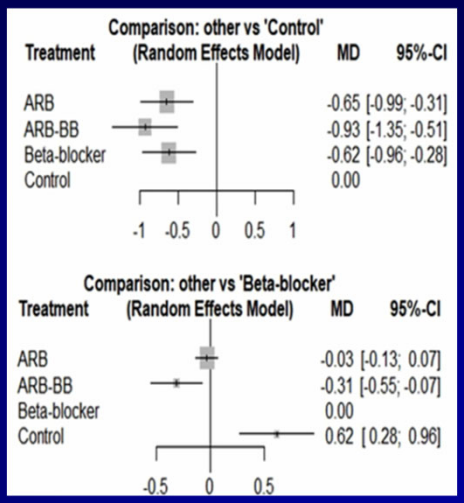
Mean Reduction in Aortic Root Dilatation (mm/year) in Marfan Syndrome

- 9 RCTs with 1,271 participants showed that the combination of BB and ARB is the most effective for prevention of aortic root dilatation in MFS compared to control group [mean difference in mm/year (MD) -0.93; 95% CI (-1.35, -0.51)]
- When compared head to head, there is no difference between BB and ARB, but the combination of ARB-BB is significantly more effective (MD -0.31; 95% CI -0.55, -0.07)



Aaqib H. Malik et al. *J Am Coll Cardiol* 2019;73:582-582.

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Marfan Syndrome

Recommendations for Medical Therapy in Marfan Syndrome Referenced Studies that Support the Recommendations are Summarized in the *Online Data Supplement*

COR	LOE	Recommendations
1	4	1. In patients with Marfan Syndrome, treatment with either a beta blocker or an ARB, in maximally tolerated doses (unless contraindicated), is recommended to reduce the rate of aortic dilation.
2a	C-LD	2. In patients with Marfan Syndrome, the use of both a beta blocker and an ARB, in maximally tolerated doses (unless contraindicated), is reasonable to reduce the rate of aortic dilation.

Same recommendation for LDS (Class 2a)

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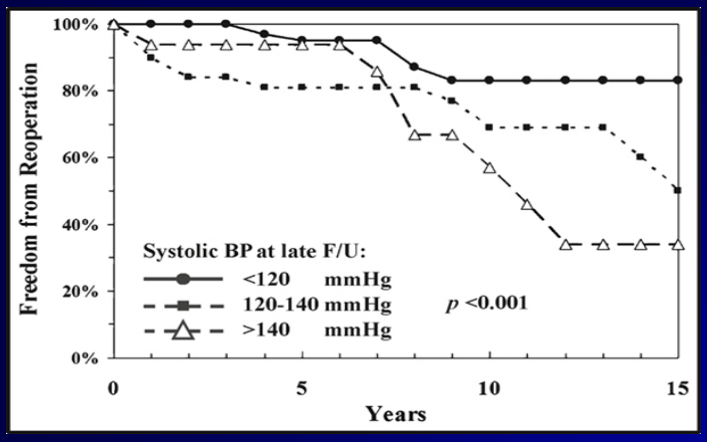
Importance of Blood Pressure Control After Repair of Acute Type A Aortic Dissection: 25-Year Follow-Up in 252 Patients



92% at 10 yrs

49% at 10 yrs

Reoperation rates:

SBP <120 mm Hg	3/85 (4%)
SBP 120-140 mm Hg	13/63 (21%)
SBP >140 mm Hg	10/30 (33%)

Melby S, et al. *J Clin Hyperten* 2013;15:63.

43

Are There Commonly Used Drugs that Pose Aortic Risk?

Calcium Channel Blockers	Ascending Aortic Dilation/Rupture in Marfan Mice	Signal of risk in Humans from GenTAC
Fluoroquinalones (Tendonitis, tendon rupture)	Aortic Aneurysm and Dissection in "Challenged" Mice (High Fat/↑ BP)	Epidemiologic Evidence of Aortic "Events" in Large Human Databases

Lemaire, S.

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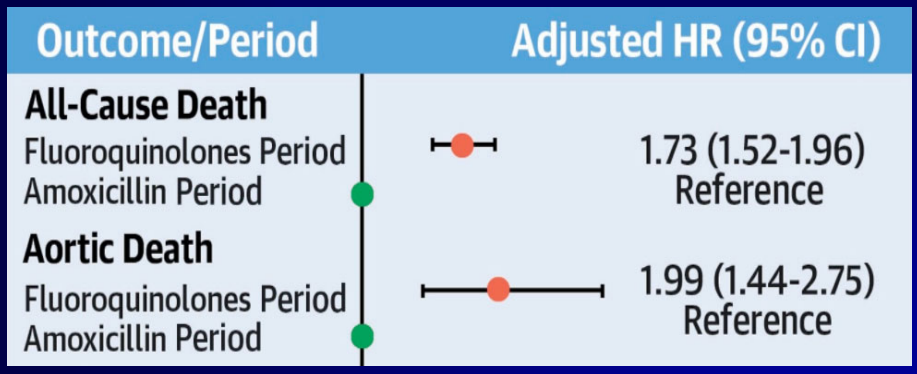
GenTAC Human Data

	Aortic Dissection		Aortic Surgery	
	Marfan	*Other*	*Marfan*	*Other*
	n=531	n=1819	n=531	n=1819
Odds in CCB	5.1%	0.57%	28.1%	10.70%
Odds in non-CCB	0.41%	0.12%	5.1%	4.4%
Odds Ratio-CCB	**12.5**	**4.7**	**5.5**	**2.4**
p-Value	0.032	NS	<0.001	<0.01
Odds Ratio (BP)	12.7	5.6	5.4	2.2
p-Value	0.06	NS	<0.001	0.016
Odds Ratio (Aortic Size)	11.2	4.1	5.0	2.2
p-Value	0.08	NS	<0.01	0.017

Doyle JJ, et al. *eLife* 2015;4:e08648.

45

Hazard of Fluoroquinalones and Aortic Dissection



Chen SW, et al. *J Am Coll Cardiol* 2021;77:1875-87.

46

Long Term Management of Aortic Dissection

- Medical management
  - Decrease dP/dT with beta blockers
  - Additional antihypertensives: ACE inhibitors, calcium channel blockers, etc
  - Goal is HR in 50's-60's, SBP 110-125
- Avoid heavy lifting or strain
  - Occupational responsibilities may be an issue
- Serial imaging studies to follow remaining aortic segments for aneurysm growth
  - Contrast-enhanced CT or MRI
  - Image abdominal aorta also if involved
  - 1, 3 and 6 months (consider 2 and 6 months)

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Pharmacological Treatment of Thoracic Aortic Disease

✓Beta blocker/ ARB
✓Other antihypertensive medications to treat hypertension
✓Statins, at least when indicated, maybe broader use
Endocarditis prophylaxis (AVR, aortic grafts, MVR, BAV)
Contraception (in women using ARB's, or at higher risk with pregnancy)

Discussing exercise and limitations of exercise

Avoid Fluoroquinolone/Levaquin- I enter it as an "allergy" in EMR

Influenza vaccine

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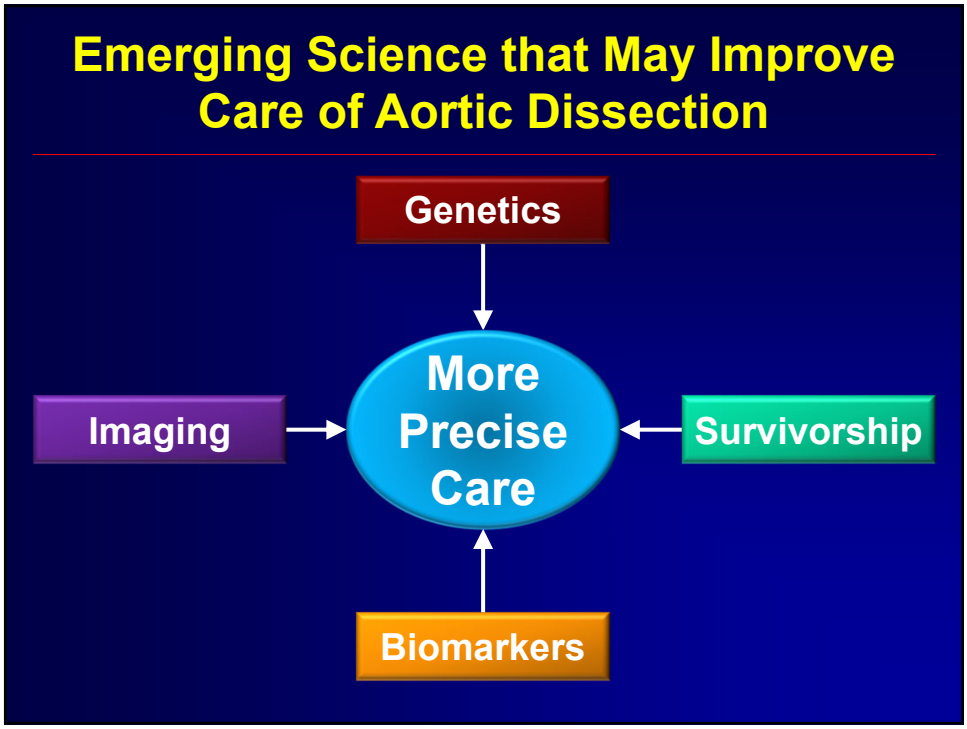

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Genetic Disorders: Thoracic Aortic Disease

Genetic Syndrome	Common Clinical Features	Genetic Defect	Diagnostic Test
Marfan Syndrome	Skeletal features Ectopic lentle	*FBN1* mutations*	Ghent diagnostic Criteria, DNA for sequencing
Loeys-Dietz Syndrome	Bifid uvula or cleft palate Arterial tortuosity Hypertelorism	*TGFBR2* or *TGFBR1* mutations	DNA for sequencing
Ehlers-Danios Syndrome	Thin, translucent skin GI rupture Rupture of gravid uterus Rupture of medium to large arteries	COL3A1 mutations	DNA for sequencing Dermal fibroblasts for analysis of type 3 collagen
Turner Syndrome	Short stature Primary amenorhea BAV Aortic coarctation	45 X karyotype	Cells for karyotype analysis

*The defective gene at a second locus for MFS is TGFBR2 but the clinical phenotype as MFS is debated.

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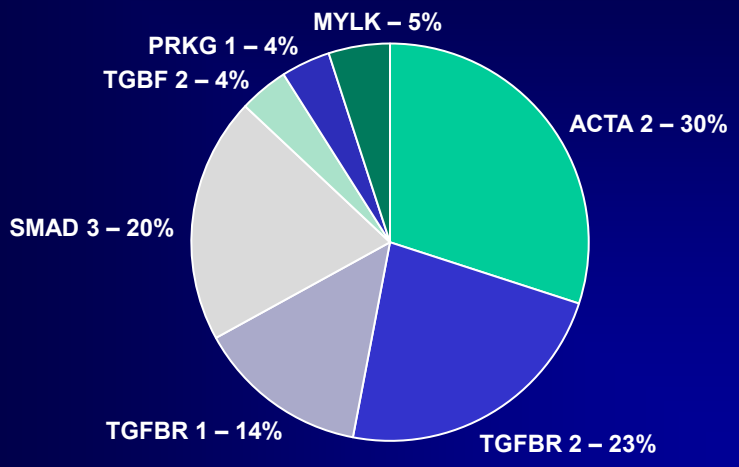
Heritable Thoracic Aortic Disease Genes

		Related syndrome (when applicable):
ECM	FBN-1 (fibrillin), COL3A1, MFAP5 (microfibril associated protein 5, BGN (Biglycan), LOX (lysyl oxidase), THSD4, ADAMS-like 6 protein	Marfan syndrome (FBN-1) vEDS (Col3A1)
TGF-β Signaling	TGFβR1 (TGF-b receptor type 1), TGFβR2 (TGF-b receptor type 2), SMAD3, SMAD4, TGFβ2,TGFβ3, latent TGF β–binding protein	LDS type I-IV
SMC	ACTA2 (smooth muscle a-actin), MYH11 (SM myosin heavy chain), MYLK (myosin light chain kinase), PRKG1 (protein kinasecGMP-dependent kinase, MAT2A (methionine adenosyl transferase Iia) FOXE3 (forkhead transcript factor E3)	

M. Roman & J. De Baker. Hereditary TAD: How to save lives *JTCVS* 2022;163:39-45.

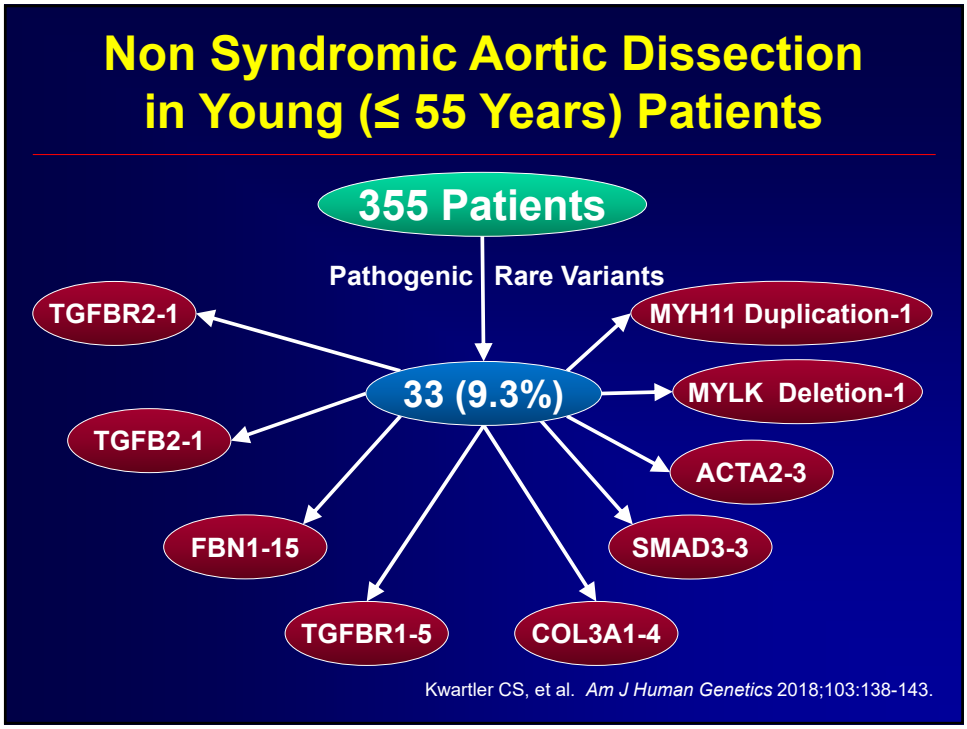
51

Familial Aortopathy: Montalcino Collaborative

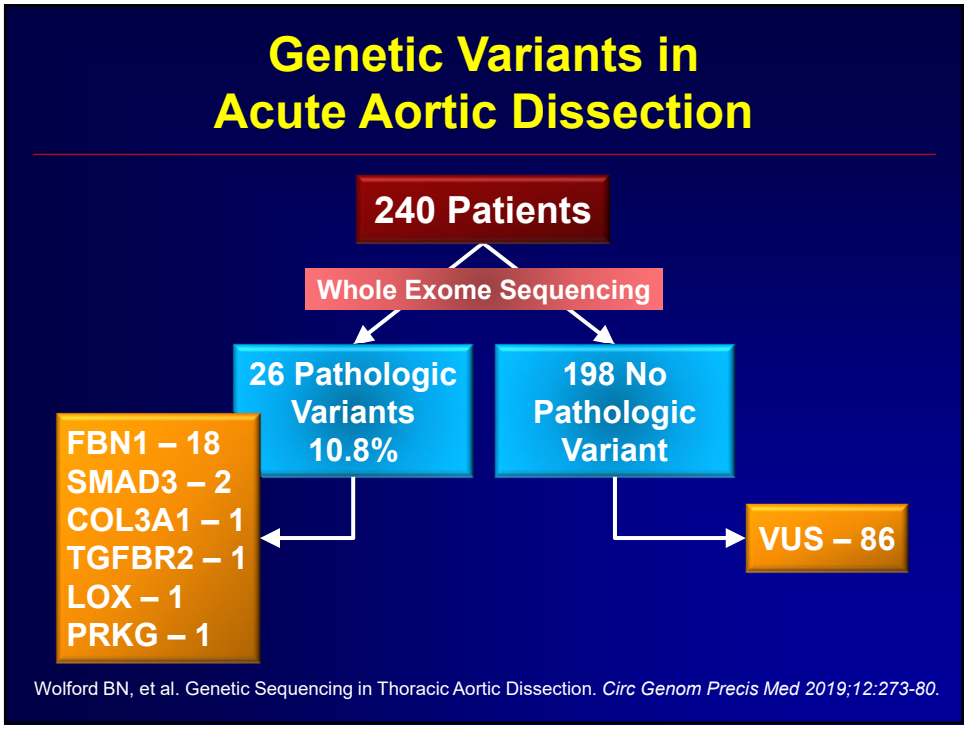


N = 1028 (9-20-20)

52


Non Syndromic Aortic Dissection in Young (≤ 55 Years) Patients
355 Patients
Pathogenic
Rare Variants
TGFBR2-1
MYH11 Duplication-1
33 (9.3%)
MYLK Deletion-1
TGFB2-1
ACTA2-3
FBN1-15
SMAD3-3
TGFBR1-5
COL3A1-4
Kwartler CS, et al. Am J Human Genetics 2018;103:138-143.

53


Genetic Variants in Acute Aortic Dissection
240 Patients
Whole Exome Sequencing
26 Pathologic Variants 10.8%
198 No Pathologic Variant
FBN1 – 18
SMAD3 – 2
COL3A1 – 1
TGFBR2 – 1
LOX – 1
PRKG – 1
VUS – 86
Wolford BN, et al. Genetic Sequencing in Thoracic Aortic Dissection. Circ Genom Precis Med 2019;12:273-80.

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Personalized Approach (Clinical Data and Gene Variant)

4.0 cm	4.2 cm	4.5 cm	5.0 cm	5.5 cm
PRKG1* TGFBR1* TGFBR2* vEDS Turner syndrome (>2.5 cm/m^2 in patients 15 y and older)	ACTA-2*	ACTA-2 TGFBR1 TGFBR2 SMAD3 TGFB2 Concomitant Aortic valve surgery # HTAD (other or unknown gene and with risk factors*)	BAV # Sporadic # Marfan syndrome HTAD Concomitant aortic valve surgery	BAV Sporadic

*Clinical risk factors of a family history of aortic dissection <5 cm or unexplained sudden death before age 50, or with rapid aneurysm growth of 0.5 cm/year or 0.3 cm in 2 consecutive years

In centers with high surgical volumes of >50 surgeries on ascending aorta per year

55

Surgical repair cut offs (cm):

- Sporadic: ≥5.5 (Symptomatic or rapid growth (≥0.3/yr x2 or ≥0.5/yr)
- NSHTAD: ≥5.0 (≥4.5 if high risk features/Hx or CT surg of another reason)
- Marfan: ≥ 5.0 (≥ 4.5 if high risk features)
- Loeys-Dietz: varies by mutation and risk factors ≥4.0-5.0
- BAV: ≥5.5 (≥5.0+RF, or ≥4.5 and CT surg for another reason 2a)

- Risk factors: Family Hx dissection, rapid growth (>0.3cm.yr), diffuse aortic root and ascending aortic dilation, or marked vertebral artery tortuosity.

Circulation. 2022 ACC/AHA Guideline for the Diagnosis and Management of Aortic Disease

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Yield of Genetic Testing in Aortic Diseases

Category	Likelihood of Finding an Abnormal Gene
Syndromic Features	90%
Family History	30%
Dissection at Age ≤55	10%

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When to Perform Genetic Testing in Patients with Aortic Disease

- Syndromic features with extra aortic manifestation suggestive for Marfan syndrome (MFS) and Loeys Dietz syndrome (LDS)
- Age <60 years
- Family history of aortic, peripheral or intracranial aneurysm
- Family history of sudden cardiac death less than 50 years in first or second degree relatives

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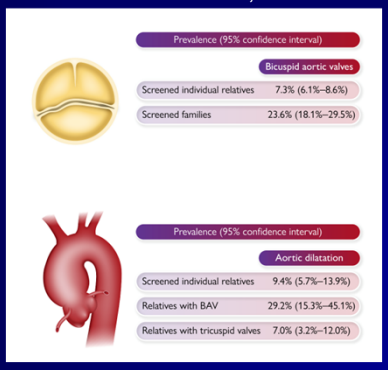
Prevalence of BAV and Aortic Dilation Among Relatives of People with BAV

A Systematic Review and Meta-analysis of 23 Studies
Including 2,297 Index Cases and 6,054 Screened Relatives



Bray JJH, et al. *Eur Heart J* 2023.

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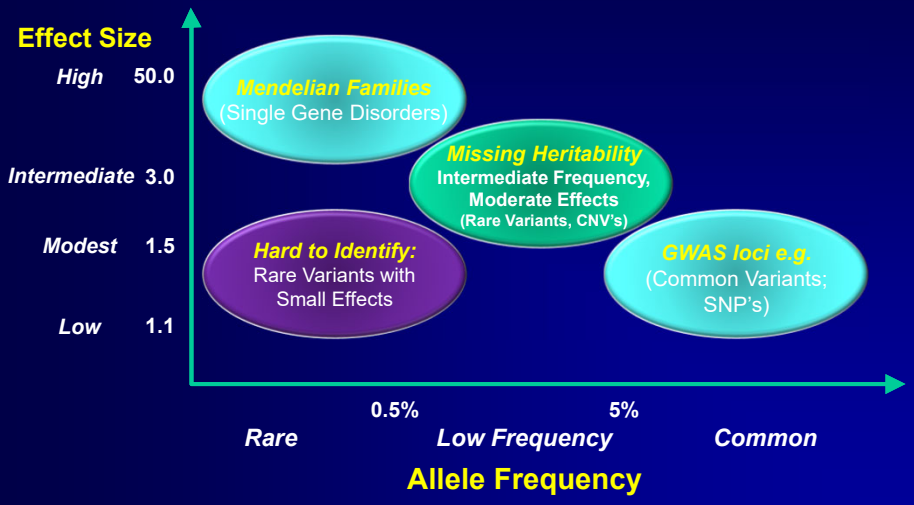
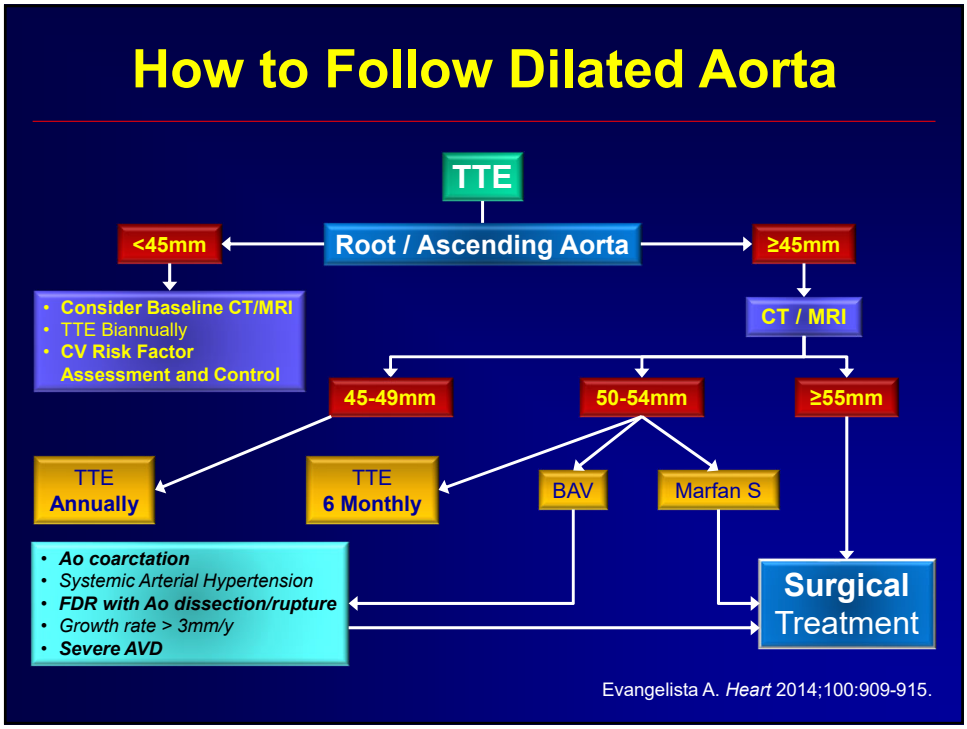
Genetics of Aortic Diseases: An Emerging Science

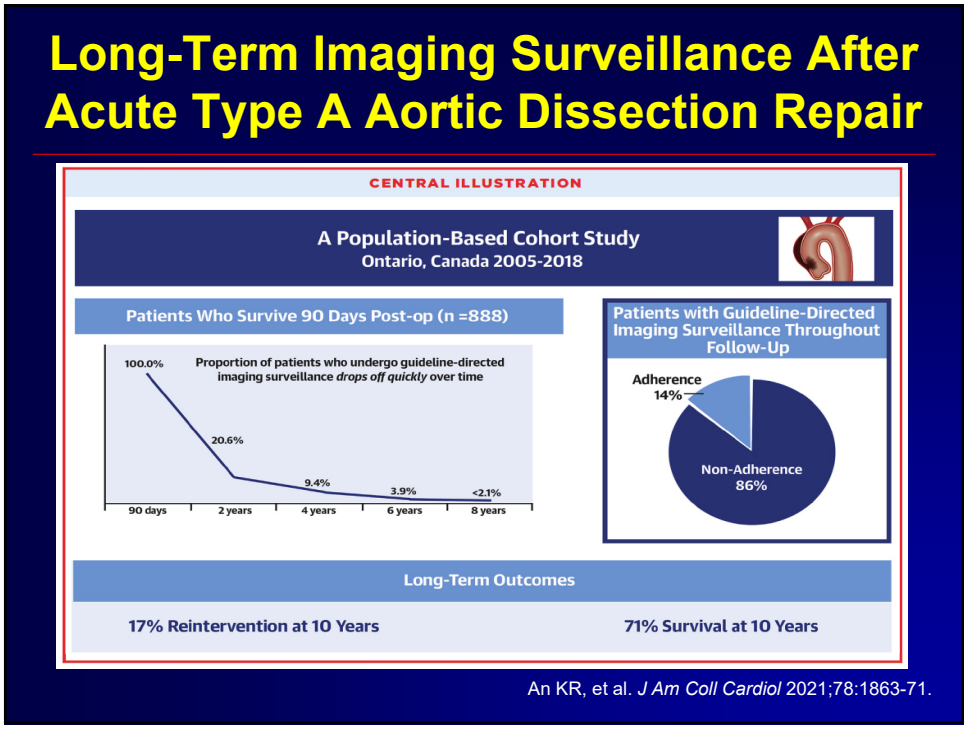


(Adapted from) Magnani JW, et al. *Circulation* 2011;124:1982-93.

60


How to Follow Dilated Aorta
TTE
Root / Ascending Aorta
<45mm
≥45mm
• Consider Baseline CT/MRI
• TTE Biannually
• CV Risk Factor Assessment and Control
CT / MRI
45-49mm
50-54mm
≥55mm
TTE Annually
TTE 6 Monthly
BAV
Marfan S
• Ao coarctation
• Systemic Arterial Hypertension
• FDR with Ao dissection/rupture
• Growth rate > 3mm/y
• Severe AVD
Surgical Treatment
Evangelista A. Heart 2014;100:909-915.

61


Long-Term Imaging Surveillance After Acute Type A Aortic Dissection Repair
CENTRAL ILLUSTRATION
A Population-Based Cohort Study
Ontario, Canada 2005-2018
Patients Who Survive 90 Days Post-op (n =888)
Proportion of patients who undergo guideline-directed imaging surveillance drops off quickly over time
100.0%
20.6%
9.4%
3.9%
<2.1%
90 days
2 years
4 years
6 years
8 years
Patients with Guideline-Directed Imaging Surveillance Throughout Follow-Up
Adherence 14%
Non-Adherence 86%
Long-Term Outcomes
17% Reintervention at 10 Years
71% Survival at 10 Years
An KR, et al. J Am Coll Cardiol 2021;78:1863-71.

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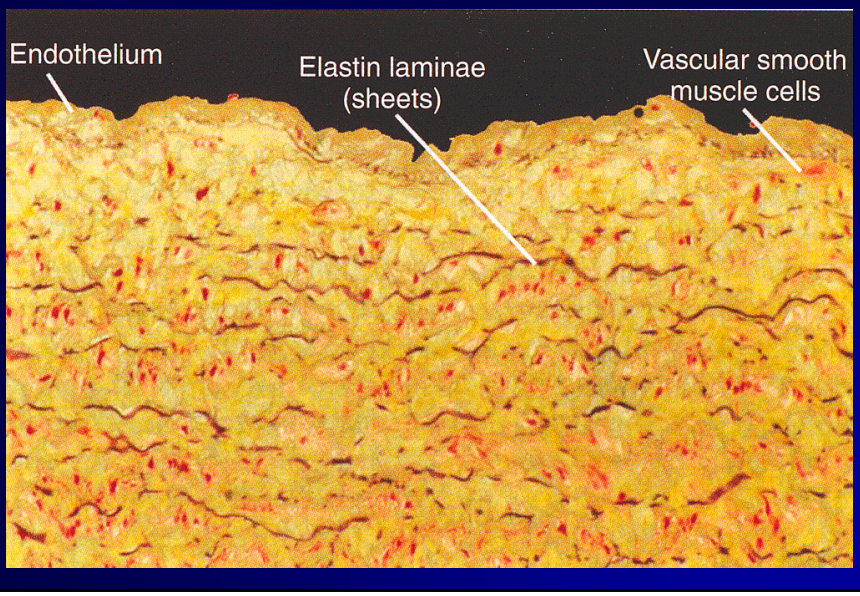
Searching for A Biomarker!



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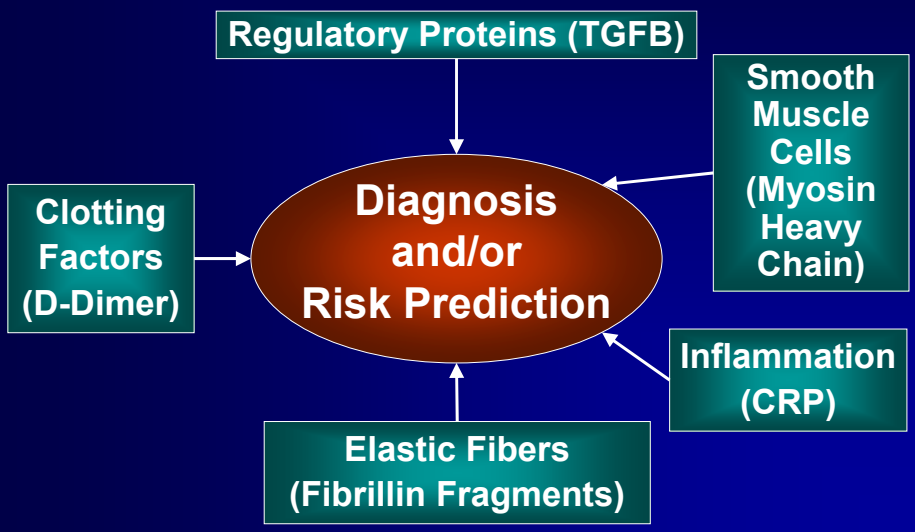
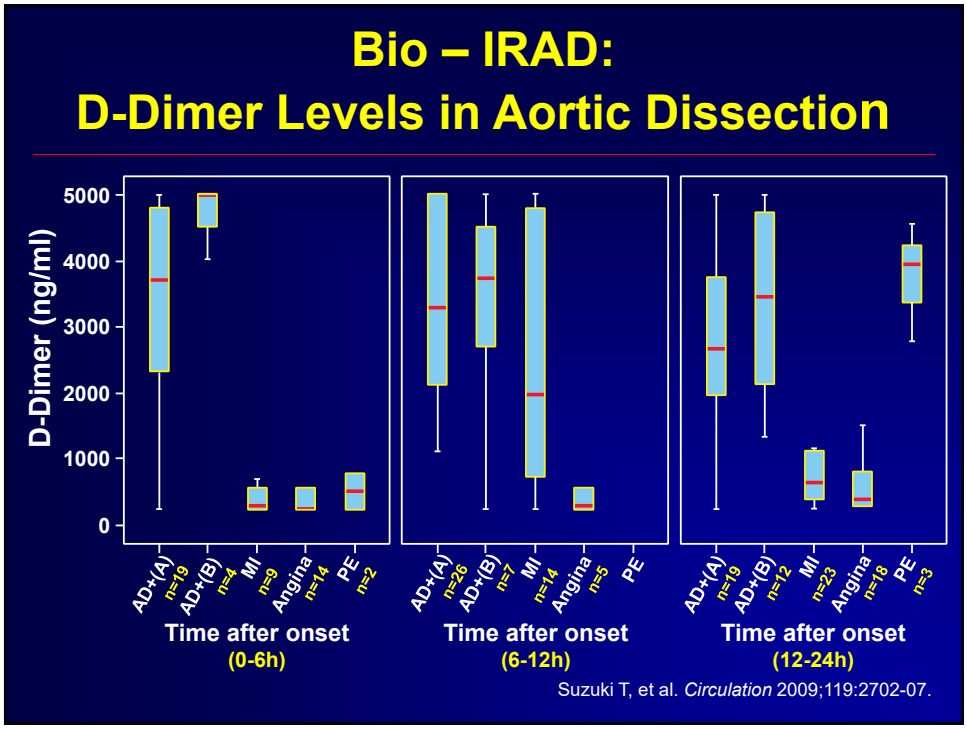
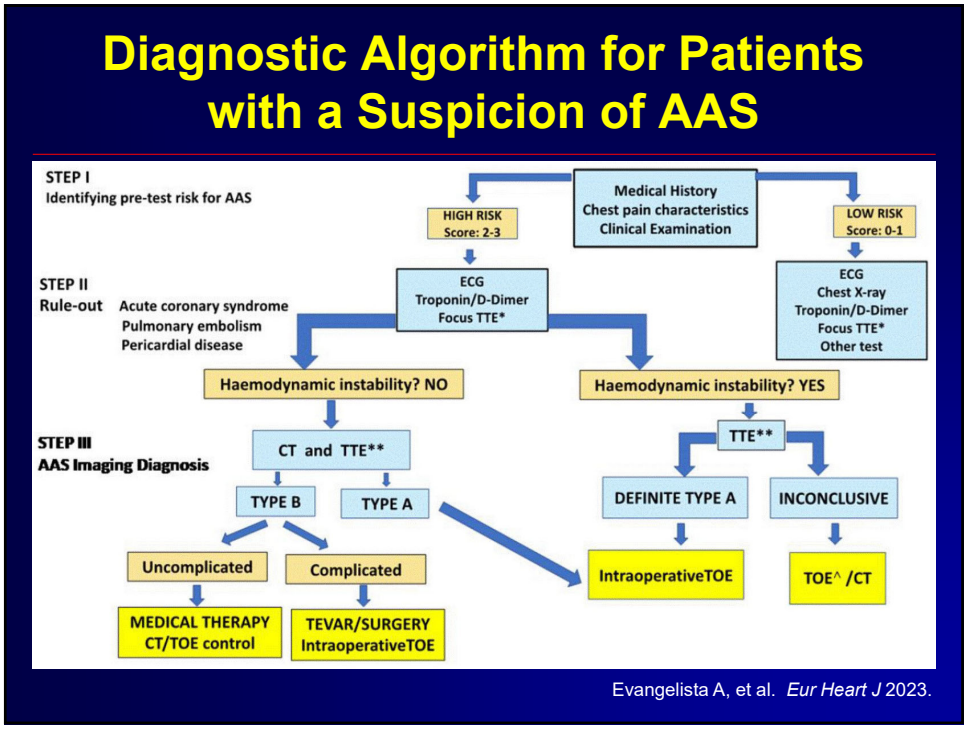
Biomarkers "Targets" in Acute and Chronic Thoracic Aortic Disease



64


Bio – IRAD:
D-Dimer Levels in Aortic Dissection
D-Dimer (ng/ml)
5000
4000
3000
2000
1000
0
AD+(A) n=19
AD+(B) n=4
MI n=9
Angina n=14
PE n=2
Time after onset
(0-6h)
AD+(A) n=26
AD+(B) n=7
MI n=14
Angina n=5
PE
Time after onset
(6-12h)
AD+(A) n=19
AD+(B) n=12
MI n=23
Angina n=18
PE n=3
Time after onset
(12-24h)
Suzuki T, et al. Circulation 2009;119:2702-07.

65


Diagnostic Algorithm for Patients with a Suspicion of AAS
STEP I
Identifying pre-test risk for AAS
Medical History
Chest pain characteristics
Clinical Examination
HIGH RISK
Score: 2-3
LOW RISK
Score: 0-1
STEP II
Rule-out
Acute coronary syndrome
Pulmonary embolism
Pericardial disease
ECG
Troponin/D-Dimer
Focus TTE*
ECG
Chest X-ray
Troponin/D-Dimer
Focus TTE*
Other test
Haemodynamic instability? NO
Haemodynamic instability? YES
STEP III
AAS Imaging Diagnosis
CT and TTE**
TTE**
TYPE B
TYPE A
DEFINITE TYPE A
INCONCLUSIVE
Uncomplicated
Complicated
IntraoperativeTOE
TOE^ /CT
MEDICAL THERAPY
CT/TOE control
TEVAR/SURGERY
IntraoperativeTOE
Evangelista A, et al. Eur Heart J 2023.

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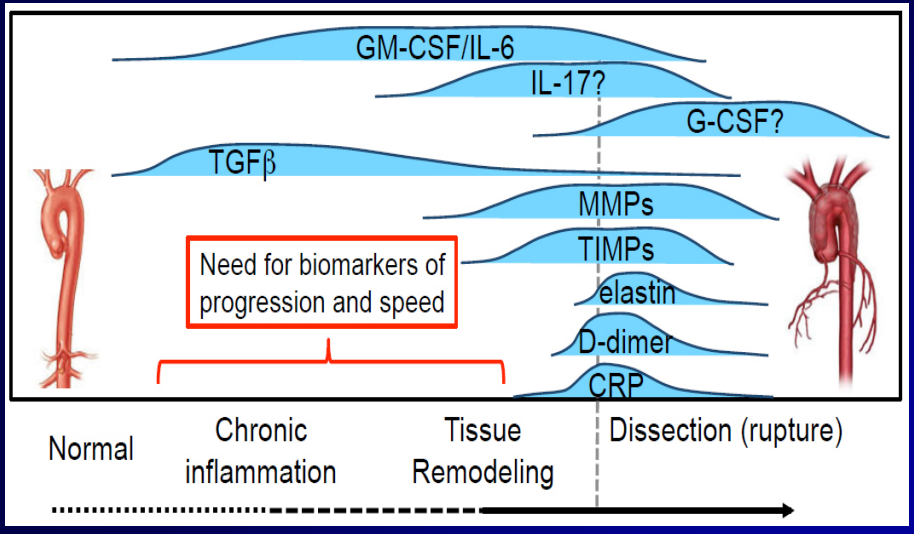
Potential Biomarkers of Chronic Dissection



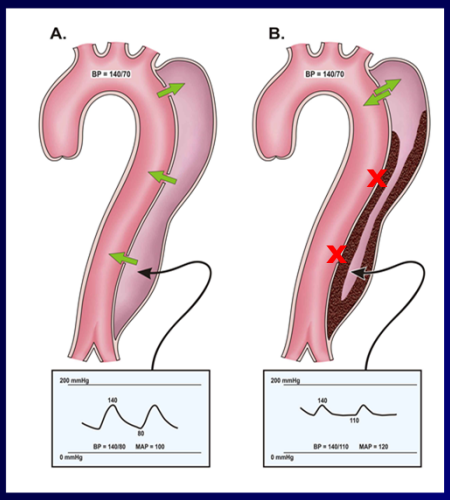
Suzuki T, et al. *Eur Heart J* 2008;29:1439-45.

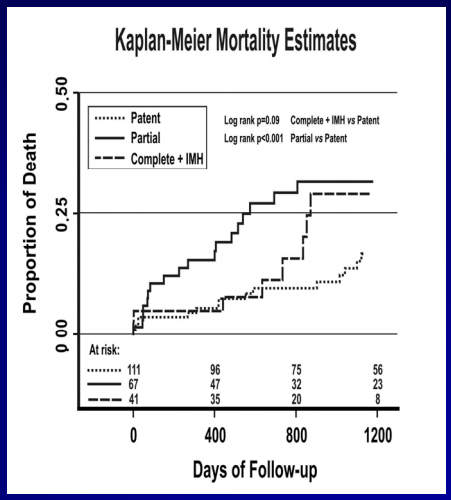
67

Imaging: Moving from Size to Susceptibility

68

More Precision Using Imaging! Partial Thrombosis of False Lumen in Acute Type B Dissection

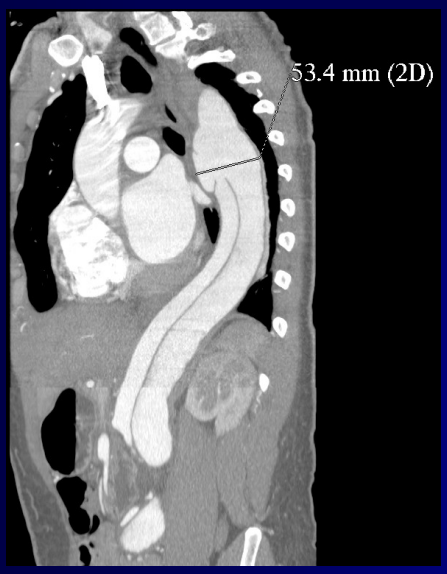


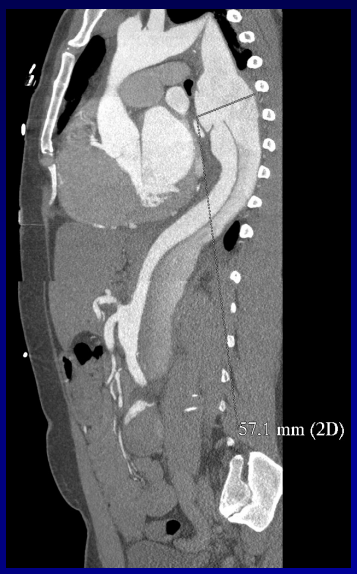


Tsai TT, et ai. *N Engl J Med* 2007;357:349-359., Tsai TT, et al. *J Vasc Surg* 2008;47:844-51.

69

Changes on Imaging and Guide Therapy!





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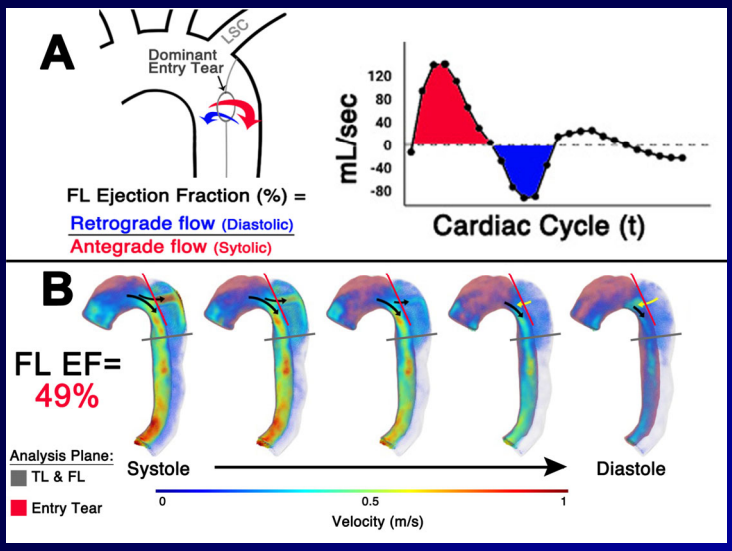
4D Flow – Estimate FL Pressurization



Burris N et al. *Eur J Cardiothorac Surg*. 11/2019 (In Press).

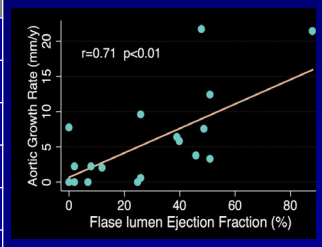
71

False Lumen EF – Predicts Growth

- Medically managed type B dissection (n=18)
- FL Ejection Fraction independent-predictor of growth

Aortic Growth Rate - Multivariate Model

Variable	β	SE	95% CI	p-value
False Lumen EF	0.15	0.04	0.06 – 0.24	<0.01
Baseline Aortic Diameter	0.37	0.14	0.07 – 0.68	0.02
Follow-up Interval[2]	-0.11	0.09	-0.32 – 0.12	0.28
Entry Tear Average Size	0.21	0.18	-0.18 – 0.60	0.26
False Lumen Net Flow	-1.50	0.77	-3.22 – 0.21	0.08
False Lumen Peak Velocity	0.04	0.05	-0.07 – 0.15	0.47
Entry Tear Distance from LSC	0.07	0.02	0.01 – 0.13	0.02



Burris N et al. *Eur J Cardiothorac Surg*. 11/2019 (In Press).

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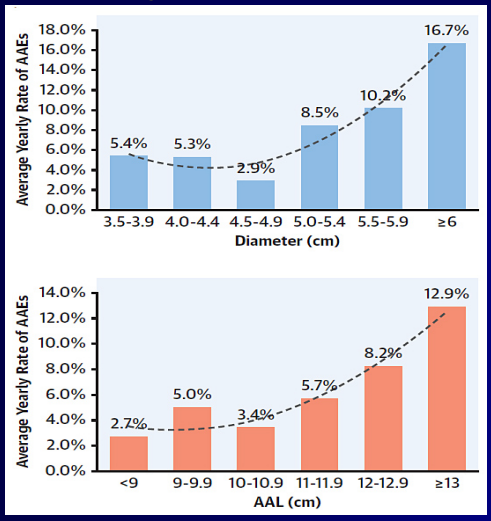
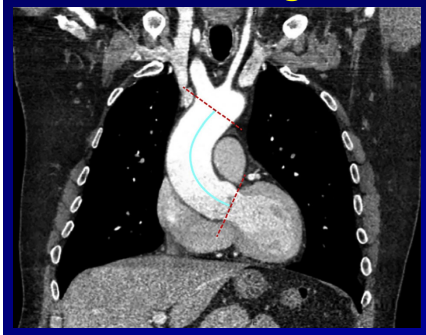
Aortic Length and Adverse Events

Yearly Rates of AAEs



Measuring Ascending Aortic Length



Wu J, et al. *J Am Coll Cardiol* 2019;74:1883-94.

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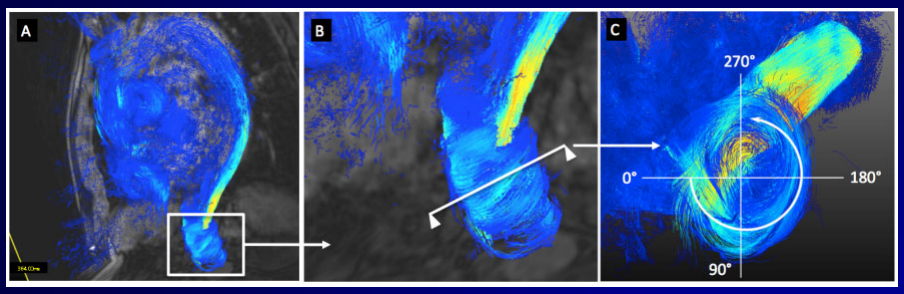
Dynamic Imaging: A Key Concept for Personalized Treatment and Follow-Up?

74

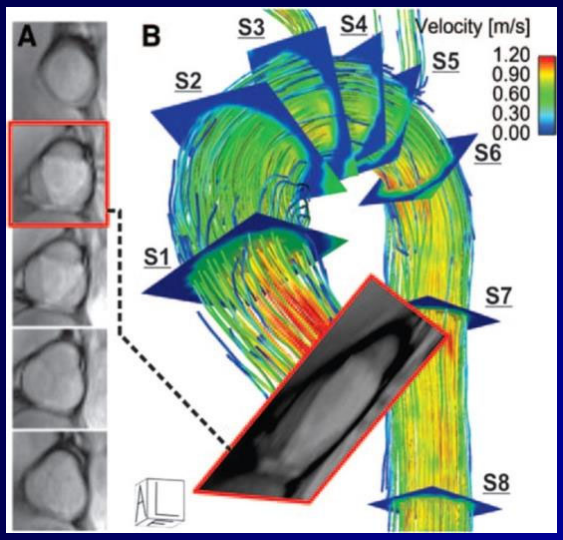
Helicity Quantification



Clough RE, et al. *J Vasc Surg* 2012;55:914-23.

75

Linear Flow - Good



Barker AJ, et al. *Circ Cardiovasc Imaging* 2012;5:457-466.

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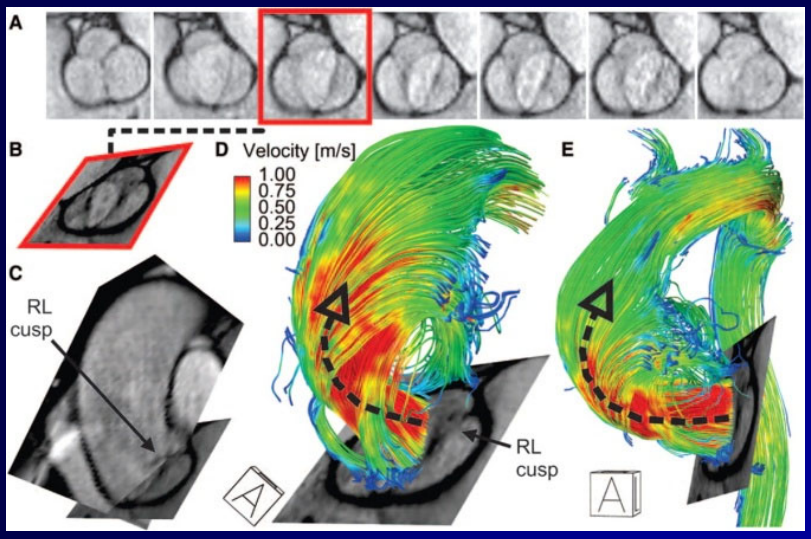
Turbulent Flow – Bad!



Barker AJ, et al. *Circ Cardiovasc Imaging* 2012;5:457-466.

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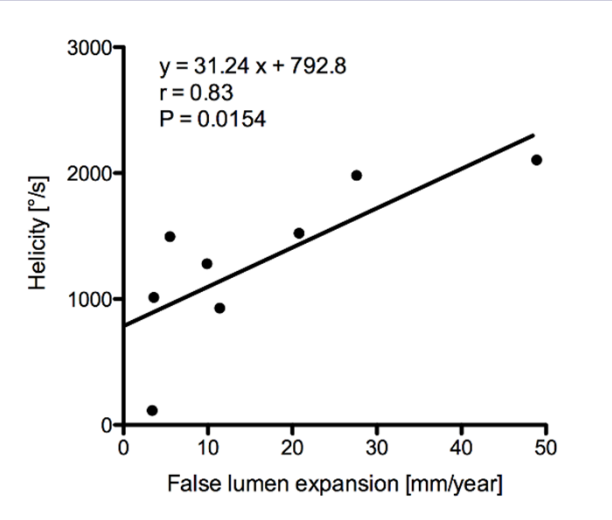
Helicity and Outcomes

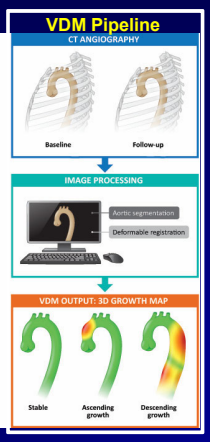


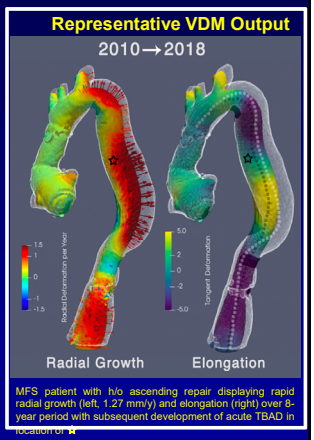
Clough RE, et al. *J Vasc Surg* 2012;55:914-23.

78

Vascular Deformation Mapping (VDM)

- Image analysis technique for 3D aortic growth measurement.
  - **Input**: Thin-slice CT scans at 2 times
  - **Output**: Colorized 3D map of growth overlaid on aortic anatomy
- **Uses standard clinical CTA images**
  - No special scan procedures
- **Three-dimensional growth map**
  - Not subject to specific plane or direction
- **Sub-millimeter accuracy[2]**
  - Outperforms expert raters





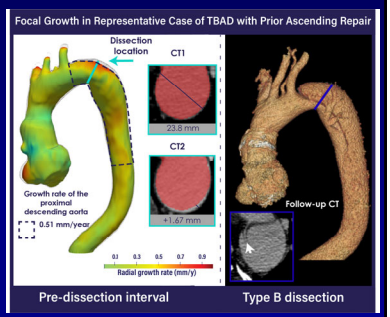
1. Burris et al. *Radiology*. 2022.
2. Bian et al. *Medical Physics*. 2022.

79

Elevated 3D Growth in MFS w/ Type B Dissection

- **105 Ghent+ MFS patients at UM:** Mean CT surveillance interval of 8 years, 70% with prior root repair
- TBAD patients significantly more likely to be **female** and have **dural ectasia**.
  - No differences in age, BP, ACE/ARB & BB use, lens or mitral disease.
- Minimally dilated pre-dissection diameter (mean of 29 mm).

VDM Analysis Descending Aortic Growth		No TBAD N=93	TBAD N=12	p-value
Radial	Absolute growth (mm)	1.07 (0.6-2.9)	3.79 (2.09-7.68)	0.001
	Growth rate (mm/y)	0.23 (0.13-0.35)	0.63 (0.45-1.39)	<0.001
Elongation	Absolute elongation (mm)	2.0 (-0.9, 8.0)	11.3 (5.3-19.3)	0.002
	Elongation rate (mm/y)	0.5 (-0.2, 1.4)	2.4 (1.3-4.5)	<0.001



Radial growth rate threshold of **0.4 mm/y** shows 92% sensitivity, 81% specificity for TBA

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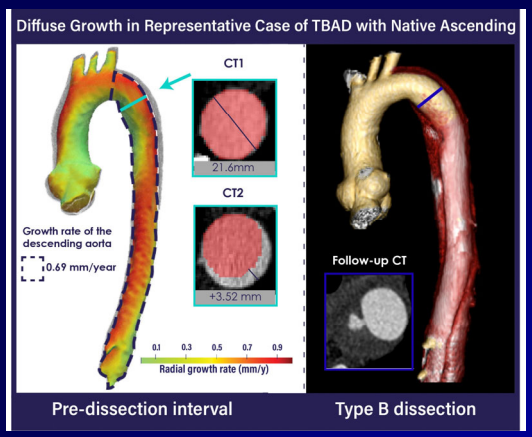
Representative case with TBAD



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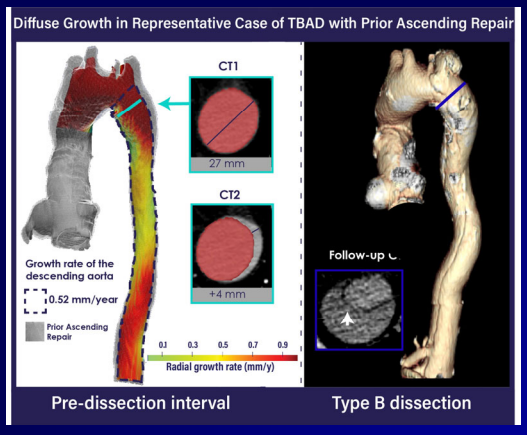
Representative case with TBAD



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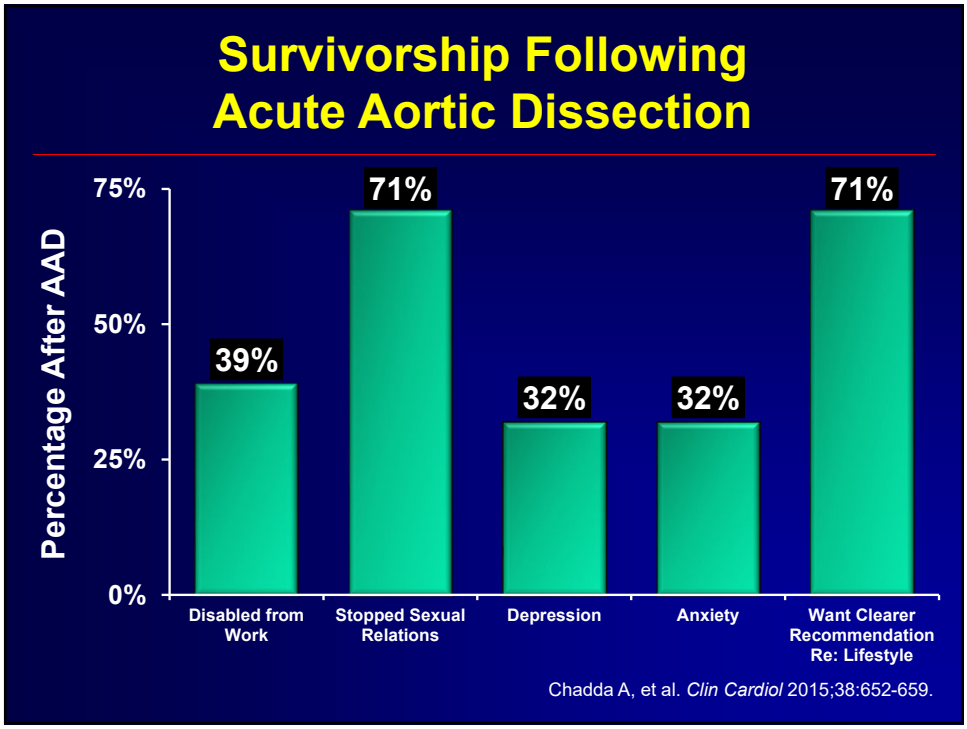

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Top Concerns of Aortic Dissection Survivors

Question/Concern	Percentage/Identifying
Does having the right educational resource for doctors improve health care for dissection	54%
Does genetic testing improve health	50%
What kind of exercise is safe & beneficial	47%
For subacute dissection, when is the right time for surgery	47%
Does education of patients and families improve outcomes	44%
What meds are best?	32%

Ref: Aortic Dissection Collaborative.

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On the Death of King George II in 1760: Aortic Dissection in Perspective

"On the 25th of October he [King George II] rose as usual at six, and drank his chocolate; for all his actions were invariable methodic. A quarter after seven he went into a little closet. His German valet de chambre in waiting heard a noise, and running in found the King dead on the floor. Nichols was directed to open and embalm the royal body. ***What he found*** (and meticulously described) ***was the first clear account of the condition we now know*** (after Laennec) ***as aortic dissection*** (AD): "…the ***pericardium was found distended with a quantity of coagulated blood, nearly a pint*** …; the whole heart was so compressed as to prevent any blood contained in the veins from being forced into the auricles; therefore the…

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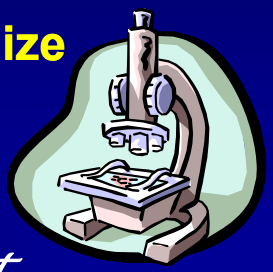
Disease is very old, and nothing about it has changed.

It is we who change as we learn to recognize what was formerly imperceptible.

- Charcot



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- Hadassah University Hospital
- Hopital Bichat
- Houston Methodist
- Hospital General Universitari Vall d'Hebron
- Hospital Universitario "12 de Octubre"
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University of Michigan Collaborators

IRAD Core
Jim Froehlich
Eva Kline-Rogers
Chih-Wen Pai
Patsy Bruenger
Tina Alexandris-Souphis
Elise Woznicki

UM Aortic Program
G. Michael Deeb
Jon Eliason
David Williams
Himanshu Patel

UM Aortic Program
Santhi Ganesh
Kristen Willer
Stan Chetcuti
Bill Armstrong
Mike Shea
Troy LaBounty
Bo Yang
Nicole Bhave
Shinichi Fukuhara
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"There is no disease more conducive to clinical humility than aneurysm of the aorta"

- Sir William Osler

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Faith, family, friends, colleagues…These are the "things" that matter…

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