Sistema Socio Sanitario

Regione Lombardia

Fondazione IRCCS Policlinico San Matteo

ASST Pavia

ATS Pavia

UNIVERSITÀ DI PAVIA

GRAND ROUNDS CLINICI DEL MERCOLEDÌ

con il Policlinico San Matteo

Aula Magna "C. Golgi" & WEBINAR

" Dissezione acuta dell'aorta: tragedia ineluttabile oppure cronaca di un evento annunciato ?".

Dr Pasquale TOTARO, Dr Stefano PELENGHI
SC Cardiochirurgia

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GRAND ROUNDS CLINICI DEL MERCOLEDÌ

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Aula Magna "C. Golgi" & WEBINAR

RC n. 08074722

"Multidisciplinary analysis by morphological and mechanical evaluation of the aortic wall in patients with aortic disease, undergoing aortic cardiac surgery, vs patients without aortic disease"

Analisi multidisciplinare mediante valutazione morfologica e meccanica della parete aortica in pazienti con patologia aortica sottoposti a chirurgia aortica vs pazienti senza patologia aortica

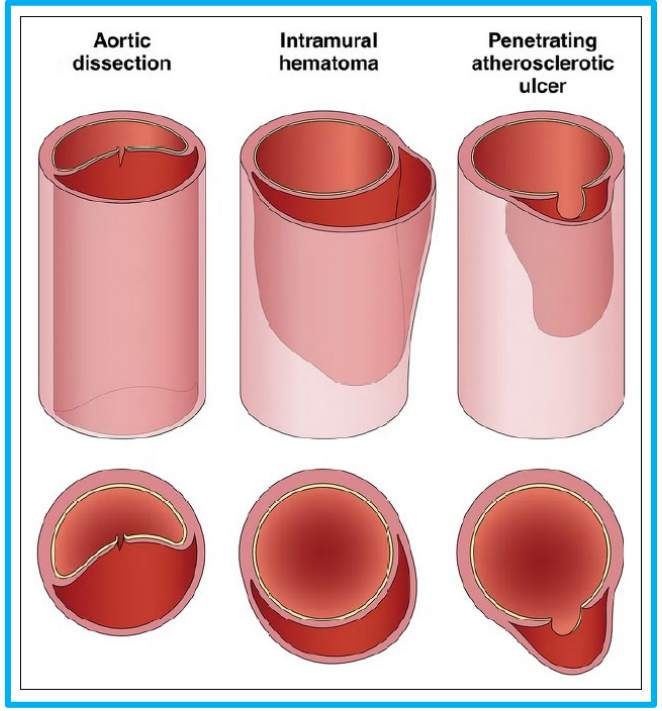
Giulia FORMENTON, Alessandro CAIMI
Dipartimento di Ingegneria Civile e Architettura (DICAR)
Università degli studi di Pavia

Who is the enemy ?

Abbaliese Livingston

Acute Aortic Syndromes

in most population series the incidence of aortic dissection ranges from 0.61 to 7.2/100 000 people



In one study in the USA performed during the 2010–2015 period, the incidences of AD, intramural haematoma (IMH) and penetrating aortic ulcer (PAU) were **4.4, 1.2 and 2.1 per 100 000 person-years,** respectively

De Martino et al. Circ Cardiovasc Qual Outcomes 2018;11:e004689.

One study in Japan reports a much higher incidence **(17.6 per 100 000),** which is probably more accurate because the authors performed systematic CT scans on all out-of-hospital deceased persons without a clear cause of death

Yamaguchi et al. Eur Heart J Acute Cardiovasc Care 2021;10:701–9.

1

Incidenza della dissezione toracica 7,7 /100.000 persone-anno

2

Incidenza dell'aneurisma toracico 5,3 /100.000 persone anno

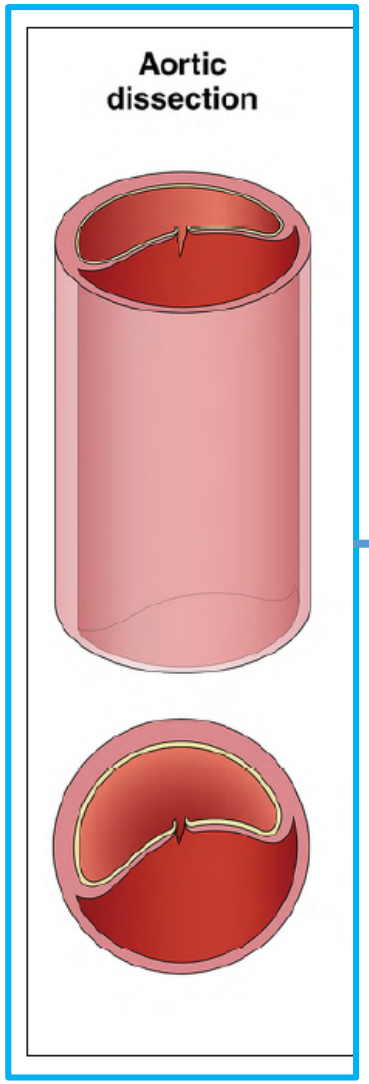
- 40 aneurismi attesi ogni anno
- 59 dissezioni attese ogni anno

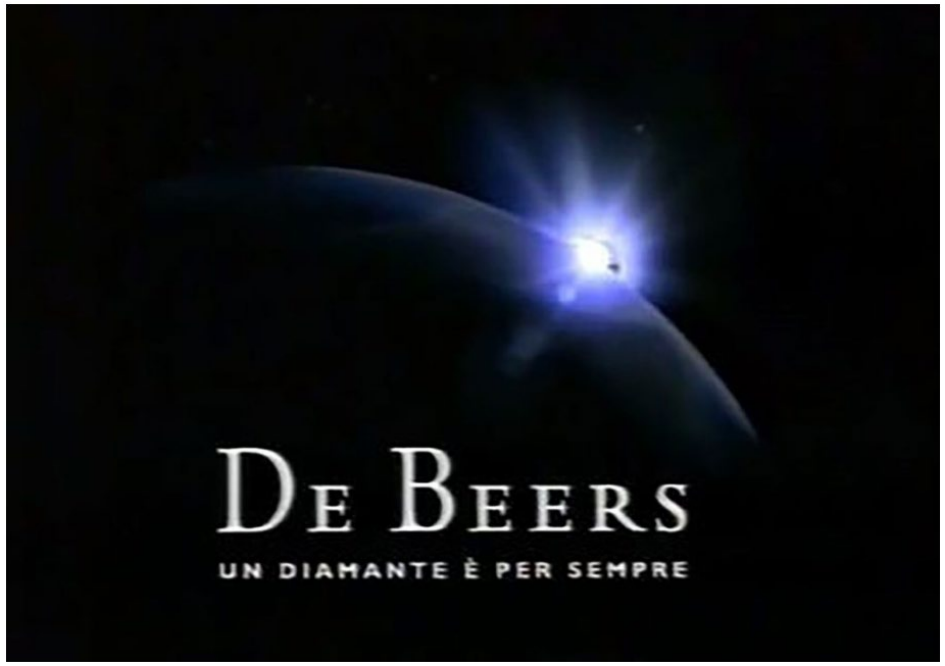
.....Acute aortic dissection of the ascending aorta is highly lethal in symptomatic patients left untreated, with an early mortality of 1% to 2% per hour after symptom onset.....

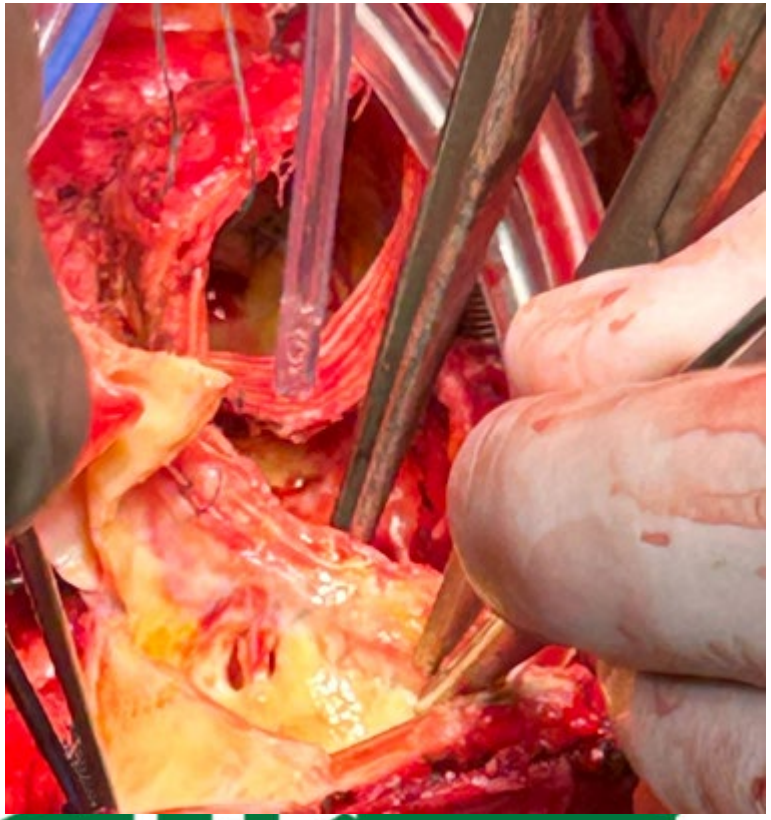
Tsai TT, Nienaber CA, Eagle KA. Acute aortic syndromes. Circulation. 2005;112:3802–3813.

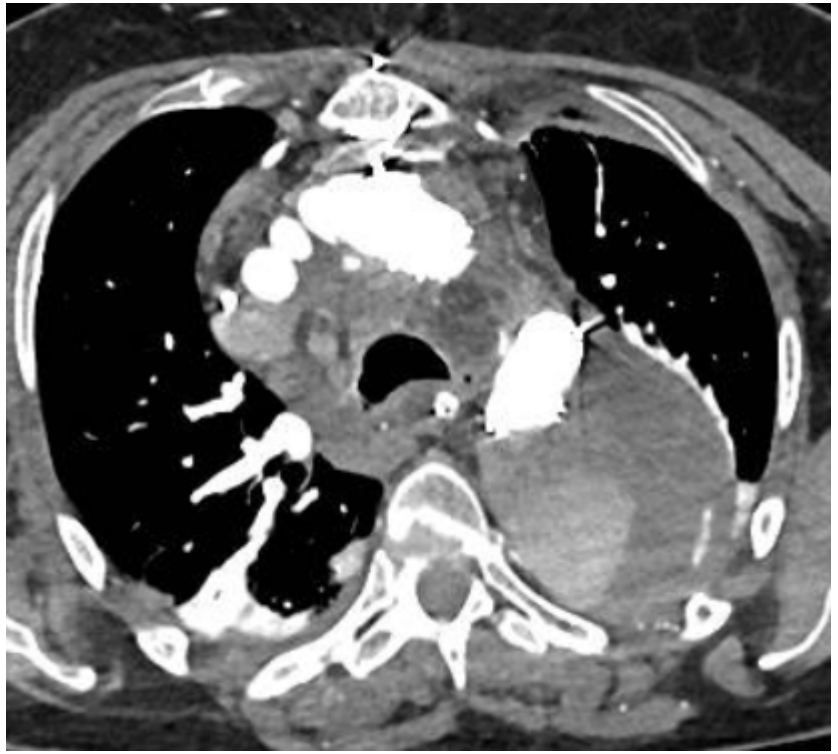
- Acute aortic syndromes (AAS) represent the most frequent emergency situation in cardiac surgery.
- Despite the improvements recorded in the last few decades, postoperative mortality in these situations is still significant (5-20%).
- The study of potential markers capable of identifying high-risk patients for AAS has monopolized the international literature for many years.
- Although many potential markers have been identified, the current guidelines are based, in the absence of morphological signs, on two keys: the maximum dilation and its evolution over time.

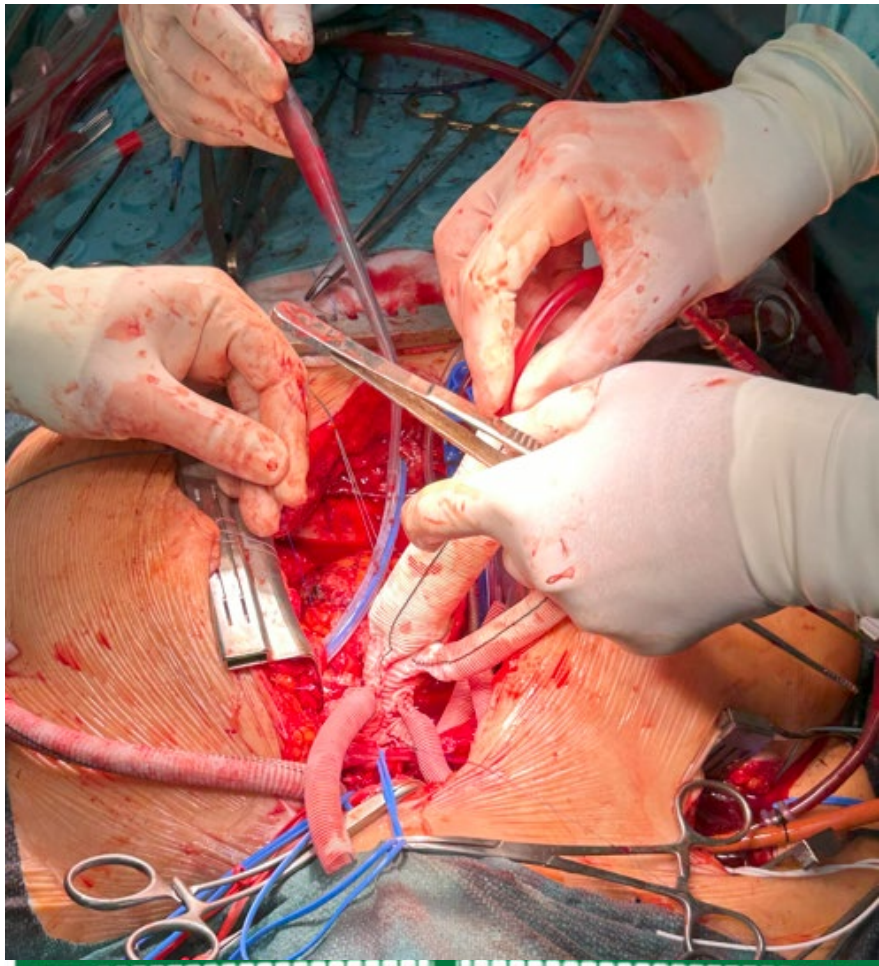
Risk Prediction











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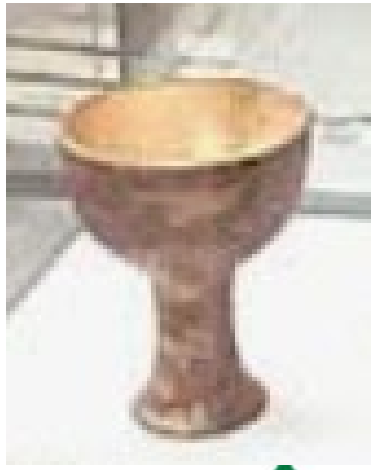
AAS Prediction



?

Is it really possible to predict an AAS

European Journal of Cardio-Thoracic Surgery 2024, 65(2), ezad426
https://doi.org/10.1093/ejcts/ezad426

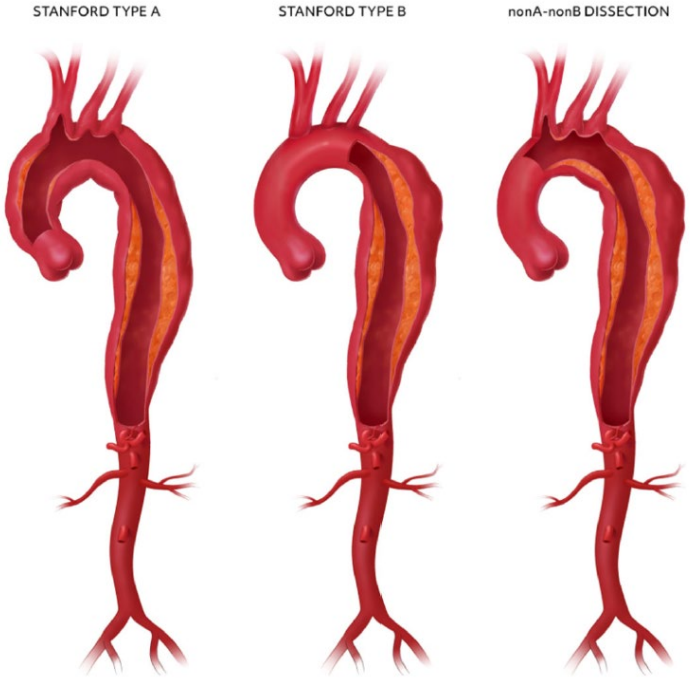
GUIDELINES

Cite this article as: Czerny M, Grabenwöger M, Berger T, Aboyans V, Della Corte A, Chen EP *et al.* EACTS/STS Guidelines for diagnosing and treating acute and chronic syndromes of the aortic organ. Eur J Cardiothorac Surg 2024; doi:10.1093/ejcts/ezad426.

EACTS/STS Guidelines for diagnosing and treating acute and chronic syndromes of the aortic organ

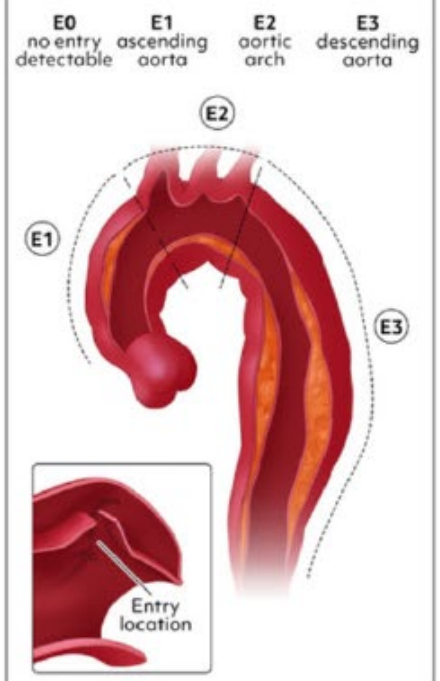
Authors/Task Force Members: Martin Czerny [a,b,*,†] (Co-Chairperson) (Germany), Martin Grabenwöger [c,d,*,†]

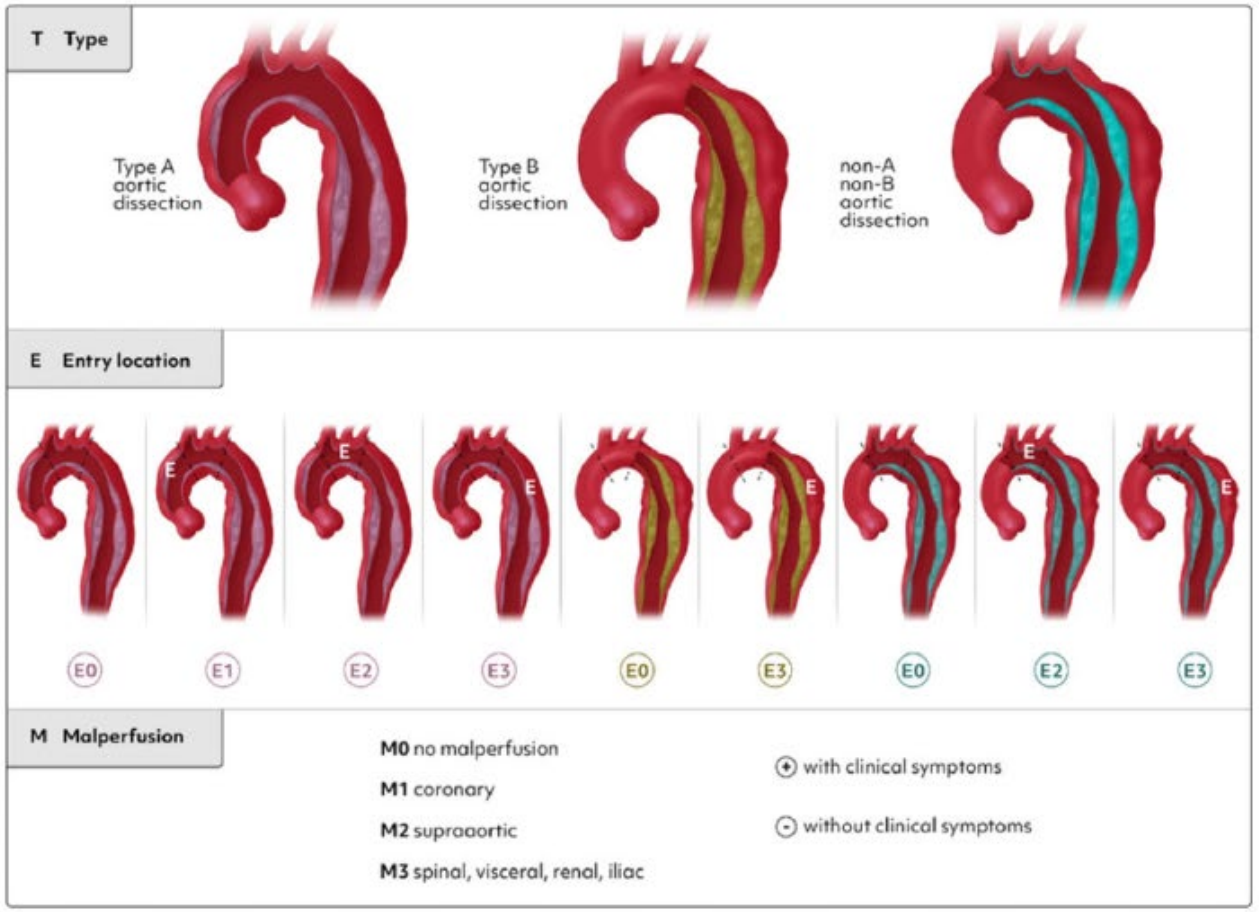
GUIDELINES



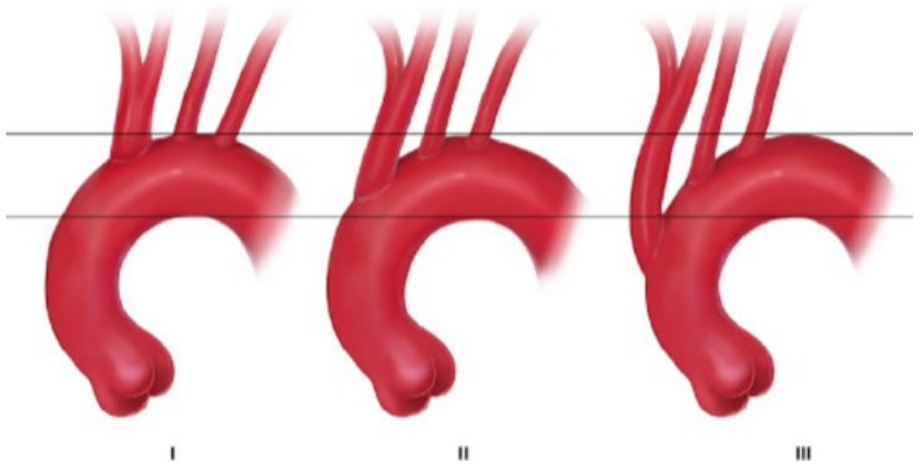
TEM Aortic Dissection Classification

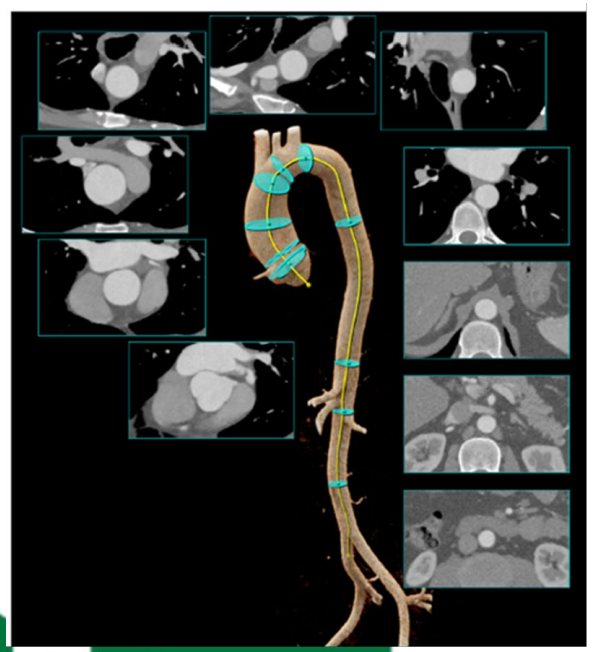
The classification is based on the modified Stanford classification that includes type, location of the primary entry tear (entry location) and malperfusion status (TEM)

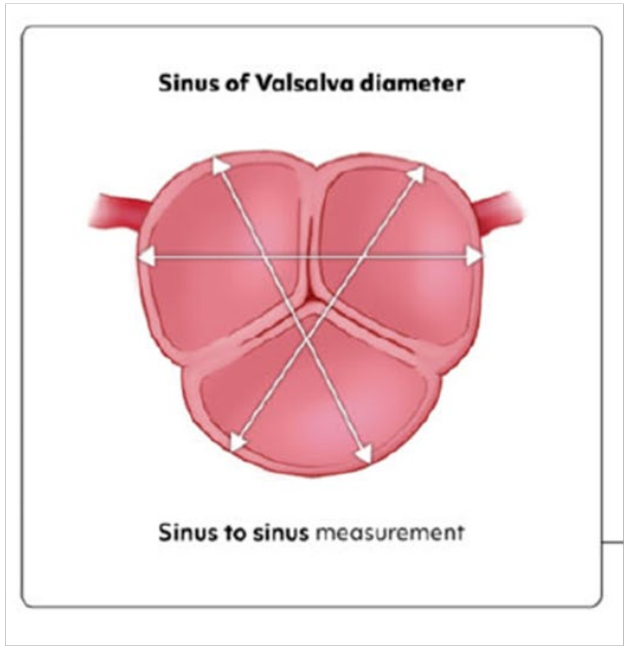


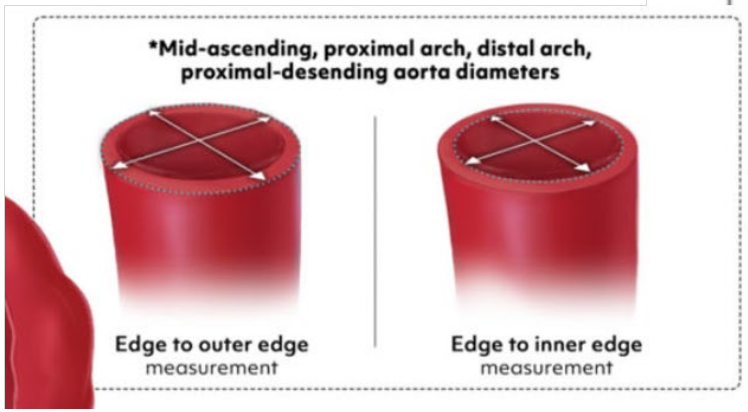


GRAND ROUNDS CLINICI DEL MERCOLEDÌ


I
II
III



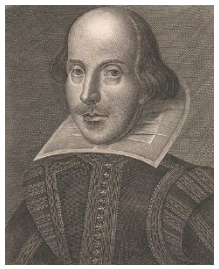

Sinus of Valsalva diameter
Sinus to sinus measurement


*Mid-ascending, proximal arch, distal arch, proximal-desending aorta diameters
Edge to outer edge measurement
Edge to inner edge measurement


Aorta length measurement

Recommendation Table 12: Chronic aortic diseases: root and ascending aorta

Recommendations	Class[a]
Surgery for an ascending aortic aneurysm located at the root or tubular tract, either with TAV or BAV, is recommended when the maximum aortic diameter is ≥55 mm.	I
Surgery for BAV-related aortopathy with 'root phenotype' is recommended when the maximum aortic diameter is ≥50 mm.	I
Surgery for TAV-associated aneurysms with 'root phenotype' should be considered when the maximum aortic diameter is ≥50 mm in a low-surgical-risk setting.[d]	IIa
In patients with low surgical risk[e] and 'ascending phenotype' dilatation, both with TAV and BAV, surgical treatment should be considered when the maximum aortic diameter is >52 mm.	IIa
In patients with low surgical risk and 'ascending phenotype' BAV-related aortopathy, surgery should be considered at a maximum diameter ≥50 mm if any of the following is present: • age <50 years • short stature (<1.69 m)[f] • ascending aortic length >11 cm[g] • aortic diameter growth rate >3 mm/year • family history of the acute aortic syndrome • aortic coarctation • refractory hypertension • shared decision with the patient[h] • concomitant non-aortic valve cardiac surgery	IIa



However

….All that glisters is not gold…..
…Often have you heard that told….

pirite anche definita *oro degli stolti*

Ascending Aortic Length and Risk of Aortic Adverse Events

The Neglected Dimension

Jinlin Wu, MD,[a,b,*] Mohammad A. Zafar, MD,[a,*] Yupeng Li, PhD,[c] Ayman Saeyeldin, MD,[a] Yan Huang, MD,[d] Rui Zhao, MD,[b] Juntao Qiu, MD,[b] Maryam Tanweer, MD,[a] Mohamed Abdelbaky, MD,[a] Anton Gryaznov, MD,[a] Joelle Buntin, MSN, RN, RN-BC,[a] Bulat A. Ziganshin, MD, PhD,[a,e] Sandip K. Mukherjee, MD,[a] John A. Rizzo, PhD,[f] Cuntao Yu, MD,[b] John A. Elefteriades, MD, PhD (Hon)[a]

J Am Coll Cardiol 2019;74:1883–94

525 Overall patients

mean follow-up of 42.0 months (range: 5 days to 336 months),

424 (81.2%) patients AAE-free
98 (18.8%) patients developed AAEs.
64 (12.2%) patients type A Aortic dissection
5 (0.9%) patients aortic rupture
31 (5.9%) died of ATAA (i.e., aortic deaths)

Aortic size Paradox

591 type A dissection patients enrolled in the International Registry of Acute Aortic Dissection between 1996 and 2005

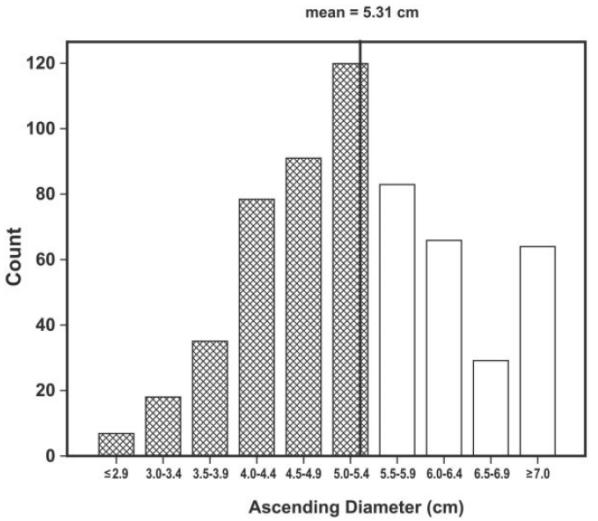
Aortic Diameter ≥5.5 cm Is Not a Good Predictor of Type A Aortic Dissection

Observations From the International Registry of Acute Aortic Dissection (IRAD)

Circulation. 2007;116:1120-1127

60% Aortic diameter <5,5 cm
40% Aortic diameter < 5,0 cm

Even with more aggressive guidelines (5 cm), preemptive aneurysm surgery would fail to prevent 40% of acute aortic dissections seen in our registry.



Aortic Size Distribution in the General Population: Explaining the Size Paradox in Aortic Dissection

Vijayapraveena Paruchuri[a] Kahled F. Salhab[b] Gregory Kuzmik[c] George Gubernikoff[a]
Hai Fang[g] John A. Rizzo[d–f] Bulat A. Ziganshin[d, h] John A. Elefteriades[d]

Cardiology 2015;131:265–272

The method of combining information from these two studies may seem unorthodox; however, our methodology is essentially arithmetic, examining proportions of numerators and denominators. Two of our coauthors (J.A.R. and H.F.) are acknowledged experts in data analysis.

Aortic size Paradox

Herein, we aim to calculate the relative risk of aortic dissection at sizes <5.5 cm by analyzing both the number of occurring dissections (numerator) and the population at risk at each aortic size (denominator

Table 1. Clinical and demographic factors from the MESA and IRAD databases

Variable	MESA	IRAD [3]
Patients in study, n	3,573	591
Age, years	60.7	60.8
Males, %	46	66
Hypertension, %	42	71

MESA was a multicenter trial initiated in 2000 that enrolled **over 6,814 patients** aged 45–84 without cardiovascular disease to investigate various risk factors for developing atherosclerosis over time.

Table 4. Evaluation of relative risk of aortic dissection in various size ranges, taking into account both the numerator (those suffering aortic dissection) and the denominator (those in the corresponding size range, thus at risk in that size range for suffering aortic dissection)

	Aortic diameter (ascending), cm	≤3.4 cm	3.5–3.9 cm	4.0–4.4 cm	≥4.5 cm[a]
Line 1	Proportion of dissections from IRAD, % [3]	4.4	4.5	12.7	76.3
Line 2	Proportion of population from MESA, %	79.2	18.0	2.6	0.22
Line 3	Relative risk (line 1/line 2)	0.055	0.25	4.9	346.8
Line 4	Relative risk (compared to aortas ≤3.4 cm)	1	4.55	89.1	6,305.5

See text for details. [a] This category summates the bottom six rows from table 3.

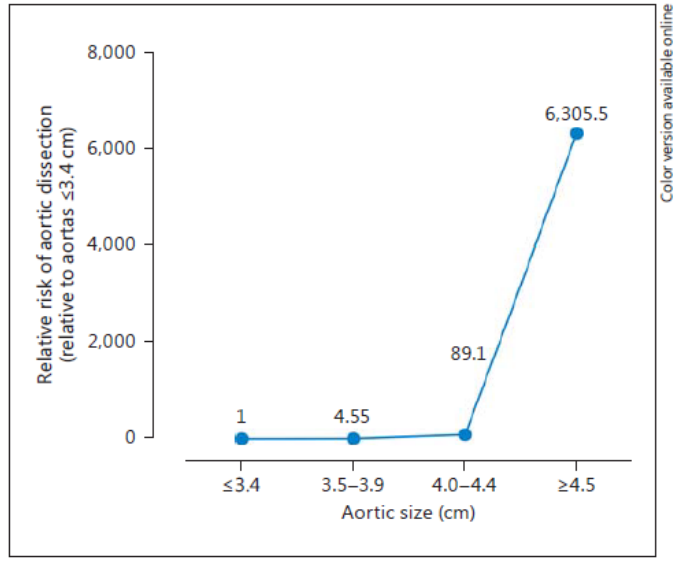
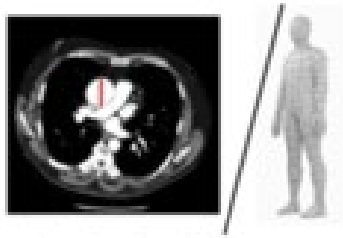


Fig. 4. Relative risk of aortic dissection by comparison of observed instances of aortic dissection to the population at risk in each size range (see text).

Body size Paradox



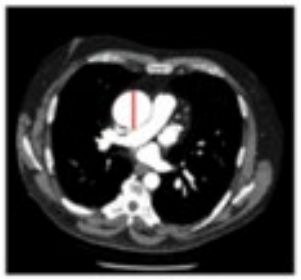
Aortic size index = diameter/BSA

↑ Peso corporeo

↑ BSA

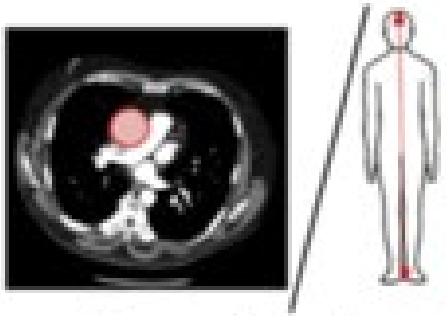
↓ Dilatazione indicizzata

↓ Rischio

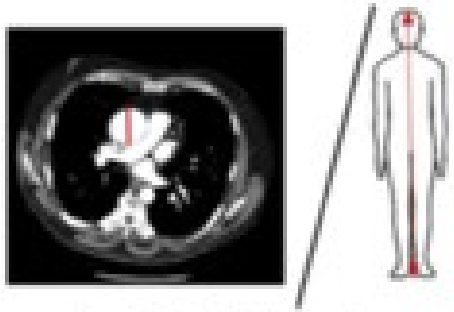


Diameter

J Thorac Cardiovasc Surg 2002;123:360-1



Cross-sectional area/height



Aortic height index= diameter/height

?

Is it really possible to predict an AAS

Clinical Practice

Multidisciplinary Research Activity

Clinical Practice

Istitutional Dedicated Outpatient Clinic

Multidisciplinary Aortic Team Meeting

Preoperative follow up and primary prevention

Post AAS event and surgery follow up and secondary prevention

STUDIO OSSERVAZIONALE

Patologie dell'aorta ascendente: quanto si correla la percezione in ambito di medicina generale e specialistico con le attuali linee guida?

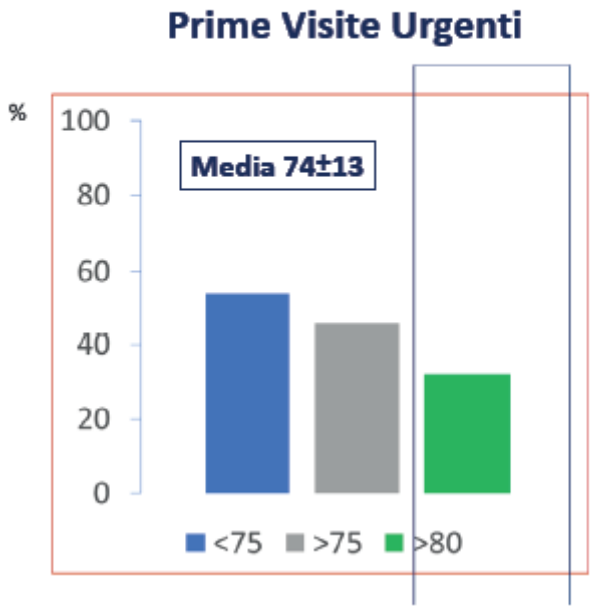
Pasquale Totaro, Antonio Sciortino, Filippo Amoroso, Zaira Preda, Stefano Pelenghi

U.O.C. Cardiochirurgia, IRCCS Fondazione Policlinico San Matteo, Pavia

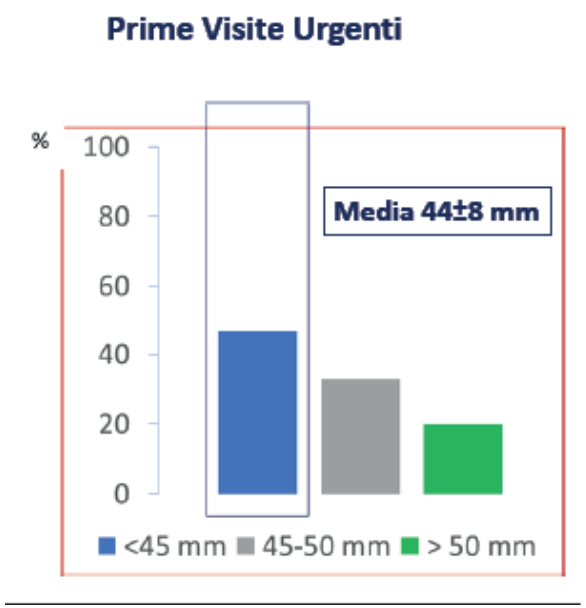
G Ital Cardiol 2023;24(12):990-996

- Età dei pazienti

B



· Dilatazione Aortica Massima



1

Incidenza della dissezione toracica 7,7 /100.000 persone-anno

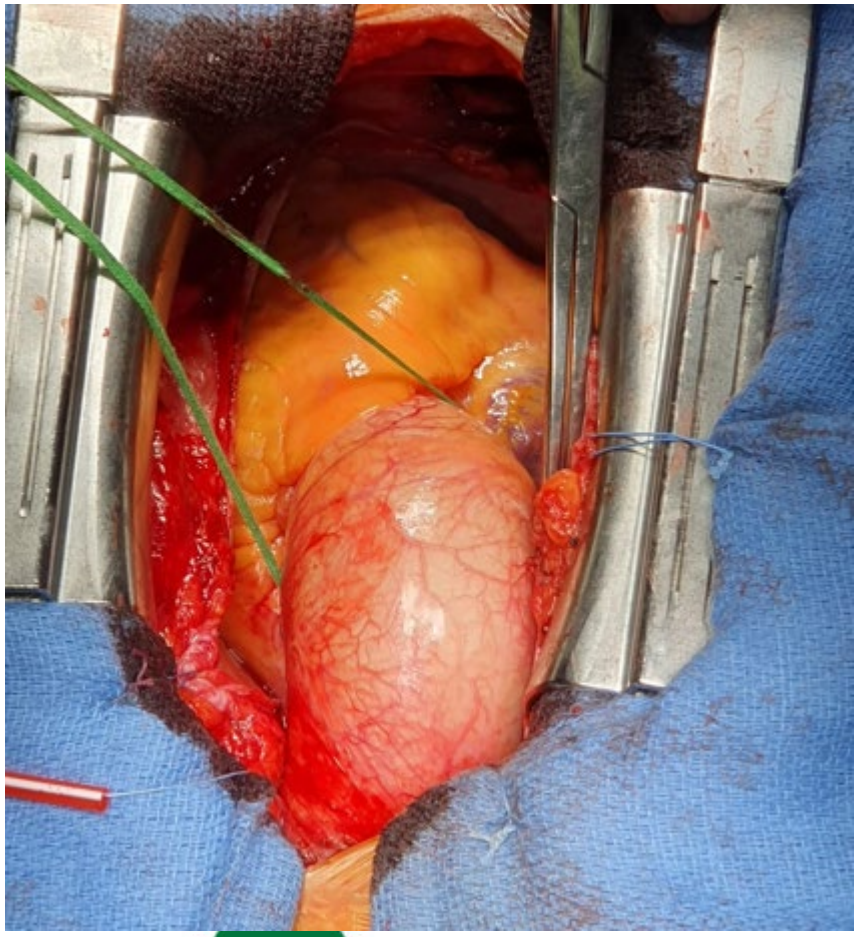
2

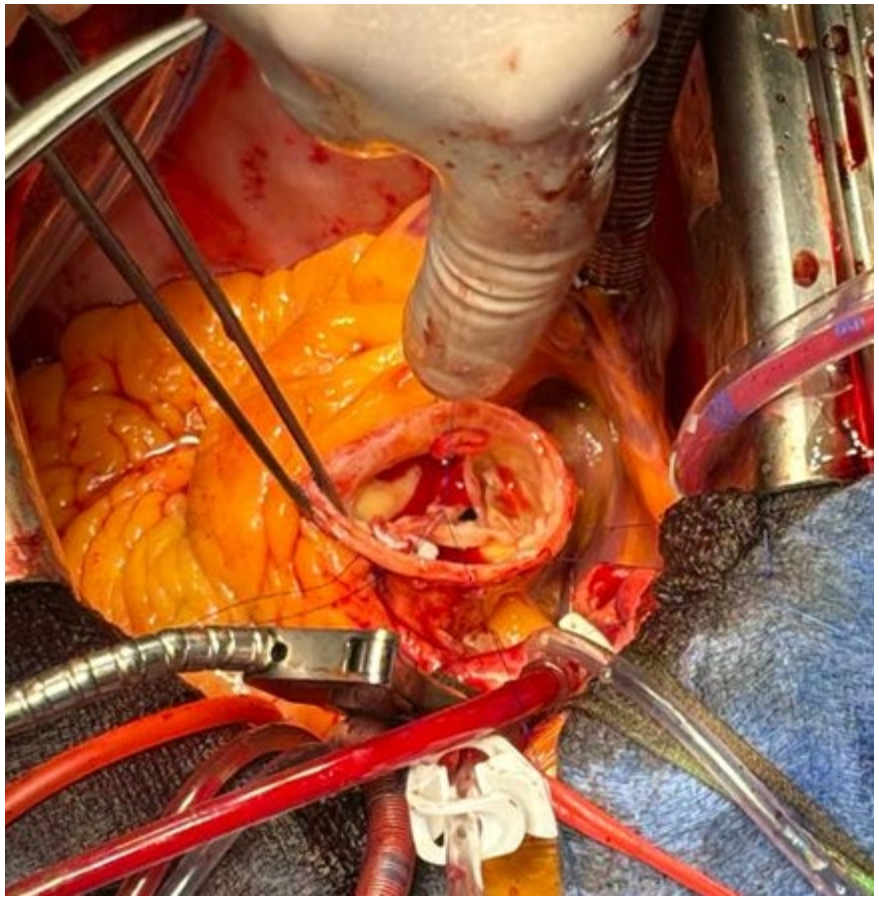
Incidenza dell'aneurisma toracico 5,3 /100.000 persone anno

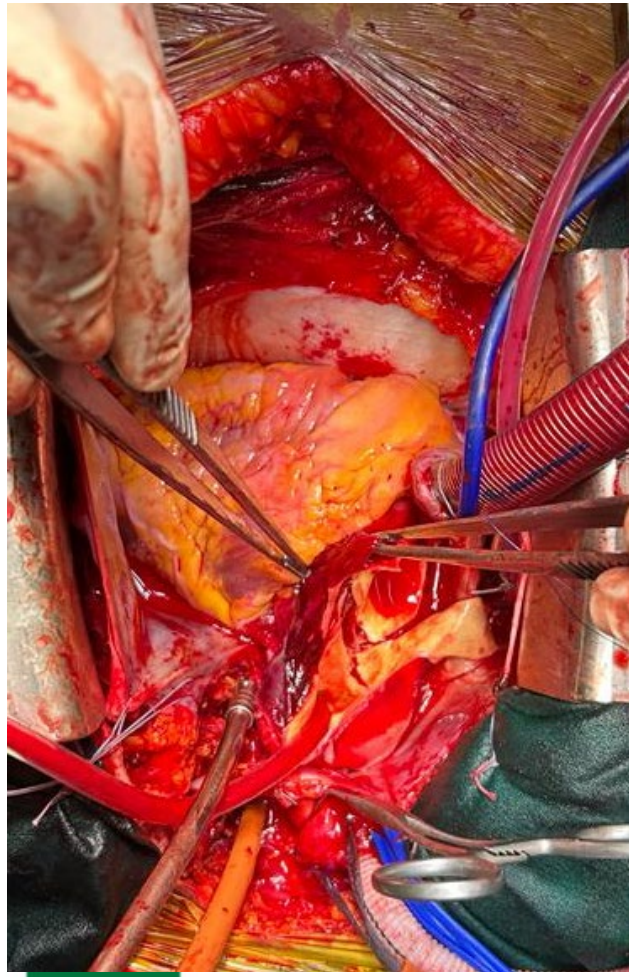
- 40 aneurismi attesi ogni anno
- 59 dissezioni attese ogni anno

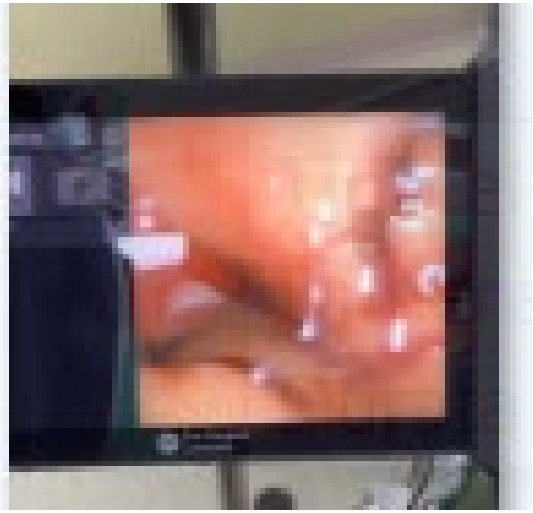
Ambulatorio Aorta Toracica
2023-2024
48+12 esterni

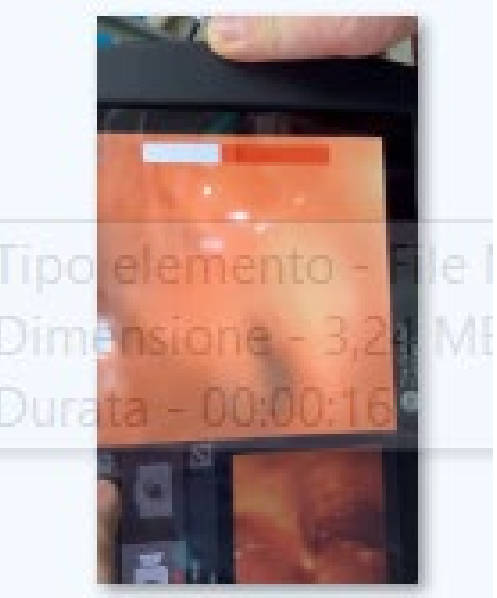
Registro Istituzionale Dissezioni
2023-2024
33 casi







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Dimensione - 3,24
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Number of Patients	328
Age Range (years) Age (Mean±sd)	16/89 65±12
Male Gender Female Gender	224(68%) 104(32%)
History of Hypertension	288 (88%)
Type of AAS Acute Dissection A Acute Dissection B IMH Other	 264 (80%) 25 (7.6%) 20 (6%) 9 (2.8%)

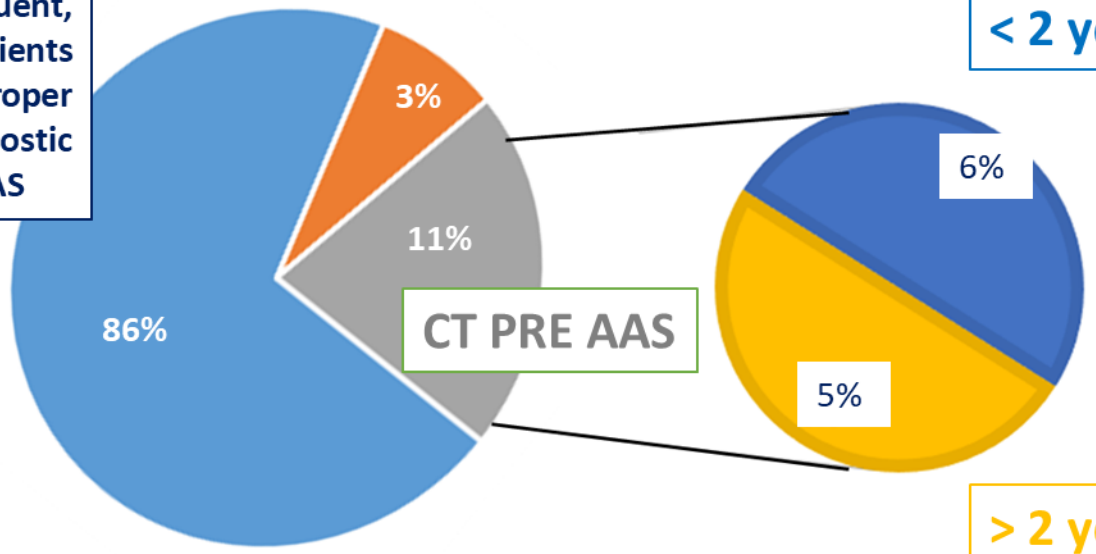
Number of Procedures	328
Hemiarch	106 (33%)
AAR	81 (27%)
ARCHHypertension	53 (16%)
Bentall	27 (8%)
DAR	16 (5%)
Hybrid	3 (1%)
Other	42 (13%)

Overall In Hospital Mortality
61 pts 18%

TT ECHO PRE AAS
n.45 (14%)

Only 7 % of patients had a CT-SCAN <2years before AAS

Despite history of hypertension was frequent, only a minority of patients had undergone proper thoracic aorta diagnostic evaluation before the AAS

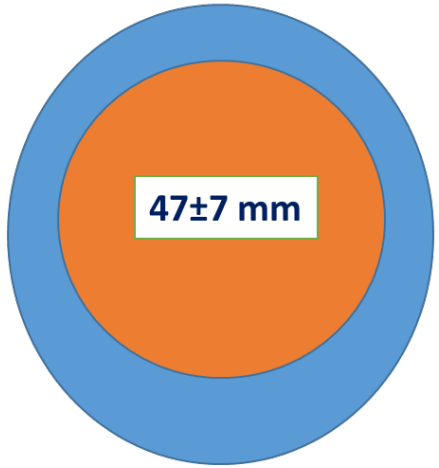


< 2 years before AAS

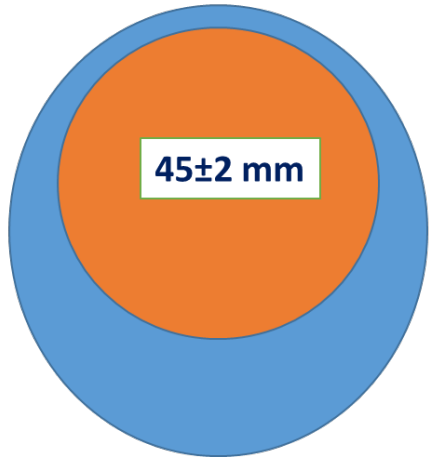
> 2 years before AAS

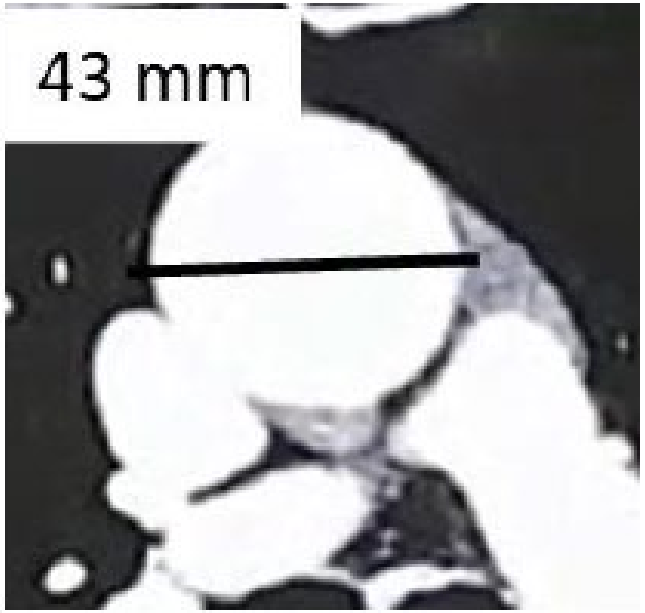
NO CT/TT ECHO PRE AAS

Dilatation at dissection

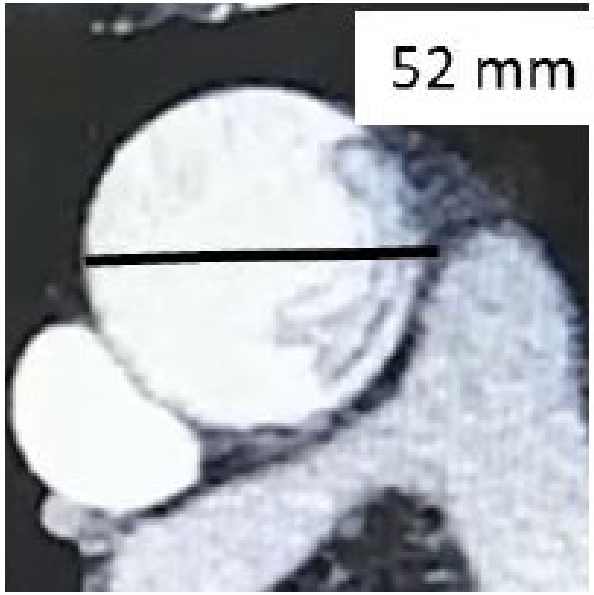


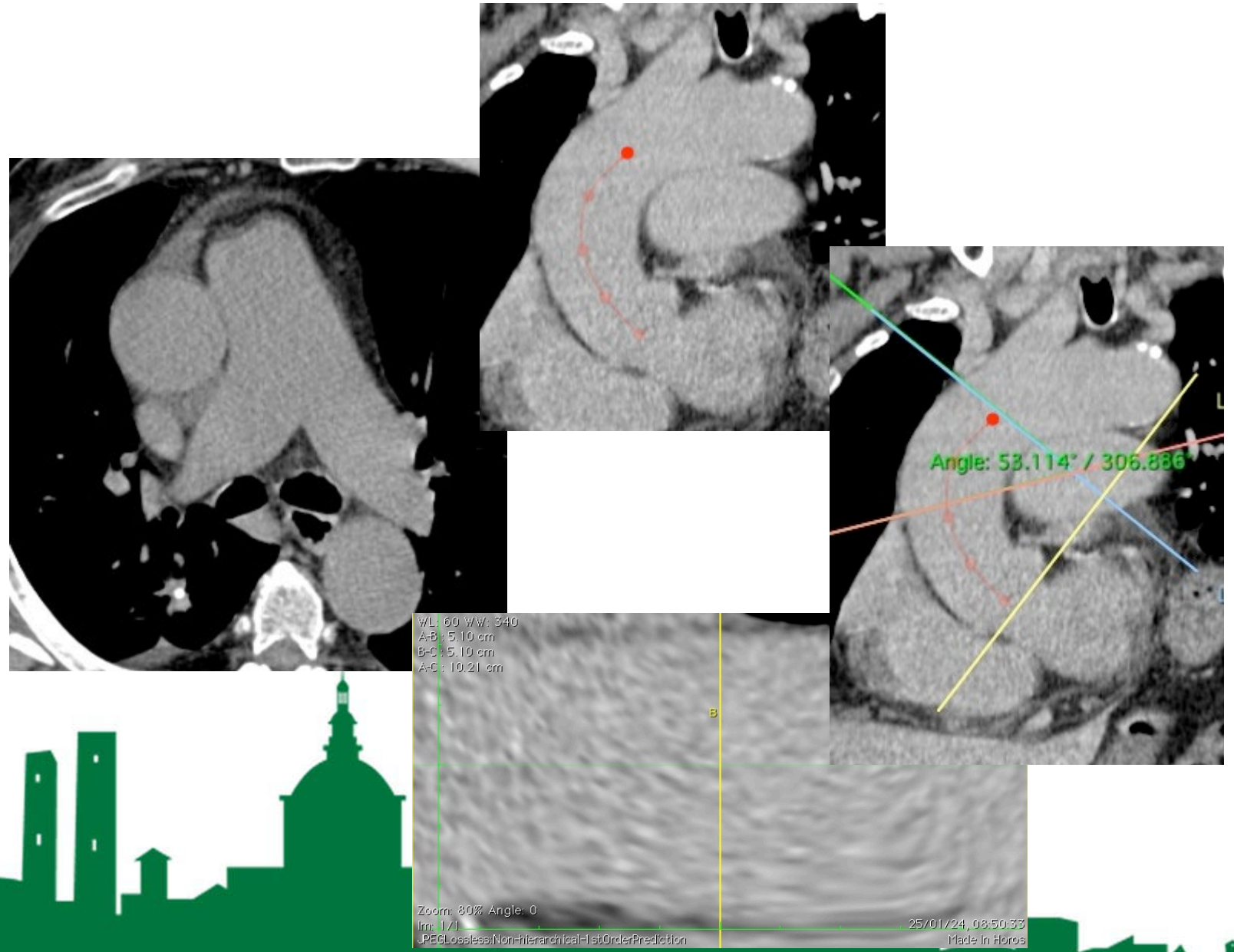
Dilatation pre-dissection

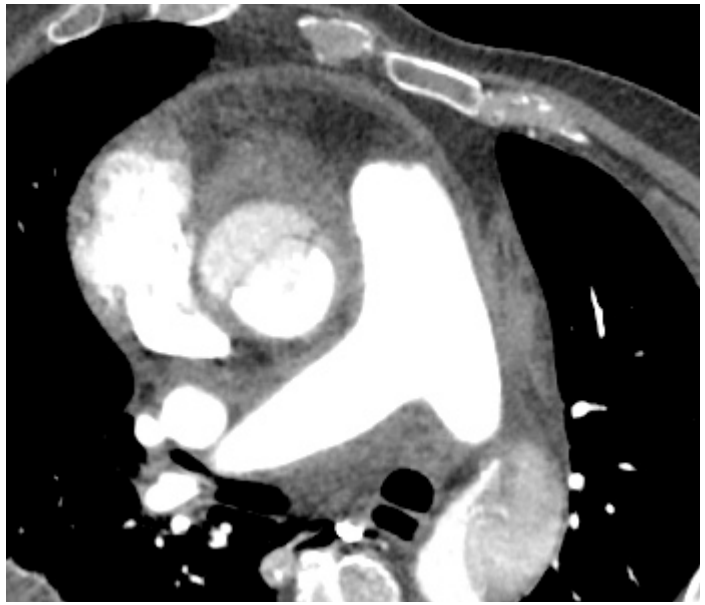




In 1 patient a CT Scan was done 1 week before AAS (left) and maximum dilatation was 43mm with no sign of increased risk of dissection. At the time of dissection dilatation reached 52 mm (right)




Angle: 53.114° / 306.886
WL: 60 WW: 340
A-B : 5.10 cm
B-C : 5.10 cm
A-C : 10.21 cm
Zoom: 80% Angle: 0
Im: 1 / 1
25/01/24, 08:50:33
JPEGLossless:Non-hierarchical-1stOrderPrediction
Made In Horos

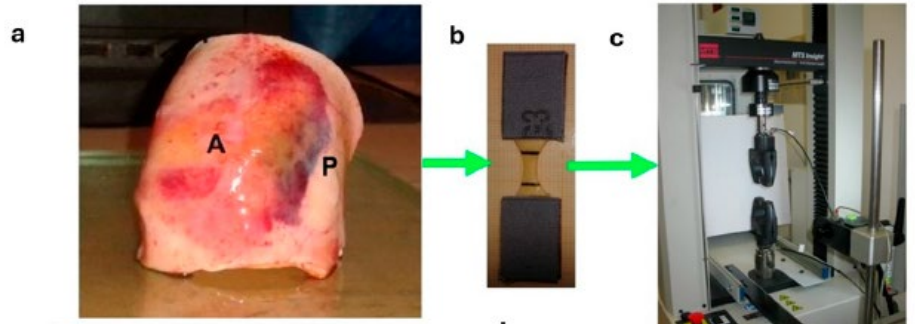


Multidisciplinary Research Activity

RC n. 08074722

"Multidisciplinary analysis by morphological and mechanical evaluation of the aortic wall in patients with aortic disease, undergoing aortic cardiac surgery, vs patients without aortic disease"

Analisi multidisciplinare mediante valutazione morfologica e meccanica della parete aortica in pazienti con patologia aortica sottoposti a chirurgia aortica vs pazienti senza patologia aortica



Archives of Cardiovascular Disease 116 (2023) 498–505

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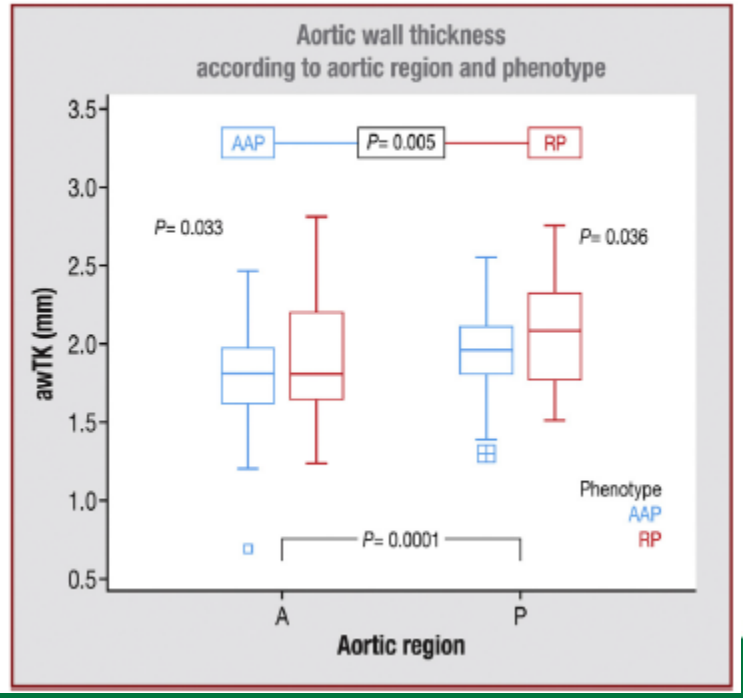
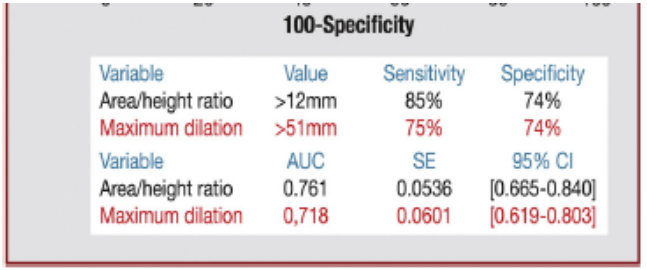
Clinical Research

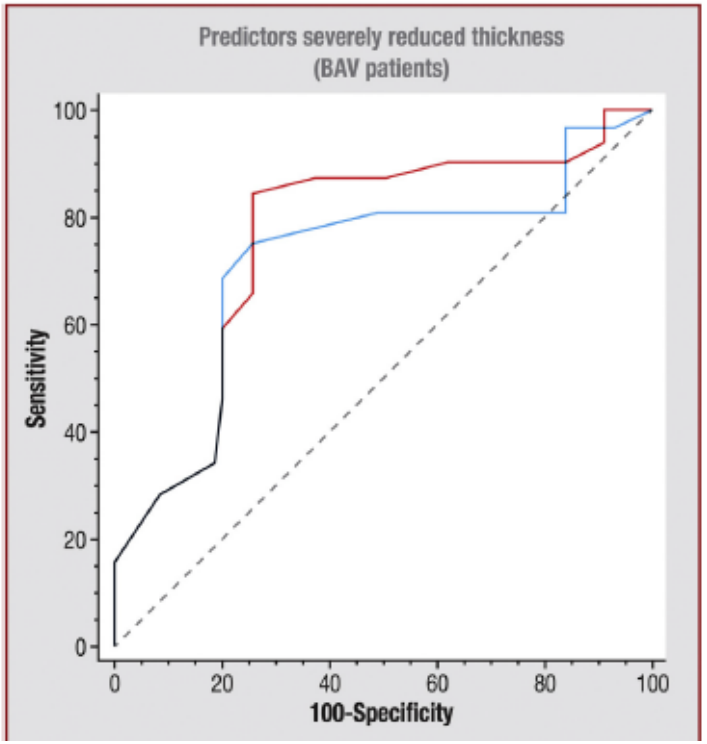
Aortic wall thickness in dilated ascending aorta: Comparison between tricuspid and bicuspid aortic valve

Pasquale Totaro[a,*], Simone Morganti[b], Ferdinando Auricchio[c], Stefano Pelenghi[a]

[a] Division of Cardiac Surgery, IRCCS Foundation Hospital "San Matteo", Piazzale Golgi 1, 27100 Pavia, Italy
[b] Department of Electrical, Computer and Biomedical Engineering, University of Pavia, 27100 Pavia, Italy
[c] Department of Civil Engineering and Architecture, University of Pavia, 27100 Pavia, Italy







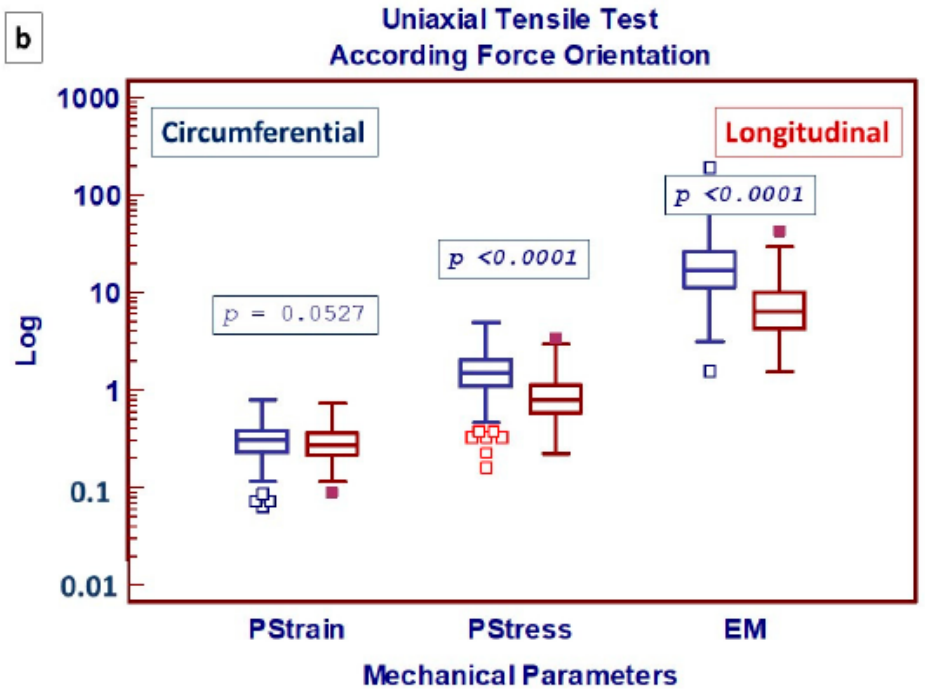
Article

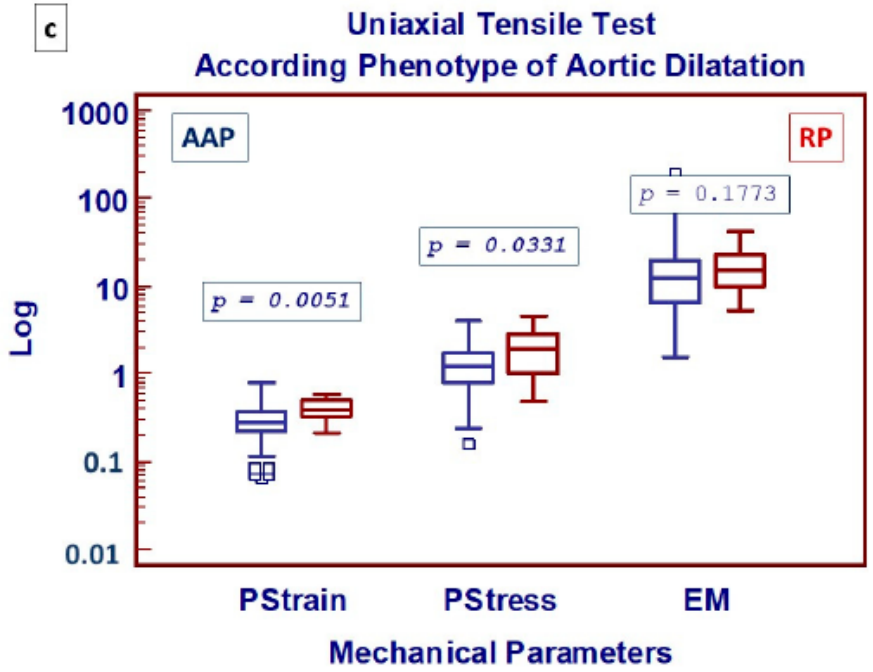
Bicuspid Valve Aortopathy: Is It Reasonable to Define a Different Surgical Cutoff Based on Different Aortic Wall Mechanical Properties Compared to Those of the Tricuspid Valve?

Pasquale Totaro [1,*], Alessandro Caimi [2], Giulia Formenton [2], Martina Musto [1], Martina Schembri [2], Simone Morganti [3], Stefano Pelenghi [1] and Ferdinando Auricchio [2]

J. Cardiovasc. Dev.Dis. 2024, 11, 312.

111 Patients
88 TAV
33 BAV





GRAND ROUNDS CLINICI DEL MERCOLEDÌ

Sistema Socio Sanitario

Regione Lombardia

Fondazione IRCCS Policlinico San Matteo

ASST Pavia

ATS Pavia

UNIVERSITÀ DI PAVIA

GRAND ROUNDS CLINICI DEL MERCOLEDÌ

con il Policlinico San Matteo

Aula Magna "C. Golgi" & WEBINAR

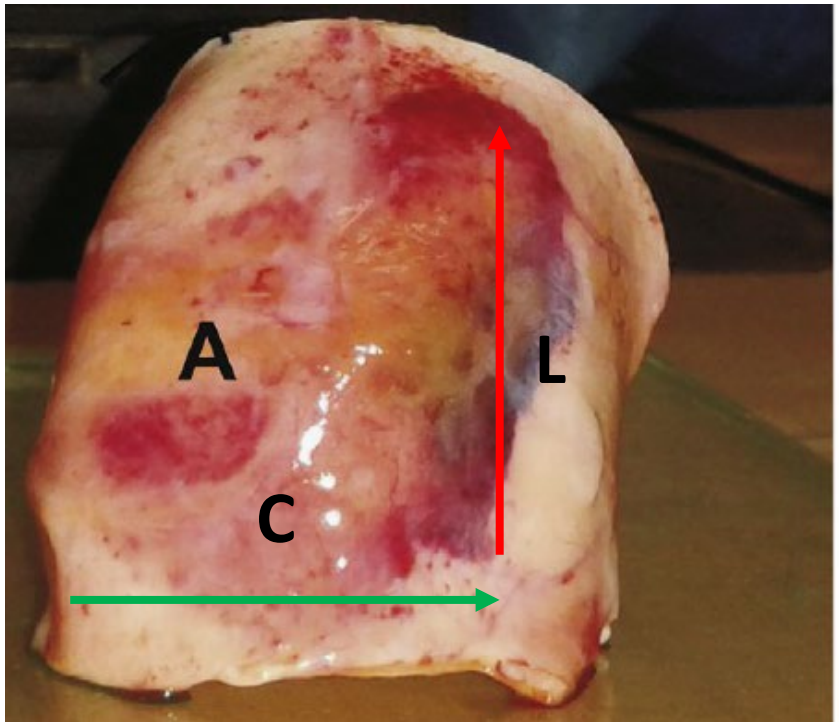
DISSEZIONE AORTICA

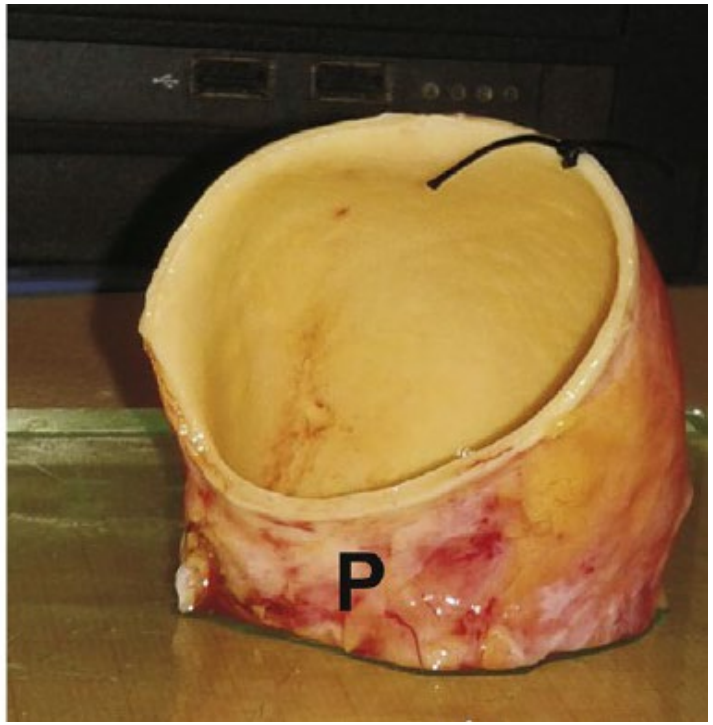
CARATTERIZZAZIONE MECCANICA DEL TESSUTO

PAZIENTI COINVOLTI

	N = 15 Pazienti
Età (media ± SD)	71 ± 10.4
Età < 70	7
Età ≥ 70	8
Uomini	8
Donne	7

CARATTERIZZAZIONE MECCANICA PARETE AORTICA





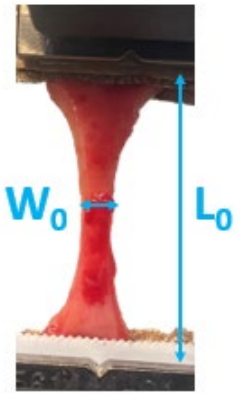
CARATTERIZZAZIONE MECCANICA PARETE AORTICA

Esempio di campione prelevato da operazione chirurgica

entro 48 h

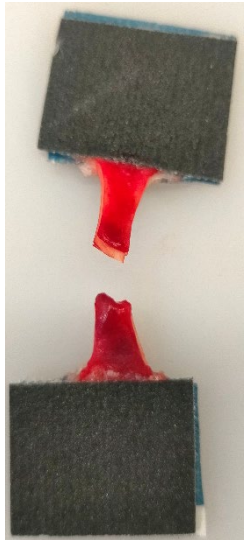
Campione preparato

Test di trazione mono-assiale

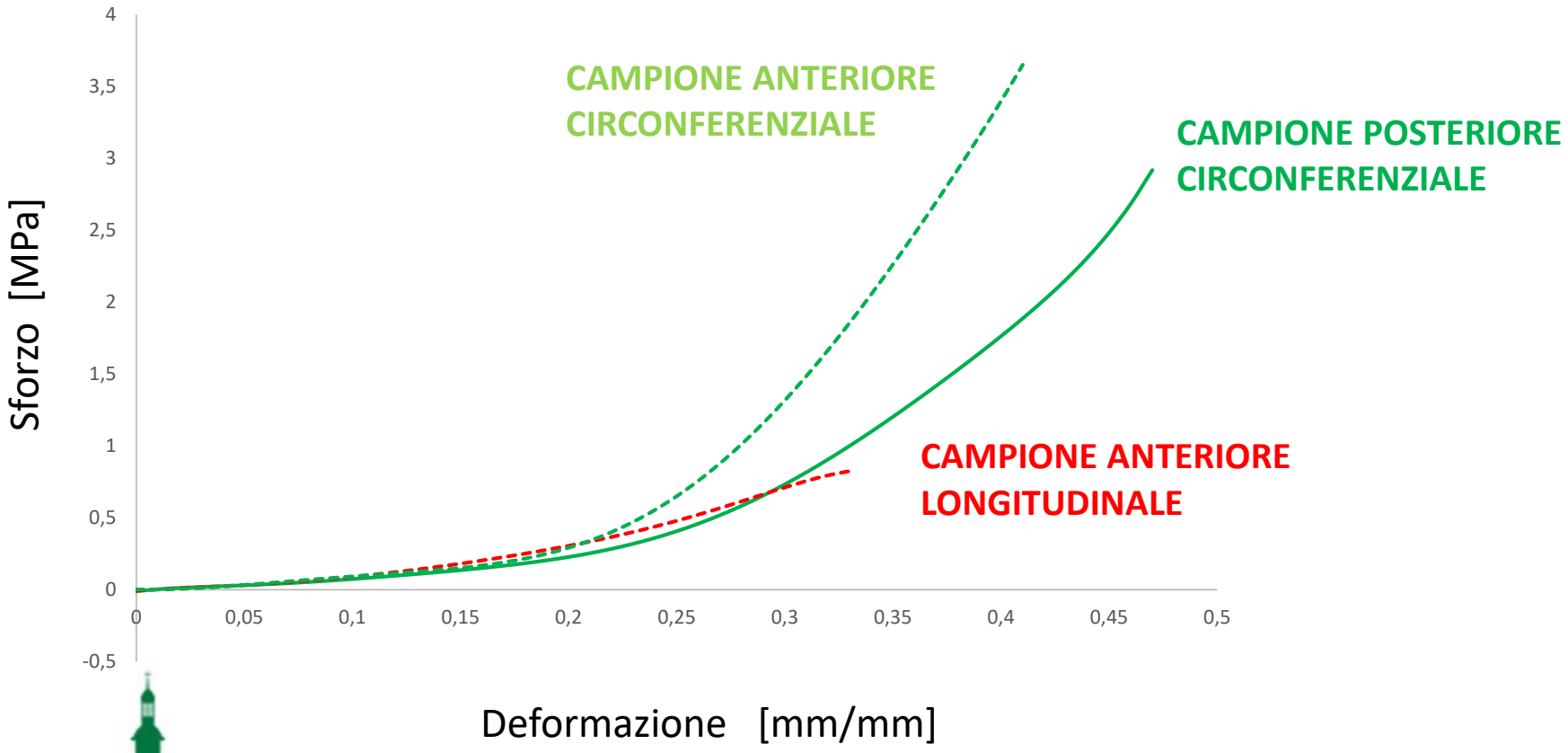


PRE

POST



CARATTERIZZAZIONE MECCANICA PARETE AORTICA

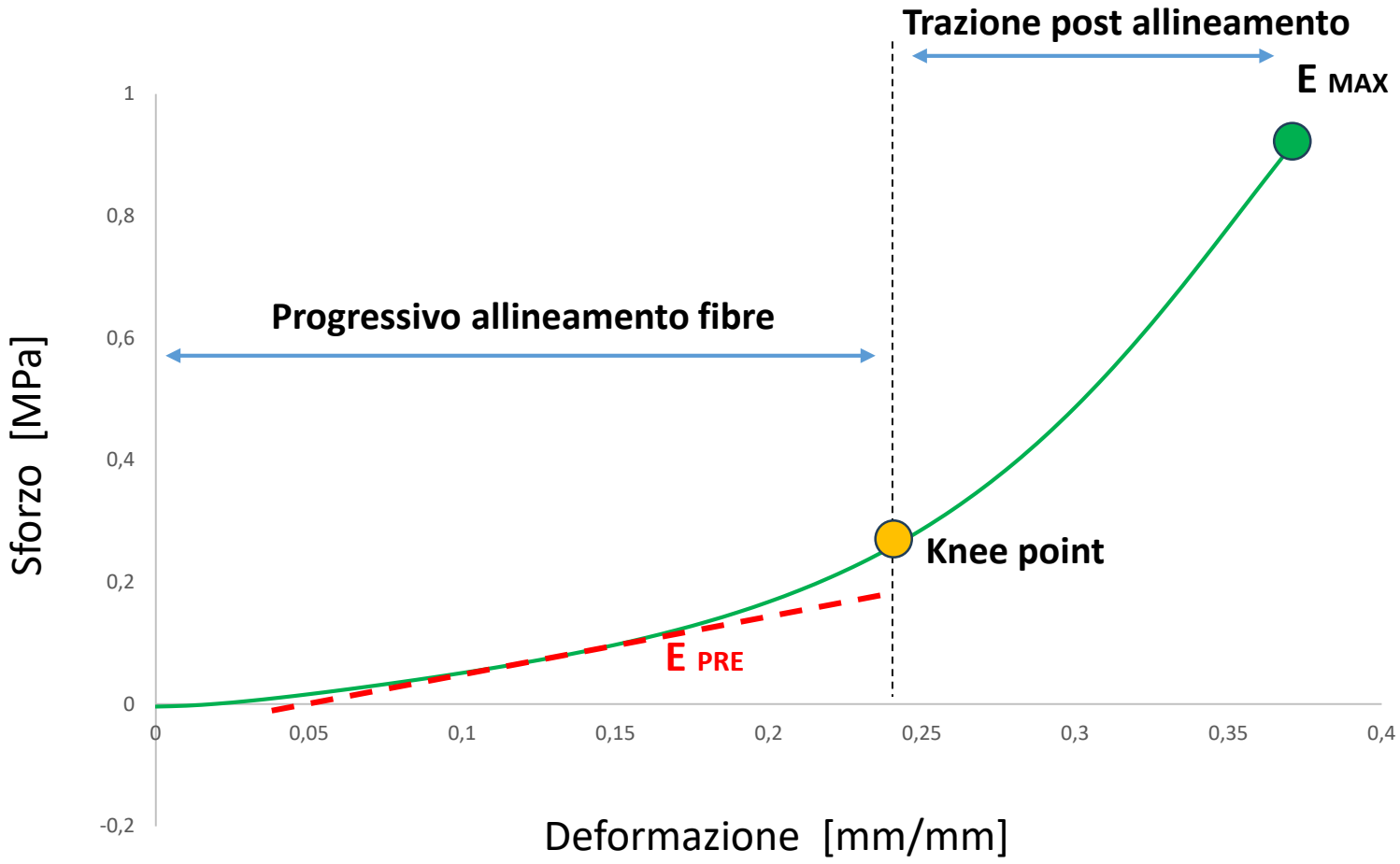


CARATTERIZZAZIONE MECCANICA PARETE AORTICA

$$\text{Sforzo} = \frac{Forza\ [N]}{Area\ [m^2]}$$

$$\text{Deformazione} = \frac{L[mm] - L_0[mm]}{L_0[mm]}$$

$$\text{Modulo di Young} = \frac{Sforzo\ [MPa]}{Deformazione}$$



RISULTATI PROVE MONO-ASSIALI

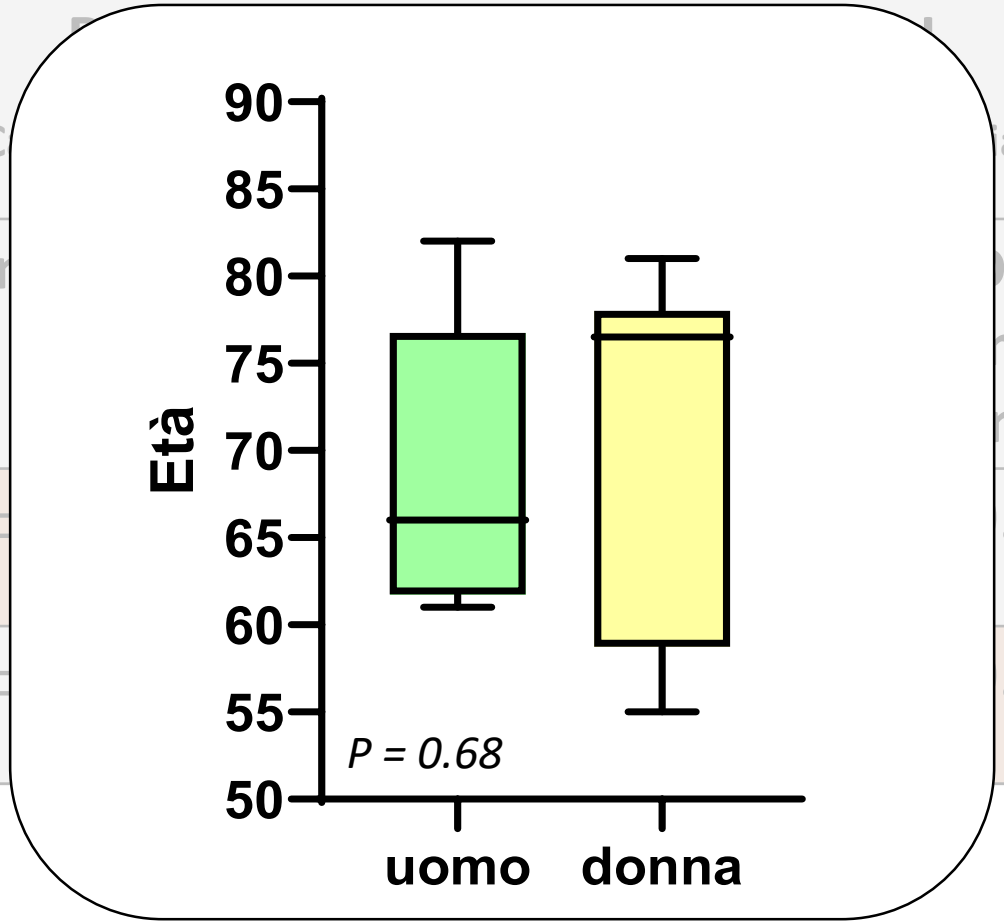
Campioni Anteriori Circonferenziali

	Spessore [mm]	E pre [MPa]	E max [MPa]	Deformazione max [mm/mm]	Sforzo max [MPa]
DONNE [6 pazienti] MEDIA ± DEV STANDARD	1.62 ± 0.34	3.17 ± 1.40	16.63 ± 6.98	0.29 ± 0.08	2.28 ± 1.2
UOMINI [6 pazienti] MEDIA ± DEV STANDARD	1.53 ± 0.13	1.73 ± 0.85	10.09 ± 3.67	0.30± 0.07	1.12 ± 0.5

- Età DONNE: 71 ± 10.7
- Età UOMINI: 68.6 ± 8.2

Highlight: Tessuto donne più fragile rispetto al tessuto degli uomini

	Thickn [mm]		Deformazione max [mm/mm]	Sforzo max [MPa]
DONNE [6 pazienti] MEDIA ± DEV STANDARD	1.62 ±		.29 ± 0.08	2.28 ± 1.2
UOMINI [6 pazienti] MEDIA ± DEV STANDARD	1.53 ±		.30± 0.07	1.12 ± 0.5



- Età DONNE: 71 ± 10.7
- Età UOMINI: 68.6 ± 8.2

RISULTATI PROVE MONO-ASSIALI

Campioni Anteriori Circonferenziali

	Spessore [mm]	E pre [MPa]	E max [MPa]	Deformazione max [mm/mm]	Sforzo max [MPa]
Età < 70 [4 uomini, 2 donne] MEDIA ± DEV STANDARD	1.60 ± 0.14	1.45 ± 0.42	12.07 ± 7	0.34 ± 0.05	1.53 ± 1.13
Età ≥ 70 [2 uomini, 4 donne] MEDIA ± DEV STANDARD	1.55 ± 0.35	3.45 ± 1.15	14.64 ± 5.89	0.25 ± 0.06	1.87 ± 1.07

Highlight: Con l'aumento dell'età il tessuto è più fragile

RISULTATI PROVE MONO-ASSIALI

Confronto Provini Anteriori e Posteriori Circonferenziali

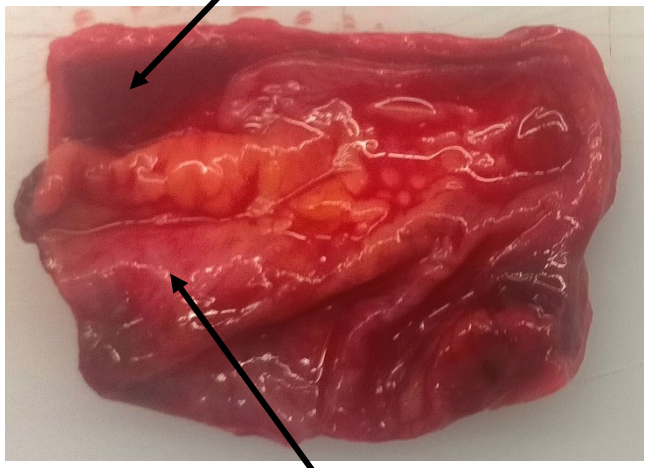
	Spessore [mm]	E pre [MPa]	E max [MPa]	Deformazione max [mm/mm]	Sforzo max [MPa]
Anteriori MEDIA ± DEV STANDARD	1.54 ± 0.11	1.58 ± 0.66	13.02 ± 7.18	0.34 ± 0.06	1.58 ± 1.13
Posteriori MEDIA ± DEV STANDARD	1.68 ± 0.20	1.76 ± 0.59	15.71 ± 6.94	0.36 ± 0.08	1.75 ± 0.81

Numero pazienti → 6 [di cui si dispone sia di provini anteriori che posteriori]
Età : 64 ± 7 [5 uomini, 1 donna]

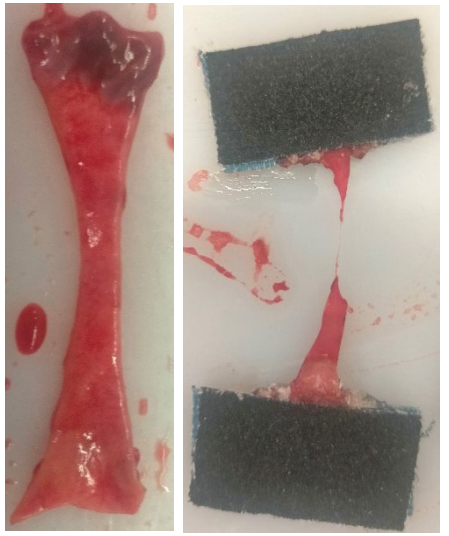
Highlight: I campioni anteriori sono meno deformabili rispetto ai campioni posteriori

ESEMPIO DI CAMPIONE

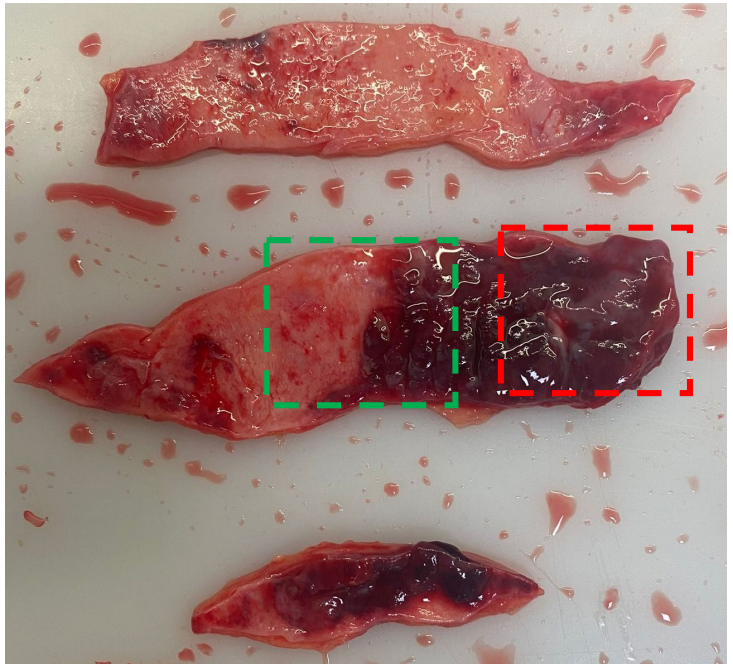
Media e Intima



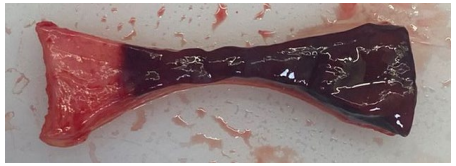
Avventizia

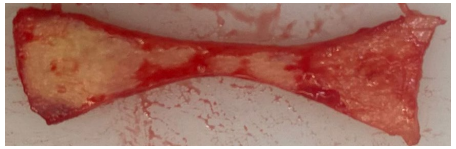


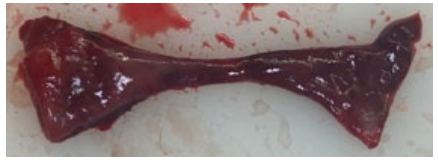
CHALLENGING



Condizione 1







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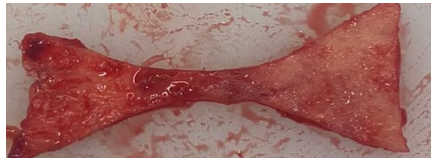
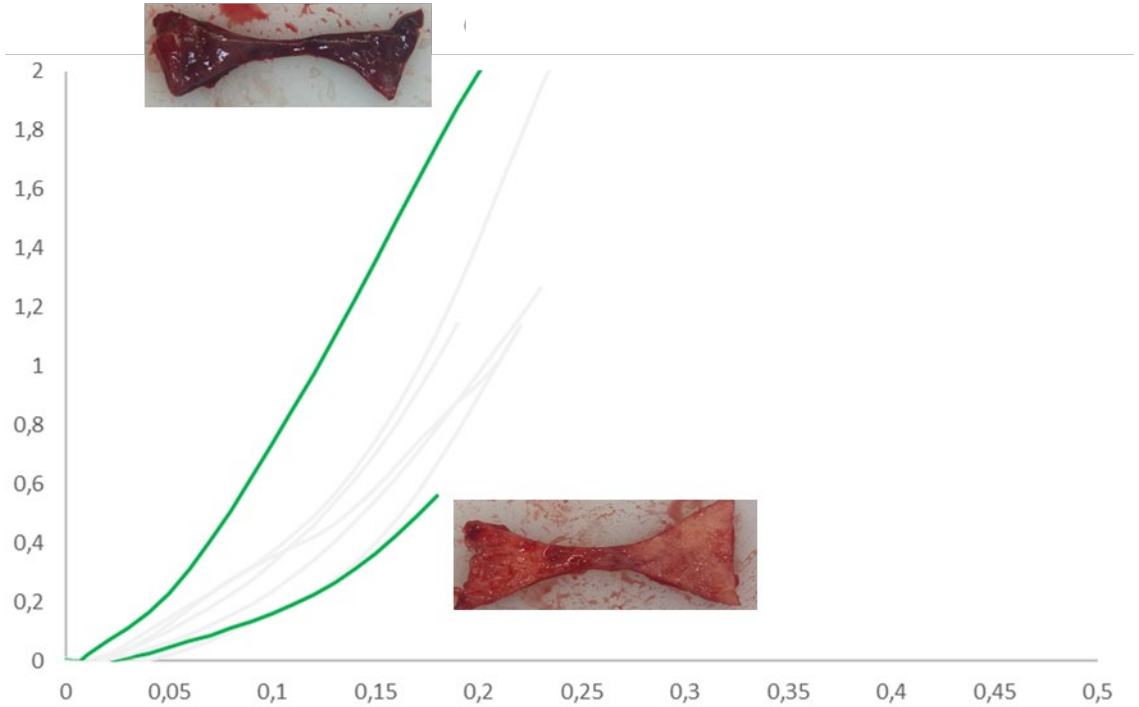


Condizione 2



RISULTATI PROVE MONO-ASSIALI

Confronto Provini Avventizia e Intima - Media Circonferenziali

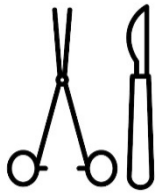
	Spessore [mm]	E pre [MPa]	E max [MPa]	Deformazione max [mm/mm]	Sforzo max [MPa]
Avventizia MEDIA ± DEV STANDARD	1.11 ± 0.19	5.08 ± 1.46	18.98 ± 6.92	0.32 ± 0.05	3.07 ± 1.51
Intima - Media MEDIA ± DEV STANDARD	1.84 ± 0.34	1.93 ± 0.61	10.83 ± 5.32	0.26 ± 0.08	1.25 ± 0.7

Numero pazienti → **4** [di cui si dispone sia di provini avventizia che intima - media]
Età : 74 ± 9 [2 uomini, 2 donne]

Highlight: I campioni estratti dallo strato più esterno, benché molto più sottili, sono molto più deformabili

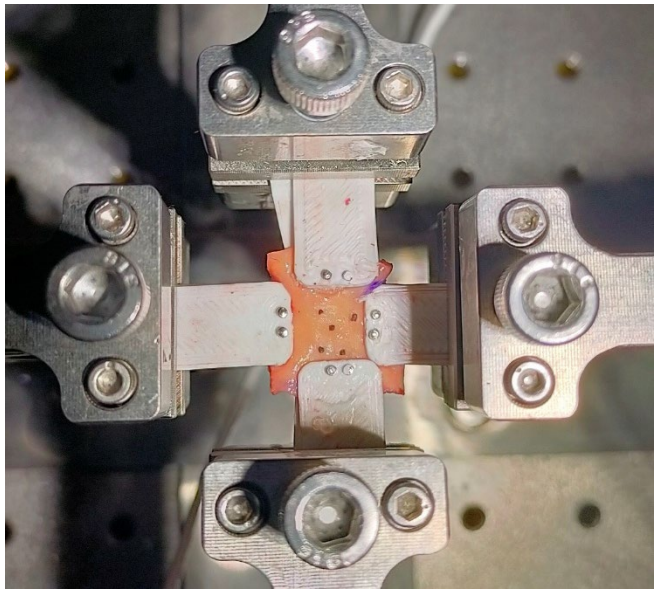
PROSSIMI SVILUPPI: PROVE BI-ASSIALI

Esempio di campione prelevato da operazione chirurgica

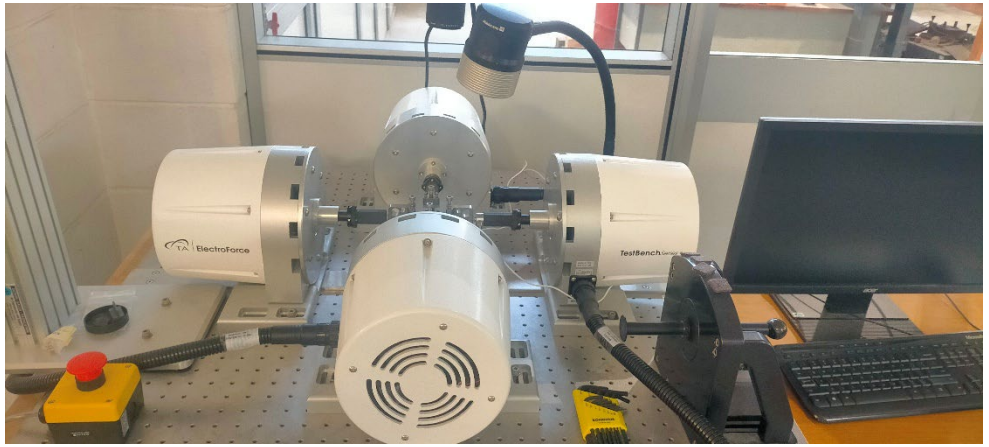


entro 48 h

Campione preparato

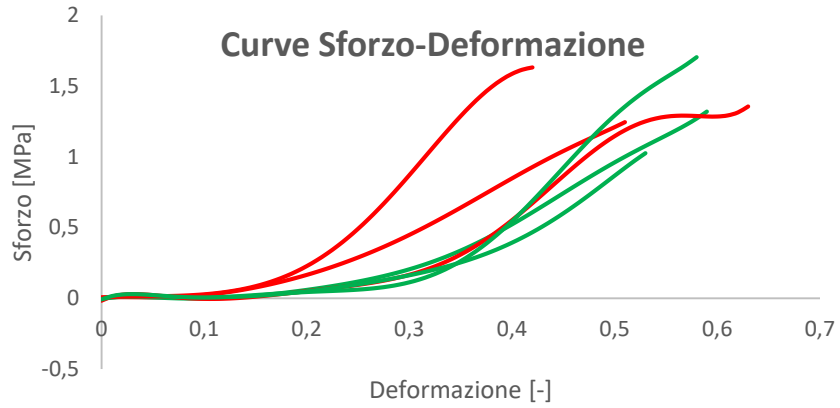


Test Bi-assiale



Direzione circonferenziale

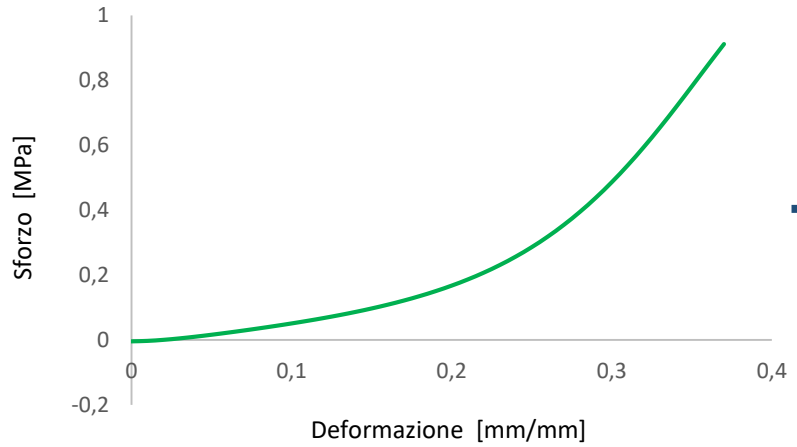
Direzione longitudinale



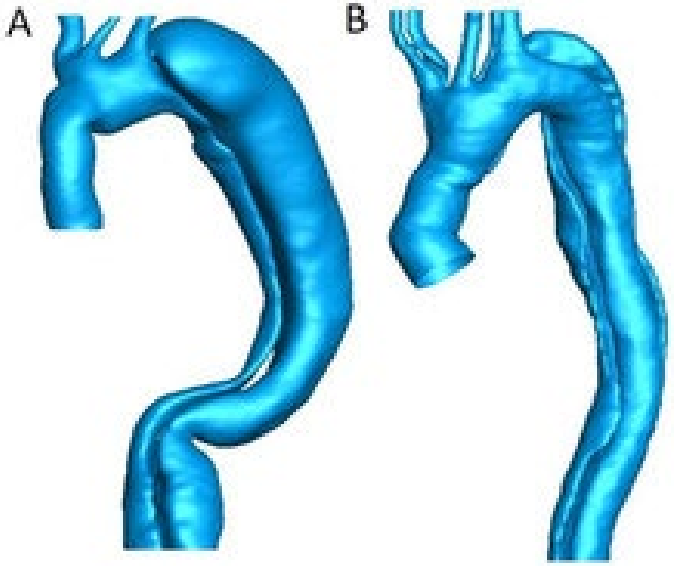
PROSSIMI SVILUPPI: SIMULAZIONE PRE-OPERATORIA

IMMAGINE TAC

CARATTERIZZAZIONE MECCANICA ACCURATA



SIMULAZIONI COMPUTAZIONALI



Forneris, A., Fatehi Hassanabad, A., Appoo, J. J., & Di Martino, E. S. (2024). Predicting Aneurysmal Degeneration in Uncomplicated Residual Type B Aortic Dissection. *Bioengineering*, *11*(7), 690

Final Take Home Message

The "real life" in contemporary cardiac surgery, therefore, seems to confirm the substantial unpredictability of an acute aortic event in the absence of systematic surveillance protocols to be adopted on the entire population at risk.

However