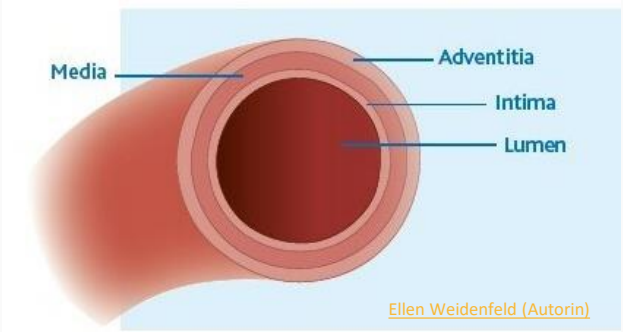
FROM EVOLUTION TO DISRUPTION –

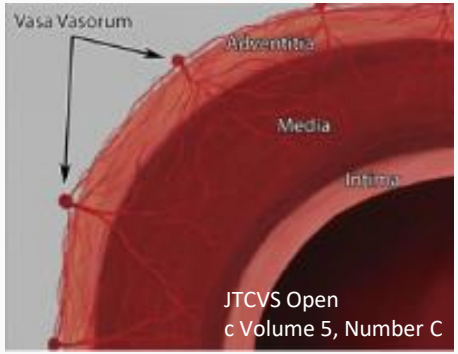
Its all about understanding the natural course of aortic disease

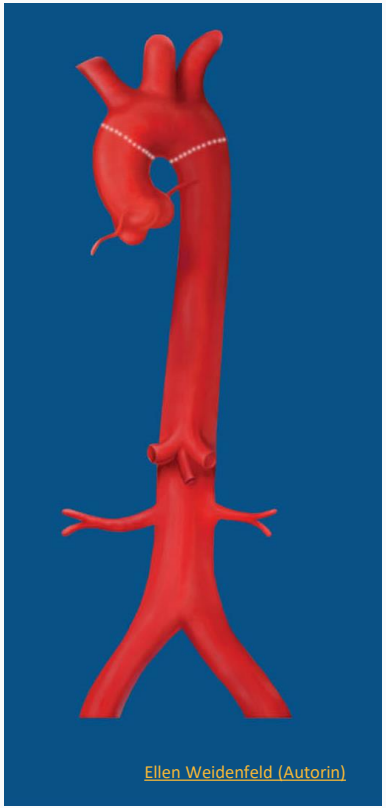
Axel Haverich, MD

Sunday, Sept. 1, 2024

From Evolution to Disruption





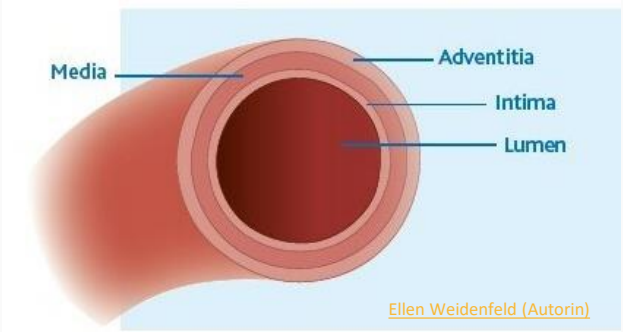


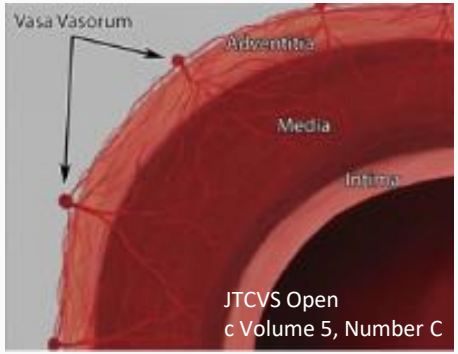
Dissection

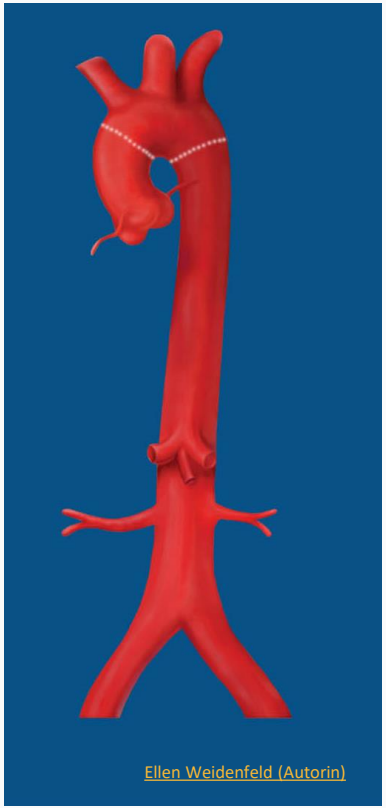
Aneurysm

Atherosclerosis

From Evolution to Disruption







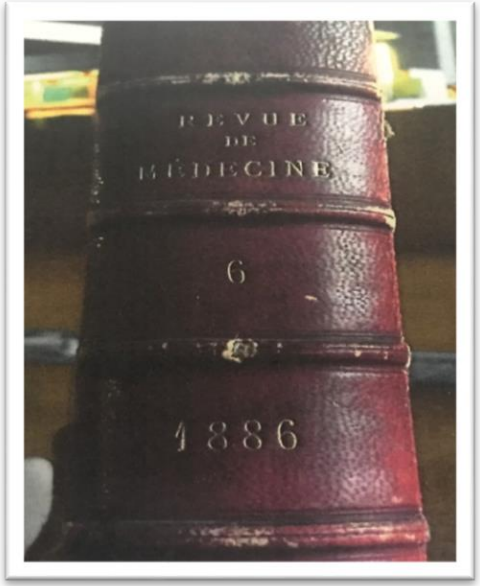
Dissection

Aneurysm

Atherosclerosis

Malfunction of vasa vasorum

From Evolution to Disruption



H. MARTIN. — PATHOGÉNIE DES SCLÉROSES DYSTROPHIQUES

LÉSIONS DYSTROPHIQUES CONSÉCUTIVES A L'ENDARTÉRITE OBLITÉRANTE PROGRESSIVE.

§ I.

Athérome artériel. — Nous avons rappelé déjà, au commencement de ce travail, l'opinion que nous avons formulée déjà en 1881 et qui, depuis lors, a été confirmée au point que nous la croyons définitivement établie aujourd'hui, à savoir que l'athérome artériel est la conséquence d'une endartérite oblitérante progressive des *vasa-vasorum* nourriciers de la paroi artérielle athéromateuse. Alors même que la plaque d'athérome n'a que quelques millimètres de diamètre, on constate déjà de l'endartérite des artérioles qui nourrissent ce petit territoire dégénéré.

On peut s'assurer, en même temps, au microscope, que la lésion des *vasa-vasorum* est l'accident primitif, car la dégénérescence athéromateuse est souvent encore à ses débuts, dans la couche profonde de la tunique interne, alors qu'un anneau fibreux épais s'est substitué, dans les artérioles malades, à la mince couche endothéliale normale.

Enfin on ne saurait admettre que l'inflammation s'est propagée successivement de ces artérioles nourricières à la tunique interne, car on sait que cette tunique n'est point vasculaire et que les capil-

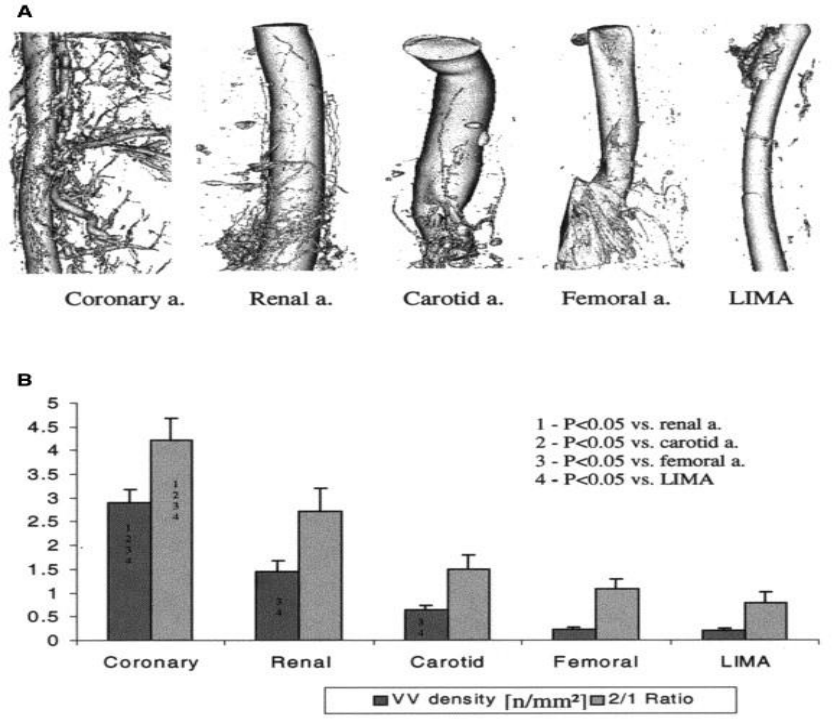
Lesions of the vasa vasorum and dissecting aneurysms of the aorta; analysis of incidence, etiological aspects, pathogenesis, and pathological changes.

McCLOSKEY JF, CHU PT

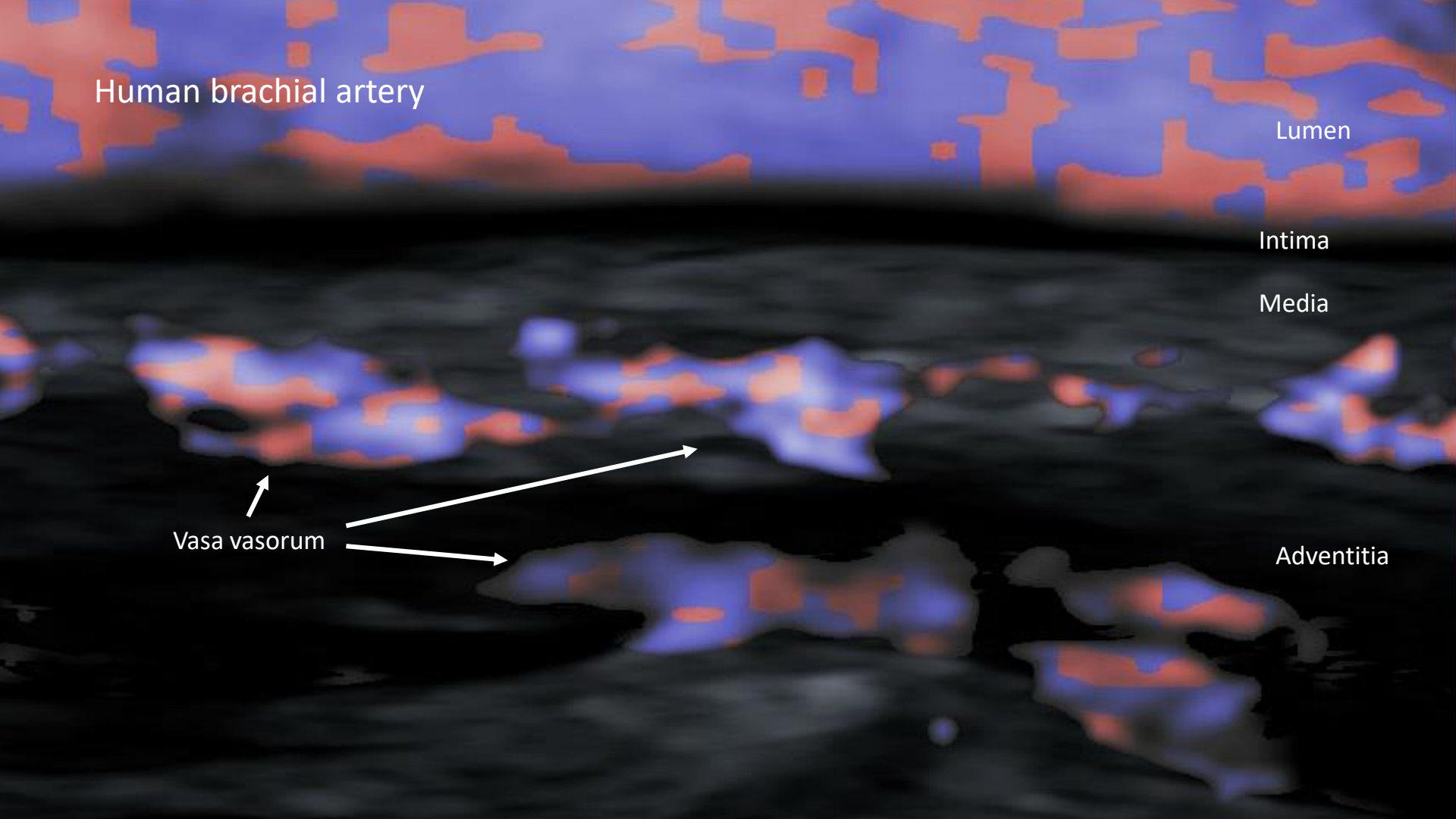
AMA Arch Pathol. 1951 Aug;52(2):132-44.

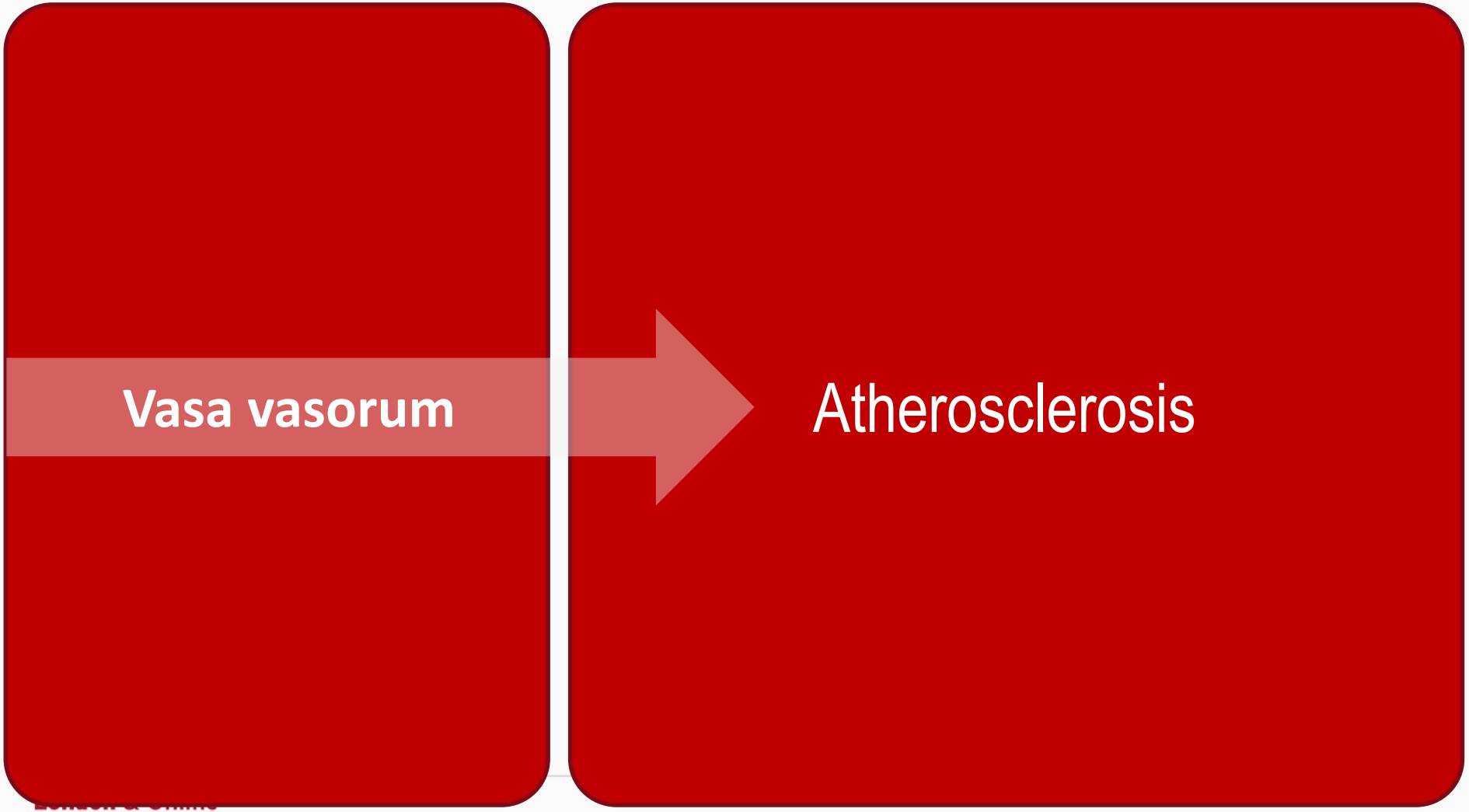
Adventitial vasa vasorum heterogeneity among different vascular beds

OfferGalili MD
JoergHerrmann MD
JulieWoodrum MS
Katherine J.Sattler MD
Lilach O.Lerman MD, PhD
AmirLerman MD

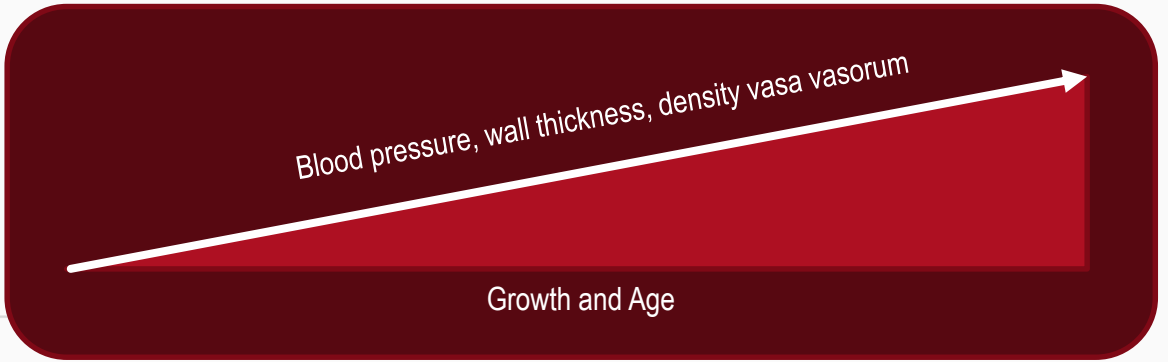


J. Vascular Surgery 40, 2004, 529-535

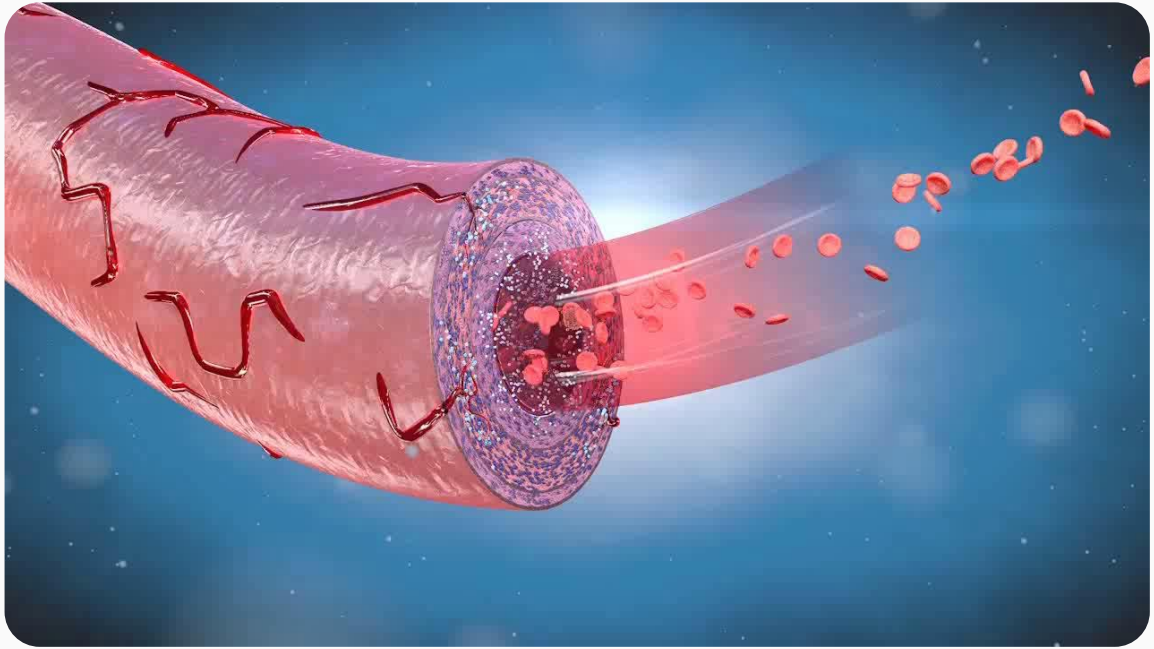

Human brachial artery
Lumen
Intima
Media
Vasa vasorum
Adventitia


Vasa vasorum
Atherosclerosis

Vasa vasorum and atherosclerosis



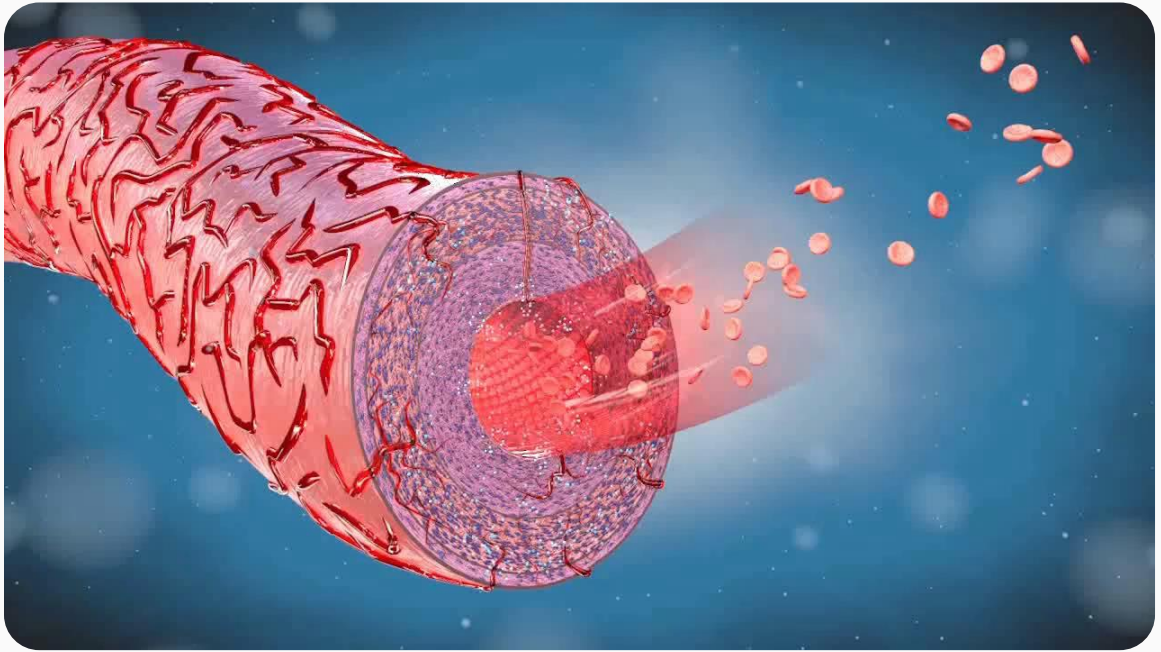
Vasa vasorum and atherosclerosis



Functional impairment

- Inflammation
- Infection (viral&bacterial)
- Small particles
- Vasoconstriction
- Thrombosis (Corona)

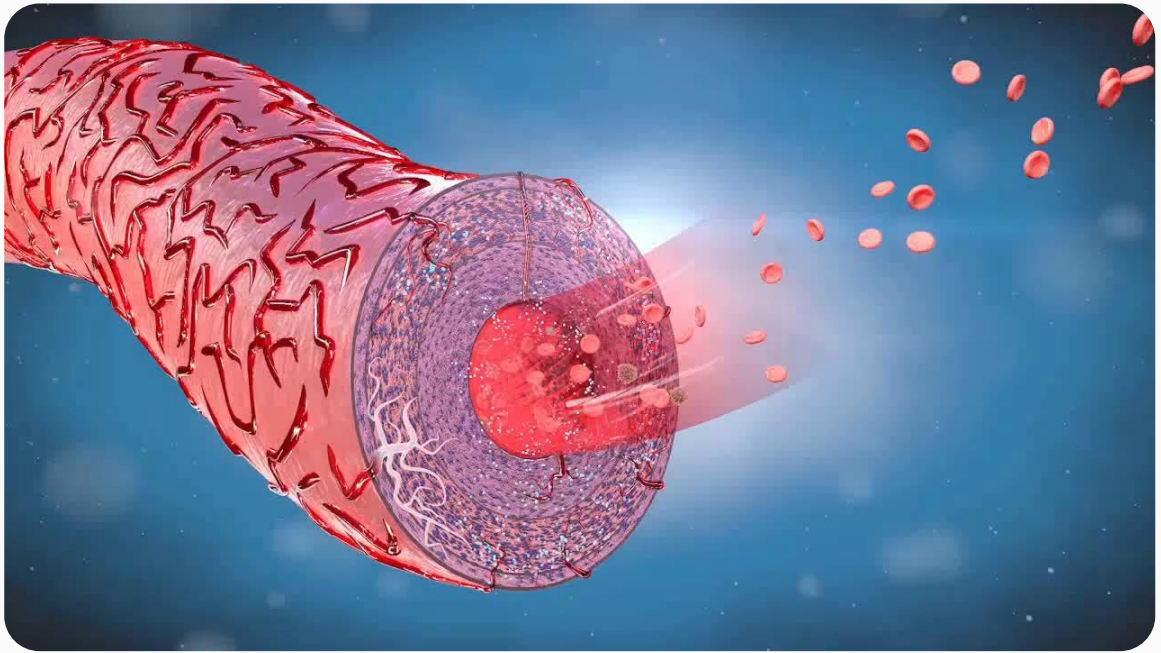
Vasa vasorum and atherosclerosis

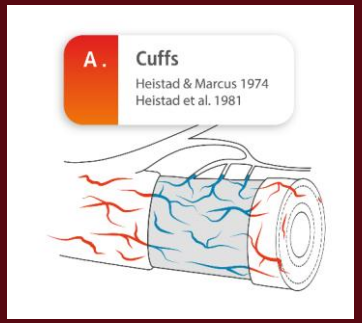


CABG

„No touch“ vein graft harvesting
= no graft atherosclerosis

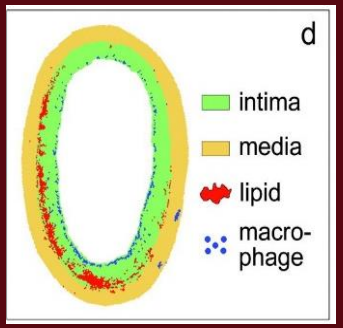
Vasa vasorum and atherosclerosis





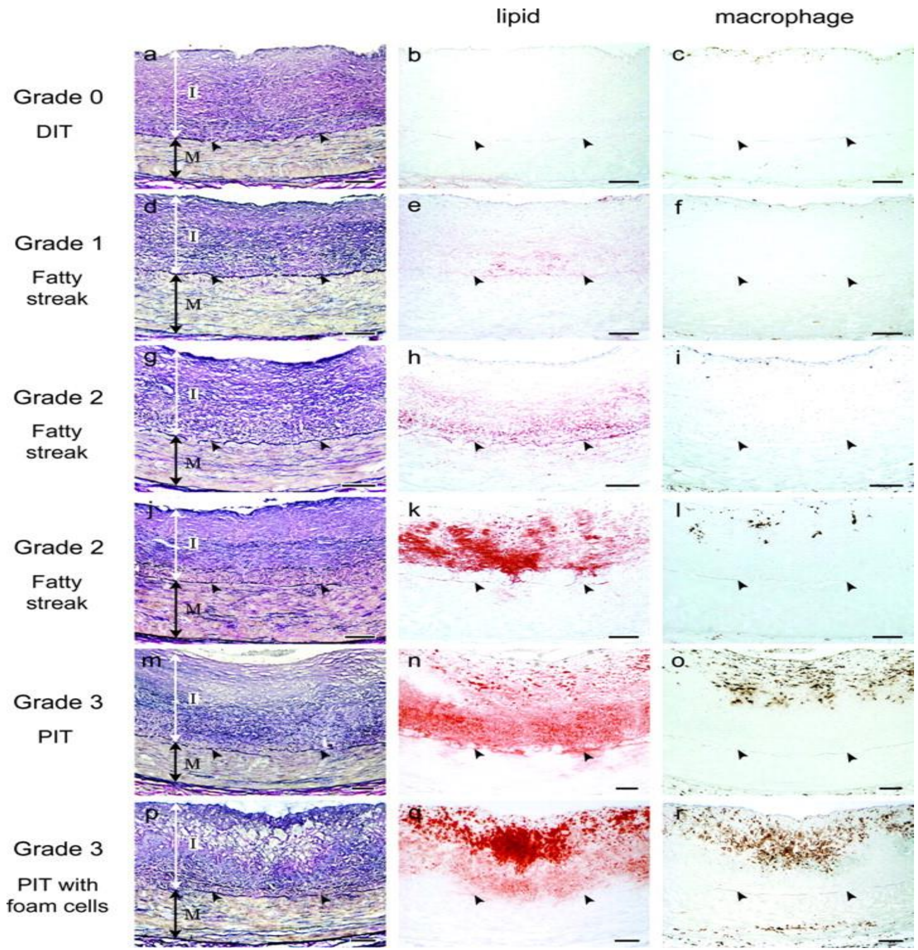
2 Weeks

Sub-intimal
lipid deposition



Vasa vasorum and atherosclerosis

Yutaka Nakashima et al. Arterioscler Thromb Vasc Biol. 2007;27:1159-1165



American Heart Association.

NO

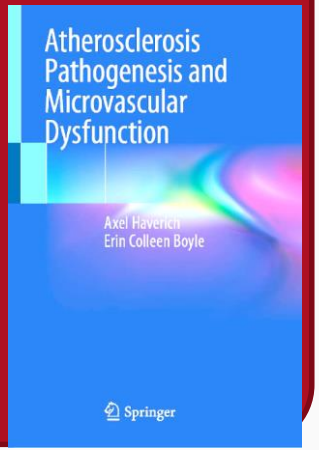
Vasa vasorum

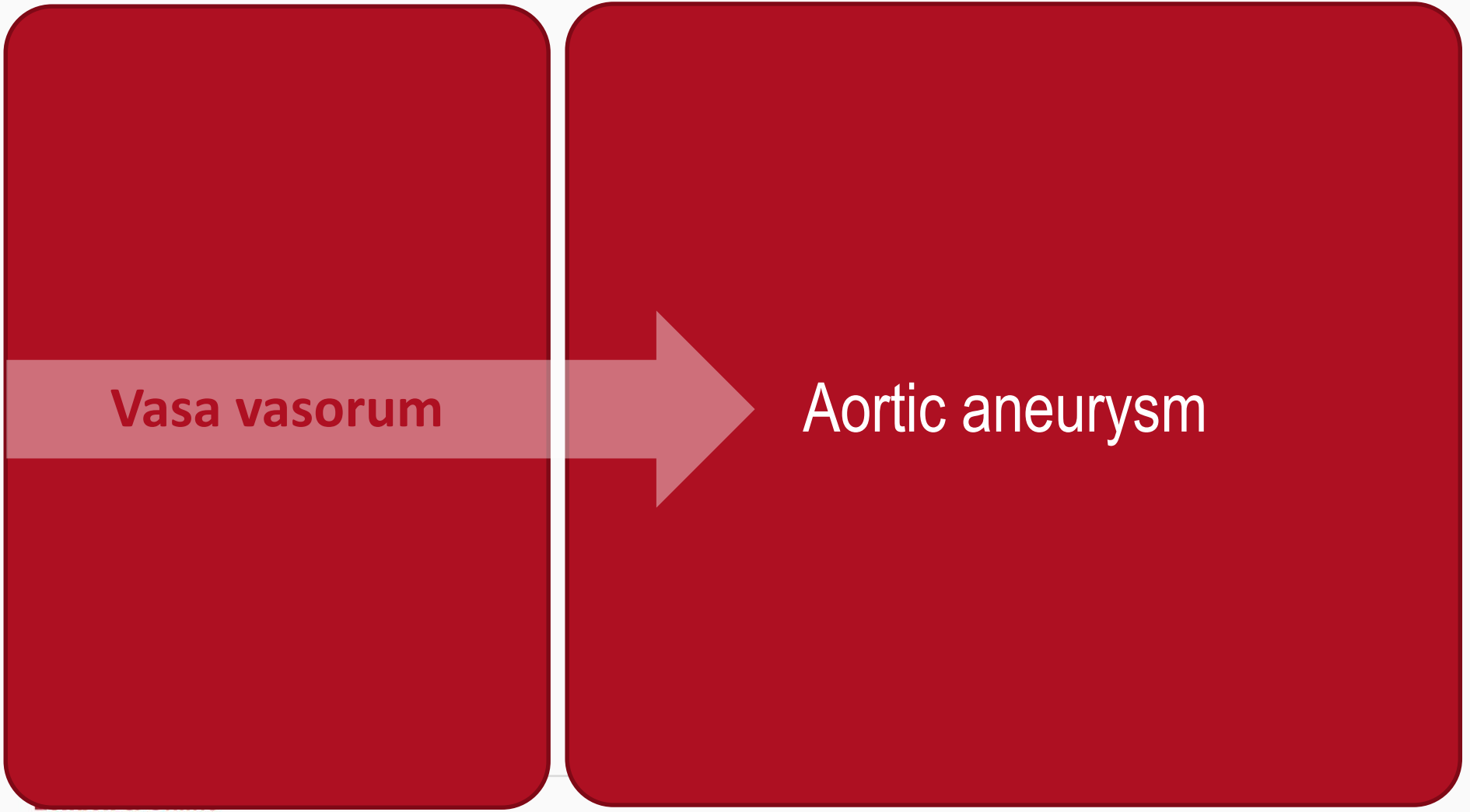
Mammary artery
Intramyocardial coronary arteries

NO

Atherosclerosis

Mammary artery
Intramyocardial coronary arteries




Vasa vasorum
Aortic aneurysm

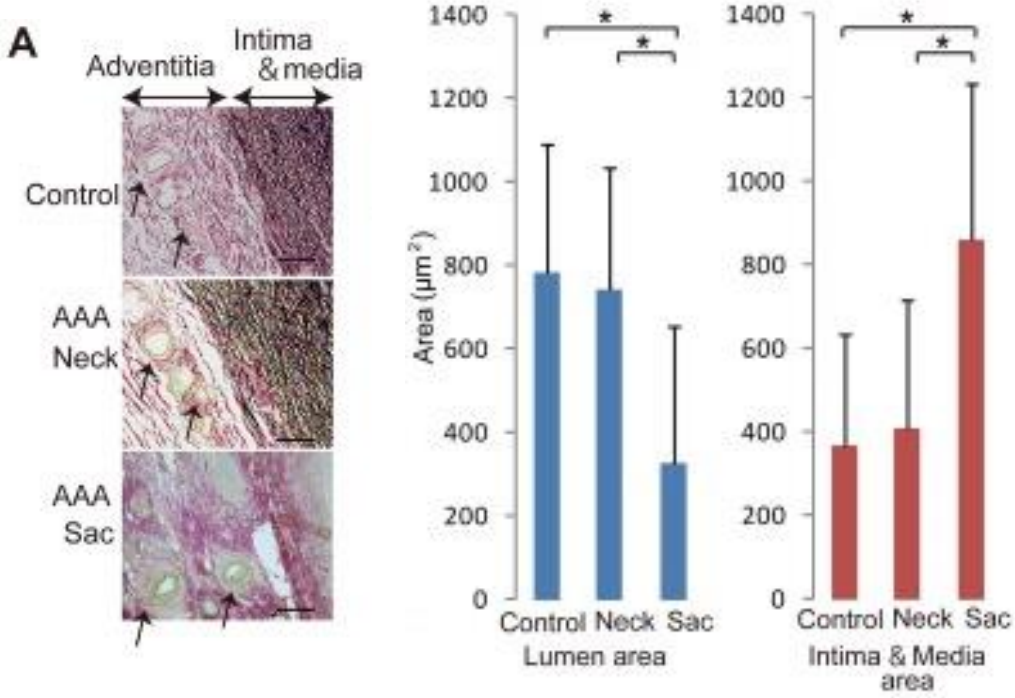
Vasa vasorum and aortic aneurysm

Tanaka H, et al. (2013)

PLOS ONE 8(2): e57398

Adventitial vasa vasorum arteriosclerosis in AAA

Tanaka H, et al. (2013)

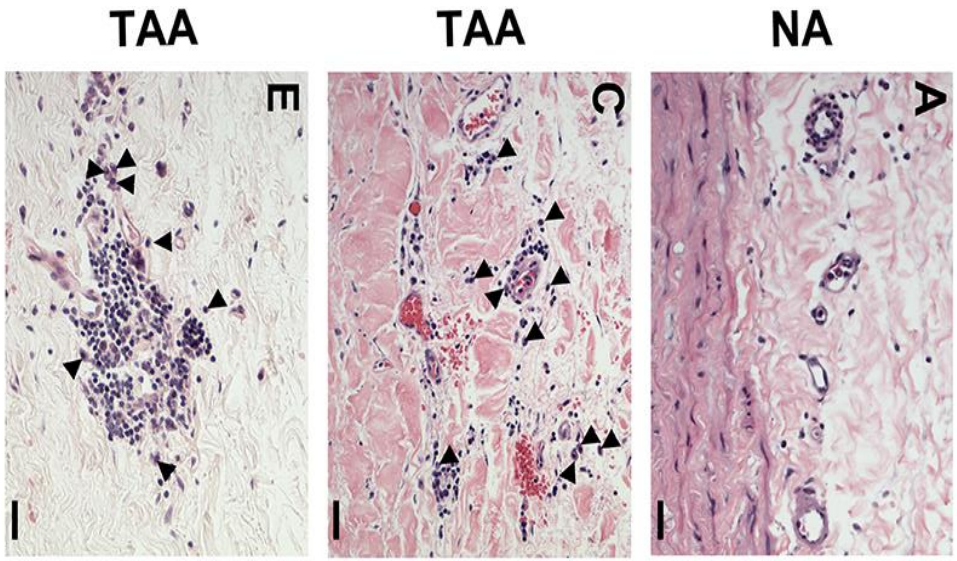


Vasa vasorum and aortic aneurysm

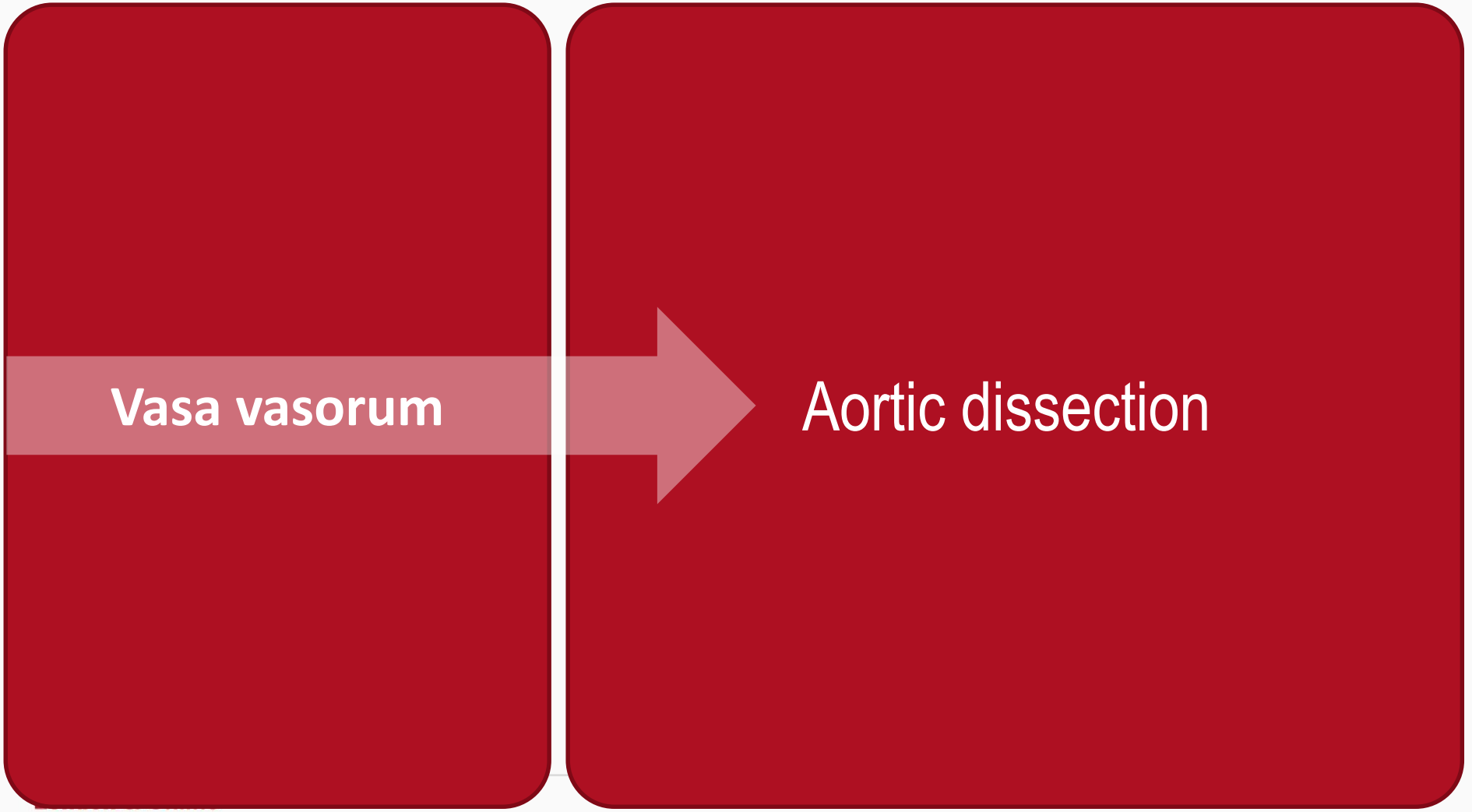
Front. Cardiovasc. Med., 17 September 2018

Medial Hypoxia and Adventitial Vasa Vasorum Remodeling in Human Ascending Aortic Aneurysm

Marie Billaud, et al, Pittsburgh, PA



Plasma cell infiltrates, adventitial Vasa vasorum


Vasa vasorum
Aortic dissection

Its all about understanding the natural course of aortic disease

Randy Griepp

„If an intimal tear would produce an aortic dissection, cardiac surgeons would produce thousands of them, every day, world-wide“

EACTS, Lisboa, 2019

Animal experiments

Vasa vasorum and aortic dissection

Am J Pathol. 1965 Oct; 47(4): 695–711.

EXPERIMENTAL INFARCTION (MEDIAL NECROSIS) OF THE DOG'S AORTA

S. L. WILENS, M.D.; J. A. MALCOLM, M.D., AND J. M. VAZQUEZ, M.D.

From the Surgical and Laboratory Services and Research Division of The New York Veterans Administration Hospital, New York, N.Y.

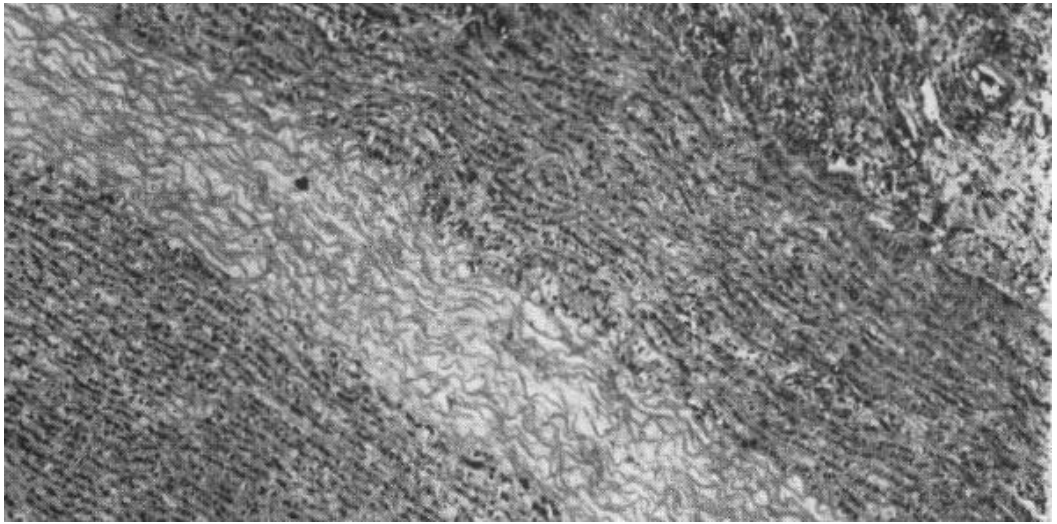


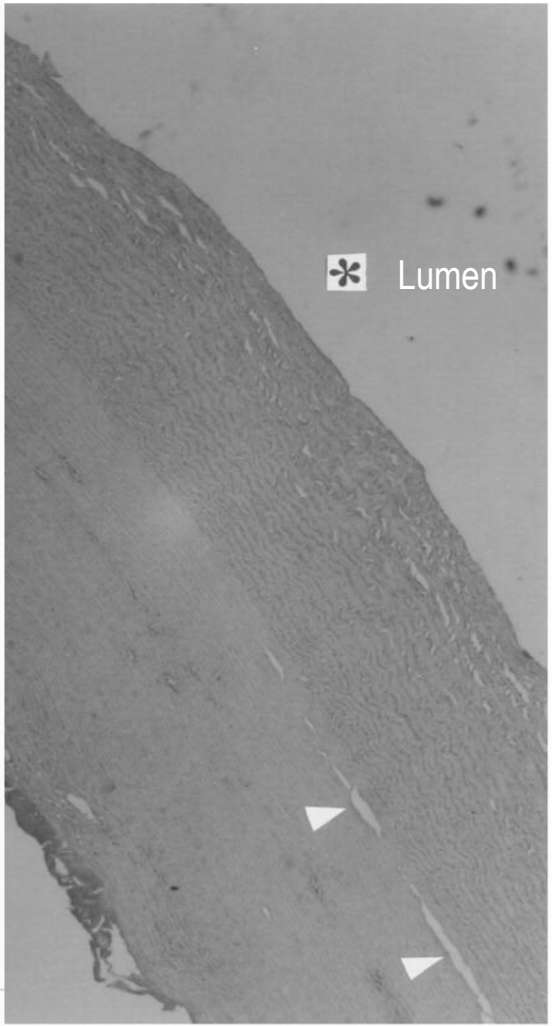
FIG. 10. Dog no. 6. A pale uniform mid-zonal area of necrosis persists 2 weeks after intercostal artery ligation. This necrotic zone extended over the entire circumference of the vessel at this level. × 123.

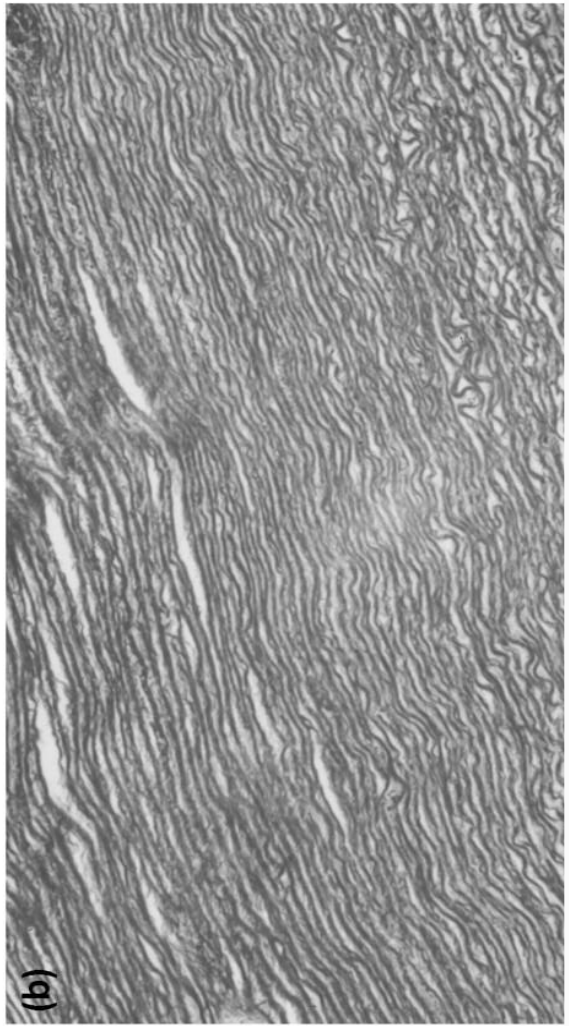
Animal experiments

Vasa vasorum and aortic dissection

Effect of impaired vasa vasorum flow on the structure and mechanics of the thoracic aorta: implications for the pathogenesis of aortic dissection

Dimitrios Angouras et al, Athens, Greece
EJCTS, 17, 2000



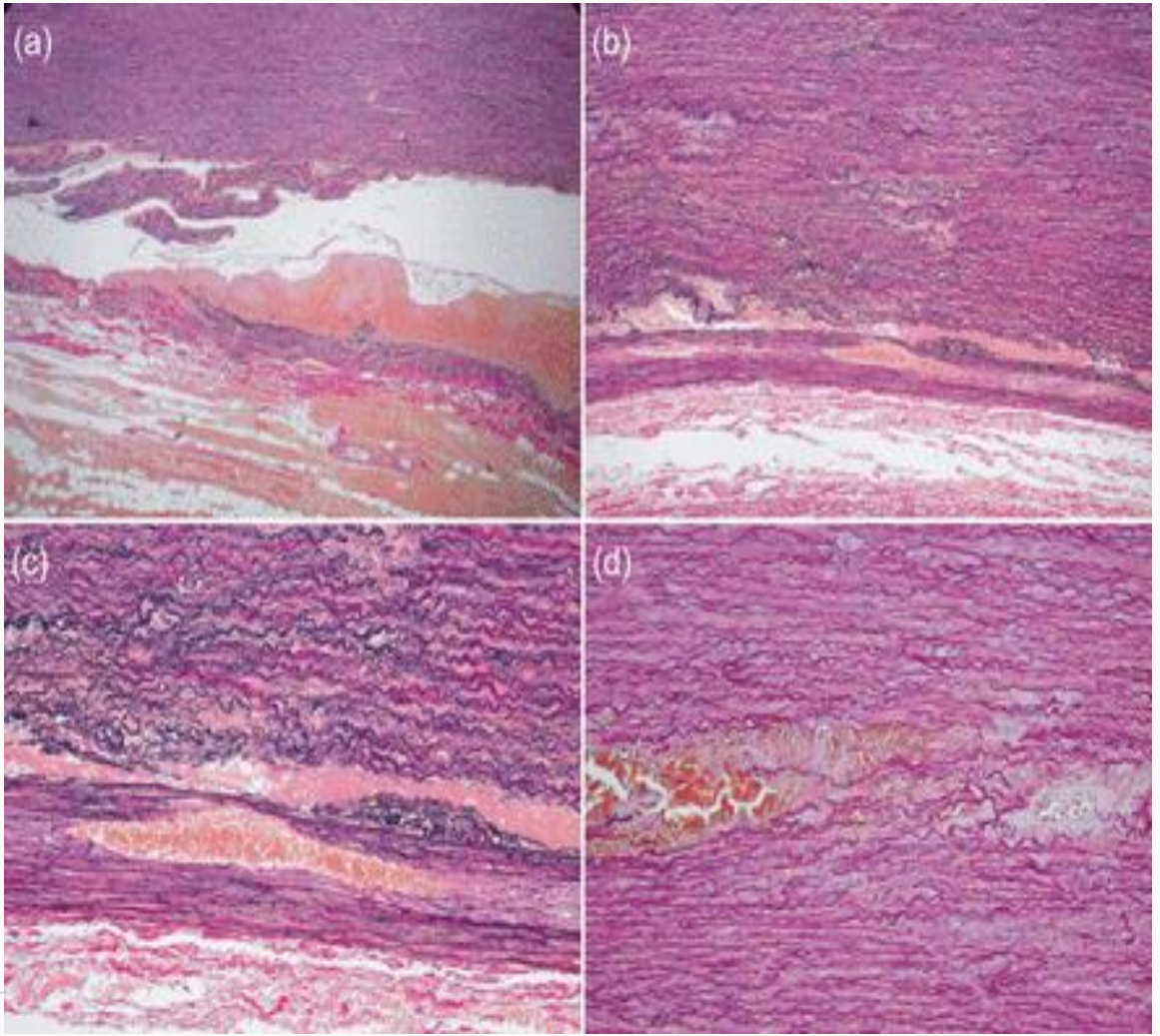


Clinical data

Vasa vasorum and aortic dissection

Aortic dissection in the outer third of the media: what is the role of the vasa vasorum in the triggering process?

Hiroaki Osada et al, Kyoto, Japan
EJCTS, 43, 2013



Clinical data

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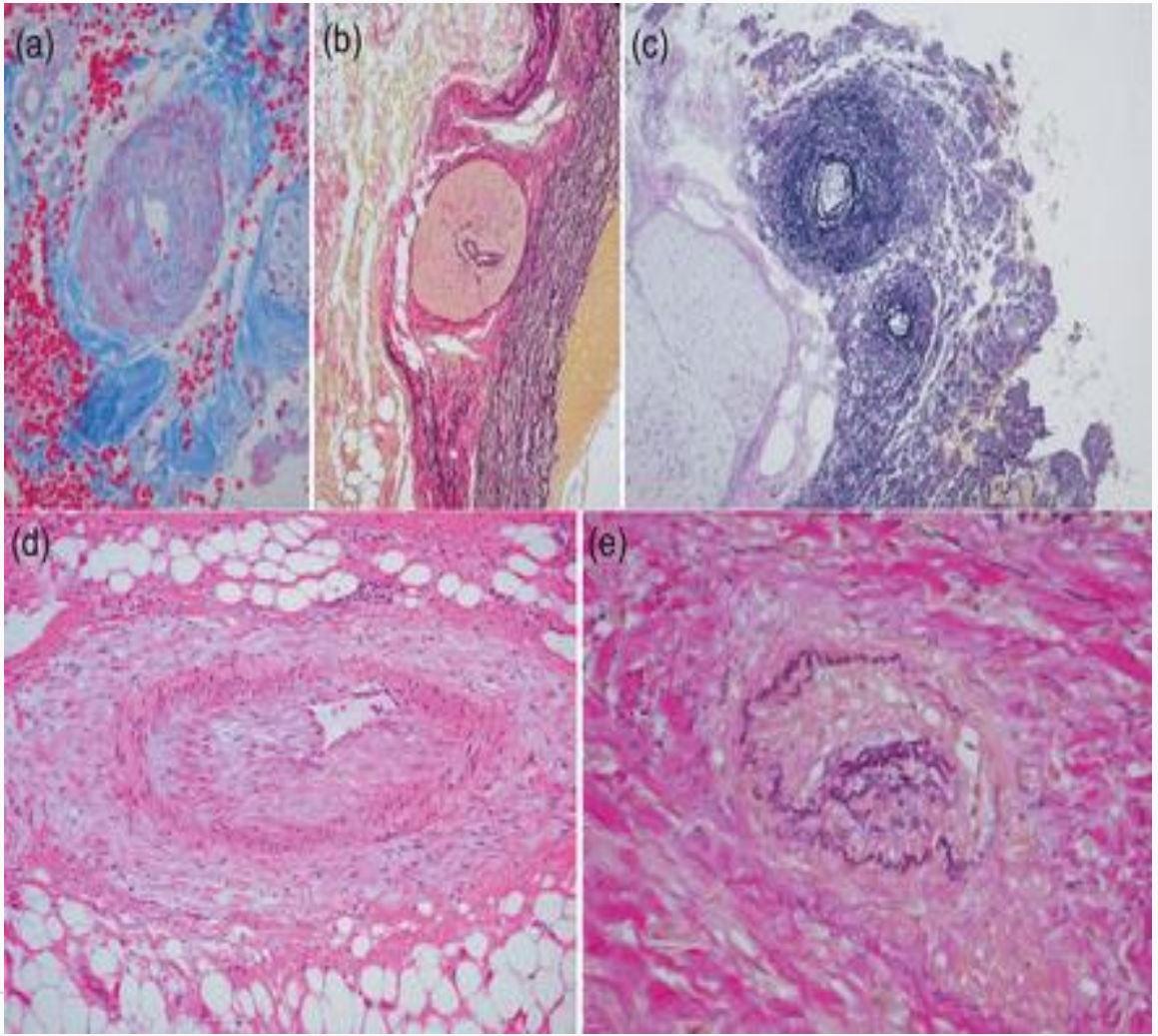
EJCTS, 43, 2013



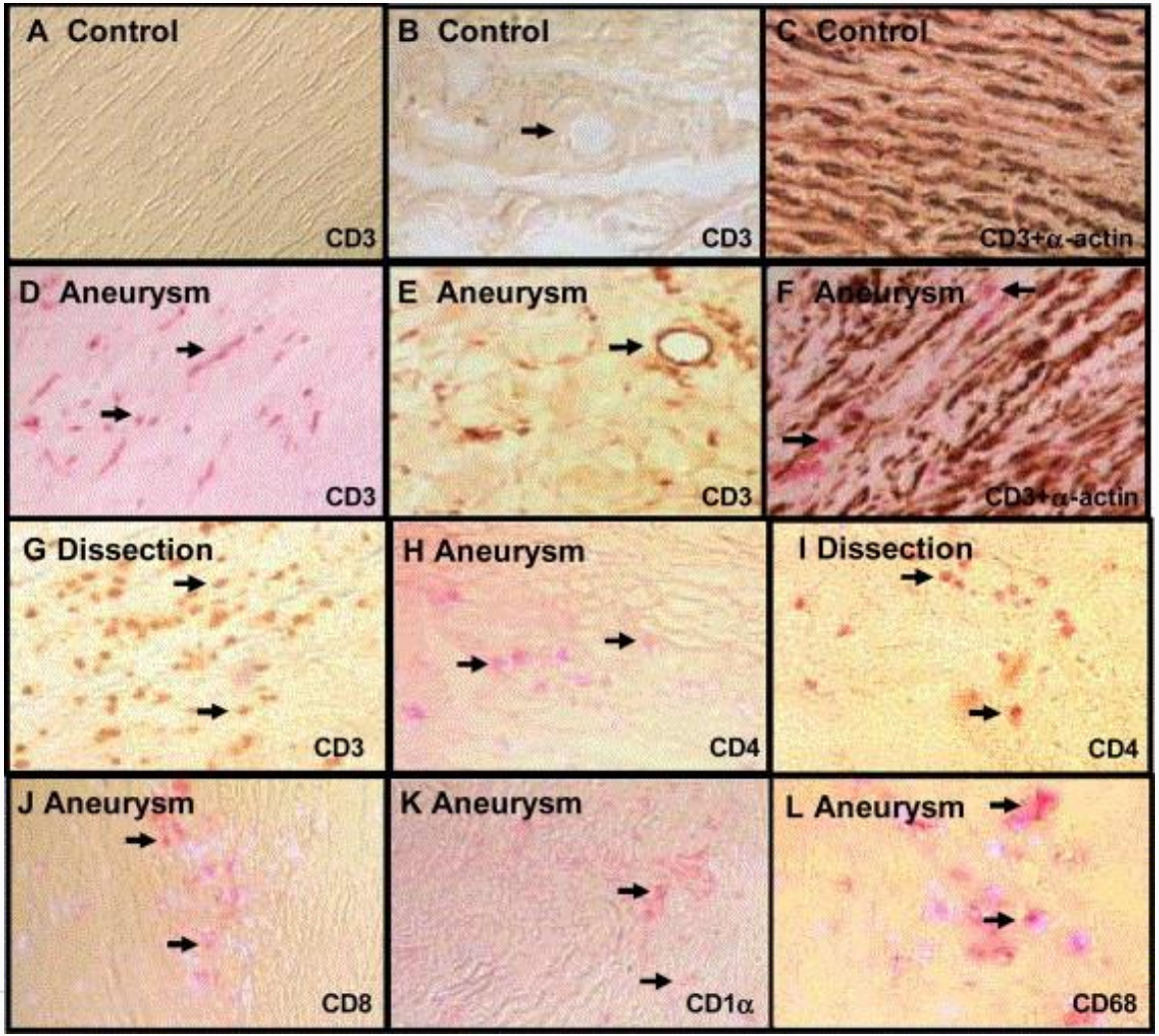
Clinical data

T-lymphocyte infiltrates in TAA and TAD

Vasa vasorum and aortic dissection

Characterization of the inflammatory and apoptotic cells in the aortas of patients with ascending thoracic aortic aneurysms and dissections.

He R Guo DC Estrera AL Safi HJ et al, Houston, Tx.
JTCVS. 2006 Mar;131(3):671-8.



Clinical data

TUNEL-positive cells present in media from control, aneurysmal, and dissected aortas

Vasa vasorum and aortic dissection

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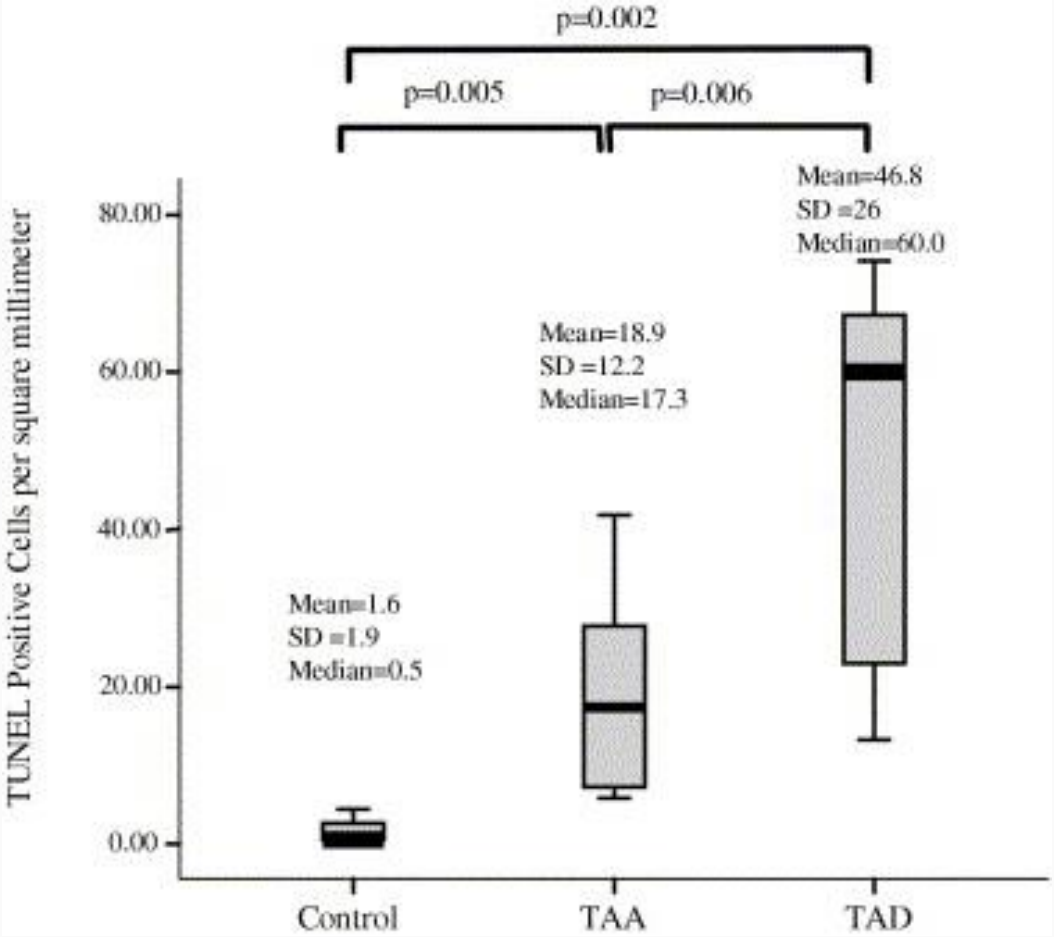
He R Guo DC Estrera AL Safi HJ et al, Houston, Tx.
JTCVS. 2006 Mar;131(3):671-8.



Experimental & clinical data

Vasa vasorum and aortic dissection

Vasa vasorum obstruction

- ischemia T.media
- media necrosis

↓

Inflammatory response

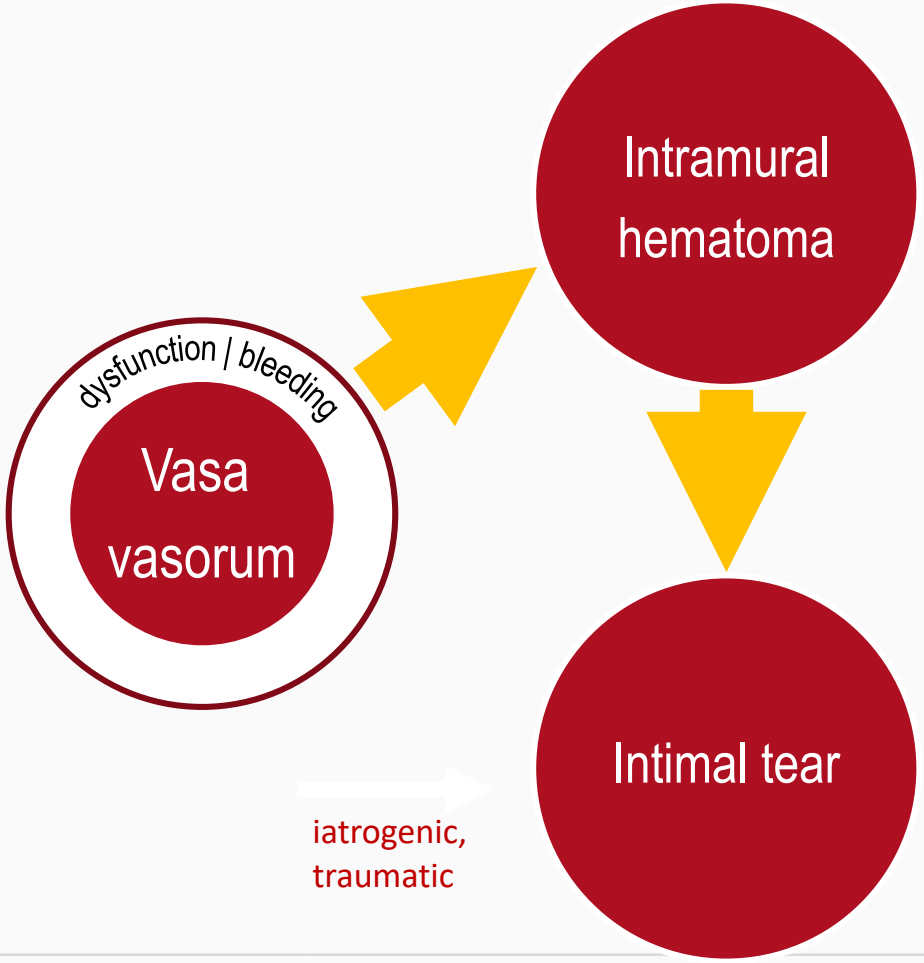
- extravasation of blood
- along vasa vasorum

=

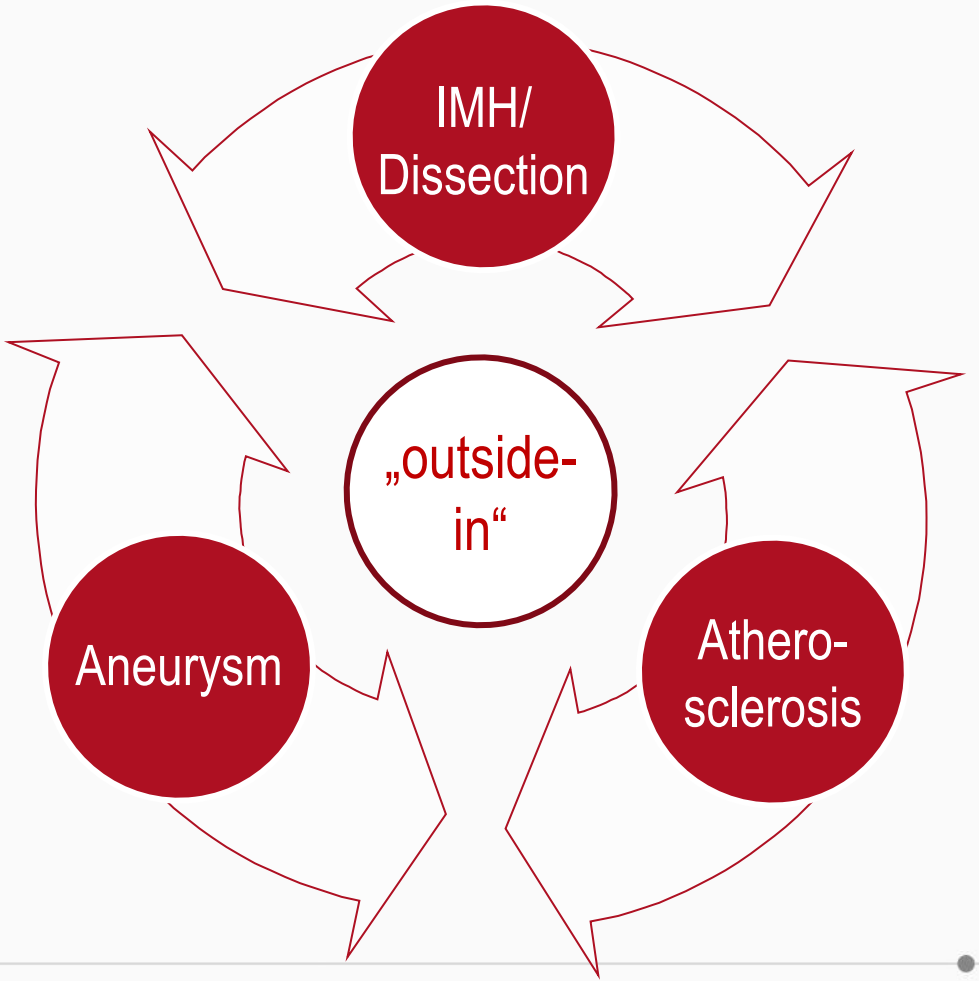
IMH

Experimental & clinical data

Vasa vasorum and aortic dissection



The role of the vasa vasorum?



„Flipping the paradigm…“

- Atherosclerosis
- Aneurysm
- IMH/ Dissection

„Flipping the paradigm…“

JTCVS Open • Volume 5, Number C 33

- Atherosclerosis
- Aneurysm
- IMH/ Dissection

Commentary: Vasa vasorum dysfunction and acute aortic syndromes: When guidelines do not follow the evolution of knowledge

Antonio M. Calafiore, MD,[a] Kostas Katsavrias, MD,[b] Massimo Di Marco, MD,[c] Stefano Guarracini, MD,[d] and Michele Di Mauro, PhD, MD[d,e]

Cosequences

of understanding the natural course of aortic disease

Preservation of an intact microcirculation of the aortic wall

Medical

- Prevention: No smoking, exercise, reduce air pollution, vaccinations
- Therapie: Infections, inflammation, (diastolic) hypertension

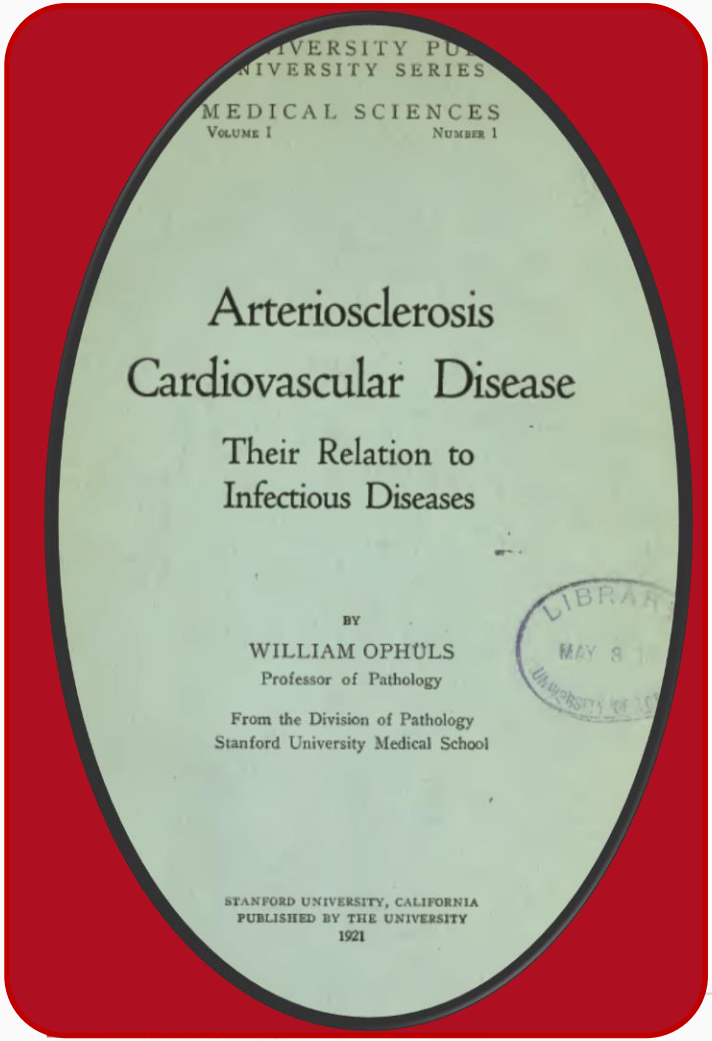
Surgical

- Protect the adventitial layer
  - bypass grafts (saphenous vein, mammary artery)
  - over-extending stents
- Secondary prevention

Trans-disciplinary

- Research in other disease areas with suspected microcirculatory pathobiology

DISCUSSION (3 slides)

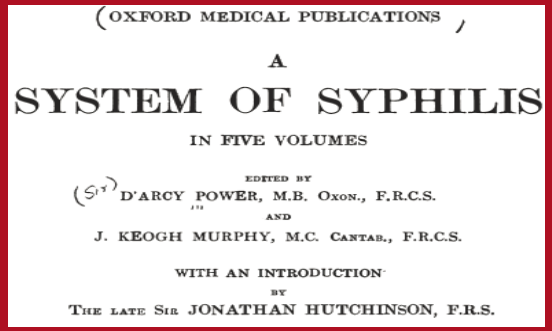


Karl Koester, Universität Bonn, 1843 - 1904

The development of spontaneous aneurysms and chronic mesarteritis.

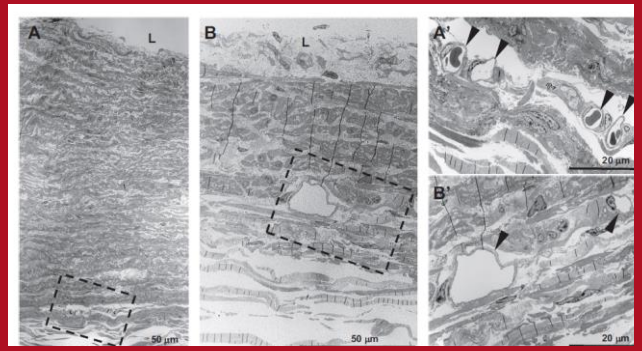
Berliner Klinische Wochenschrift 1875.

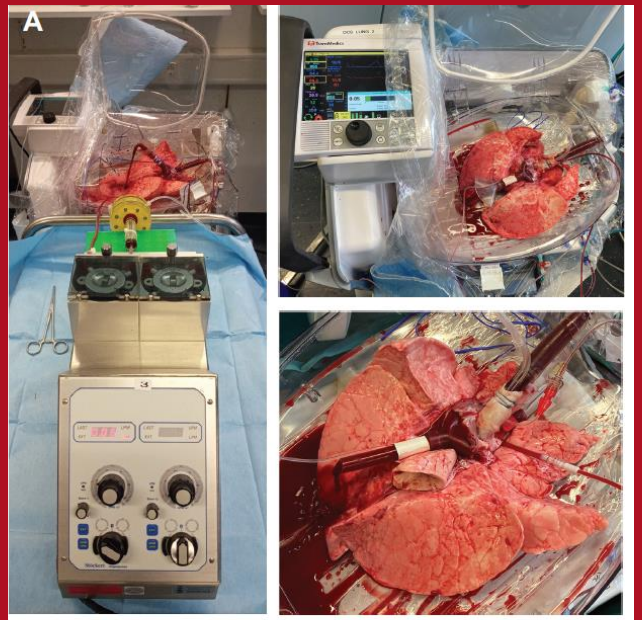
Inflammation of the adventitia along the vasa vasorum in the media



Vasa vasorum and pulmonary artery hypertension

- understanding the natural course of disease





american physiological society

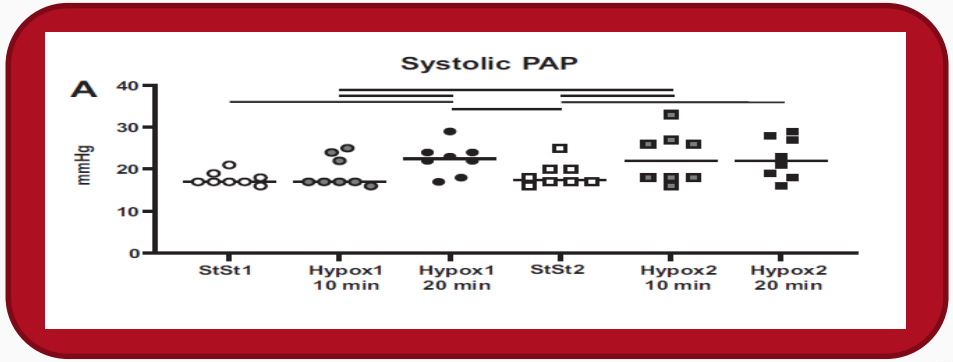
AMERICAN JOURNAL OF PHYSIOLOGY
LUNG CELLULAR AND MOLECULAR PHYSIOLOGY

Am J Physiol Lung Cell Mol Physiol 327: L79–L85, 2024.
First published April 23, 2024; doi:10.1152/ajplung.00346.2023

SHORT REPORT

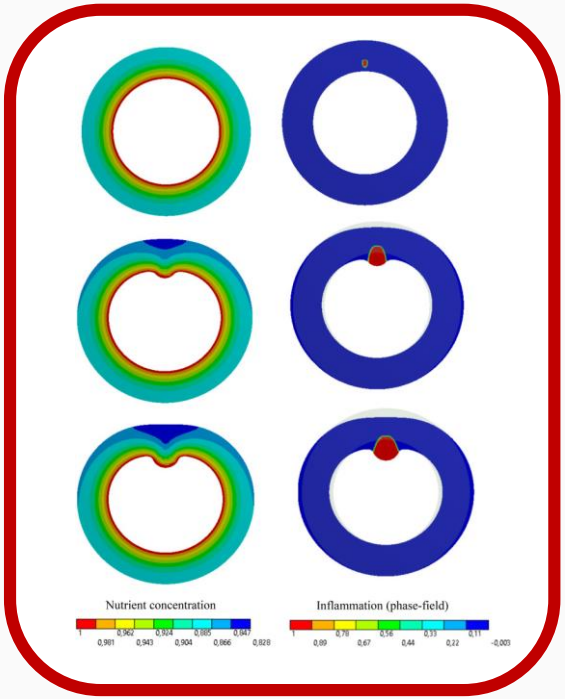
Hypoxic perfusion of pulmonary arterial vasa vasorum increases pulmonary arterial pressure

Emma L. Heise,[1] Jawad Salman,[1,2] Karolin S. Webs,[1,2] Klaus Höffler,[1] Christina Brandenberger,[2,3,4] Dietmar Böthig,[1] Christian Mühlfeld,[2,3]* and Axel Haverich[1]*



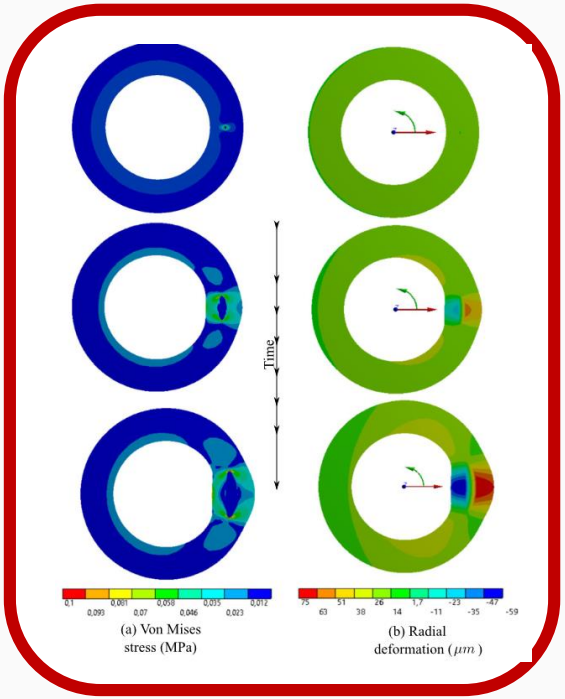
Mathematical Modeling and Numerical Simulation of Atherosclerosis

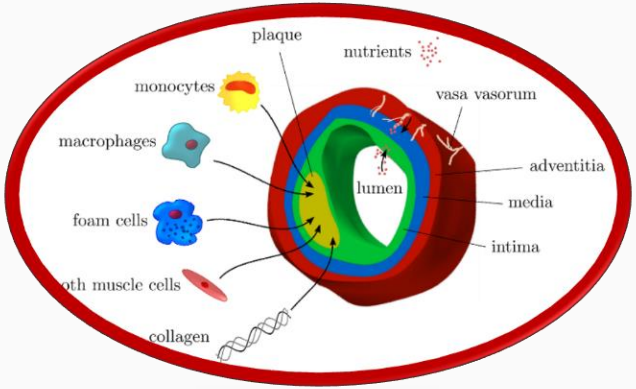
Soleimani M, Haverich A, Wriggers P.
Arch Comput Methods Eng. 2021;28(6):4263-4282.



Mathematical modeling and numerical simulation of arterial dissection

Soleimani M, Deo R, Hudobivnik B, Poyanmehr R, Haverich A, Wriggers P. Biomech Model Mechanobiol. 2023 Dec;22(6):2097-2116





Mechano-chemo-biological model of atherosclerosis formation based on the outside-in theory

Gierig M, Tragoudas A, Haverich A, Wriggers P.
Biomech Model Mechanobiol. 2024 Apr;23(2):539-552