# Biomarcadores da doença vascular

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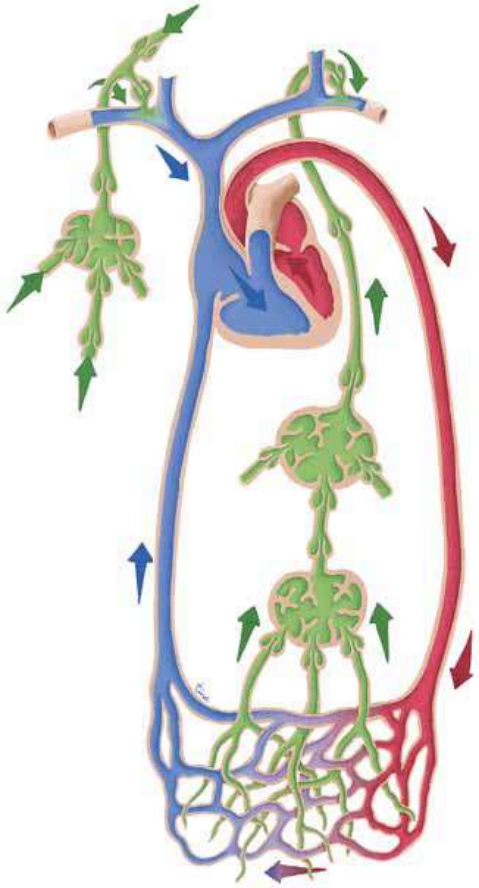
XXIV JORNADAS CIENTÍFICAS DE ANÁLISES CLÍNICAS E DE GENÉTICA HUMANA

# Doença vascular

Doença do sistema  circulatório

- Artérias
- Veias
- Linfáticos



# Doença cardiovascular

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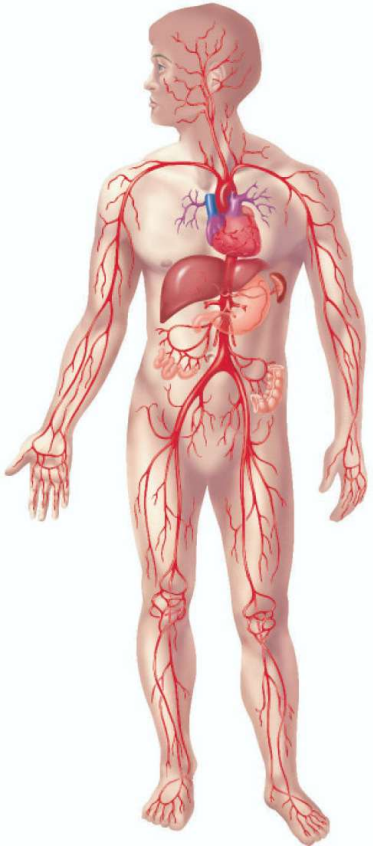
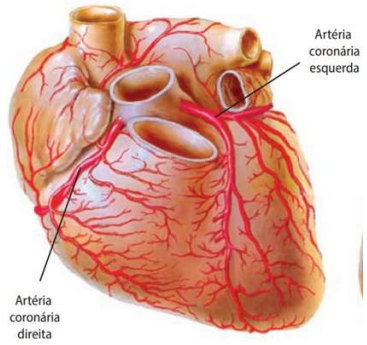
Doença do sistema  cardiovascular

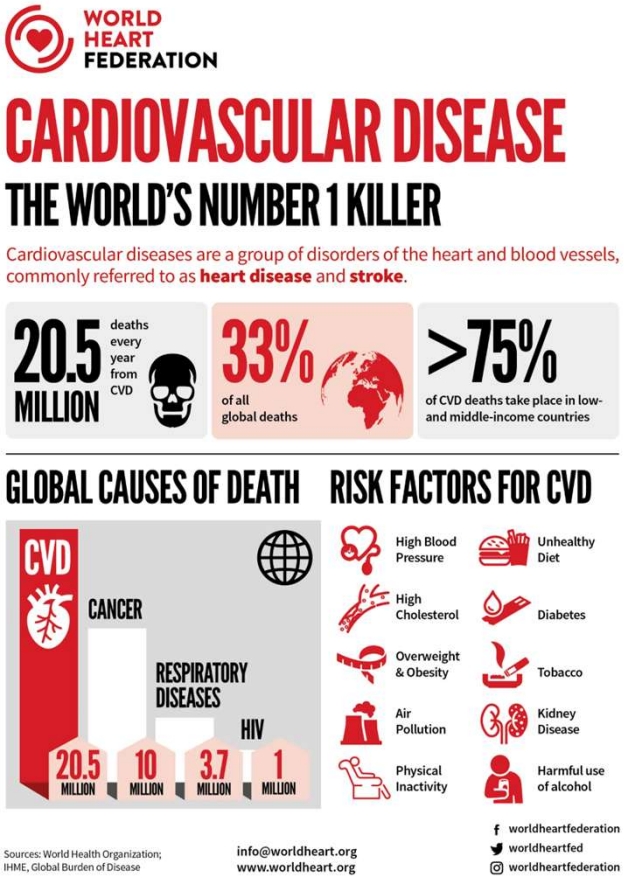
- Coração
- Artérias
- Veias






https://cursoenemgratuito.com.br/sistema-cardiovascular/

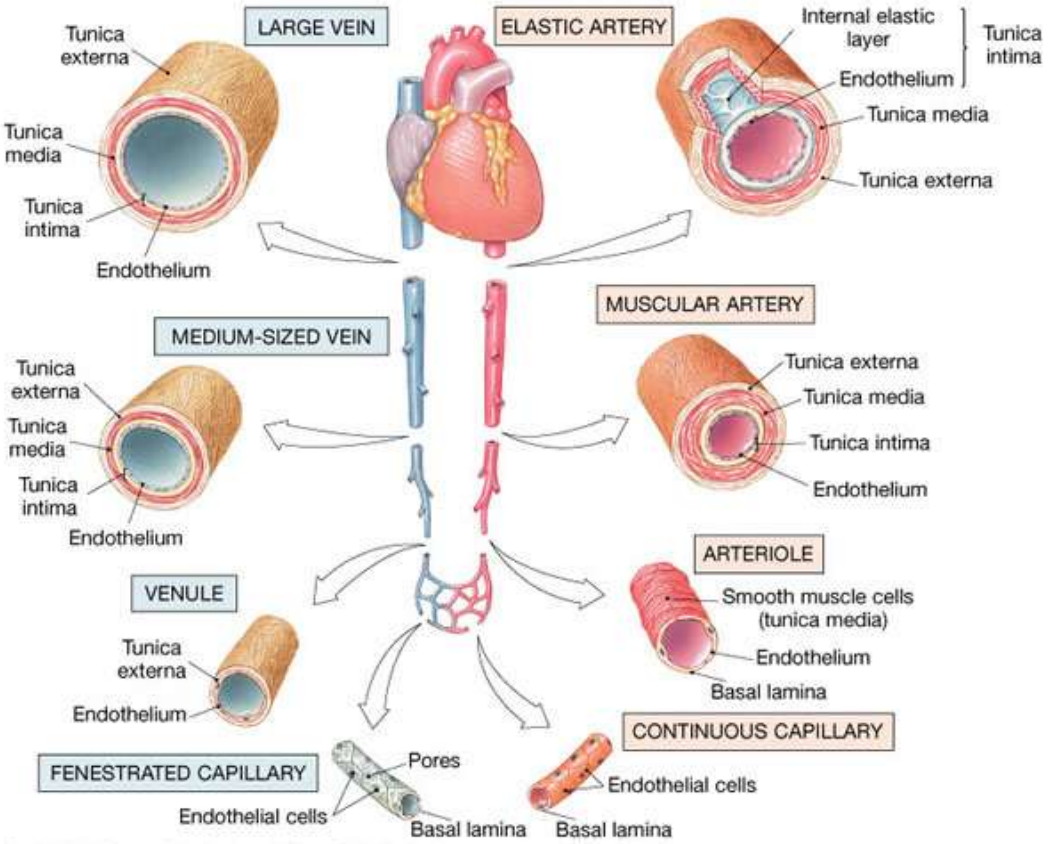
# Doença cadiovascular




https://world-heart-federation.org/resource/cardiovascular-disease-infographic/

Bozkurt et al, HF STATS 2024

# Tipos de vasos sanguíneos



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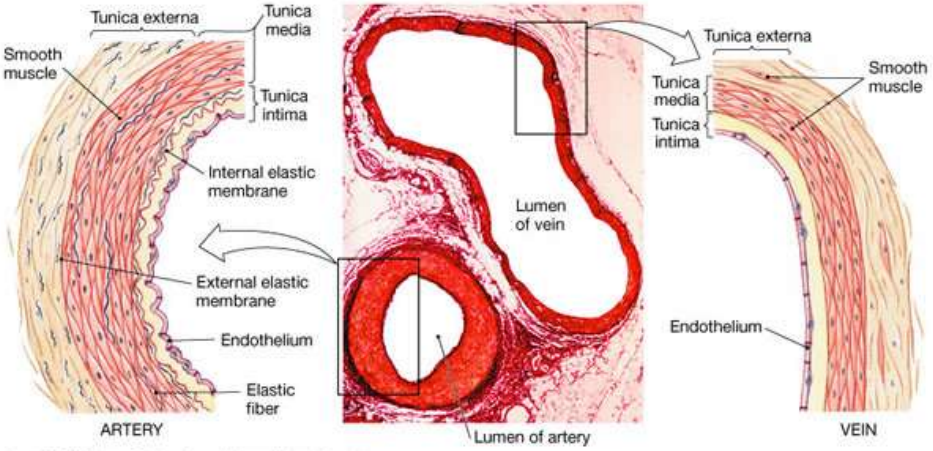

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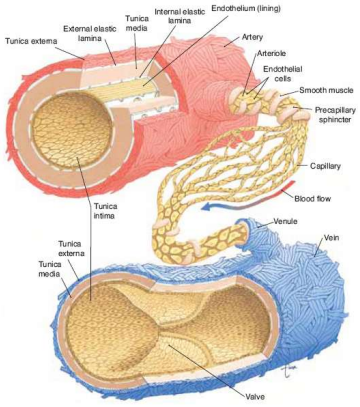


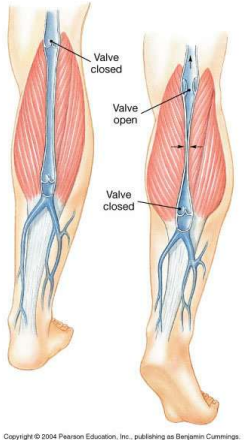

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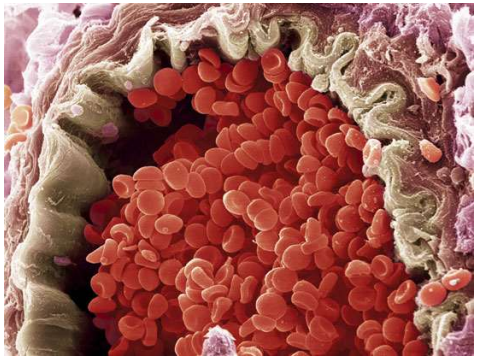
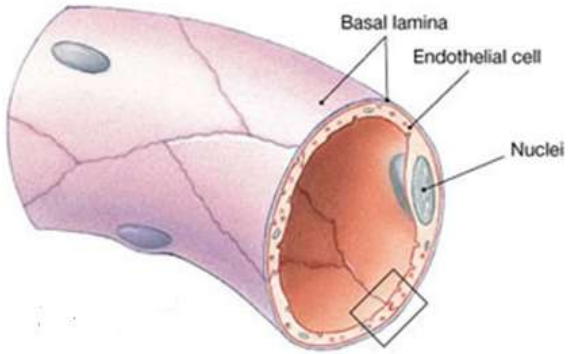
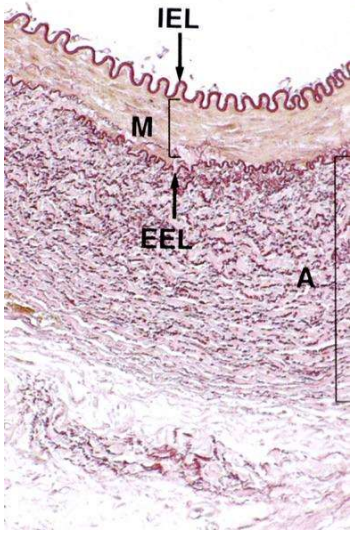
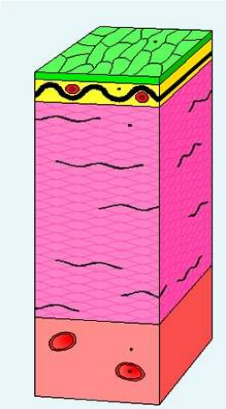
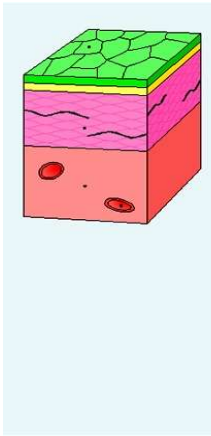
# Constituição dos vasos sanguíneos



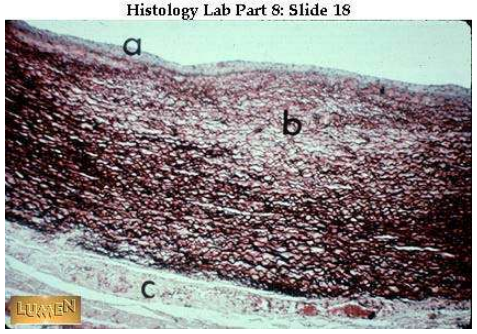


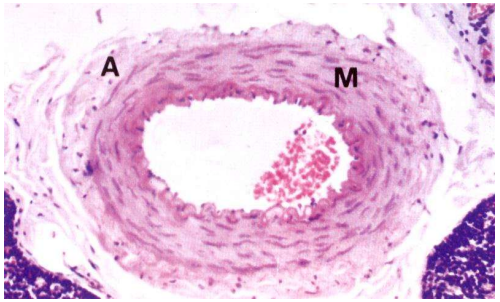



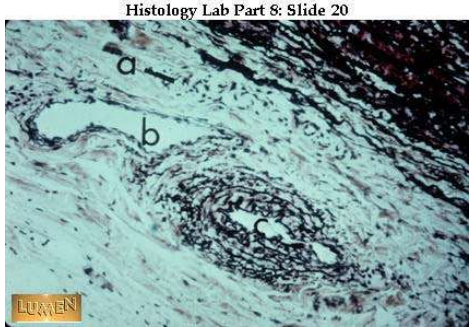


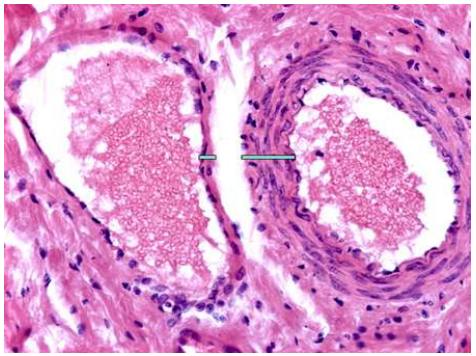
Histology Lab Part 8: Slide 18



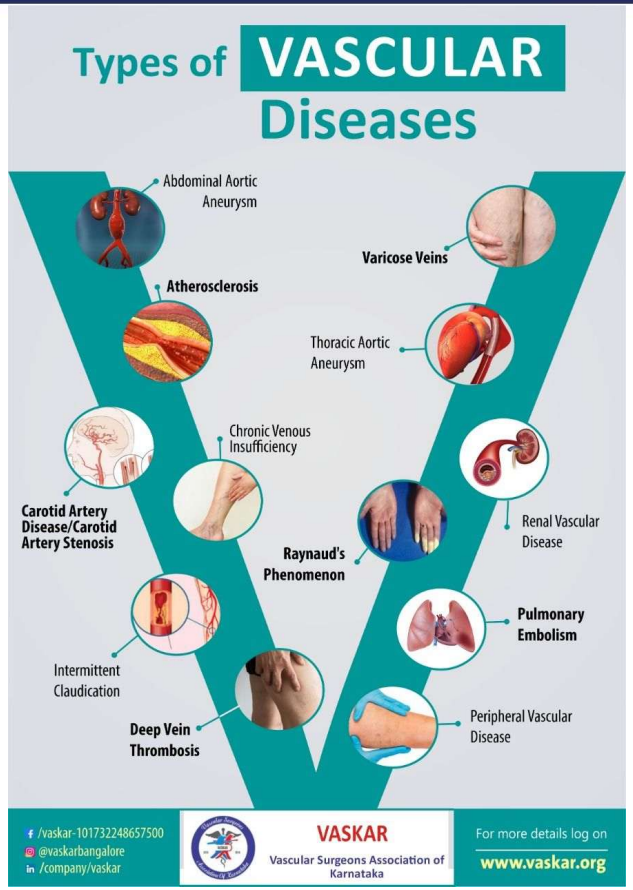




Histology Lab Part 8: Slide 20

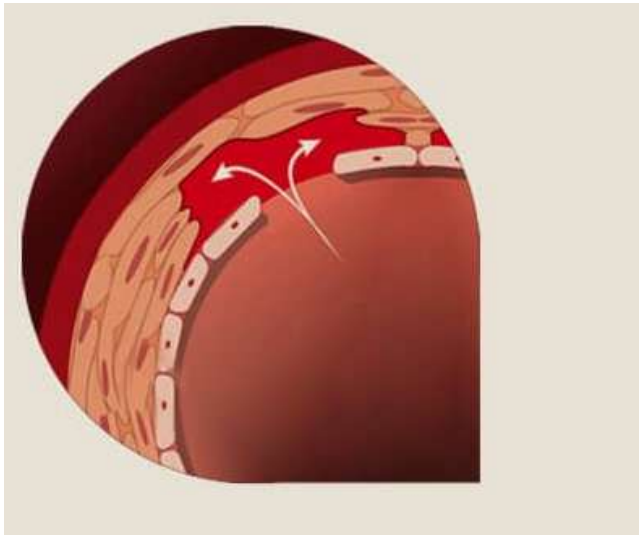


# Tipos de doenças vasculares



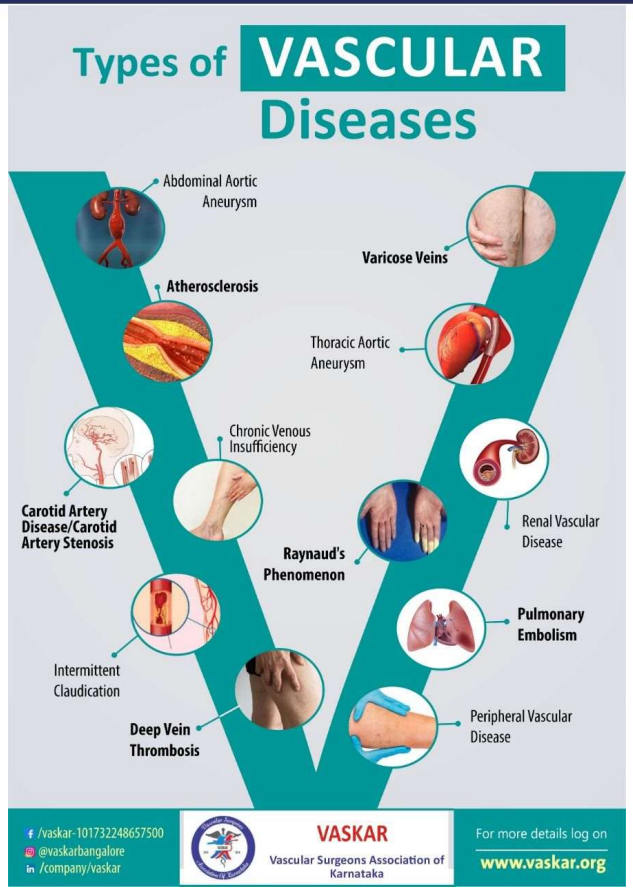

https://www.linkedin.com/posts/vaskar_bangaloresurgeon-karnatakahospital-bangalore-activity-6778230645748486144-SKSP?trk=public_profile_like_view



https://www.rodrigopaez.com.br/procedimento/aneurismas-de-aorta/

https://www.eumedicoresidente.com.br/post/aterosclerose-fisiopatologia-sintomas-tratamento

# Tipos de doenças vasculares

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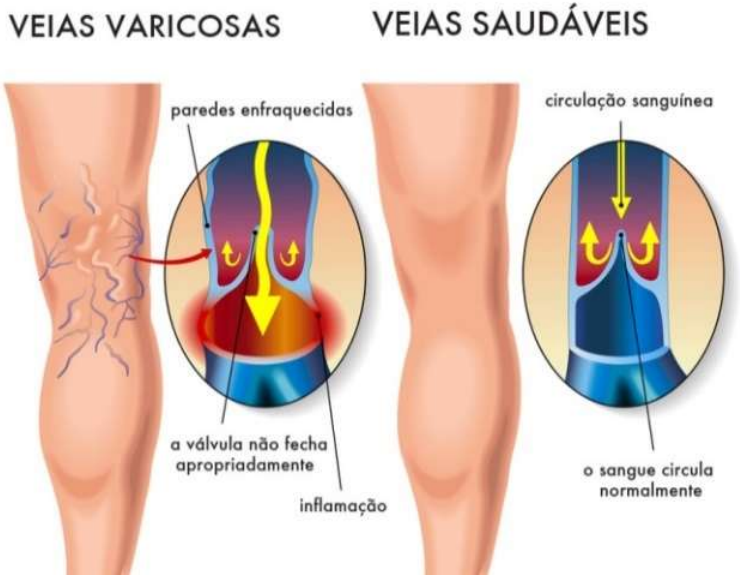
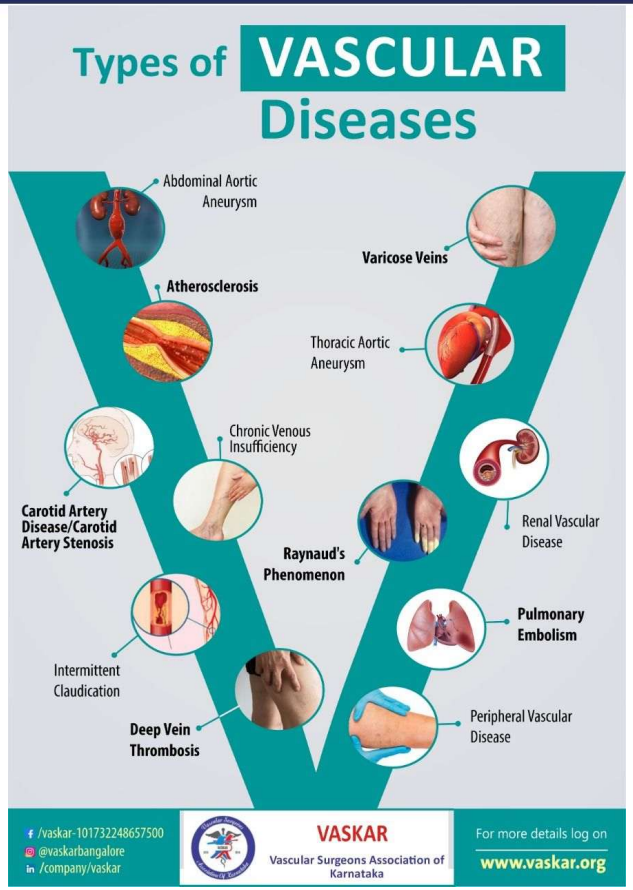



https://dranayarabatagini.com.br/varizes-quais-sao-causas-e-os-sintomas/

# Tipos de doenças vasculares

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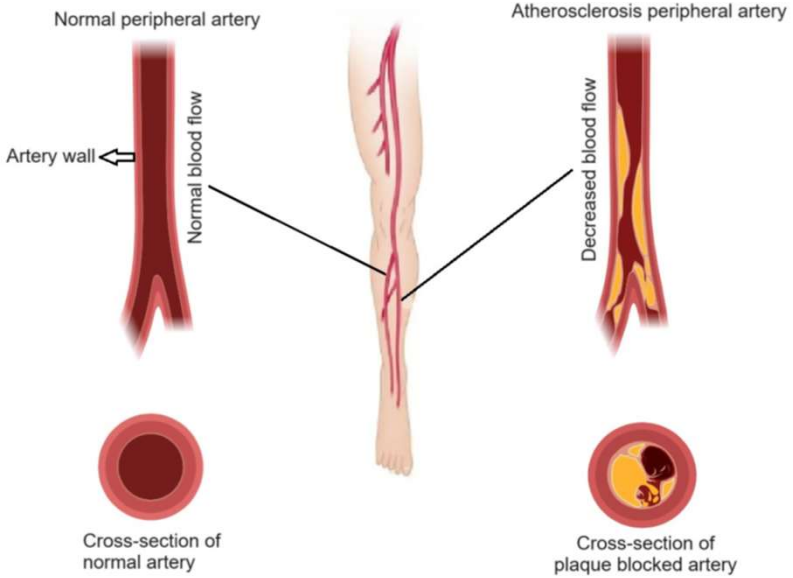
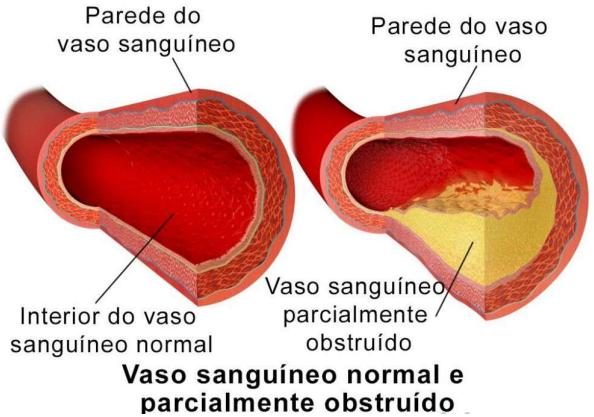


Netala et al, Cells 2024

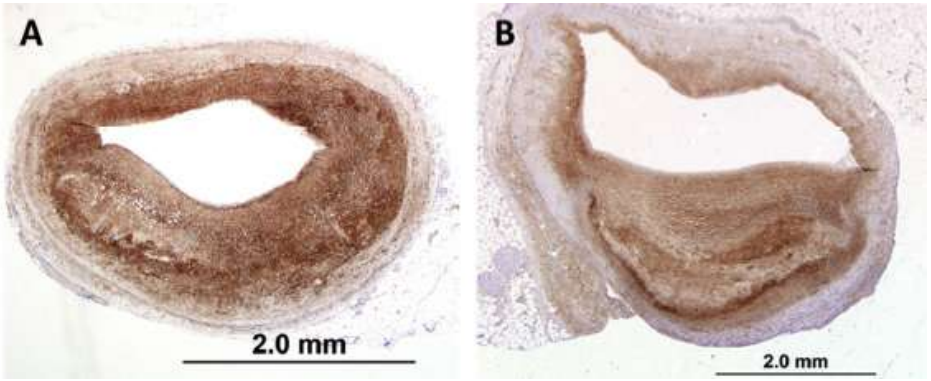
https://pt.dreamstime.com/aterosclerose-e-acidente-vascular-cerebral-derrame-como-doen%C3%A7a-causada-por-c%C3%A9lulas-sangu%C3%ADneas-bloqueadas-gordura-colesterol-se-image277474002

https://brasilescola.uol.com.br/saude/aterosclerose.htm

# Placas de ateroma

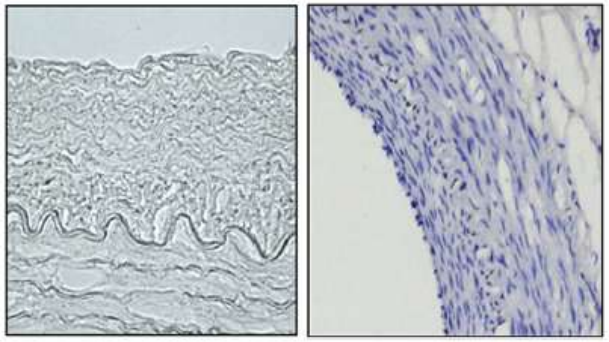


Vaso sanguíneo normal e parcialmente obstruído



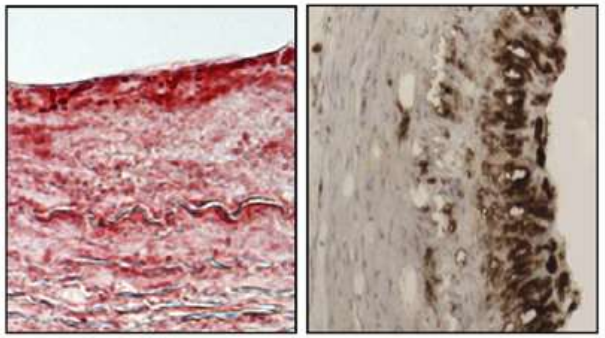

**Non-atherogenic phenotype**

Oil red O | Anti-macrophage



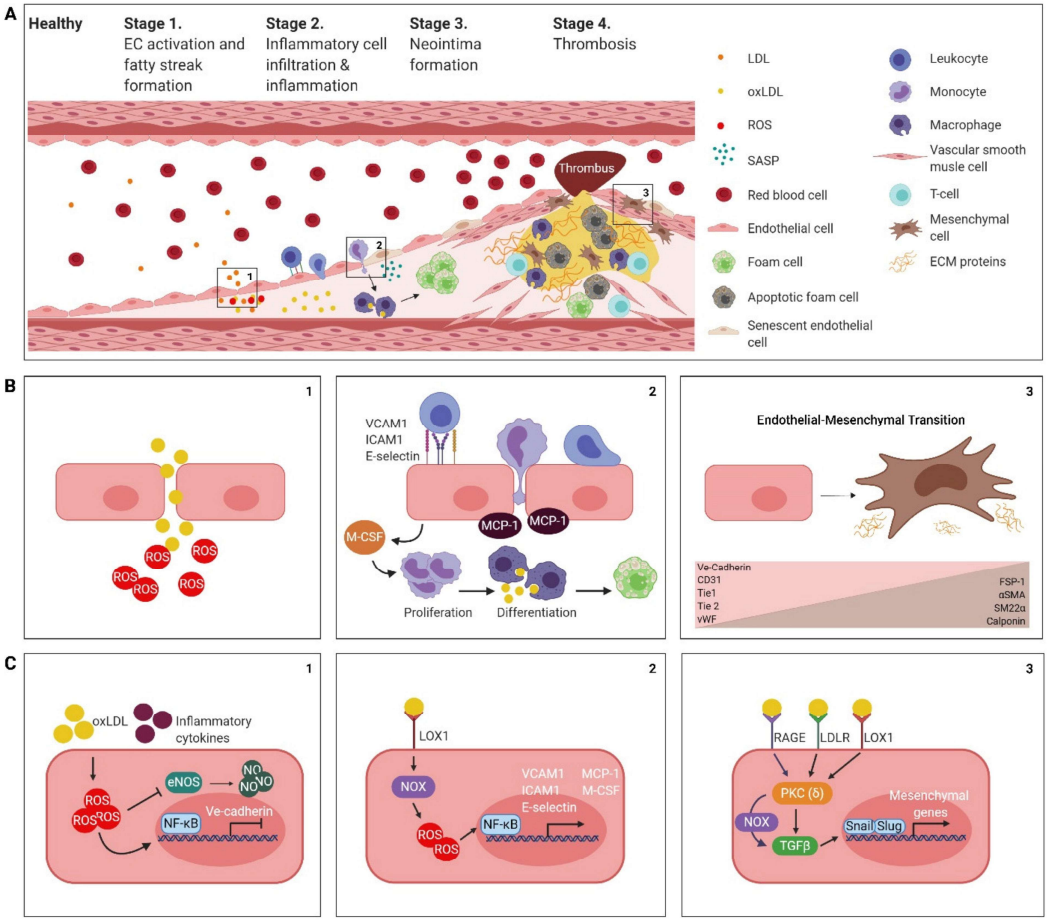
**Atherogenic phenotype**

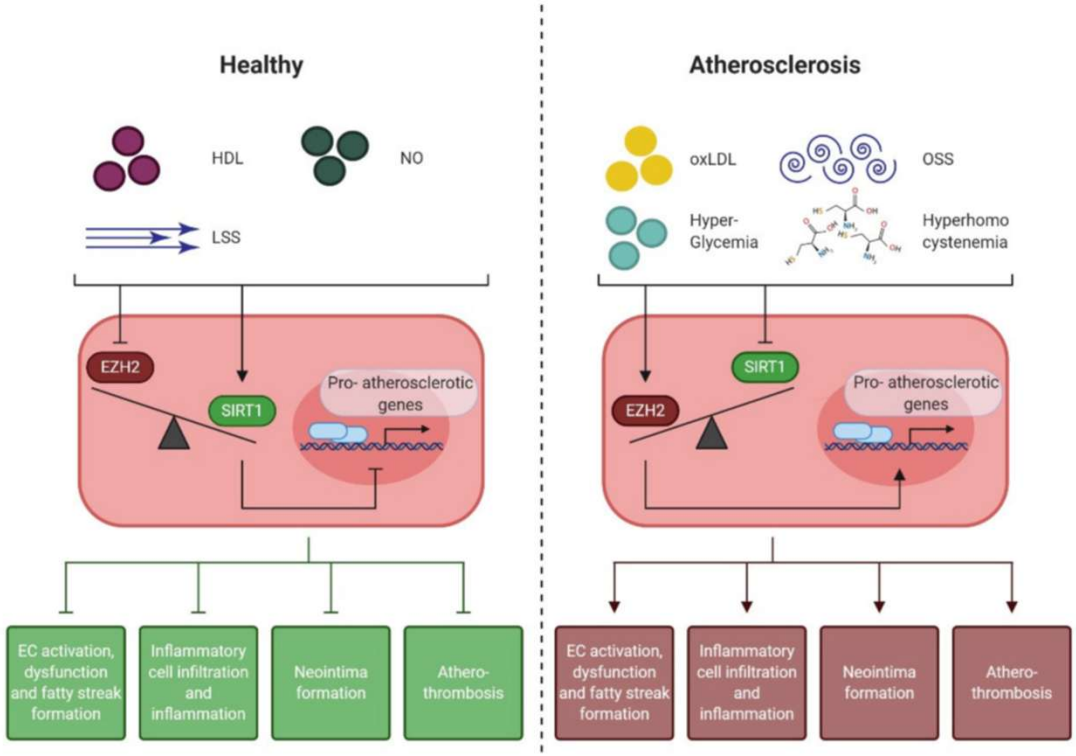
Increased lipid | Increased inflammation



Wight, Matrix Biol 2018

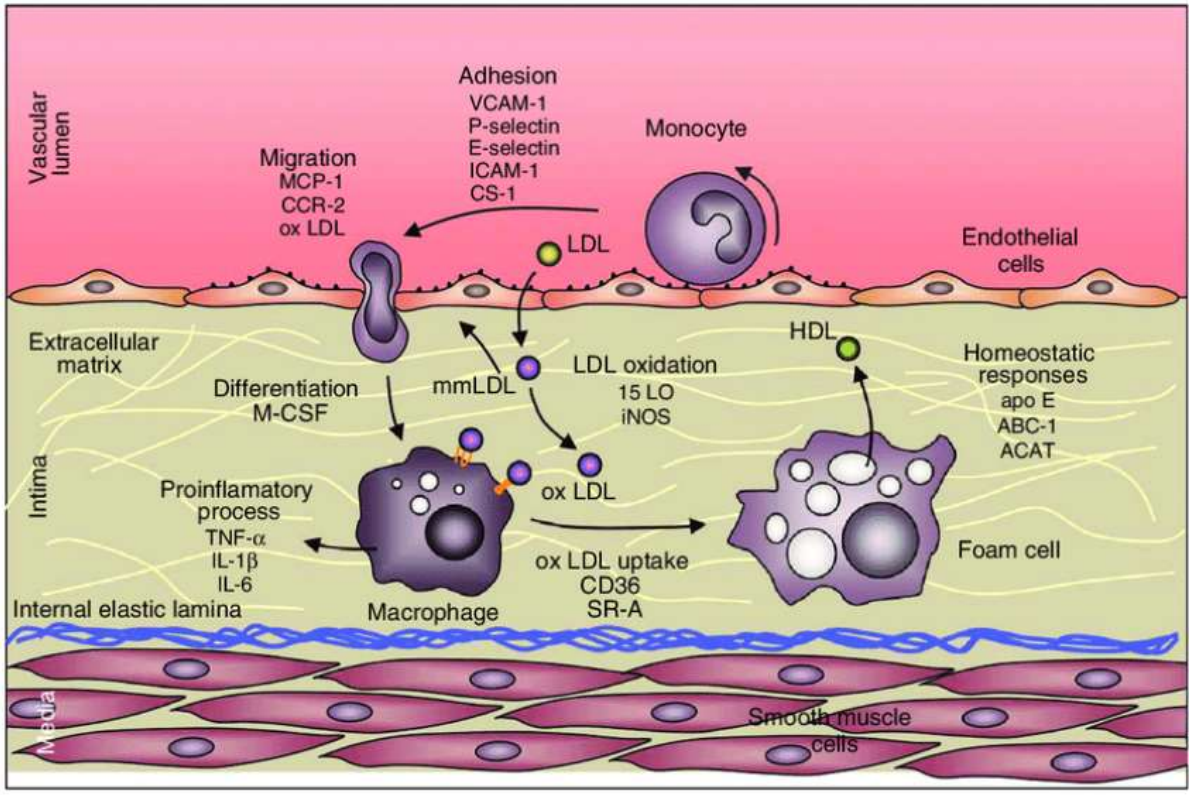
# Formação de placas de ateroma

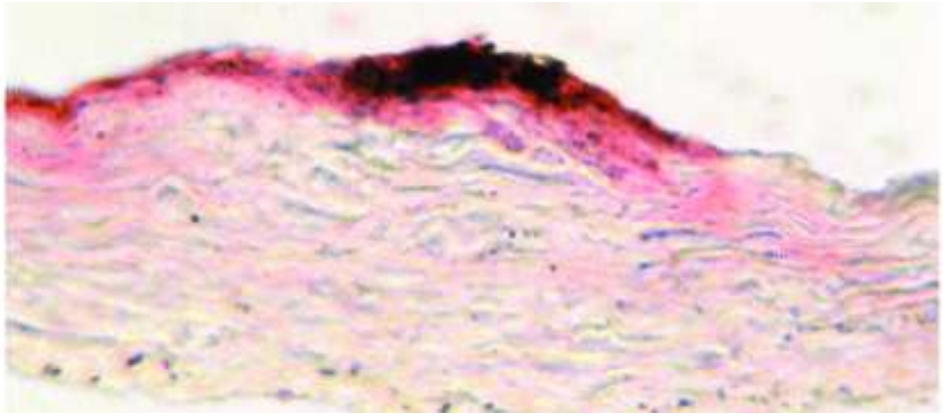



Fledderus et al, J Pers Med 2021

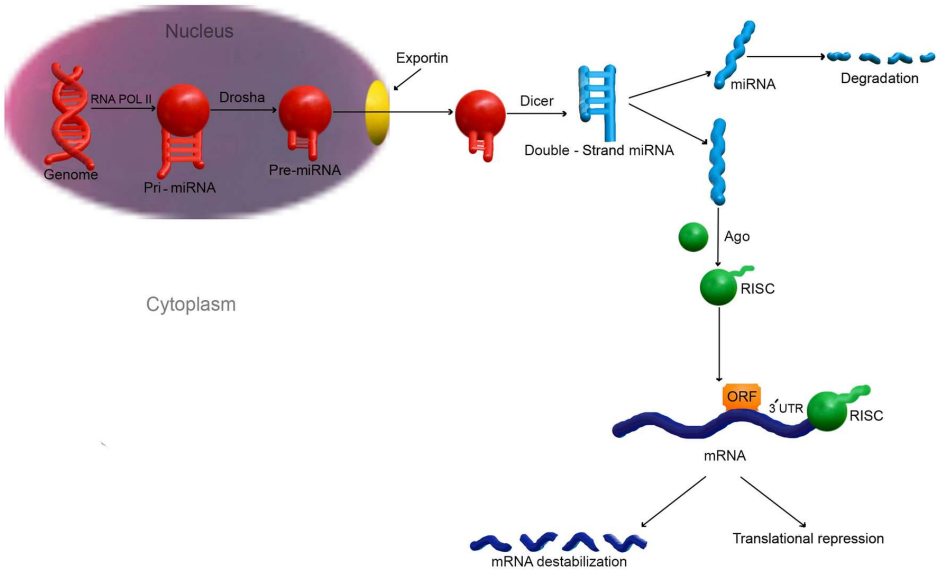
# Formação de placas de ateroma



Valledor et al, eLS 2015

# Formação de placas de ateroma




Yang et al, Cancer Cell Int 2023

**Table 2.** Role of microRNAs in atherosclerosis initiation and progression.

| Cell Line | Athero-Protective | Pro-Atherogenic |
|---|---|---|
| Endothelial cells | miR-155 [270]<br>miR-10a [271], miR-31 and miR-17-3p [272]<br>miR-146a [275]<br>miR-181b [274]<br>miR-92a [278,279]<br>miR-let-7g [280] | miR-216a [281] |
| Macrophages | miR-146a [275]<br>miR-125a [276]<br>miR-223 [277] | miR-125b [282]<br>miR-342-p [283]<br>miR-33 [292] |
| VSMCs * | miR-21 [285]<br>miR-221 and miR-222 [286]<br>miR-26a [287]<br>miR-663 [290] | miR-143, miR-145 and miR-1 [288]<br>miR-29a and miR-24 [289]<br>miR-133a [288]<br>miR-15b and miR-16 [291] |

* Anti-atherogenic, considered as VSMC activation and phenotype switching.

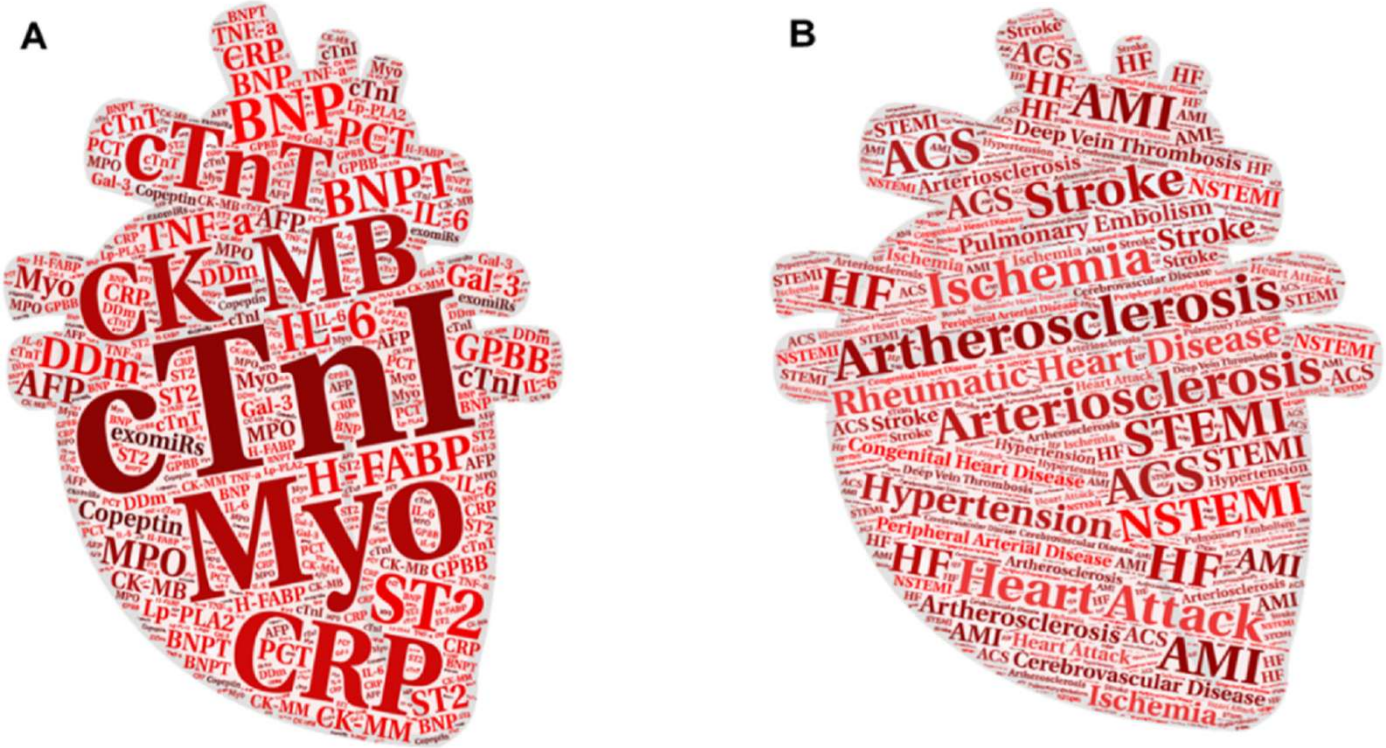
**Table 3.** Role of microRNA in plaque rupture.

| Anti-Atherogenic | Pro-Atherogenic |
|---|---|
| miR-24 [265] | miR-322 [295] |
| miR-133a [297] | miR-712 [296] |
| miR-29 [299,300] | miR-494 [298] |
| miR-21 [301] | miR-155 [303] |
| miR-223 [302] | miR-365 [304] |

Jebari-Benslaiman et al, Int J Mol Sci 2022

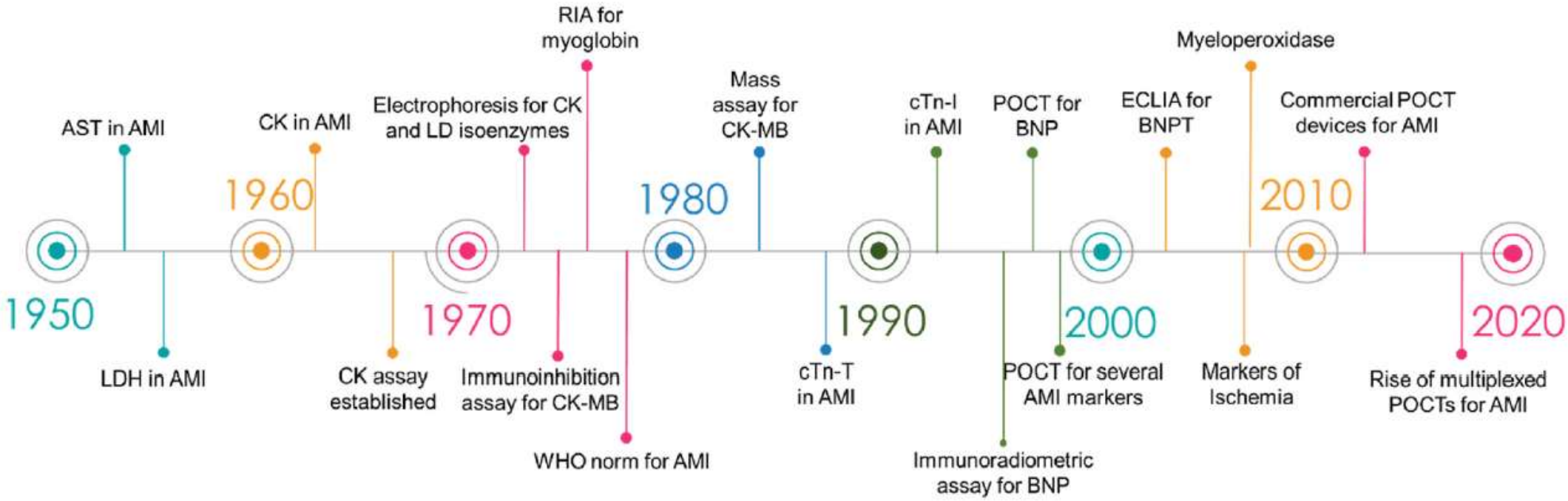
# Biomarcadores da doença cardiovascular






Mani et al, Biosens Bioelectron 2022

# Descoberta de biomarcadores da doença cardiovascular




AMI, acute myocardial infarction; AST, aspartate aminotransferase; LDH, lactate dehydrogenase; CK, creatine kinase; CK-MB, creatine phosphokinase MB; cTN-T, cardiac troponin T; cTN-I, cardiac troponin I; BNP, brain-type natriuretic peptide; POCT, point-of-care testing

Mani et al, Biosens Bioelectron 2022

# Principais biomarcadores da doença cardiovascular

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**Table 2.** Cardiac biomarkers and their primary roles and clinical applications in cardiovascular diagnosis/prognosis.

| Biomarker | Type | Primary Role/Function | Diagnostic/Prognostic Utility | Associated Conditions | References |
|---|---|---|---|---|---|
| Cardiac Troponins (cTnI, cTnT) | Protein | Detects myocardial injury, diagnosis of AMI, and monitoring of chronic heart disease | Gold standard for diagnosing MI; elevated levels indicate cardiac muscle damage | AMI, chronic heart conditions, and HF | [38–40] |
| CK-MB | Enzyme | Detection of reinfarction; differentiation of new vs. ongoing cardiac injury | Useful for detecting reinfarction due to rapid rise and fall; less specific than troponins due to elevation in skeletal muscle injury | AMI, skeletal muscle damage | [41–43] |
| B-Type Natriuretic Peptide (BNP)/NT-proBNP | Hormone | Differentiation of heart failure (HF) from other causes of dyspnea; monitoring HF severity and treatment | Elevated levels correlate with HF severity; used for diagnosis, prognosis, and monitoring response to therapy, cardiac stress, and ventricular dysfunction | HF, cardiac stress, and ventricular dysfunction | [44–50] |
| Mid-Regional Pro-Atrial Natriuretic Peptide (MR-proANP) | Protein fragment | Diagnosis and risk stratification of HF; assessment of cardiac wall stress and fluid overload | Useful in differentiating HF from other dyspnea causes elevated levels associated with higher risk of hospitalization and mortality | Heart failure | [51–53] |

Netala et al, Cells 2024

# Principais biomarcadores da doença cardiovascular

XXIV JORNADAS CIENTÍFICAS DE ANÁLISES CLÍNICAS E DE GENÉTICA HUMANA

Table 2. *Cont.*

| Biomarker | Type | Primary Role/Function | Diagnostic/Prognostic Utility | Associated Conditions | References |
|---|---|---|---|---|---|
| Mid-Regional Pro-Adrenomedullin (MR-proADM) | Protein fragment | Assessment of cardiovascular health, vascular dysfunction, and systemic inflammation | Elevated in response to cardiovascular stress and inflammation. Useful in critical care for early identification of complications, such as sepsis or acute HF | Heart failure, sepsis, systemic inflammation | [54–57] |
| C-Reactive Protein (CRP)/hs-CRP | Protein | General marker of inflammation; assessment of cardiovascular risk. | Useful in assessing the inflammatory component of atherosclerosis. High hs-CRP levels predict future cardiovascular events independent of cholesterol levels | Atherosclerosis, acute coronary syndrome (ACS), HF | [58–60] |
| Heart-Type Fatty Acid-Binding Protein (H-FABP) | Protein | Reflects myocardial injury and oxidative stress | Early marker for myocardial infarction; assessment of myocardial injury; useful in the early detection of acute coronary syndromes | AMI, ACS | [61–63] |
| Myeloperoxidase (MPO) | Enzyme | Assessment of inflammation and oxidative stress in cardiovascular diseases, risk stratification in ACS | Elevated MPO levels are linked to plaque instability, endothelial dysfunction, and increased risk of cardiovascular events | ACS, atherosclerosis | [64–67] |
| Myoglobin | Protein | Early diagnosis of MI | Early release into the bloodstream aids in prompt MI diagnosis, monitoring muscle injury | MI, skeletal muscle injury | [68–70] |
| Ischemia-Modified Albumin (IMA) | Protein | Signals myocardial ischemia | Indicates early ischemic changes before myocardial necrosis; useful for early detection of ACS | ACS, myocardial ischemia | [71–73] |
| Galectin-3 | Glycoprotein | Involved in inflammation and fibrosis | High levels indicate worse outcomes in HF; aids in assessing disease severity, prognosis, and monitoring response to therapy | Heart failure (HF), cardiac remodeling | [74–77] |
| Copeptin | Peptide | Reflects neurohormonal activation | Provides early diagnostic and prognostic information in ACS and HF; rises rapidly following myocardial injury; useful for early MI detection | Acute myocardial infarction (AMI), heart failure (HF) | [78–80] |
| Fibroblast Growth Factor 23 (FGF-23) | Hormone | Regulates mineral metabolism and is linked to cardiovascular pathology | Elevated levels predict adverse cardiovascular outcomes, especially in CKD and HF; associated with LV hypertrophy and vascular calcification | Chronic kidney disease (CKD), heart failure (HF) | [81–83] |

Table 2. *Cont.*

| Biomarker | Type | Primary Role/Function | Diagnostic/Prognostic Utility | Associated Conditions | References |
|---|---|---|---|---|---|
| Growth Differentiation Factor-15 (GDF-15) | Cytokine | Reflects cellular aging and systemic inflammation | Elevated levels are linked to increased cardiovascular risk; provides prognostic information in HF, CAD, and other cardiovascular conditions | HF, CAD, atrial fibrillation | [84–86] |
| Soluble ST2 (sST2) | IL-1 receptor | Indicator of cardiac stress and remodeling | Elevated levels correlate with worse HF outcomes; valuable for risk stratification and monitoring treatment efficacy | HF, cardiac remodeling | [87,88] |
| Endothelin-1 (ET-1) | Peptide | Potent vasoconstrictor involved in regulating vascular tone and blood pressure | Elevated levels are associated with hypertension, HF, and atherosclerosis; contributes to endothelial dysfunction and vascular remodeling | Hypertension, HF, atherosclerosis | [89,90] |
| Cardiac Myosin-Binding Protein-C (cMyBP-C) | Protein | Involved in sarcomere function in cardiomyocytes | Emerging biomarker for early diagnosis of myocardial infarction; elevated levels correlate with cardiac injury | Acute myocardial infarction (AMI) | [91] |
| Trimethylamine-N-oxide (TMAO) | Amine oxide | Metabolite produced by gut microbiota from dietary choline and carnitine | High levels are associated with an increased risk of cardiovascular events, including atherosclerosis and heart failure | Atherosclerosis, HF | [92] |
| Adiponectin | Hormone | Anti-inflammatory adipokine; regulates glucose levels and fatty acid breakdown | Low levels are associated with obesity, insulin resistance, and increased cardiovascular risk; higher levels are cardioprotective | Metabolic syndrome, vascular health | [93,94] |
| Interleukin-6 | Cytokine | Pro-inflammatory cytokine | High levels are associated with increased cardiovascular risk and adverse outcomes in HF; marker of systemic inflammation | HF, atherosclerosis | [95,96] |
| TNF-α | Cytokine | Key cytokine in systemic inflammation | Elevated levels reflect inflammatory processes in HF and atherosclerosis; potential targets for anti-inflammatory therapies | HF, atherosclerosis | [97,98] |
| MicroRNAs (miRNAs) | Nucleotides | Involved in gene regulation during cardiovascular diseases | Specific miRNAs serve as novel biomarkers for the diagnosis and prognosis of AMI, arrhythmia, and HF; provide insights into molecular mechanisms | AMI, arrhythmia, and HF | [99–101] |

Netala et al, Cells 2024

# Características dos principais biomarcadores da doença cardiovascular

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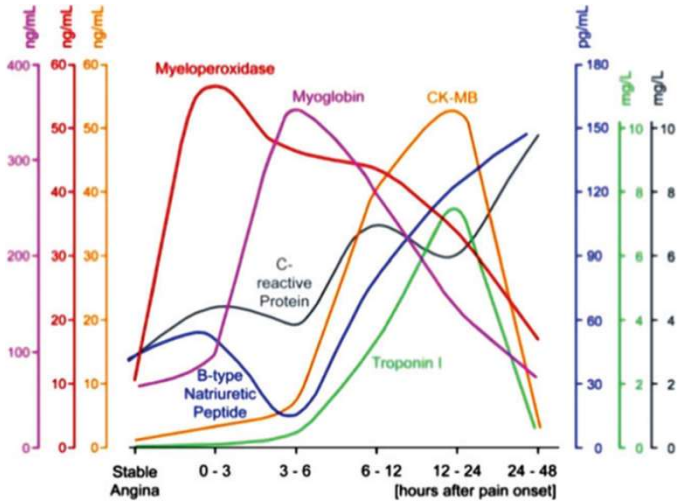
**Table 1**
Physiological characteristics of major CVD biomarkers.

| Cardiac marker | CVDs | Cut-off level (ng/mL) | Initial elevation (h) | Time to peak (h) | Returns to normal (days) | Specificity Level |
|---|---|---|---|---|---|---|
| cTnI | Detection of AMI | 0.03 | 2 | 4 | 6–10 | High |
| cTnT | Detection of AMI | 0.01 | 2 | 4 | 7–10 | High |
| BNP | Acute coronary syndromes, heart failure, ventricular overload | 0.1 | ND | ND | ND | High |
| BNPT | Acute coronary syndromes, heart failure, Ischemia, necrosis | 0.25–2.0 | ND | ND | ND | High |
| CK-MB | Early detection of AMI | 10 | 4 | 12 | 3–4 | Moderate |
| MPO | Inflammation of heart | 350 | ND | ND | ND | Moderate |
| CRP | Inflammation, cardiac risk factor, ischemia | <1000 (low-risk), <3000 (high risk) | 4–6 | 12–24 | 3–5 | Moderate |
| Myo | Early detection of AMI | 70–200 | 1 | 6 | 25–50 | Low |
| TNF-α | Inflammation, cardiac risk factor | 3600 | ND | ND | ND | Low |
| Lp-PLA2 | Inflammation risk predictor for stroke | 200 | ND | ND | ND | Low |
| IL-6, IL-1 | Myocardial infarction Inflammation, atherosclerotic plaque formation | 1000 | ND | ND | ND | Low |
| H-FABP | Myocardial necrosis | 6.0 | 2–3 h | 8–10 | 1–2 | Low |




AMI, acute myocardial infarction; cTNI, cardiac troponin I ; cTN-T, cardiac troponin T; BNP, brain-type natriuretic peptide, BNPT, N-terminal proBNP; CK-MB, creatine phosphokinase MB; MPO, myeloperoxidase; CRP, C-reactive protein; Myo, myoglobin; TNF-α, tumour necrosis factor α- ; LP-PLA2, lipoprotein-associated phospholipase A2; IL-6, interleukin-6; IL-1, interleukin-1; HFABP, heart fatty acid binding protein.

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# Análise multiplex dos principais biomarcadores da doença cardiovascular

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**Table 5**
Commercial sensor devices available for multiplexed analysis of CVD biomarkers.

| Commercial device | Company | Biomarkers | Method | Sample volume (μL) | Analysis time (min) | Measuring range (ng/mL) | Sample type |
|---|---|---|---|---|---|---|---|
| Fluoro-Check | Nano-Ditech | cTnI, CK-MB, Myo | Chromatographic coupled time-resolved fluorescence | 80 | ≈15 | cTnI: 0.03–30<br>CK-MB: 2.0–200<br>Myo: 10-500 | Whole blood, plasma, serum |
| CardioDetect | Renesa | cTnI, H-FABP | Chromatographic assay | 100–120 | ≈30 | – | Whole blood |
| Nano-Check | Nano-Ditech | cTnI, CK-MB, Myo | Chromatographic assay based on AuNPs | 200–250 | ≈15 | cTnI: 0.5, CK-MB: 5, Myo: 80 | Plasma, serum |
| Randox Biochip Cardiac Array | Randox | cTnI, CK-MB, Myo, H-FABP | Chemiluminescence | – | – | cTnI: 0.18–50<br>CK-MB: 0.4–100<br>Myo: 1.8–700<br>H-FABP: 0.15–100 | Serum |
| Triage Cardio3 Panel | Quidel | cTnI, BNP, CK-MB | Fluorescence microcapillaries | | ≈20 | cTnI: 0.01–10<br>BNP: 0.005–5<br>CK-MB: 1–80 | Whole blood, plasma |

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# Desenvolvimento de  novos métodos multiplex e de dispositivos de doseamento portáteis

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Table 2
Multiplexed colorimetry and fluorescence biosensors. The sequences of biomarkers given in the *'Biomarker panel'* column stands for the columns of linear range and LOD.

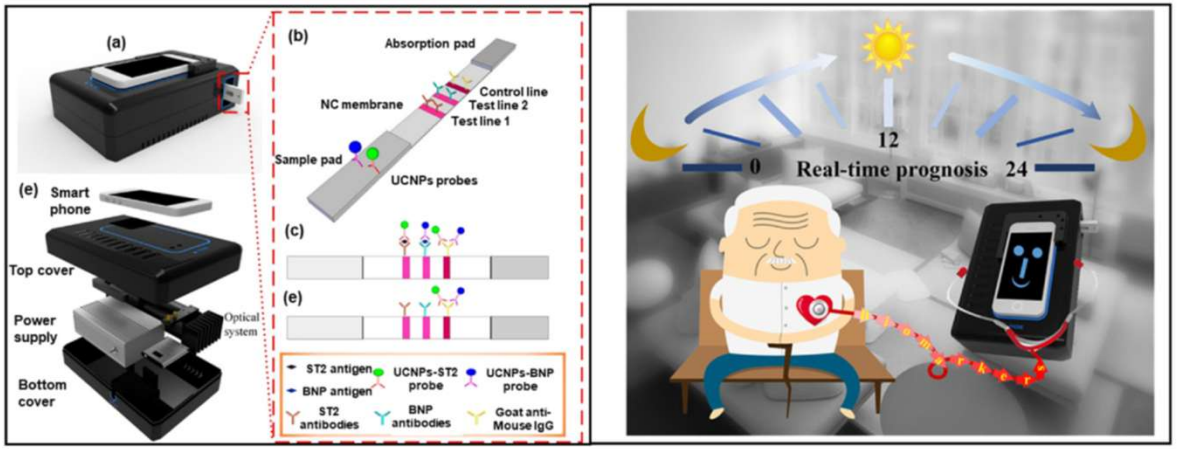
| Biomarkers | Materials | Method | Sample volume (μL) | Assay time (min) | Real sample | Linear Range | LOD | Advantages | Drawbacks |
|---|---|---|---|---|---|---|---|---|---|
| Colorimetry | | | | | | | | | |
| GPBB, CK-MB, cTnT (Lim et al. 2019) | CP: pPAD/$Ab_2$ DP: AuNPs/$Ab_2$ (cTnT), AgNPs/$Ab_2$ (GPBB), Au urchin/$Ab_2$ (CK-MB) | Sandwich Immunoassay | 10 | 10 | Human serum | 0-100, 0-100, 0-200 ng/mL | 0.5, 0.5, 0.05 ng/mL | Distinguish non-ST elevation MI and unstable angina. Use of phone camera, disposable | Limited dynamic range |
| cTnI, H-FABP, BNPT (Chen et al. 2020) | CP: PMMA-PET microfluidic chip/ magnetic beads/$Ab_1$ DP: biotinylated $Ab_2$-streptavidin-HRP | Sandwich Immunoassay | 4.0 | 20 | | | | | |
| BNPT, CK-MB, cTnT (Pei et al. 2019) | CP: plates/$Ab_1$, DP: $Ab_2$-alkachitic dyes-3D Au nanowickles | Immunoassay | 50 | 60 | | | | | |
| CRP, IL-6 (Dong et al. 2020) | CP: aldehyde chips/$Ab_1$, DP: $Ab_2$-AuNP-sDNA | Immunoassay | 15 | 40 | | | | | |
| cTnI, H-FABP, CRP (Ryzova et al. 2019) | CP: LFA strip/$Ab_1$, DP: biotinylated $Ab_2$-Au NPs/streptavidin-HRP | Immunoassay | 50 | 10 | | | | | |
| Myo, CRP, DDm (Ryzova et al. 2019) | CP: LFA strip/$Ab_1$, DP: $Ab_2$-Au NPs conjugate | Immunoassay | 60 | 1.5 | | | | | |
| Fluorescence | | | | | | | | | |
| BNP, ST2 (You et al. 2017) | CP: LFA strip/$Ab_1$ DP: $Ab_2$/Core-shell upconversion NPs | Sandwich Immunoassay | 10 | – | | | | | |
| Myo, cTnI, CK-MB (Huang et al. 2020) | CP: LFA strip/$Ab_1$ DP: $Ab_2$/fluorescent microspheres | Sandwich Immunoassay | 120 | 15 | | | | | |
| cTnT, H-FABP (Guo et al. 2021) | CP: LFA/$Ab_1$, DP: ZnMOF@CdTe NPs/$Ab_2$ | Sandwich Immunoassay | – | 8 | | | | | |
| CRP, cTnT (Liu et al. 2021) | CP: LFA/$Ab_1$ DP: Silica/$ZrO_2$@CdTe NPs-$Ab_2$ | Sandwich Immunoassay | 100 | 20 | | | | | |
| H-FABP, cTnI, Myo (Guo et al. 2019b) | CP: Paper/ZnO NWs/ $Ab_1$, DP: FITC fluorophore labeled $Ab_2$ | Sandwich Immunoassay | 15 | 5 | | | | | |
| cTnI, Myo, CK-MB ( | CP: $Ab_1$, DP: Boronic-acid functionalized g- | Immunoassay | 50 | 20 | Human blood | 0.01-5, 0.04-20, | 121, 515, 74 | Simple one-step assay, low cross- use | Complex material synthesis, narrow |

Table 3
Multiplexed electrochemical and photoelectrochemical biosensors.

| Biomarkers | Materials | Method | Sample volume (μL) | Incubation time (min) | Real sample | Linear Range | LOD | Advantages | Limitations |
|---|---|---|---|---|---|---|---|---|---|
| Electrochemical | | | | | | | | | |
| CRP, cTnI, PCT (Boonlaor et al. 2021) | PAD/inkcarbon-printed carbon electrode/GO/ Ab. Mediator: $[Fe(CN)_6]^{3-/4-}$ | Label-free immunoassay | 4.0 | 30 | Human serum | $1\text{-}10^3$, 0.001-250, 0.0005-250 ng/mL | 300, 0.16, 0.27 pg/mL | PoC detection, PAD device, label-free | 30 min incubation time required. |
| Myo, CRP, cTnI (Gupta et al. 2016) | Vertically aligned carbon nanofiber arrays/Ab; Mediator: $K_4[Fe(CN)_6]$ | Label-free immunoassay | 15-20 | 60 | Human serum | 50-5000, 50-5000, 20-2000 ng/ | 50, 50, 20 ng/ mL | Label-free, offers three parallel multiplexed tests | Long incubation time. Needs external reference |
| cTnI, cTnT, BNP (Shanmugam et al. 2018) | Au electrode/ZnO/Ab | Immunoassay | <50 | | | | | | |
| cTnI, cTnT (Radha Shanmugam et al., 2017) | Polyimide substrate/ Au nanostructure/ ZnO/Ab | Immunoassay | <50 | | | | | | |
| BNPT, CRP (de Ávila et al. 2014) | BNPT: SPCE/MB-COOH/$Ab_2$-HRP. CRP: SPCE/MB-COOH/$Ab_2$ (CP), Strep-HRP-$Ab_2$ (DP) | Competitive and Sandwich Immunoassay | 25 | | | | | | |
| CRP, cTnI (Li et al. 2017) | CP: GCE/PDANS/$Ab_1$ DP: $Ab_2$-PDANS@$Cu^{2+}$ (cTnI), $Ab_2$-PDANS@$Pb^{2+}$ (CRP) | Immunoassay | – | | | | | | |
| Photoelectrochemical | | | | | | | | | |
| cTnI, CRP (Zhang et al. 2016) | CP: $TiO_2$ $NT_s$/GiS (Qb-$Ab_1$, DP: $Ab_2$-ALP (cTnI) and $Ab_2$-AChE (CRP) | Sandwich immunoassay | 25 | | | | | | |
| Myo, cTnI (Cao et al. 2020) | ITO/AuNPs/GiS NWs or $SnNb_2O_6$ NS | Label-free Immunoassay | 20 | | | | | | |

Table 4
Multiplexed chemiluminescence, electrochemiluminescence, SERS, and miscellaneous biosensors.

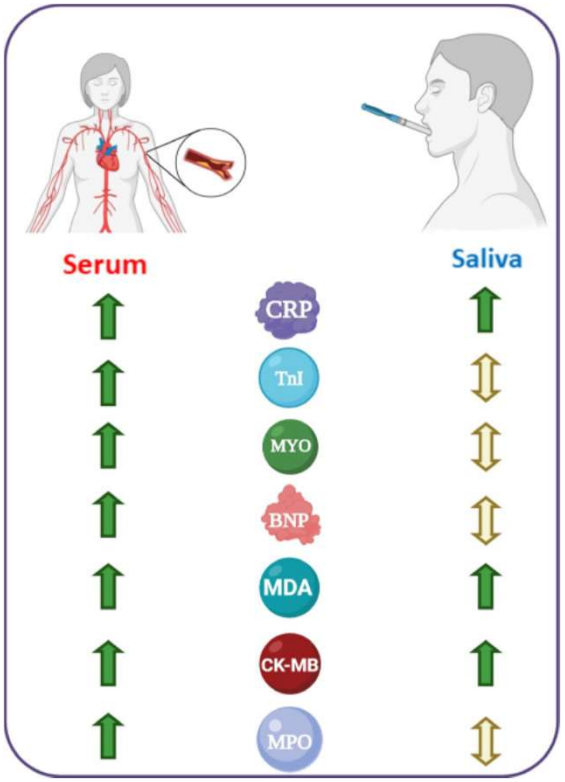
| Biomarkers | Materials | Method | Sample volume (μL) | Incubation time (min) | Real sample | Linear Range | LOD | Advantages | Limitations |
|---|---|---|---|---|---|---|---|---|---|
| Chemiluminescence | | | | | | | | | |
| cTnI, CK-MB, Myo (Zhao et al. 2019) | CP: NC membrane/$Ab_1$ DP: $Ab_2$-$SiO_2$-HRP | Sandwich Immunoassay | 90 | 60 | Human serum | 0.02-80, 0.2-120, 0.3-480 ng/ mL | 6, 67, 100 ng/ mL | High sensitivity, practicality, CL imaging | Long incubation time |
| Copeptin, H-FABP, cTnI (Yang et al. 2019) | CP: $Cr^{3+}$-ABEI-$Fe_3O_4$@void@C-CS/Au-$Ab_1$, DP: 3D μPAD | Label-free Immunoassay | 100 | 720 | Human serum | 1.0-1000 pg/ mL | 0.40, 0.32, 0.5 pg/mL | Sensitive, and low-cost paper device | Tedious steps expensive, long incubation time. |
| Electrochemiluminescence | | | | | | | | | |
| cTnI, BNP (Zhao et al. 2020) | CP: GCE/AuNPs/$Ab_1$ DP: $Ab_2$-AuNPs/ABEI (cTnI), $Ab_2$-AuNPs/p-$C_3N_4$ (BNP) | Sandwich Immunoassay | – | 240 | Human serum | 0.005-20 ng/ mL | 3.8, 3.2 pg/mL | Low LOD, less cross-reactivity, High specificity | Long incubation time |
| Myo, cTnI, cTnT (Yang et al. 2018) | CP: Au electrode/ aptamer DP: biotinylated Ab | Immunoassay coupled Aptasensor | 100 (PMT) | 180 | Human serum | 0.05-1.0, 0.001-0.01, 0.5-4.0 ng/ mL | 0.03, 0.0008, 0.3 ng/ mL | Small sample volume, one single probe sense three analytes | Long incubation time, high-end laboratory setup |
| | | | 2.5 (CCD) | 120 | Human serum | 0.5-10, 0.5-10, 5.0-100 ng/ mL | | | |
| BNP, cTnI (Liang et al. 2016) | CP: biotinylated $Ab_1$/ GCP: DP: $Ab_2$/NDI/RU (BNPT), $Ab_2$/NI2/LUM (cTnI) | Sandwich Immunoassay | – | 40 | Human serum | 0.1-8000, 0.2-1000 pg/ mL | – | 20-fold signal amplification, less cross-reactivity, imaging detection | Highly complex, need expert technician, |
| Surface-enhanced Raman spectroscopy | | | | | | | | | |
| Myo, cTnI, CK-MB (Zhang et al. 2018) | CP: LFA strip/$Ab_1$, DP: $Ab_2$/$Ag^{DTB}$@Au core-shell | Sandwich Immunoassay | 100 | 7 | Serum of AMI patients | 0.01-500, 0.01-50, 0.02-90 ng/ mL | 3.2, 0.44, 0.55 pg/ mL | AMI patients' serum samples tested, Raman mapping images | A complex synthesis of embedded core-shell structure |
| CK-MB, cTnI (Chen et al. 2014) | CP: $Ab_1$/magnetic beads DP: RhTC/$HGN_{CTAB}$ and MGITC/$HGN_{CTAB}$ | Competitive Immunoassay | 10 | 15 | Serum of patients | – | 42.5, 23.7 pg/ mL | Rapid, less sample volume, validated with commercial test kits | Requires antibodies labeling |




Mani et al, Biosens Bioelectron 2022

# Principais biomarcadores da doença cardiovascular na saliva

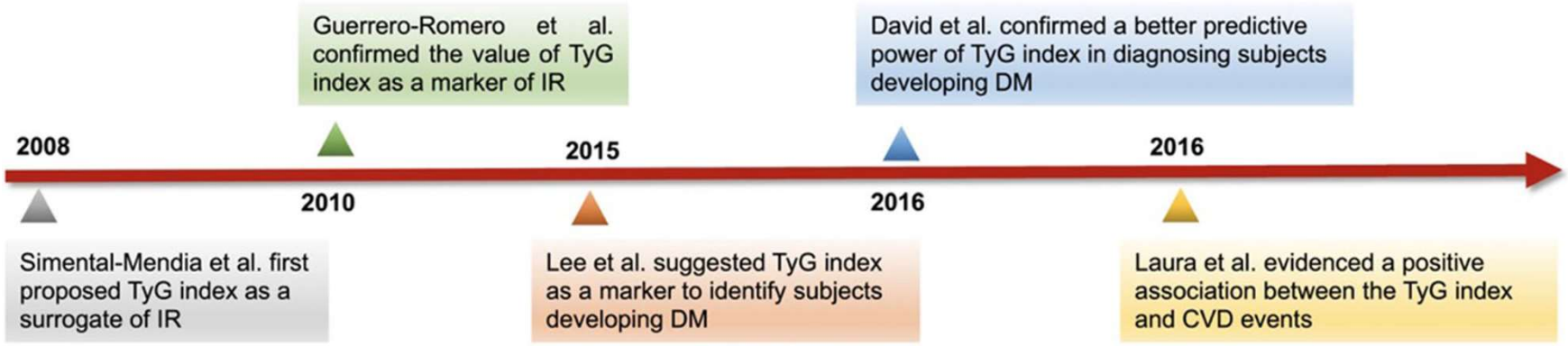


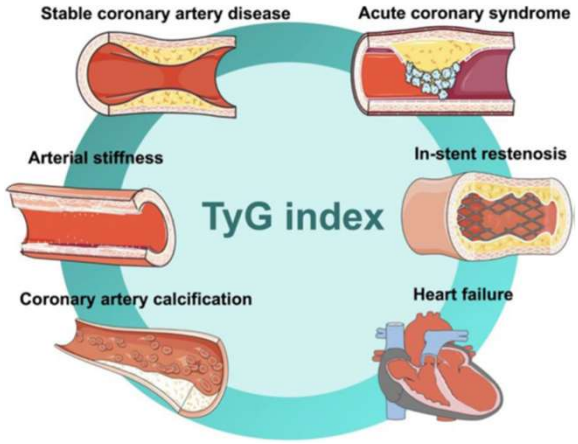


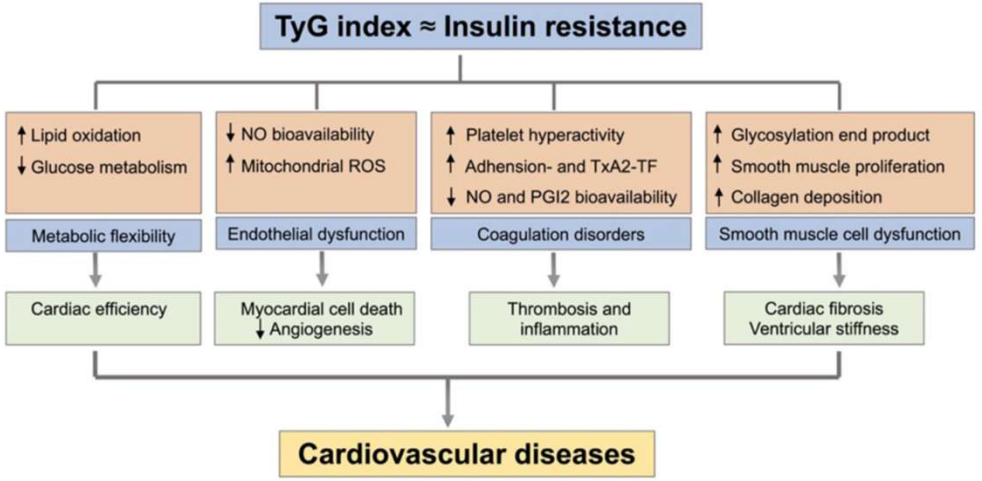

Bahbah et al. FEBS J 2021

CRP, C-reactive protein; TnI, troponin I; MYO, myoglobin; BNP, brain-type natriuretic peptide; MDA, malondialdehyde; CK-MB, creatine kinase myocardial band; MPO, myeloperoxidase.

# Outros biomarcadores de doença cardiovascular: índice triglicéridos-glucose



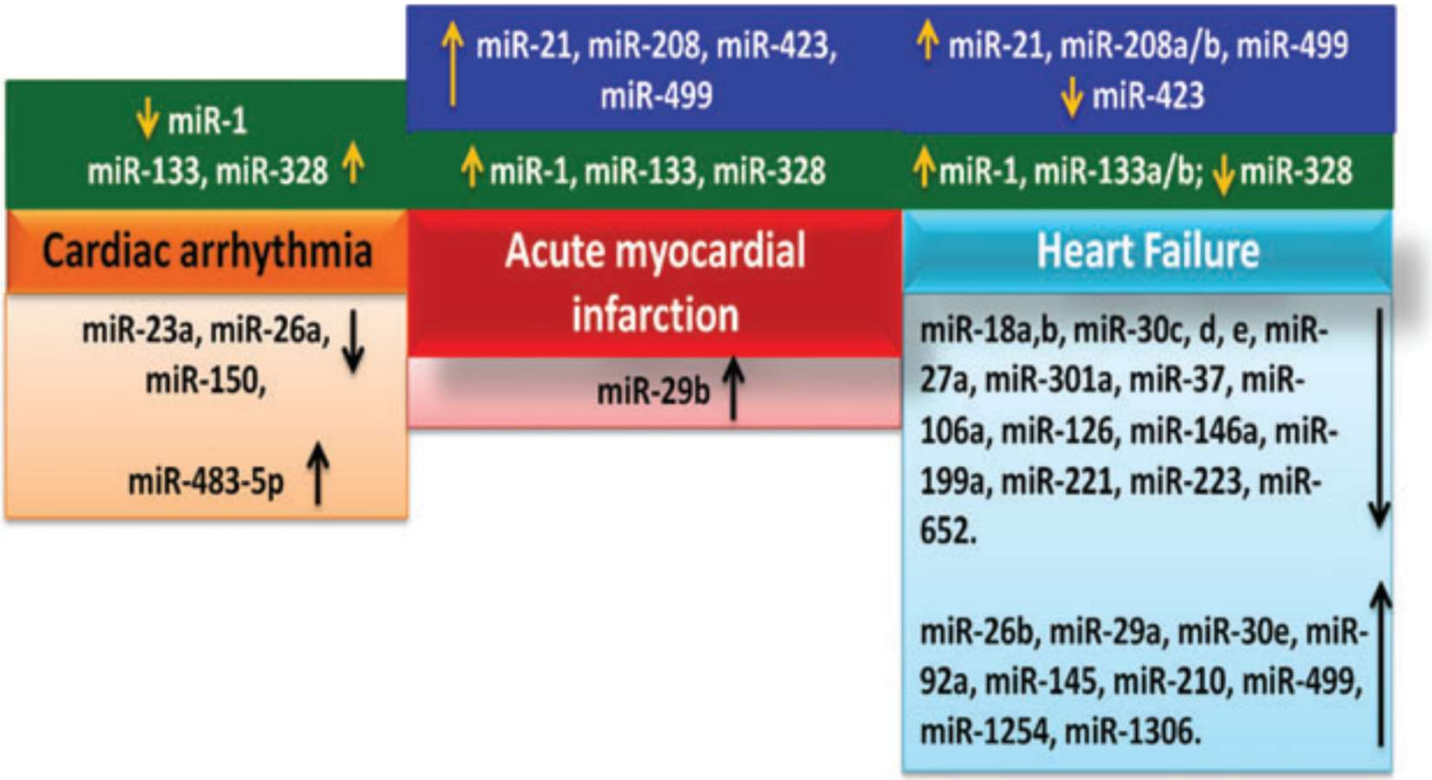




TyG, triglyceride-glucose index

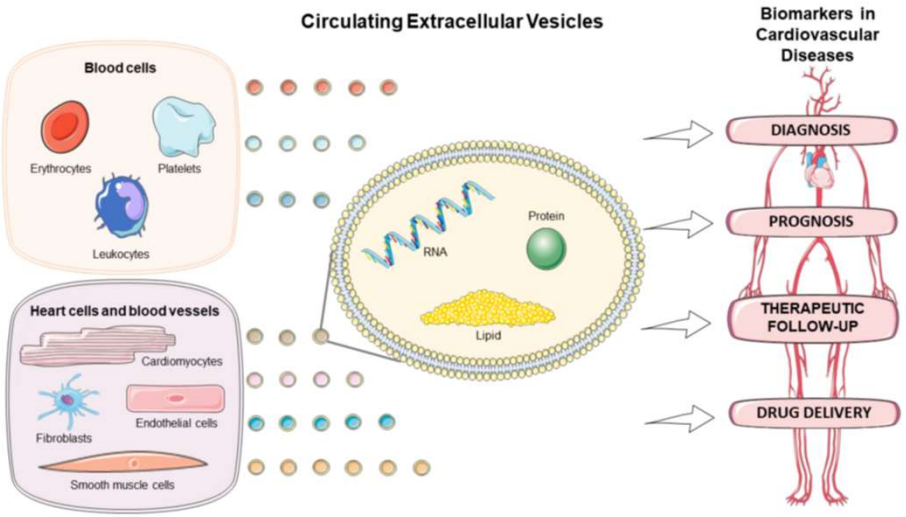
Tao et al, Cardiovasc Diabetol 2022

# Outros biomarcadores de doença cardiovascular: microRNAs

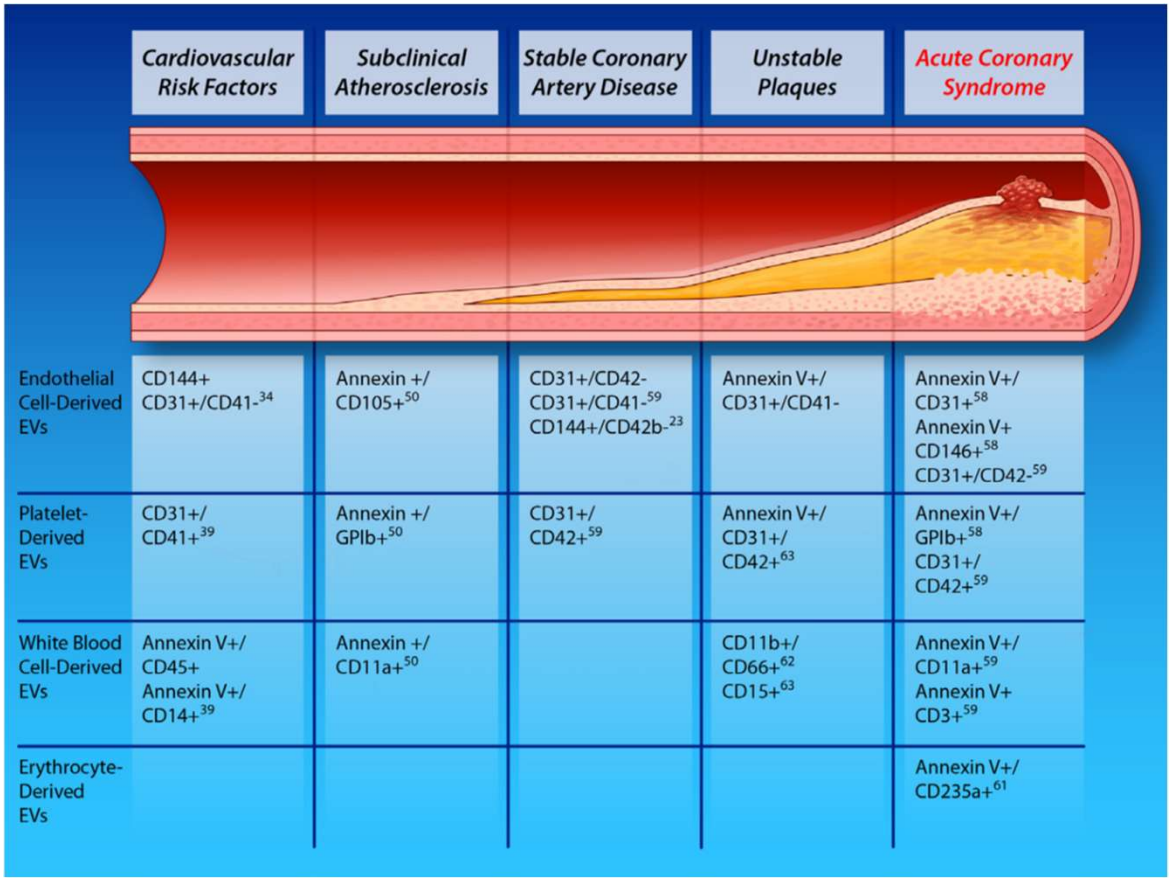



Parsanathan and Jain, Metab Synd Relat Disord 2020

# Outros biomarcadores de doença cardiovascular: vesículas extracelulares



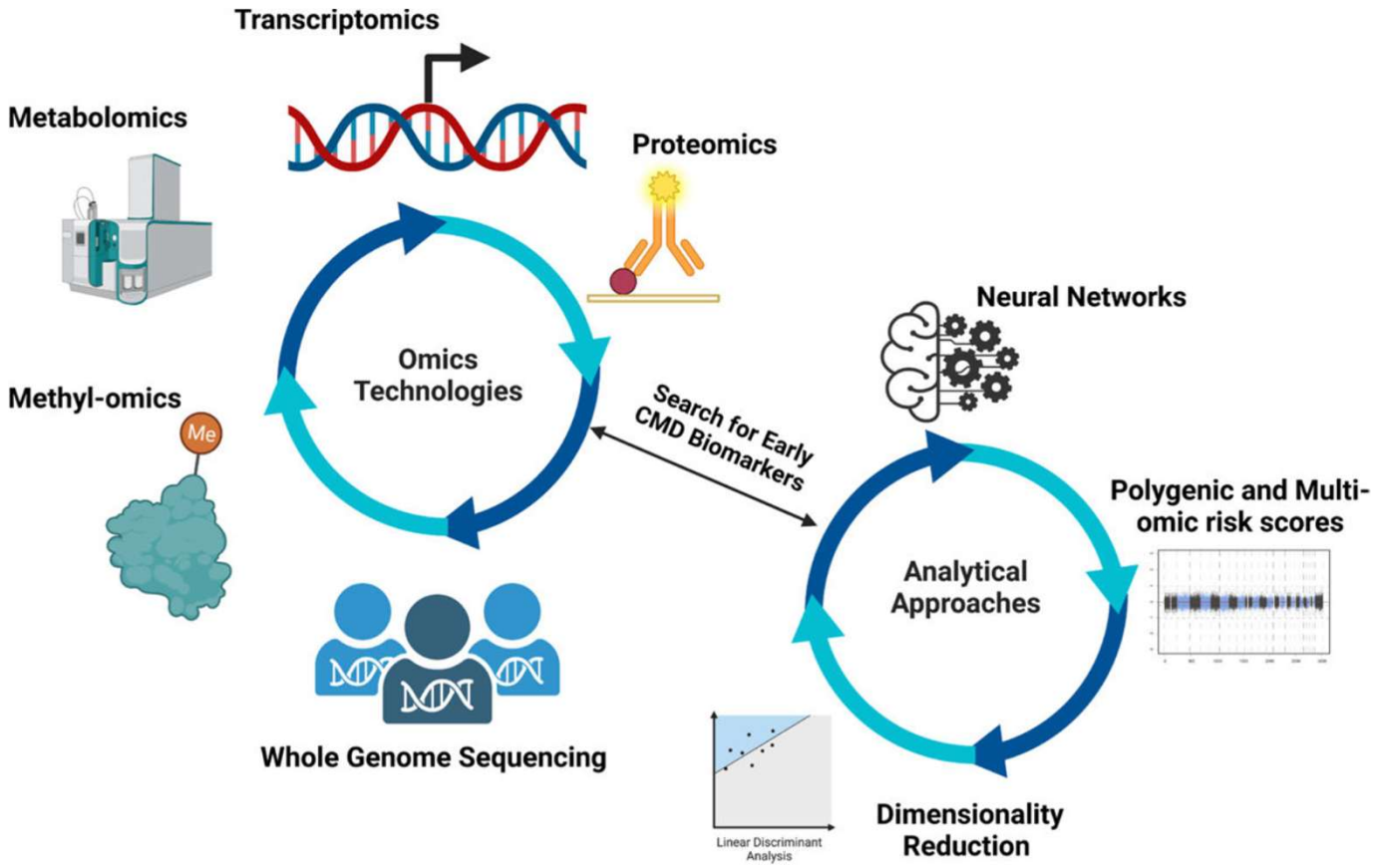

Costa de Freitas et al, Biomolecules 2021



| | Cardiovascular Risk Factors | Subclinical Atherosclerosis | Stable Coronary Artery Disease | Unstable Plaques | Acute Coronary Syndrome |
|---|---|---|---|---|---|
| Endothelial Cell-Derived EVs | CD144+ CD31+/CD41-[34] | Annexin +/ CD105+[50] | CD31+/CD42- CD31+/CD41-[59] CD144+/CD42b-[23] | Annexin V+/ CD31+/CD41- | Annexin V+/ CD31+[58] Annexin V+ CD146+[58] CD31+/CD42-[59] |
| Platelet-Derived EVs | CD31+/ CD41+[39] | Annexin +/ GPIb+[50] | CD31+/ CD42+[59] | Annexin V+/ CD31+/ CD42+[63] | Annexin V+/ GPIb+[58] CD31+/ CD42+[59] |
| White Blood Cell-Derived EVs | Annexin V+/ CD45+ Annexin V+/ CD14+[39] | Annexin +/ CD11a+[50] | | CD11b+/ CD66+[62] CD15+[63] | Annexin V+/ CD11a+[59] Annexin V+ CD3+[59] |
| Erythrocyte-Derived EVs | | | | | Annexin V+/ CD235a+[61] |

Jansen et al, Circ Res 2017

# Descoberta de novos biomarcadores de doença cardiovascular: direções futuras




Tahir and Gerszten, Circ Res 2023

# Conclusões

A doença cardiovascular requer uma pronta e adequada intervenção terapêutica a fim de assegurar a sobrevivência e qualidade de vida dos doentes. Para isso é necessário:

- Conhecer os diferentes tipos de biomarcadores e do seu perfil temporal
- Descobrir novos biomarcadores, de diferentes classes, com maior sensibilidade e especificidade
- Desenvolver metodologias para a sua análise, de forma integrada, e acessíveis em termos de custo e portabilidade

## Agradecimentos

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# Obrigada!