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Mechanism of Calcification / Mineralization in Cardiovascular Diseases

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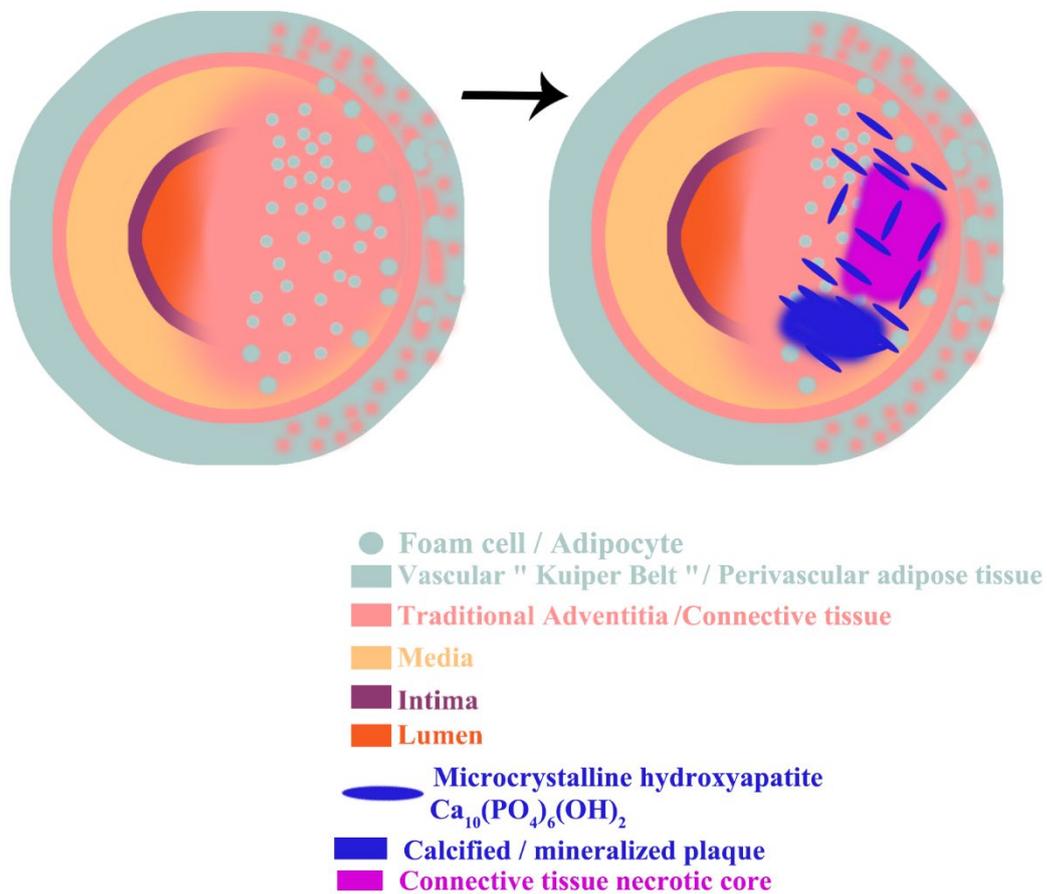


Figure 1. Taking the calcification / mineralization of atherosclerotic plaque as an example, it shows the fundamentals of calcification / mineralization of connective tissue in cardiovascular system. (The formation principle of atherosclerotic plaque is shown in the paper¹: Physical Principles of Vascular Developing and Remodeling. DOI: 10.13140/RG.2.2.20693.76003.)

Main text

Fibrosis can lead to atherosclerosis, myocardial fibrosis, myocardial hypertrophy, etc.¹⁻²⁰. Vascular calcification, valve calcification and myocardial calcification are common in cardiovascular diseases, such as atherosclerosis, stiffening, valvular diseases, etc. The mechanism of cardiovascular calcification is unclear before.

Recently, the mechanism of atherosclerosis, stiffening, aneurysm, myocardial hypertrophy, myocardial sclerosis, dilated cardiomyopathy (DCM) and ventricular aneurysm has become clear¹⁻²⁰. They are closely related to the loss / dysfunction of smooth muscle cells / cardiomyocytes¹⁴. Various risk factors could lead to the loss / dysfunction of smooth muscle cells / cardiomyocytes, and thus cause cardiovascular media dysfunction¹⁵. Vascular / cardiac endothelial cells, fibroblasts, etc. have to bear bigger force, resulting in the transformation of these cells into myofibroblasts²¹. Myofibroblasts could secrete a large amount of extracellular matrix (ECM) to form a large aggregation of collagen fibers in blood vessels / heart. Collagen fibers are rich in serine and glycine, which is conducive to the combination with phosphate. The distance between the gap area between collagen fibers is consistent with the distance between calcium ions in microcrystalline hydroxyapatite $[\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2]$, which is conducive to the deposition of calcium salt. Calcium and phosphorus are deposited in blood vessels and heart in the form of microcrystalline hydroxyapatite $[\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2]$ (Figure 1). In fact, bone is also a kind of vascular tissue²². Therefore, vascular calcification / mineralization is similar to bone mineralization $[\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2]$ ²² (Figure 1). Since the mineralized substances in cardiovascular system are not only the

deposition of calcium, but also the deposition of phosphate, etc., it is more appropriate to call it “mineralization”.

The accumulation of collagen fibers after injury / degeneration of blood vessels, valves or myocardium is the main inducing factor of vascular calcification, valve calcification or myocardial calcification. In addition, the changes of Ca / P, vitamin D, parathyroid hormone (PTH) or calcitonin (CT), etc. should also play an important role in the calcification / mineralization of cardiovascular diseases.

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