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ION Channels in Smooth Muscle Cells and Their Role in Physiological Functions

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Abstract: Modern biology, especially the sciences of physiology and biophysics, is characterized by the importance of studying the mechanisms of transport processes from cell membranes as well as the calcium homeostasis of cells. Because calcium ions play an important role in many cellular processes, including cell excitability, muscle contraction and relaxation, mediators and hormone secretion, and a number of other physiological processes. Therefore, as a result of disruption of calcium homeostasis in cells, the functional activity of cells is impaired. This can lead to certain pathological conditions in the body and the development of various diseases.

Key words: smooth muscle, ion channels, diseases, Ca2 + channels,

Introduction

Calcium ions also play an important role in maintaining the contractility of vascular smooth muscle cells and their functional activity. Changes in the concentration of calcium ions in the sarcoplasm of smooth muscle cells lead to disruption of Ca2 + -transport systems, resulting in changes in the electrical properties of their membranes. Excitability and contractile activity are impaired. These changes, in turn, can lead to serious pathological conditions in the body, including the regulation of vascular tone and disorders of the heart and blood vessels. For example, ischemic heart disease, myocardial infarction, hypertension, stroke and others.

Therefore, much attention is paid to the study of the mechanisms of modulation of calcium homeostasis in smooth muscle, as well as the mechanisms of pharmacological control of transport systems.

In smooth muscle cells, the transport of Ca2 + ions through plasma membranes and cell organelle membranes is carried out by transport systems located in their plasma membranes. The sarcoplasmic reticulum and mitochondria are directly involved in this process as organelles that store Ca2 +. Potassium-dependent Ca2 + channels in plasmolemmas play a key role in this process. They ensure the entry of Ca2 + into smooth muscle cells as well as muscle contraction. At the same time, the entry of Ca2 + from the intercellular fluid into the smooth muscle cell is carried out through reserve operiruyemiy and receptor-controlled Sa2 + channels. Changes in the concentration of Ca2 + ions in the smooth muscle cell are provided by special mechanisms through the sarcoplasmic reticulum. Restoration of the initial amount of Ca2 + ions in smooth muscle cells is ensured by the exchange of Ca2 + -ATF and Na + / Ca2 + - in their plasmolemmas.

Thus, the regulation of Sa2 + homeostasis in smooth muscle cells is ensured by cellular organelles and various Sa2 + transport systems in the plasmolemma. It goes without saying that other cellular systems also play a role in the normal functioning of the smooth muscle cell.

Mainly depends on the operating potential of the membrane. The activity of Ca2 + channels is activated by intracellular signaling systems as well as secondary messengers. Similar mechanisms of operation of other types of Ca2 + channels and Ca2 + transport systems have been identified. Ca2 + ions in smooth muscle cells, in turn, are modulators for various intracellular signals and processes.

Different types of ion channels play a key role in maintaining the functional activity of smooth muscle cells. To date, experimental results have shown that vascular smooth muscle cells contain 5 types of calcium channels, 4 types of potassium channels, and a maximum of 2 types of chlorine channels.

The Ca2 + channels of smooth muscle cells are differentiated into potential-dependent, receptor-controlled, and reserve-dependent channels according to their functional and regulatory mechanisms.

Potential-dependent Ca2 + -channels have been extensively studied in various smooth muscle cells. They are closed during the resting potential, the potential changes as a result of channel activation (opening) and are characterized by membrane depolarization. According to their biophysical and pharmacological properties, the potential-dependent Ca2 + -channels are of L, T, N, Q and P types.

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The L-type of Ca2 + -channels is the basis of calcium transport in all smooth muscle cells. The opening of L-type calcium channels occurs when the membrane potential is -50mV. At this point, their permeability is long. This is due to their long-lasting (Catterall, 2000).

Calcium ions passing through this channel not only provide the generation of action potentials, but also participate in the activation of the contractile apparatus of smooth muscle cells. In fact, blocking these channels by calcium ontogonists reduces the transfer of calcium ions to smooth muscle cells, reducing their contractile activity. The classic blockers of these channels are derivatives of 1,4-dihydropyridine (nifedipine and nitrendipine), derivatives of phenylalkylamine (verapamil and D-600) and derivatives of benzodiazepines (diltiazem). Ca2 + -channel blockers are widely used in medical practice as hypotensive drugs due to their ability to control the entry of calcium into smooth muscle cells.

T-type Ca2 + -channels (derived from the word transient, meaning short-lived) are found in some smooth muscle cells and often negatively alter membrane potential, i.e., they accelerates the transition to smooth muscle cells. These smooth muscle channels are thought to play a key role in maintaining vascular tone. This type of channels is not sensitive to dihydroperidine, and the classic blockers specific to these channels have not yet been identified. T-type Ca2 + -channels are common in heart cells and are important for maintaining their functional status.

Receptor-controlled Ca2 + -channels also play an important role in maintaining the functional status and contractile activity of smooth muscle cells. The functional state of these channels does not depend on the membrane potential, their activation is provided by special types of substances mediators and hormones. Unlike potential-dependent Ca2 + -channels, the receptor-controlled Ca2 + -channels of smooth muscle cells do not show high selectivity for calcium ions. Currently, receptor-controlled calcium channels are divided into 3 groups.

True receptor-controlled Ca2 + -channels act as receptors or channels in this group of channels or interact directly with the channel structure. Examples of such channels are nicotine cholinergic receptors. They carry calcium, but under physiological conditions it transports more sodium and potassium. True receptor-controlled channels also include channels activated by glutamic acid (glu-receptors) and adenine nucleotides (R2-purinoreceptors).

The mechanism of action of acetylcholine and glutamate receptors is common because they have a similar structure. Changes in the receptors of cation channels at the location of the receptors lead to the opening of these channels. Ca2 + -channels activated by adenine nucleotides were first detected in smooth muscle cells of the ear arteries. ATF / ADF-activated Ca2 + channels are common in animal cells. Channels associated with R2-purinoreceptors have been identified in macrophages, platelets, and the heart.

Ca2 + -channels activated by the secondary mediator The excitation of receptors in the Ca2 + -channels belonging to this group occurs as a result of the involvement of secondary mediators. The activators of these channels are inositol-1,4,5-triphosphate (IP3), inositol-1,3,4,5-tetrachophosphate, Ca2 + -ions and cyclic nucleotides (sGMF and sAMF). Of the Ca2 + channels activated by the secondary mediator, the channels affecting sGMF and sAMF have been studied the most.

Reserve-dependent Ca2 + -channels were identified in the late 1980s and also play an important role in the supply of smooth muscle cells. Activation of this type of Ca2 + -channels depends on the release of reserve Ca2 + ions in the sarcoplasmic reticulum. These channels have a very low selectivity for calcium, and when they open, the positive values of the membrane potential increase. However, it has been shown that some reserve-connected channels may be hypersensitive to calcium. It is assumed that the activation of these channels involves a mobile factor, such as G-proteins released from the sarcoplasmic reticulum, cyclic guanesine monophosphate (sGMF), various lipids and protein kinases.

Ca2 + -channels in the sarcoplasmic reticulum. The sarcoplasmic reticulum plays an important role in ensuring the functional activity of smooth muscle cells and is involved in the regulation of calcium homeostasis through their specialized Ca2 + -channels. These specialized Ca2 + -channels bind to rianodine and IP3-receptors.

Ryanodine receptor (RyR) has a complex system of activation, which includes specific electromechanical and Ca2 + -inductive calcium release mechanisms. Receptor activity depends on calcium-

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calmodulin, which may be enhanced by phosphorylation of protein kinase and dephosphorylation of calcium-calcineurin. The main modulator of the rianodine receptor is the plant alkaloid rianodine. Ryanodine receptor blockers are plastic anesthetic procaine and ruthenium red.

IP3 receptors are activated by phospholipase C using IP3, which is formed from phosphatidylinositol. Activation of IP3 receptors is influenced by Ca2 + ions and ATF. IP3 receptor activity depends on sAMR. Protein kinase, protein kinase C, and calcium-calmodulin-dependent protein kinases may be increased. Effective inhibitors of IP3-receptors are rianodine, ruthenium red, and local anesthetic procaines.

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