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Vlasenko K., Kostiuk Ye., Sukhonosov R., Halycha M.
MORPHOFUNCTIONAL SIGNIFICANCE OF THE CARDIAC PLEXUS……. 210

Кремінська І., Ковалевський В., Кропивницька А.
ПАТОФІЗІОЛОГІЧНІ ДЕТЕРМІНАНТИ ХРОНІЧНОГО СОМАТИЧНОГО СТРЕСУ ТА ЇХНІЙ ВПЛИВ НА ДИСРЕГУЛЯЦІЮ АВТОНОМНОЇ НЕРВОВОЇ СИСТЕМИ……... 214

Трач В.В., Суховєєва А.О., Власенко А.В.
СУЧАСНІ СТРАТЕГІЇ ДІАГНОСТИКИ ТА ЛІКУВАЛЬНОГО ВЕДЕННЯ АНОМАЛІЇ ЕБШТЕЙНА…… 219

Посохов М.Ф., Супрун Е.В., Кутовий І.О., Лемонджава З.М.
ДОСЛІДЖЕННЯ ВМІСТУ ПОКАЗНИКІВ ГУМОРАЛЬНОГО ІМУНІТЕТУ В ГОСТРОМУ ПЕРІОДІ БОЙОВОЇ ЧМТ…….. 224

Медведєв І.О., Орловська К.В.
АНАЛІЗ ВИПАДКІВ ЗАХВОРЮВАНОСТІ НА ТУЛЯРЕМІЮ У 2021-2023 рр. …… 230

Section: Occupational Health

Карпачов Д.В., Пожидаєв М.Ю.
СПЕЦІАЛЬНА ФІЗИЧНА ПІДГОТОВКА ЯК ЗАСІБ ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ ЗАТРИМАННЯ ПРАВОПОРУШНИКІВ……... 233

Карпачов Д.В., Анісімов Д.О.
ЗНАЧЕННЯ СПЕЦІАЛЬНОЇ ФІЗИЧНОЇ ПІДГОТОВКИ У ПРОФЕСІЙНІЙ ДІЯЛЬНОСТІ ПРАВООХОРОНЦІВ……. 236

Section: Oil and Gas Technologies, Engineering and Thermal Power Engineering

Чернова О., Мартинюк Р.
КРИТЕРІЇ КОРОЗІЙНОГО ЗНОСУ СТАЛЕВИХ РЕЗЕРВУАРІВ…….. 240

Section: Pedagogy, Philology and Linguistics

Кифенко А., Циганчук Ю., Клименко М.
ХОР ЯК ЗАСІБ ДУХОВНОГО, ЕСТЕТИЧНОГО ТА МУЗИЧНОГО РОЗВИТКУ ОСОБИСТОСТІ…….. 243

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MORPHOFUNCTIONAL SIGNIFICANCE OF THE CARDIAC PLEXUS

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Relevance of the Topic: Cardiovascular diseases occupy a leading place among the causes of mortality worldwide, which determines the need for an in-depth study of the mechanisms of autonomic regulation of cardiac activity. Particular attention is drawn to the cardiac plexus, the dysfunction or damage of which may lead to the development of various pathological conditions. The study of the morphofunctional features and clinical significance of the cardiac plexus is of practical importance for specialists in cardiology and cardiac surgery, as it contributes to the improvement of methods for diagnosing and treating cardiovascular diseases, and also helps prevent possible complications during surgical interventions.

Purpose of the Study: To determine the morphofunctional features of the cardiac plexus, its role in the regulation of cardiac activity, as well as its significance in the pathogenesis and symptomatology of cardiovascular diseases.

Research Methods: analysis and systematization of literary and informational scientific sources.

Main Body of the Study: The innervation of the heart is carried out by the parasympathetic and sympathetic nervous systems, which provide an accurate and continuous mechanism of its functioning. The totality of efferent (sympathetic, parasympathetic) and afferent (sensory) nerve fibers that conduct impulses to and from the cardiac muscle forms the cardiac plexus *(plexus cardiacus).* The conduction of nerve impulses between the central nervous system and the cardiac plexus is carried out by postganglionic fibers that originate from the cervical and upper thoracic ganglia of the sympathetic trunk *(truncus sympathicus),* as well as by preganglionic parasympathetic fibers of the vagus nerve *(n. vagus)* through cervical and thoracic cardiac branches. Additionally, the phrenic nerve *(n. phrenicus)* and *n. depressor* may also be involved, although their role in the innervation of the heart has not yet been fully studied and requires further research. [2, 3]

The cardiac plexus is divided into superficial, deep (extracardiac), and intracardiac (intramural) plexuses. Each of them has its own morphological features and performs important functions in the autonomic regulation of the heart. [1, 3]

The superficial cardiac plexus *(plexus cardiacus superficialis)* is located in the region of the concave part of the aortic arch, at the level of the bifurcation of the pulmonary trunk, predominantly on the left side relative to the midline. This plexus is involved in the initial regulation of heart rhythm and vascular tone, influencing the activity of the atria and the sinoatrial node. Due to the predominance of parasympathetic fibers, it is capable of reducing the heart rate and causing constriction of the coronary vessels. Therefore, it is important to consider that during surgical interventions, trauma or damage to this plexus may provoke bradycardia and even lead to cardiac arrest. Possible dysfunction of this plexus should also be considered in the analysis of the pathogenesis of arrhythmias and syncopal states. [1, 5]

The deep cardiac plexus *(plexus cardiacus profundus)* is located behind the aortic arch, in front of the bifurcation of the trachea, medial and deeper in relation to the superficial plexus. It has a predominantly symmetrical arrangement with a possible slight displacement to the right relative to the midline. It affects the cardiac conduction system, atria, and ventricles; regulates myocardial contractile activity, heart rhythm, and vascular tone. Due to the combination of sympathetic and parasympathetic fibers, it can both increase and decrease the heart rate and the strength of cardiac contractions, which may lead to arrhythmias in case of its dysfunction or surgical injury. Sympathetic fibers have a stimulating effect: they enhance myocardial contractility and dilate the coronary vessels, improving coronary blood supply. Due to the presence of sensory fibers, the deep plexus participates in the regulation of reflexes and perception of pain and discomfort in the heart region (for example, in ischemia, pericarditis, mediastinitis). [1, 5]

Small cardiac nerve ganglia *(ganglia cardiaca)* are located around the aortic arch, from which efferent autonomic fibers extend. These fibers then spread along the coronary arteries and penetrate the subepicardial zone, where they form the intracardiac plexus, whose intramural part belongs to the metasympathetic nervous system. It includes the subendocardial, intramuscular (intramural), and subepicardial plexuses, which are functionally interconnected. [1, 3]

The subendocardial plexus *(plexus cardiacus subendocardialis)* is located beneath the inner layer of the heart (endocardium), encompassing the atria (especially the right atrium in the region of the vena cava openings) and the ventricles. It interacts with the myocardium and the cardiac conduction system, participating in the regulation of the tone and excitability of cardiomyocytes, the frequency, strength, and rhythm of heart contractions, as well as neurohumoral adaptation of the heart to metabolic and hemodynamic changes. This plexus is clinically important because it may be damaged in myocardial infarction (especially subendocardial), taking part in the formation of pain syndrome due to tissue necrosis, and contributing to the development of ischemia, angina pectoris, and arrhythmias. [1, 4]

The intramuscular plexus *(plexus cardiacus intramuscularis)* is located directly in the thickness of the myocardium. It participates in the regulation of the conduction system activity, myocardial vascular tone, and cardiomyocyte contractility. It is involved in the implementation of cardiac reflexes (Bainbridge, Bezold–Jarisch), and in maintaining homeostasis of cardiac activity (especially under pathological cardiac conditions). In clinical practice, it is considered a target for neuromodulation in the treatment of arrhythmias and angina pectoris. [1, 4]

Particular significance in the study of cardiac innervation belongs to the contribution of Volodymyr Petrovych Vorobiov – a well-known Kharkiv anatomist and founder of the macro-microscopic method, through which he was one of the first to thoroughly study the distribution of cardiac nerve structures, including the subepicardial plexus *(plexus cardiacus subepicardialis).* In the course of his research, it was established that this plexus consists of 6 regional sub-plexuses, each of which is associated with a corresponding ganglionic field:

1 and 2. The right and left anterior sub-plexuses are located between the aorta and the pulmonary trunk, in the region of the coronary sulcus. Their fibers spread along the coronary arteries, providing innervation to the anterior parts of the ventricles, the interatrial septum, and adjacent areas of the myocardium and atria.

3. The right posterior sub-plexus begins in the area between the superior vena cava and the right pulmonary veins, spreading its branches to the posterior wall of the right atrium and ventricles, and also innervating the sinoatrial (Keith–Flack) node.

4. The left posterior sub-plexus is located in the posterolateral part of the coronary sulcus and in the projection of the oblique vein of Marshall on the posterior surface of the left atrium. Its fibers innervate the posterior parts of both ventricles and cardiac septa, as well as the endocardium and the conduction system in the region of the atrioventricular node and the His bundle originating from it.

5. The anterior atrial sub-plexus covers the anterior walls of the atria, directing its branches to the interatrial and interventricular septa. Its ganglionic field is located at the transition of the transverse sinus of the pericardium to the posterior surface of the left pulmonary artery.

6. The ganglionic plexus of Haller's sinus lies in the oblique sinus of the pericardium – in the upper posterior part of the left atrium between the openings of the right and left superior pulmonary veins, also innervating adjacent areas of the myocardium.

Considering the numerous morphofunctional features, dysfunction and damage to the components of the subepicardial plexus may contribute to rhythm and conduction disorders, the development of local arrhythmias (particularly atrial fibrillation), ischemia, and pain syndrome in angina pectoris. These aspects must be taken into account when performing cardiac neuromodulation and certain interventional procedures in areas topographically associated with ganglionic fields. [1, 4]

It should be noted that the structures of the cardiac plexus are subject to agerelated changes and degeneration; in particular, a decrease in the number of ganglia and

neurons may be observed, which may negatively affect the efficiency of autonomic regulation of cardiac activity, contributing to the development of various cardiovascular pathologies. [4, 5]

Conclusion: Cardiovascular diseases currently remain the leading cause of mortality in the world. This determines the need for a detailed study of the mechanisms of autonomic regulation of cardiac activity. The cardiac plexus plays a particularly important role in this system, providing coordination between the sympathetic and parasympathetic nervous systems, influencing the frequency and strength of heart contractions. Disturbance or damage to the cardiac plexus may cause serious pathological changes, including arrhythmias, circulatory disorders, and heart failure. Therefore, the study of the morphofunctional features and clinical significance of the cardiac plexus is important for cardiology and cardiac surgery. Deep knowledge of the structure and functions of the cardiac plexus contributes to improving the methods of diagnosis and treatment of cardiovascular diseases, and also makes it possible to take into account the risks of its damage during surgical interventions. This, in turn, increases the safety and effectiveness of surgical procedures, preventing the development of postoperative complications. Thus, the study of the cardiac plexus has not only theoretical but also practical significance, as it forms the basis for improving cardiac care and reducing mortality from cardiovascular diseases. Therefore, the cardiac plexus is a complex multicomponent neural structure of the heart that plays a key role in its innervation, providing autonomic regulation of cardiac activity. Its dysfunction may contribute to the development of arrhythmias, ischemia, and many other cardiovascular diseases. Due to its wide range of functional influence and clinical significance, the cardiac plexus may serve as an important object in the analysis of pathogenesis, symptomatology, as well as neuromodulatory and interventional methods of treatment of cardiac pathologies.

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