Features of anaesthetic echocardiomonitoring in dogs weighing up to 10 kg with heart disease

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Abstract. A traumatic factor affecting tissues causes a complex of morphological and functional disorders of structures. The body responds to this damage with a protective-adaptive reaction, which regulates the effect of the stimulus by the neurohumoral defense of the body. Decreased cell resistance and physiological functions result from disorders of the nervous and endocrine system. In terms of anesthetic complications and mortality related to anesthesiological practice, which are the cause of 25–50% of fatal outcomes after non-cardiological operations. The aim of the work was a comparative assessment of echocardiographic parameters of systolic and diastolic heart function in dogs that were undergoing elective anesthesia. Ultrasonographic examination was performed initially before and after general anesthesia based on propofol, isoflurane and zoletil. In the long term, after 1 month and 1 year after anesthesia. The results of the study showed a decrease in the systolic and diastolic functions of the heart. The criterion for assessing systolic function is a decrease in the ejection fraction, an increase in end-systolic and end-diastolic size. The criterion for assessing diastolic function is a decrease in the maximum speed of the transmitral flow during early diastole and an increase in the maximum speed of the transmitral flow during the late diastole. A month after anesthesia, the progression of a decrease in myocardial contractility was revealed. Due to an increase in the end-diastolic volume in a month and a year after anesthesia, the overloaded left ventricle maintained a normal cardiac output even with a decrease in the fraction of the emission.

1. Introduction
The physiological state of cells and organs in the post-narcotic period depends on the functional state of the whole organism, especially the state of the cardiovascular system, which plays an important role in its neurohumoral response. Compensatory and adaptive mechanisms in the post-narcotic period are insufficient, take on a pathological nature, which causes cardiovascular complications and are the cause of 25–50% of deaths after non-cardiac surgery in animals. [1,2,3,4] At present, with the development of veterinary surgery, complex surgical operations are carried out in pets. [5] For this reason, the study of post-anesthetic complications is one of the main problems of veterinary surgery. Regardless of the available research in this issue, the issues of clinical symptoms, quantitative assessment of systolic and diastolic heart function remain little studied. There are no objective echocardiographic criteria for the differential diagnosis of pathological conditions of the heart in the post-anesthetic period, including such indicators as the size of the thickness of the interventricular septum and the diastolic thickness of the posterior wall of the left ventricle, the ratio of the left atrium to the aorta, end-diastolic size and ejection fraction.
fraction of the left ventricle, etc. complications associated with impaired activity of the mechanisms of autoregulation of the heart, excessive or insufficient perfusion dictates the need for an in-depth study of the clinical picture, systolic and diastolic function of the heart in order to develop a comprehensive measure for the prevention of postoperative complications. Objective. On the basis of a scientifically grounded echocardiological approach, present the main criteria for assessing the systolic and diastolic heart function of dogs weighing more than 10 kg undergoing elective anesthesia.

The following tasks must be completed:

- To reveal morphofunctional changes in the parameters of systolic and diastolic functions of the heart in response to anesthesia based on propofol, isoflurane and zoletil by the method of ultrasonographic examination.
- To present the immediate and long-term results of the parameters of the systolic and diastolic functions of the heart in the post-anesthetic period.

2. Experimental section

The objects of the study were dogs (n = 41) with a 3 degree of operational and anesthetic risk at the age from 7 to 17 years: 22 healthy dogs (group A) and 19 dogs with concomitant cardiological diseases (group B). They entered the planned surgical treatment: removal of the breast tumor and surgical treatment of spinal cord compression. All patients admitted for surgical treatment underwent a clinical examination, anamnesis, taking HD and OCA blood, as well as additional methods of instrumental diagnostics: echocardiography, electrocardiography and X-ray examination. Premedication included the antibiotic cefotaxime at a dose of 50 mg / kg, a solution of diphenhydramine 1% at a dose of 10 mg / kg, and tramadol 2 mg / kg. The induction was carried out by intravenous administration of "propofol" 4-6 mg / kg, intubated and intravenous administration of "Zoletil" (Tiletamin + zolazepam) 2 mg / kg. Anesthesia was maintained with 1.0% isoflurane on an anesthesia-respiratory apparatus and Zoletil IPS (Tiletamine + zolazepam) at a rate of 3-4 mg / kg / h. Vital signs of functions were monitored using a patient monitor and pulse oximeter [6], indicators of respiratory parameters and capnometry (figure 8).

During the operation, to support hemodynamics, infusion therapy was performed with Ringer's solution 5 ml / kg / hour. The operation was completed with hemostasis control, suturing in layers, and infusion and anti-shock therapy [6]. After the completion of the operation, intensive care was carried out, the respiratory and cardiovascular systems were monitored, drip therapy, antibiotic therapy and postoperative analgesia were performed. All dogs underwent complex echocardiography on a Siui Apogee 5300 ultrasound system after anesthesia, after one month and one year (table 1, 2).

3. Results and discussion

Echocardiography quantified and measured end-diastolic and end-systolic volumes, systolic and diastolic left ventricular posterior wall thickness, left atrial to aortic ratio, pulmonary artery, mitral valve size and regurgitation, peak E, peak A, aortic valve size and regurgitation, pulmonary artery size, and regurgitation (figure 1-6) (table 1). [7,8] The condition of large vessels, valves, pleural and pericardial cavities was also assessed. Measurements of such important parameters as the diameter of the aorta and the left atrium were carried out, the shortening fraction and ejection fraction were assessed, and blood flows in the heart and vessels were measured. [9,10] The absence of neoplasms, thrombi and birth defects in 100% of dogs in both groups.

To assess systolic function and the effect on it of anesthesia based on propofol, isoflurane, and zoletil, the changes in the parameters of end-systolic and end-diastolic volume and left ventricular ejection fraction after anesthesia were assessed. In experimental group B, after anesthesia, the ejection fraction decreases from 66.5 ± 2.66 to 65.8 ± 2.57, and the end-systolic size increases from 18.8 ± 1.30 to 19.1 ± 1.57, of course - diastolic size increases from 29.7 ± 1.94 to 30.4 ± 2.21. In the control group A, the ejection fraction decreased from 64.8 ± 1.80 to 64.0 ± 2.13, and the end-systolic size decreased from 21.2 ± 1.36 to 20.4 ± 1.45, end-diastolic size decreases from 31.8 ± 1.60 to 30.4 ± 1.61.
To assess the diastolic function and the effect of anesthesia on it, changes in the parameters of the transmitral blood flow of the maximum velocity of the E wave and A wave (PeakE: Vmax and PeakA: Vmax) were assessed. In experimental group B after anesthesia Peak E: Vmax increases from 0.56 ± 0.05 to 0.63 ± 0.07, Peak A: V max increased from 0.50 ± 0.04 to 0.51 ± 0.04... In control group A, after anesthesia, Peak E: Vmax decreased from 0.58 ± 0.03 to 0.57 ± 0.03. Peak A: V max has not changed. All inhaled drugs inhibit myocardial function, but clinically, the depressive effect may increase and the effect on cardiac output may vary. The minute volume of blood flow during anesthesia is maintained by the sympathetic activity of tiletamine.

Both isoflurane and propofol cause vasodilation and decrease contractility, as they inhibit sympathetic activity. Isoflurane reduces the performance of the heart due to direct depression of myocardial contractility and a decrease in vascular tone. In geriatric patients, the gas anesthetic causes a greater decrease in blood pressure due to a concomitant drop in the minute volume of blood circulation and is a powerful vasodilator. The use of positive end-expiratory pressure when using isoflurane inhalation can reduce circulation due to suppression of the sympathoadrenal system and an increase in angiotensin 2. It reduces the slow incoming Ca2+ flow to a close. The depth of myocardial depression, correlating well with the concentration of free calcium in the sarcoplasm of the cardiomyocyte. The presence of a mechanism for impairing the accumulation of Ca2+ by the sarcoplasmic reticulum, and associated with the suppression of ATPase activity. Facilitating the release of calcium and inhibition of its reuptake, leading to its deficiency for triggering the subsequent muscle contraction, underlies the rapidly transient increase in contractility. Isoflurane, affecting the myocardium, inhibits the activity of contractile proteins, calcium-mediated formation of the actinomyocytic complex and a drop in the [Ca2+]/tension ratio in myofibrils, a decrease in the dynamic stiffness of myofibrils and inhibition of myosin ATPase activity. A decrease in the minute volume of the heart and the tone of the vascular system occurs due to circulatory depression of propofol. In patients with CHF, it reduces the pressure in the pulmonary artery. The stimulatory effect of tiletamine is of a central nature in the nuclei of the solitary pathway of the medulla oblongata and exceeds the negative inotropic effect on the myocardium with the release of adrenaline and norepinephrine of the sympathetic nervous system. An increase in end-diastolic size in group B after anesthesia indicates an overload in the left ventricle volume that was caused by muscle stiffness. That is a compensatory response and increases the filling of the ventricular chamber in the diastole phase. A decrease in the ejection fraction after anesthesia in group B, which occurs under the action of isoflurane, indicates a negative inotropic effect of the anesthetic, which inhibits sodium-calcium metabolism in myocytes, which leads to a decrease in the contractility of the heart. The established fact of functional disorders of systolic function is consistent with the data of the study [11], where changes in systolic and diastolic parameters in dogs were revealed and corresponded to the general impairment of left ventricular function during anesthesia [11]. When evaluating the parameters of systolic function: in experimental group B, the ejection fraction decreased from 65.8 ± 2.57 to 63.7 ± 2.36 one month after anesthesia, and after a year it increased to 64.1 ± 2.69. The end-systolic size after a month increased from 18.7 ± 1.57 to 19.3 ± 1.41, and after a year it decreased to 19.1 ± 1.44. The end-diastolic size after a month decreased from 30.4 ± 2.21 to 29.6 ± 1.87, and after a year it decreased to 29.4 ± 1.90. In the control group A, the ejection fraction a month after anesthesia decreased from 64.0 ± 2.13 to 62.4 ± 1.37, and after a year it did not increase. The end-systolic size after a month increased from 20.4 ± 1.45 to 21.5 ± 1.33, and after a year it decreased to 21.4 ± 1.31. The end-diastolic size in a month increased from 30.4 ± 1.61 to 32.2 ± 1.54 and did not change after a year.

When evaluating the parameters of diastolic function: in the experimental group B, the maximum transmitral flow rate during early diastole PeakE: Vmax one month after anesthesia increased from 0.63 ± 0.07 to 0.57 ± 0.05 and to 0.63 ± 0.06 a year later. The maximum speed of the transmital flow during late diastole PeakA: Vmax after a month decreased from 0.51 ± 0.04 to 0.46 ± 0.03, and after a year it increased to 0.48 ± 0.04. In control group A, the maximum transmital flow rate during the early diastole period PeakE: Vmax one month after anesthesia increased from 0.57 ± 0.03 to 0.58 ± 0.02 and to 0.61 ± 0.03 a year later. The maximum speed of the transmital flow during late diastole PeakA: Vmax in a
month increased from 0.43 ± 0.03 to 0.44 ± 0.03, and after a year it increased to 0.45 ± 0.02. When studying the change in parameters a month after anesthesia, a decrease in systolic function was revealed in both groups. A decrease in end-systolic size one year after anesthesia in experimental group B is a marker of an increase in myocardial contractility.

An increase in ventricular contractility could be associated with myocardial hypertrophy, which is compensation for pathology of the cardiovascular system, or the influence of the vagus nerve. The stiffness of the heart muscle is a compensatory response and increases the filling of the ventricle in the diastole phase, which is reflected by an increase in end-diastolic size in both groups one month after anesthesia. One year after anesthesia, both groups showed improvement in systolic function. In experimental group B, with a reduced ejection fraction, the heart can maintain normal ejection despite an overloaded left ventricle. One month and one year after anesthesia, a significant improvement in diastolic function was found in both groups.

**Table 1.** The mean value of echocardiographic parameters in groups of dogs from 10 kg (group A: n = 22, group B: n = 19, M ± m).

| Indicators | Before surgery | After surgery |
|------------|----------------|--------------|
|            | A              | B            | A             | B             |
| EDD        | 31.8±1.60      | 29.7±1.94    | 30.4±1.61     | 30.4±2.21     |
| ESD        | 21.2±1.36      | 18.8±1.30    | 20.4±1.45     | 19.1±1.57     |
| IVSd       | 8.0±0.52       | 7.7±0.37     | 8.1±0.55      | 7.5±0.46      |
| LVFWd      | 8.2±0.46       | 8.3±0.41     | 8.2±0.47      | 8.2±0.44      |
| LA         | 24.9±1.46      | 28.9±1.67    | 26.0±1.32     | 29.4±2.01     |
| AO         | 19.7±1.03      | 19.4±0.98    | 19.7±1.03     | 19.3±0.96     |
| LA/AO      | 0.3±0.04       | 0.3±0.03     | 0.3±0.04      | 0.3±0.10      |
| PA         | 19.2±1.09      | 19.0±0.89    | 19.0±1.11     | 19.3±1.08     |
| FS %       | 32.9±1.18      | 33.6±1.91    | 32.8±1.43     | 33.5±1.81     |
| EF %       | 64.8±1.80      | 66.5±2.66    | 64.0±2.13     | 65.8±2.57     |
| MV A       | 0.43±0.03      | 0.50±0.04    | 0.43±0.03     | 0.51±0.04     |
| regurgitation MK | -    | 1.1±0.26    | -             | 1.1±0.26      |
| AO         | 0.7±0.06       | 0.9±0.09     | 0.7±0.06      | 0.9±0.09      |
| regurgitation Ao | -    | 0.3±0.13    | -             | 0.3±0.13      |
| PA         | 0.8±0.06       | 0.9±0.05     | 0.8±0.05      | 0.9±0.06      |
| regurgitation PA | -    | 0.1±0.05    | -             | 0.05±0.06     |

**Table 2.** Average value of echocardiographic parameters of systolic and diastolic heart function in a group of dogs from 10 kg (group A: n = 22, group B: n = 19, M ± m).

| Indicators | Before surgery | After surgery | 1 month after surgery | 1 year after surgery |
|------------|----------------|--------------|-----------------------|---------------------|
|            | A              | B            | A         | B            | A                | B            |
| EDD        | 31.8±1.60      | 30.4±2.21    | 32.2±1.54 | 29.6±1.87    | 32.2±1.58       | 29.4±1.90    |
| ESD        | 21.2±1.36      | 18.7±1.57    | 21.5±1.33 | 19.3±1.41    | 21.4±1.31       | 19.1±1.44    |
| EF         | 64.8±1.80      | 65.8±2.57    | 62.4±1.37 | 63.7±2.36    | 62.4±1.49       | 64.1±2.49    |
| MV E       | 0.58±0.03      | 0.57±0.07    | 0.58±0.02 | 0.57±0.05    | 0.61±0.03       | 0.63±0.06    |
| MV A       | 0.43±0.03      | 0.50±0.04    | 0.43±0.03 | 0.44±0.03    | 0.46±0.03       | 0.45±0.02    |

**4. Conclusion**

The use of general anesthesia based on propofol, isoflurane and zoletil revealed a decrease in the systolic function of the heart. The criterion for assessing systolic function is a decrease in the ejection fraction.
of the heart, an increase in end-systolic and end-diastolic dimensions, which occurs under the action of isoflurane, which has the property of inhibiting sodium-calcium metabolism in myocytes, which leads to a decrease in the contractile ability of the heart. Propofol has a vagotropic effect and reduces the contractile ability of the myocardium. Zoletil, as a dissociative anesthetic, has a direct inhibitory effect on the myocardium (negative inotropic effect) and, when used in parallel with other anesthetics in animals with heart disease, it causes depression of the cardiovascular system.

A month after anesthesia based on propofol, isoflurane and zoletil, the progression of the decrease in myocardial contractility was revealed. The criterion for evaluating systolic function is a decrease in the ejection fraction of the heart, an increase in end-systolic and end-diastolic size. Due to the increase in end-diastolic volume one month and one year after anesthesia, with a decrease in ejection fraction, the overloaded left ventricle maintains normal cardiac output.

![Figure 1. Echocardiological examination. Dog 8 years old DCMP. CHF C2.](image1)

![Figure 2. Echo - cardiological examination. Dog 7 years old DCMP. CHF B2.](image2)

![Figure 3. Echo - cardiological examination. Dog 9 years old. Hypertrophy of the posterior wall of the left ventricle CHF B2.](image3)

![Figure 4. Echocardiological examination. Dog 11 years old. DCMP. Mitral endocardiosis. CHF B2.](image4)

![Figure 5. Echocardiological examination. Dog 8 years old. Mitral endocardiosis. Stagnation of the small circle of blood circulation. CHF C1.](image5)

![Figure 6. Echo – cardiac examination. Dog 7 years old. DCMP. CHS C3.](image6)

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