

Assessment of Parameters of Remodeling of the Right Heart Regions and the Level of Pulmonary Hypertension in Surgical Patients with Intra-Abdominal Pressure

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Abstract When a patient has a severe degree of intra-abdominal pressure, the signs of remodeling of the right and left ventricles with the signs of volumetric hypertrophy of the left ventricle (LV) will develop, the cavity of the right ventricle (RV) and the RV outflow tract expands, the thickness of the anterior wall of RV (AWRV) increases, the trunk of the left pulmonary artery (PA) expands, the systolic pressure in the PA (SDPA) increases, as well as type first diastolic dysfunction of the ventricles of the heart will occur.

Keywords Right ventricle, Remodeling, Surgical patients

1. Introduction

Acute diseases of the abdominal organs are often accompanied by the development of severe complications, including multiple organ failure, which are the main cause of death in 95-97% of cases [1-3].

One of the reasons for the development of multiple organ failure syndrome in this category of patients is intra-abdominal hypertension (IAH). Intra-abdominal hypertension syndrome (IAHS) is a complex of symptoms that develop as a result of increased pressure in the abdominal cavity and is characterized by the development of multiple organ failure [4,5].

2. Purpose of the Research

To study the parameters of remodeling of the right heart and the level of pulmonary hypertension in surgical patients with intra-abdominal pressure.

3. Material and Methods

The research was based on clinical and laboratory examination of 170 patients whose IAP has increased during and after surgery and 40 apparently healthy people of

comparable age for an adequate assessment of laboratory data.

The comparison group included 74 (43.5%) patients without increased IAP, who were treated in the intensive care unit, and the main group included 96 (56.5%) patients with increased IAP of varying degrees.

During the study of RV systolic function, the following parameters were studied: RV diameter in diastole (RVD), RV outflow tract (RVOT), RV anterior wall thickness in diastole, diameter of the pulmonary artery (PA) and its branches, systolic pressure in PA (SPPA). The systolic pressure in the pulmonary artery (PPP) was calculated as the sum of the systolic pressure gradient between the RV and the atrium and the pressure in the RV:

$$SDPA = Gd \text{ systolic TC} + \text{right atrial pressure.}$$

The systolic transtricuspid pressure gradient was calculated from the speed of the maximum tricuspid regurgitation stream, substituted into the simplified Bernoulli formula ($4V^2$). The flow of tricuspid regurgitation was assessed using continuous wave Doppler from the apical four-chamber position or, in poor visualization, from the subcostal position of the long axis of the heart.

4. Results

When comparing the parameters of the right ventricle in patients of subgroup 1 compared with subgroup 3, significant signs of hypertrophy were revealed (0.74 ± 0.11 and 0.49 ± 0.07 , $P < 0.001$) compared with subgroup 3 (0.66 ± 0.08 and 0.49 ± 0.07 , respectively, $P < 0.001$). When

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comparing the 1st and 2nd subgroups, a more pronounced thickening of the RV wall was found in the group of patients with a strangulated ventral hernia ($P < 0.01$).

Right heart function indicators are presented in Table 1.

Patients with AP, subgroup 2 compared with subgroup 1, RV diameter (2.55 ± 0.39 and 2.05 ± 0.23 , $P > 0.05$) and RVOT (2.63 ± 0.37 and 2.57 ± 0.28 , $P < 0.001$) statistically significantly expanded. The diameter of the RV and the RVOT in patients 1st group also exceeded these parameters than in patients of subgroup 3 and were 2.85 ± 0.53 and 2.05 ± 0.23 ($P > 0.05$) and 2.63 ± 0.36 and 2.57 ± 0.28 , respectively ($P > 0.05$).

Table 1. Indicators of remodeling of the right ventricle, pulmonary artery and pulmonary hypertension

Indicators	Comparison group (n = 74)	Main group (n = 96)		
		1 subgroup (n = 12)	2 subgroup (n = 50)	3 subgroup (n = 34)
RVD, cm	3.1 ± 0.29	2.85 ± 0.53	2.55 ± 0.39	2.05 ± 0.23
RVOT, cm	2.70 ± 0.12	2.63 ± 0.36	3.13 ± 0.37 ***	2.57 ± 0.28 ***
PA, cm	2.81 ± 0.22	2.74 ± 0.27	2.63 ± 0.20	2.62 ± 0.16
PA right branch	1.98 ± 0.18	1.93 ± 0.38	1.82 ± 0.12	1.51 ± 0.12
PA left branch	1.79 ± 0.11	1.72 ± 0.18	1.66 ± 0.13	1.58 ± 0.09
SPPA, mm Hg	29.2 ± 0.31	31.16 ± 1.61	35.04 ± 0.87	34.38 ± 0.80 *

Note: * - differences relative to the data of the comparison group are significant (* - $P < 0.05$, ** - $P < 0.01$, *** - $P < 0.001$)

The PA diameter was enlarged both among patients of subgroup 1 (2.74 ± 0.27 and 2.02 ± 0.16 , $P > 0.05$), and in the subgroup of patients with AP (2.63 ± 0.20 and 2.02 ± 0.16 , $P > 0.05$) compared with subgroup 3.

SPPA in the 1st and 2nd groups of patients (31.16 ± 1.61 and 35.04 ± 0.87 , respectively) statistically insignificantly exceeded this indicator in the 3rd subgroup (34.38 ± 0.80 , $P < 0.05$). The level of SDPA in patients of subgroup 1 was higher than in patients of subgroup 2 ($P > 0.05$).

PH, which was diagnosed in patients of subgroups 1 and 2 in most cases was in a moderate nature, which corresponds to the data of many authors. PH was detected in 85% of patients in subgroup 1, 83% of patients in subgroup 2 and in 27% of patients in subgroup 3. Significant PH (more 50 mm Hg) was determined only in 21.8% of patients in subgroup 1, in 5.8% of patients in group 2 and in none of patients in subgroup 1.

Thus, analyzing the parameters of the RV in patients of subgroups 1 and 2, it was revealed that they had significant structural changes in comparison with patients in the control group: RV dilatation, dilatation of the pulmonary artery and its branches, pulmonary hypertension.

Remodeling processes of the RV in patients of subgroup 1 and subgroup 2 occur already with a moderate increase in

SPPA. More significant and reliable signs of remodeling of the right heart were revealed in patients of subgroup 1.

In order to study the relationship between the severity of PH and the parameters of RV remodeling, a correlation analysis was carried out between SPPA and Anterior-posterior size of the right ventricle (APSRV) in patients of groups 1 and 2.

As a result of the performed correlation analysis using Spearman's correlation, it was revealed that a significant linear correlation was observed between the values of SPPA and APSRV in patients of subgroup 1 ($r = 0.65$, $P < 0.001$) and SDLA - $p > 0.5$, $p < 0.05$). In patients of group 2, this relationship was moderate (APSRV - $r = 0.33$, $P < 0.001$; AWRV - $r = 0.4$, $P < 0.001$).

5. Clinical Example

Patient H.R., 34 years old, No. IB, No. 1001. Was admitted to the Emergency Medical Center on 13.01. 2006.

Discharged on January 21, 2006.

Clinical diagnosis: Traumatic rupture of the extraperitoneal rectum. Ruptures of the parietal peritoneum of the recto-vesical part. Intra-abdominal bleeding. The laparotomy operation, sigmoidostomy, suturing of the rectal defect procedures are carried out. Cleansing and drainage of the abdominal cavity. The operation time was from 10.25 minutes to 15.50 minutes on January 13, 2006.

A preliminary premedication was carried out followed by induction with the connection of mechanical ventilation O2-3.0 l/min, DO -600 ml, MOD-9.2 l/min. SP O2-100%.

The blood loss was 2000 ml. Infusion -4200ml. Diuresis 1500 ml.

Initially, IAP 17.5 mm Hg, CVD-50, AD-110/70 mm Hg, HR-92 per minute.

Echocardiographic examination: Parasternal access, position of the long axis of the aorta: diameter of the aorta - 3.3 cm; left atrial diameter-3.8 cm; Apical approach, four-chambered section through the chambers of the heart: end-diastolic LV dimension -5.8 cm; L-left ventricle -7.2 cm, end-systolic LV size - 4.2 cm; thickness of IVS -1.1 cm; LV posterior wall -1.0 cm, LV ejection fraction by disc method (Simpson) - 47%, AS - 26%.

Anteroposterior dimension of the right ventricle - 3.3 cm, the outflow tract of the right ventricle - 3.2 cm, the thickness of the anterior wall of the right ventricle - 0.5 cm... The diameter of the pulmonary artery at the level of the cusps is 2.4 cm. Apical four-chamber position - the dimensions of the RA 3.5×4.7 cm. PG Tricuspid valve is 59 mm Hg. The systolic pressure in the PA is 49 mm Hg. A clinical diagnosis was established.

Doppler study of transmitral flow: E-0.48 m/s, flow A-0.54 m/s, E/A 0.88, Trans tricuspid flow (by pulse-wave Doppler method) peak E-0.34, peak A-0.4, the ratio of the peaks E/A 0.80. Study of the systolic flow on the RA, at the level of the valves: the speed was 0.40 m/s.

This clinical example demonstrates the presence in a

patient of severe IAH with the development of signs of remodeling of the right and left ventricles with signs of LV volumetric hypertrophy, expansion of the RV cavity, RV outflow tract, an increase in the thickness of the AWRV, expansion of the PA trunk, an increase in SPPA, and the occurrence of type first diastolic dysfunction of the ventricles of the heart.

In dynamics - with a decrease in intra-abdominal pressure with other postoperative changes, there is a significant regression of pathological changes in cardiac and central hemodynamics. Such as improving the ventricular ejection fraction and increasing the percentage of myocardial fiber shortening fraction, restoring the diastolic function of the ventricles of the heart, as well as a decrease in the pressure gradient on Tricuspidal valve and RA valve. That is the negative effect in the form of an increase in resistance in the small and large circle of blood circulation by an increase in IAP, with its decrease or stabilizing, contributes to the stabilization of cardiac hemodynamic parameters.

An echocardiogram has been provided on the third day after the operation, as well as in the background of constant drainage of the abdominal cavity, along with monitoring of hemostasis indicators, calculation of infused and excreted fluid, body temperature, blood pressure, heart rate. IAP during the study was 11 mm Hg. CVP -16 mm Hg, Blood pressure 115/70 mm Hg, heart rate - 84 per minute.

Echocardiography indicators: diameter Ao -3.3 cm, LA - 3.5 cm, LVID ED - 5.6 cm, L - 7.4 cm, LVID ES - 3.7 cm, IVS -1.1 cm, Posterior wall of LV - 1,0 cm. EF -52%, AS 29%.

The RV-anteroposterior dimension was -3.1 cm, the outflow tract of the RV-2.9 cm. RA -3.3 × 4.1 cm, PG TV 48 mm Hg. SDRA - 35 mm Hg. Doppler sonography of flows: on MV peak E 0.62, peak A-0.58, E / A mitral - 1.0 tricuspid

flows - peak E-0.40, peak A-0.38, E/A tricuspid. 1.0. Pressure gradient on TR ventricle amounted to 0.48 mm Hg. The systolic flow rate on the RA was 0.48 m/s.

6. Conclusions

The negative effect of IAP in the form of an increase in resistance in the small and large circulation due to an increase in IAP, with its decrease or stabilization contributes to the normalization of cardiac hemodynamic parameters.

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