EFFECT OF THORACOPLASTY ON CARDIORESPIRATORY AND IMMUNE SYSTEMS OF TUBERCULOSIS PATIENTS

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Study findings on the effect of thoracoplasty (one of the chief surgical treatments for pulmonary tuberculosis) on respiratory function, central hemodynamics, and immune status are presented. High compensatory capacities of the respiratory system and increased humoral immunity were detected, canceling the need for remedial therapy. Treatment with nitrates and ganglionic blockers was proposed for remedy of hemodynamic abnormalities.

Keywords: tuberculosis, thoracic surgery, thoracoplasty, cardiorespiratory system, immune system, remedial therapy

Background. Surgical treatment of consumption – pulmonary form of tuberculosis – was first attempted by Austrian surgeon Sauerbruch F. in 1888 [18], when he removed small rib portions close to the spine, at the diseased side. The effect of the surgery topped all expectations; the patient recovered. From that time on, thoracoplasty has become a chief method for surgical treatment of tuberculosis, being successfully used until now. Many variations of the original surgical procedures have evolved [5,10]. Fairly detailed descriptions have been made for post-resection conditions as a problem in surgically operated lung [1,2,6]. At the same time, thoracoplasty produces a certain biophysical effect of collapsed lung, unlike resection [9], and thus has various effects also on cardiorespiratory system and on indicators of systemic immunity. [11,12,16].

Material and methods

197 patients having pulmonary tuberculosis were the clinical material for the study; of them, 84 (42.6%) with fibrocavitary TB, 84 (42.6%) with cavitary TB, and 29 (14.8%) with disseminated TB. All patients underwent standard upper posterior thoracoplasty by Bogush L.K. [3].

Home-produced “Metatest-2-02” equipment was used to study respiratory function. We determined respiratory frequency (Rf), minute ventilation (MV), maximum voluntary ventilation (MVV), vital capacity (VC). Flow-volume loop rates, peak expiratory flow rate (PEFR), PEFR at 25%, 50% and 75% of VC, forced expiratory volume in 1 second (FEV1) were assessed using “Spirosift” equipment from Fukuda Denshi (Japan).

Forced expiration rates were compared to reference predicted normal values by Klement

R.F. [8], interpretation of the respiratory function test findings with determination of the type and severity of the impairment of pulmonary ventilatory capacity were done based on recommendations by Nefedov B.V. [15].

Central hemodynamic rates were assessed using MLC-1200 computer densitometer from "Nihon Kohden" (Japan). Additionally, M.I. Tishchenko's method of integral rheography [17] was employed for dynamic observation in follow-up period. Systolic pulmonary artery pressure (sPAP) was assessed using electrocardiography via V.P. Melnik's modification [13] of S.A. Dushanin's indirect method [7].

Cell-mediated and humoral immunity were assessed by standard methods [12].

All examinations were performed before the surgery and on days 9–12 and 30 postoperatively. Besides that, central hemodynamics was assessed either for 2–3 days, or hourly if medications were administered to correct central hemodynamic abnormalities.

Statistical data processing was done by Microsoft Excel tools for statistical analysis, employing standard methods for variable assessment. Assessment of statistically significant (reliable) differences in mean values between the study groups was done by Student's test and chi-square test for 95% (p=0.05) probability of unmistakable prediction, and based on the presence of correlations by linear correlation analysis (r).

Results. For dynamic assessment of the effect of thoracoplasty on the function of respiratory organs, tests were performed in 116 patients, who had the following forms of pulmonary tuberculosis: 83 (71.5%) with fibrocavitary TB, 4 (3.4%) with disseminated TB, 29 (25.1%) with cavitary TB. Decreased MVV (77.7±4.09%), along with the heightened MV (190.6%±10.6%) were the most noticeable baseline patient characteristics, which indicated the presence of 1-2 degrees of respiratory distress. Importantly, the increase in MV levels developed not only due to increased tidal volume (TV) (9±4.5%), but due to increase in frequency as well. After thoracoplasty, respiratory function indicators reduced abruptly, down to 40% of the baseline levels, due to the injury of the respiratory organs (intercostal muscles, deep and superficial thoracic muscles, rib removal). On the other hand, while MV increased by 8.6%, TV was decreasing to 7.1%, which was evidence that compensatory mechanisms are producing a smoothing effect on respiratory distress. Study of the expiratory fraction (PEFR at 75% of VC) in early postoperative period showed decrease to 17.6±6.09; this finding signalized about the obstructive component in larger bronchi. But nearer to the day 30, respiratory function indicators were observed to restore: VC restored by 9.7%, MVV restored by 35.4%, MV decreased by 40.1% together with the increase in TV to baseline indicators, patency of the large bronchi improved (PEFR at 75% of VC) to 26.6±5.6%.

To determine the effect of thoracoplasty on central hemodynamics, examinations at various stages of thoracoplasty were done in 82 patients, of them 55 with fibrocavitary (67.2%), 7 with disseminated (8.5%), and 20 with cavitary (24.3%) pulmonary tuberculosis.

By E.A. Vagner's classification [4], blood flow types at baseline were as follows: 58 (70.7%) patients had eukinetic circulation, 16 (19.5%) had hypokinetic circulation, 8 (9.7%) had hyperkinetic circulation. Pre-operatively, no meaningful differences were found in central hemodynamic indicators of patients with different clinical forms of tuberculosis, possibly because of similar extents of the specific tuberculosis process.

In early postoperative period, thoracoplasty caused sharp changes in hemodynamic indicators. Cardiac index (CI) heightened from 1.80±0.04 to 2.40±0.10 L/min/m^2 ($p<0.05$). Systolic pulmonary artery pressure increased from 42.01±1.22 to 44.53±3.24 mmHg ($p>0.05$). Left-side thoracoplasty was associated with more marked hemodynamic disorders, then right-side surgery. Pulse, stroke volume (SV), CI and sPAP ($P<0.05$) remained significantly high at all stages of treatment; this should be regarded as typical effect of thoracoplasty on cardiovascular system.

Analysis of postoperative hemodynamic indicators suggested unequal rearrangements in systemic and pulmonary circulation of the patients after thoracoplasty. We supplemented the anesthetic care with antispasmodics: 0.01% solution of nitroglycerin (NG) in drop infusions. Such care was sufficient to provide adequate anesthesia and to stabilize hemocirculation. The use of pentamin (0.01-1.2 mg/kg body weight) provided total sympathetic blockade, manifesting as improved flow of blood to the heart, due to neutralized post-exercise vascular resistance.

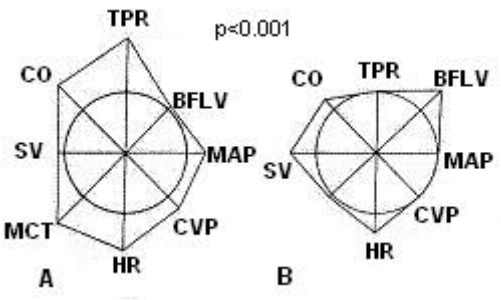

Fig. 1 Correction of central hemodynamics: A - before; B - after

For correction of hemodynamic abnormalities, nitrate (nitroglycerin) and ganglionic blocker (pentamin) classes of drugs were administered in threshold doses under monitoring. Use of nitroglycerin was associated with marked systemic vasodilation, manifesting as the reduction of systolic and diastolic AP to 14% from baseline ($p<0.05$). Total peripheral resistance (TPR) decreased concurrently with the increase in levels of cardiac output (CO) (from 4.87±0.23 to 5.54±0.23 L/min/m2; $p<0.05$) and SV (from 58.3±4.2 to 75.6±3.4 mL/min/m2; $p<0.05$), decrease in levels of central venous pressure (CVP) (from 6.9±0.4 to 3.9±0.3 mmHg; $p<0.05$) and venous tone;

the latter contributed to improvement of blood flow to the heart. However, the decrease in pulmonary arterial vascular tone was not reliable. Use of pentamin produces the desired clear effect of decreased pressure in pulmonary circuit. This effect was confirmed by shortening of mean circulation time (MCT) (from 20.1±0.12 to 13.9±0.43 sec; $p<0.05$), which was an adequate reflection of the reduced pulmonary hypertension (Fig.1).

Considerable traumaticity of thoracoplasty can be smoothened by means of similar vasoparetic agents that improve the adequacy of the anesthesia care. These agents provide sufficient antistress defense and restrict the pulmonary arterial barrier. This facilitates adaptation of respiratory and cardiovascular systems to altered postoperative functional state; this adaptation is directed primarily at optimization of ventilation-perfusion ratios.

Immune status indicators at different stages of thoracoplasty were studied in 32 patients, of them: 14 (43.8%) with fibrocavitary tuberculosis, 9 with cavitary TB and 9 with disseminated TB (28.1%) respectfully.

Patients' baseline immunological assessments were compared to relative assessments in normal individuals. Pre-operative status of T-cell-mediated immunity in surgical patients was on fairly high level, as measured by total counts of T-lymphocytes, although levels of regulatory cells showed the predominance of T-suppressors. Analysis of immune indicators in patients with different clinical forms of TB showed that T-cell immunity reduced most profoundly in disseminated TB (45.9±3.65, $p<0.05$), while in cavitary disease T-lymhocyte counts approximated those in control group (52.3±5.84, $p<0.05$). T-helper subpopulation counts reduced more in patients with fibrocavitary or disseminated TB, and less so in patients with cavitary TB. The latter contributed to predomination of T-suppressors and hence to reduction of immunoregulatory index.

Intensification of humoral immunity was noted in all cases, due to increased relative and absolute numbers of B-cells. In turn, predomination of B-cell immunity correlated with the increase in levels of serum class A and G immunoglobulins.

Study of immune response at postoperative days 9-12 showed changes in T-cell immunity: reduction in T-helper content from 27.15±1.53 to 23.54±0.9% ($p<0.05$), increase in T-suppressors from 22.0±1.66 to 26.33±2.57% ($p<0.05$). B-lymphocyte counts were observed to decrease from 28.25±1.58 to 13.01±2.08% ($p<0.05$).

In stage 3 of the study (postoperative day 30), total populations of T-lymphocytes rose to baseline levels; the same trend was observed in T-helpers. These positive changes in immunoregulatory cells were observed in all patients irrespective of the clinical form of tuberculosis, although more markedly in patients with cavitary TB ($p<0.05$) and less manifested in

disseminated pulmonary TB ($p<0.05$).

Positive changes were observed in B-cell indicators as well, with more pronounced manifestations in fibrocavitary TB ($p<0.05$) and a bit less so in cavitary TB, compared to disseminated TB. Immunoglobulins showed a trend to normalization in IgA and IgG levels, reflecting the reduction of inflammatory activity in the lungs (Table 1).

Table 1

Systemic immune indicators at various stages of thoracoplasty

No	Immune response indicators	Baseline levels (M±m)	Postoperative period (M±m)	
	Test timings		Days 9–12	Day 30
1.	T lymphocytes (x^{10})	0.935 ± 0.06	0.737 ± 0.04	1.07 ± 0.08
2.	T lymphocytes (%)	50.09 ± 1.88	49.56 ± 2.19	51.05 ± 1.98
3.	T helpers (%)	27.15 ± 1.53	23.54 ± 0.9	25.35 ± 1.31
4.	T supressors (%)	22.0 ± 1.66	26.33 ± 2.57	23.58 ± 2.03
5.	Leucocytes (x^{10})	6.22 ± 0.12	19.62 ± 1.78	31.45 ± 1.04
6.	Lymphocytes (%)	28.25 ± 1.58	13.01 ± 2.08	26.94 ± 1.6
7.	B lymphocytes (x^{10})	0.533 ± 0.02	0.405 ± 0.03	0.570 ± 0.02
8.	B lymphocytes (%)	27.13 ± 1.21	22.93 ± 1.06	21.5 ± 0.07
9.	Ig A (%)	2.35 ± 0.11	2.34 ± 0.09	2.15 ± 0.07
10.	Ig M (%)	0.95 ± 0.33	1.07 ± 0.06	0.92 ± 0.04
11.	Ig G (%)	14.3 ± 0.46	12.37 ± 0.7	13.38 ± 0.37

To conclude, changes in immune indicators in postoperative period gave evidence for various degrees of the damaging effect that disease persistence and adaptation of the body to new postoperative state have on immune system. In patients with cavitary TB changes in immune indicators testified for better and quicker restoration of immune system, than in patients with disseminated or fibrocavitary forms of TB.

Conclusions:

1. Although spirometric indicators were acutely reducing after thoracoplasty, significantly improved breathing activity and partially restored respiratory function were found on postoperative day 30, demonstrating high compensatory capacities of the respiratory system. This can be

attributed to the fact that thoracoplasty is less traumatic for the lung and preserves lung parenchyma, which is of greater clinical and prognostic significance, than the surgical damage to respiratory organs.

2. In short term following thoracoplasty, systemic and pulmonary hemodynamic indicators are found to be inhibited ($p<0.05$), and this is a condition requiring corrective therapy. Use of nitrate and ganglionic blocker classes of drugs substantially improves the central hemodynamics and ventilation/perfusion ratio ($p<0.001$).

3. Changes in immune status indicators following thoracoplasty had a compensatory nature caused by natural rearrangement of immune system, and did not require active immune corrective therapy.

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