THE BRONCHODILATOR EFFECT OF CERTAIN PROCEDURES ON THE CHEST IN CHILDREN

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The aerodynamic resistance to respiration was investigated by general plethysmography in conjunction with impedance pneumography in children aged from 3 days to 14 years, mainly with diseases of the lungs. Prolonged operations under general anesthesia induce an increase in the bronchial resistance, especially in the hours immediately after anesthesia. However, in patients undergoing thoracic surgery, the resistance falls sharply after the end of the first postoperative day, falling in many cases below normal. The causes of the bronchodilatation may be stretching of the lungs (compensatory emphysema) and a reflex to trauma to the chest wall; the bronchodilator action of baths confirms this latter hypothesis.

Factors inducing bronchodilatation include sympathimimetic (orthosympathetic) drugs [9-11] and reflex stimulation arising to stretching of the lung tissue [6].

This paper describes the bronchodilator effect of mechanical action on the chest wall.

EXPERIMENTAL METHOD

Changes in lung function were analyzed in 500 children aged from 3 days to 14 years with various medical and surgical diseases [1, 4, 5]. Sixty patients were investigated before and after operations on the abdomen and the retroperitoneal space: resections and plastic operations on the intestine, splenectomy, pylorotomy, plastic operations on the urinary tract, nephrectomy. Another 75 children were investigated before and after operations on the chest: drainage of abscesses, resection of the lungs, pneumonectomy, removal of mediastinal tumors, plastic operations on the esophagus and diaphragm, thoracoplasty. Most operations were carried out under endotracheal oxygen–nitrous oxide–halothane anesthesia with muscle relaxants. To investigate the role of anesthesia, experiments were carried out before and after minor operations (herniotomy) on 20 children.

Cupping of the chest and simultaneous estimation of the aerodynamic resistance were carried out 6 times on 5 children aged 4–5 years during attacks of asthma, and 8 times on 5 healthy children aged 10–14 years and on one healthy adult.

TABLE 1. Comparison of VA_A/V_T, Calculated per Kilogram Body Weight, in Healthy Children and Children Undergoing Thoracic Surgery (M ± m)

	Healthy (wt. 5-10 kg)	Patients (wt. 5-10 kg)	Healthy (wt. 11-16 kg)	Patients (wt. 12-16 kg)
Number of children	22	12	15	14
Number of tests	22	33	15	36
$\frac{VA_A}{V_T}$ (in liters · cm water · cm/kg	0,37±0,017	0,14±0,023	0,19±0,02	0,09±0,007
P	<0,01		<0,01	

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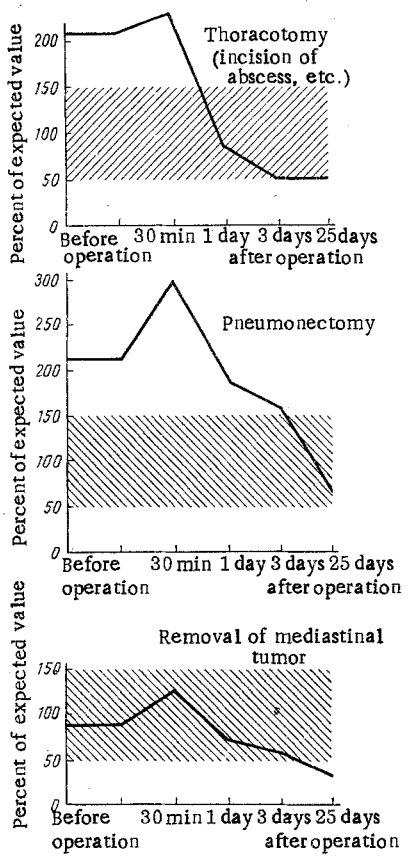

Fig. 1. Changes in mean values of VA_A/V_T in typical groups of patients weighing 5-16 kg. Tests carried out before and 30 min, 1, 3, and 25 days after operation. Shaded area corresponds to limits of one standard deviation above and below mean for healthy subjects.

The pressure in a whole-body plethysmograph and the impedance pneumogram (variations in the electrical resistance of the chest during passage of a current with a frequency of about 100 kHz) were recorded. The area of the oscillographic loop formed by the pressure curve and the pneumogram is proportional to the product of the lung volume (V) and the work done in overcoming the aerodynamic resistance (A_A); the ratio between the area of the loop and the height of the pneumogram (depth of respiration V_T) is an index proportional to the aerodynamic resistance (VA_A/V_T). This index varies with a change in the aerodynamic resistance and in the lung volume. In most cases the resistance (and its derivative, the work A_A) and the lung volume (V) can be considered to change simultaneously and in the same direction [10, 11]. The main cause of the changes in VA_A/V_T can be established by the use of ordinary clinical methods.

The technique described can also be used to assess decompression of the badly ventilated alveolar gas, reducing the elasticity of the lungs in dyspnea, and the depth of respiration can be calculated [1, 7].

Besides the mechanics of respiration, other parameters investigated in these patients were the acid-base balance and the oxygen partial pressure in the capillary blood by the micro-Astrup method.

EXPERIMENTAL RESULTS

In 350 patients with various diseases of the organs of respiration treated conservatively, VA_A/V_T was above normal (or more exactly, more than one standard deviation above the normal means) in 250 cases of 1500 tests and below the normal (below the limit of one standard deviation calculated from the results of investigations on healthy children) in only 25 cases. A decrease usually occurred in atelectasis and severe pneumonia in premature infants, and in these cases very often the decrease in VA_A/V_T was considerable, so that it might be connected with a decrease in both the lung volume and the aerodynamic resistance [5].

After abdominal and neurological operations VA_A/V_T increased in the first hour and then fell slightly, although it remained statistically above normal for 3 days. Nitrous oxide–halothane anesthesia by itself dilates the bronchi a little in most patients [3]: in 11 patients after herniotomy VA_A/V_T was significantly lowered, in 5 patients it was raised, and in 4 it was virtually unchanged.

After thoracic operations this index rose during the first few hours and then fell in the great majority of patients, frequently below normal. Of 200 investigations carried out on 75 patients between 1 and 50 days after the operation, VA_A/V_T was below normal in 65 cases (in all these cases the children breathed through their noses). A statistically significant decrease in VA_A/V_T below normal occurred from 2 to 40 days after the operation in patients weighing 5-16 kg (Table 1, Fig. 1).

In 3 patients undergoing combined thoraco-abdominal operations VA_A/V_T at first rose after the operation but then fell below normal, i.e., it changed in the same way as in many patients undergoing operations on the chest only.

In the follow-up investigation of 4 patients 6-12 months after the operation VA_A/V_T was found to be increased to a varied degree.

Cupping of the chest is known to relieve attacks of asthma and often to facilitate drainage of the bronchi in pneumonia during the stage of improvement. Cupping of children during asthmatic attacks reduced VA_A/V_T by 30-70% in all 6 subjects examined. In healthy children and the healthy adult cupping reduced VA_A/V_T by 10-30% in all 8 investigations (Fig. 2).

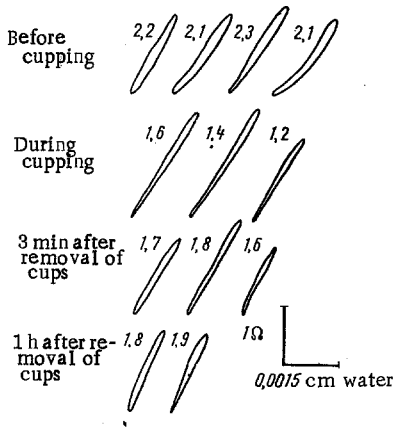

Fig. 2. "Respiratory loops" of a healthy child aged 14 years (copies taken from oscilloscope screen). Vertical axis – pneumogram; horizontal axis – plethysmograph pressure (with corresponding calibration marker). Numbers by loops give values of VA_A/V_T (in liters · cm water). Tests carried out in a whole-body plethysmograph with a capacity of 550 liters.

In many patients the drainage function of the bronchi was definitely upset in the postoperative period and pneumonia was present. This gives added interest to cases with normal and low values of VA_A/V_T, indicating dilation of at least some of the bronchi.

The simplest and most convincing explanation of the bronchodilatation is by stretching of the functioning lung, or "compensatory emphysema" developing after removal of part of the lung, a tumor, or funnel-shaped compression of the chest wall, as well as in massive pneumonia and atelectasis. The possibility cannot be ruled out that injury to the chest wall also induces reflex dilation of the bronchi, just as after operations on the abdominal organs a decrease in intestinal tone is observed. The bronchodilator action of cupping revealed by the experiments is an argument in support of this last hypothesis.

A lowering of resistance probably takes place after thoracic operations in some adult patients [8].

This phenomenon may partly explain the temporary beneficial effect of some operations on bronchial asthma [2].

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