SEPARATE INVESTIGATION OF HEMODYNAMICS OF RIGHT AND LEFT LUNGS BY DYE DILUTION AND CATHETERIZATION OF THE PULMONARY ARTERY

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A new method of recording the pulmonary blood flow is suggested: combination of the dye dilution method with catheterization of the pulmonary circulation. The dye (methylene blue) is injected by means of a cardiac catheter directly into the right, and then into the left pulmonary artery. Dye dilution curves are recorded by a detector located on the subject's ear. Changes in the dye dilution curve depending on the volume of the lesion and the type of lung resection were established.

The method of catheterization of the right heart and pulmonary artery presents great opportunities for investigation of the hemodynamics of the pulmonary circulation. However, the most valuable information concerning hemodynamic indices of each lung is difficult to obtain because an additional method of investigation (angiopulmonography) must also be used, and the apparatus is complicated.

The writers have studied the pulmonary blood flow during catheterization by means of a dye dilution method. The results suggest that the hemodynamic indices of the right and left lungs can be studied separately. If the circulation time in the "arm–ear" and "lungs–ear" segments of the vascular system is determined, the results will reflect the general pattern of hemodynamics of the pulmonary and systemic circulations, and will depend to some extent on the state of the cardiohemodynamics, so that injection of dye directly into the pulmonary artery of each lung should yield information concerning the state of the vascular system of each lung.

The mean dynamic in the pulmonary arteries, as in communicating vessels, does not differ. If the vascular resistance of the right and left lungs differs, the minute volume of blood flowing through them must also differ. As it passes through the vascular system of the lung, the blood moves through a large number of parallel channels which differ in cross section and length. The dye dilution curve under these circumstances reflects the different conditions of movement of the blood through the lung vessels. Dye dilution curves obtained by injection of indicator into the pulmonary arteries of a healthy and affected lung will therefore characterize the state of the blood vessels in them.

EXPERIMENTAL METHOD

The right heart and pulmonary artery were catheterized in the usual manner. Tests were carried out on 45 persons, 27 men and 18 women aged from 22 to 59 years, with extensive pulmonary tuberculosis. Catheterization of 20 subjects was carried out before operation, on 16 after bilateral resection, and on nine patients after unilateral resection with the presence of destructive tuberculosis in the opposite lung. The catheter was passed successively into the pulmonary artery of one, and then of the other lung. It was first

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TABLE 1. Parameters of Dye Dilution Curves

Indices of circulation and ratios between them	Examination									
	before operation				after bilateral resection of lungs				after first resection	
	right lung (less extensive lesion)	left lung (more extensive lesion)	right lung (more extensive lesion)	left lung (less extensive lesion)	right side (less extensive resection)	left side (more extensive resection)	right side (more extensive resection)	left side (less extensive resection)	right side (side of resection)	left side (destructive lesion in lung)
PA–E	4.70	5.40	4.50	4.50	4.70	4.30	5.20	5.30	4.10	4.70
EM	3.30	3.90	4.20	4.0	3.50	3.50	5.15	4.60	3.90	3.58
MO	5.95	4.75	6.90	6.50	4.07	6.10	4.75	5.0	4.0	5.52
MO/EM	1.80	1.21	1.65	1.62	1.16	1.60	0.92	1.09	1.0	1.47
MO/PA–E	1.26	0.88	1.53	1.44	0.87	1.41	0.91	0.95	0.98	1.13
EM/PA–E	0.70	0.63	0.93	0.89	0.74	0.88	0.99	0.87	0.95	0.76

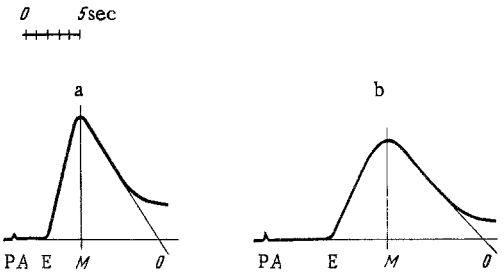

Fig. 1. Dye dilution curves following injection of methylene blue into pulmonary artery. Slowing of the blood flow with an increase in intervals EM and MO on side of more extensive lesion (left): a) right lung; b) left lung.

filled with dye (1% methylene blue solution). Some of the dye (2 ml) was left in the syringe connected to the external end of the catheter. To record the dye dilution curve, a type 0-36M oxyhemograph, in which the paper-winding mechanism was speeded up to 4 mm/sec,was used. The circulation time from the pulmonary artery of each lung to the ear (PA–E), the time for the dye concentration to increase from zero to its maximum (EM), the clearance time (MO), and the ratios MO/EM, MO/PA–E, EM/PA–E were determined from the resulting curves.

RESULTS

Mean values of the circulation time, time for the dye concentration to increase, and clearance time, and the ratios between these values are given in Table 1.

It follows from Table 1 that with extensive involvement of the left lung, the PA–E index was increased. If the right lung was more extensively affected, no difference was found between the indices. If a more extensive resection was performed on the left side, the circulation time on that side was reduced; if, however, a more extensive resection was performed on the right side, the difference between the PA–E values for the two lungs was negligible.

The IM index was greater on the side of the more extensive lesion. After bilateral resections of the lungs, IM was greater on the side on which the more extensive resection was performed. Similar changes were observed in patients on whom a unilateral lung resection was performed, and a destructive lesion was present in the opposite lung.

The clearance time of dye, when the principal lesion was on the left side, was smaller on this side, but if the more extensive lesion was on the right side, it was increased on the right side. If a more extensive operation was performed on the left side on patients undergoing bilateral resection of the lungs, the CT index was greater on the left, but if the more extensive resection was performed on the right side, the clearance time on the right and left sides differed negligibly. It was impossible to determine these indices in healthy

subjects. However, on the basis of accepted figures for the relative roles of the right and left lung in respiration (55 and 45%), it can be concluded that the volume velocity of the blood flow in the right lung is greater than in the left. This evidently accounts for the differences obtained in investigations of the right and left lung.

Characteristic dye dilution curves obtained on a patient with a more extensive tuberculous lesion of the left lung are given in Fig. 1.

Analysis of the results showed that as the diluted dye passes through the blood vessels of the affected lung, most of the injected indicator reaches the recording point later, as the result of a decrease in capacity of the vascular system and the presence of changed and deformed vessels in that lung. After resection of the pathologically changed portions of the lung, including the affected blood vessels, and also through a decrease in the reserve capacity of the vessels, the maximum concentration of dye in the ear is recorded sooner.

Consequently, injection of indicator into the pulmonary artery during catheterization of the right heart yields a characteristic dye dilution curve giving information concerning the state of the blood vessels of each lung.