THE CORRELATION BETWEEN VARIOUS ASSESSMENTS OF PULMONARY ARTERIAL PRESSURE IN MITRAL STENOSIS.

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In a random sample of 50 patients with mitral stenosis who had undergone mitral commissurotomy, the radiological assessment of the pulmonary vascular status was compared with other methods for assessing this feature. In each case, from the data available, the following were selected. (a) The clinical grading. (b) The pressure in cm. of saline recorded in the main pulmonary artery; only the mean pressure has been utilized. (c) The assessment of the pre-operative radiographs. (d) The histology of the tip of the lingular lobe of the left lung, obtained at operation. Each investigator assessed independently the degree of pulmonary vascular change that might be expected in each case from the particular data with which he was most familiar. These results were then correlated with those of the other members of the team.

RESULTS

(1) *Clinical Data.* Among the 50 patients there were 37 women. The sex distribution in the sample, therefore, is the same as that in our larger series and in those of others: namely about three women coming to mitral surgery for every man. The ages of these 50 patients ranged from 16 to 48 years. While the symptoms complained of varied greatly, all patients had breathlessness of various degrees of severity, extending from as short a period as three months to as long as 28 years in duration. In 19 there was paroxysmal dyspnoea. In 26 there was a history of hæmoptysis of various grades of severity. Before operation there had been four episodes of systemic arterial emboli in three patients.

The pre-operative clinical grading of each patient was made according to the criteria used by Baker *et al.*, 1952 and 10 were in grade 2, 34 in grade 3, and 6 in grade 4.

(2) *Pulmonary Arterial Pressures.* The mean pressure was determined by puncturing the main pulmonary artery with a needle connected to a saline manometer immediately the chest was opened at operation and before the left lung was collapsed. Zero point of reference was taken as the root of the main pulmonary artery. The systemic arterial pressure was noted at the same time. In some cases cardiac catheterization had been carried out before operation. In the main there was no gross discrepancy between the mean pulmonary arterial pressure determined at this time and later at the time of operation. It was 20–40 cm. saline in 8 cases, 40–60 cm. in 17, 60–80 cm. in 14, and above 80 cm. in 11.

(3) *Radiological Assessment.* The films available for study consisted in most cases of a P.A. view taken at standard distance with standard technique (Whitaker and Lodge, 1953). The films together with a fluoroscopic examination had mostly been taken within the period of a fortnight before operation, but in one or two there was an interval of a few months during which period the cardiovascular status of the patient might conceivably have altered.

From each film, the following points were studied: overall heart size, size of the individual chambers, the presence of valvular calcification, the size of the aortic knuckle, the pulmonary conus, the main pulmonary artery and branches, the hilar vessels, the state of the perihilar vessels, the occurrence of "amputation" of the pulmonary arterial branches (Steiner and Goodwin, 1953), the general state of the lungs, the occurrence of hæmosiderosis, the presence of old infarcts or of pleurisy, and the presence or absence of horizontal lines. For the assessment of the height of the pulmonary arterial pressure, the following points were considered to be important: (a) the heart size (a small heart was rarely associated with a high pulmonary arterial pressure); (b) the size of the pulmonary artery; (c) the size of the hilar vessels; (d) the state of the perihilar vessels; (e) the presence of amputation of the pulmonary arteries; and (f) the occurrence of horizontal lines.

The size of the pulmonary conus was found to bear no relation to the presence or severity of pulmonary hypertension.

Based on these criteria, the films were graded into four groups: 2 showed no abnormality, 14 mild changes, 22 moderate, and 12 severe changes. An example of the mildest and severest grade is shown in Fig. 1 and 2 respectively.

FIG. 1.—Example of minimal radiological changes.

FIG. 2.—Example of gross radiological changes.

(4) *Histological Assessment.* The lingular biopsies were removed with the lung expanded so that distortion would be minimal. The conical piece of tissue measuring roughly 2.5 cm. in length by 2.5 cm. across the base was immersed immediately in 10 per cent formol-saline and later sliced parallel to the base. All the material was processed. Sections were stained by hæmatoxylin and eosin and by Weigert's method for elastica: Masson's trichrome stain and Perl's method for hæmosiderin were used when required.

In each case, five pulmonary arterioles which were cut transversely were measured by a micrometer. The mean diameter of the lumen and the mean wall thickness were thus obtained according to the method originally reported by Kernohan *et al.* (1929). From each case, therefore, an average lumen/wall ratio was obtained and the distribution of this for the 50 cases is shown in Fig. 3. This curve agrees closely with that published by Enticknap (1953). For the pulmonary arterioles the

FIG. 3.—Distribution curve of lumen/wall ratio of pulmonary arterioles in 50 lingular biopsies.

normal value is about 5.5/1.0 or higher. The scatter of the curve was divided into four areas giving four arbitrary groups which are shown in Table I. Examples of pulmonary arterioles from the first and fourth groups are shown in Fig. 4 and 5.

TABLE I						
HISTOLOGICAL ASSESSMENT						
Lumen/Wall Ratio:	10.9-8.6/1.0	..	..	..	..	1
	8.5-5.7/1.0	..	..	..	..	5
	5.6-2.9/1.0	..	..	..	..	28
	2.8-0.0/1.0	..	..	..	..	16
Total		..	..	..	..	50

FIG. 4.—Normal pulmonary arteriole. L/W Ratio 10.3/1.0. H. and E.

FIG. 5.—Gross arteriole damage with circular lumen and gross intimal and medial hypertrophy. L/W Ratio 2.1/1.0 H. and E.

CORRELATION OF GROUPS

Each method of assessing the pulmonary arterial pressure can be compared with the three other methods. There are, therefore, six possible combinations which are indicated in Tables II, III, IV, V, VI, and VII. Since each item has been graded into four categories, it is reasonable to expect, if there is any correlation between the two items compared in each Table, that the majority of the results will lie along the diagonal extending from the bottom left corner to the top right. A scatter of one block on each side of this diagonal was allowed and the arbitrary limits have been drawn at these points.

TABLE II

CLINICAL GRADES *v.* PULMONARY ARTERY PRESSURES

Pulmonary Artery Pressure (cms saline)					
>80	0	2	7	2	11
60-80	0	2	9	3	14
40-60	0	3	13	1	17
20-40	0	3	5	0	8
	0	10	34	6	50
	1	2	3	4	
	Clinical Grades				

TABLE III

CLINICAL GRADES *v.* RADIOLOGICAL ASSESSMENT

Radiological Assessment					
Severe	0	0	8	4	12
Moderate	0	4	16	2	22
Mild	0	6	8	0	14
Nil	0	0	2	0	2
	0	10	34	6	50
	1	2	3	4	
	Clinical Grades				

TABLE IV

CLINICAL GRADES *v.* HISTOLOGICAL ASSESSMENT

Histological Assessment Lumen/Wall Ratio					
28-0.9/10	0	3	10	3	16
5.6-29/10	0	6	19	3	28
8.5-57/10	0	1	4	0	5
10.9-86/10	0	0	1	0	1
	0	10	34	6	50
	1	2	3	4	
	Clinical Grades				

TABLE V

PULMONARY ARTERY PRESSURES *v.* RADIOLOGICAL ASSESSMENT

Radiological Assessment					
Severe	1	2	4	5	12
Moderate	1	12	7	2	22
Mild	4	3	3	4	14
Nil	2	0	0	0	2
	8	17	14	11	50
	20-40	40-60	60-80	>80	
	Pulmonary Artery Pressures (cms saline)				

(1) *Clinical Gradings* (Tables II, III, and IV). These agree very closely with the radiological and histological assessment. They agree less closely with the pulmonary arterial mean pressures.

(2) *Pulmonary Arterial Mean Pressures* (Tables II, V, and VI). The gradings of this item do not agree as closely with the clinical and radiological assessments and less so with the histological assessment.

TABLE VI

PULMONARY ARTERY PRESSURES *v.* HISTOLOGICAL ASSESSMENT

Histological Assessment Lumen/Wall Ratio	26-0-0/10	2	5	5	4	16
	5-6-29/10	5	9	8	6	28
	8-5-57/10	1	2	1	1	5
	10-9-86/10	0	1	0	0	1
		8	17	14	11	50
		20-40	40-60	60-80	> 80	
		Pulmonary Artery Pressures (cms saline)				

TABLE VII

RADIOLOGICAL ASSESSMENT *v.* HISTOLOGICAL ASSESSMENT

Radiological Assessment	Severe	0	0	6	6	12
	Moderate	1	3	11	7	22
	Mild	0	1	10	3	14
	Nil	0	1	1	0	2
		1	5	28	16	50
		10-9-8-6	8-5-5-7	5-6-2-9	2-8-0-0	
		Lumen/Wall Ratio				
		Histological Assessment				

(3) *Radiological Gradings* (Tables III, V, and VII). This agrees very closely with the clinical and histological gradings but less so with the pulmonary pressure gradings, but nevertheless the correlation is present.

(4) *Histological Gradings* (Tables IV, VI, and VII). The histological assessment agrees very closely with the clinical and radiological gradings. It shows the least correlation of any of the six pairings when aligned against the pulmonary arterial pressures.

CONCLUSIONS

It appears that the criteria employed for (a) grading the patients clinically, (b) for assessing the radiological appearances with respect to pulmonary arterial pressure, and (c) for measuring the lumen/wall ratio of the pulmonary arterioles, correlate fairly accurately with one another.

The circumstances under which the pulmonary arterial pressure is measured at operation are somewhat artificial since the patient is under general anaesthesia, one pleural cavity is open and the patient is in lateral recumbency. It appears that the pressures thus recorded are too low, particularly in the lower grades of pulmonary hypertension in this series.

Given a recent P.A. film, we believe that an accurate statement can be made about the pathological state of the pulmonary arterial tree, the degree of disablement of the patient with mitral stenosis, and a reasonable assessment of the pulmonary arterial pressure.

REFERENCES

- Baker, C., Brock, R. C., Campbell, M., and Wood, P. (1952). *Brit. med. J.*, 1, 1043.
 Enticknap, J. B. (1953). *J. clin. Path.*, 6, 84.
 Kernohan, J. W., Anderson, E. W., and Keith, N. M. (1929). *Arch. intern. Med.*, 44, 395.
 Steiner, R. E., and Goodwin, J. F. (1953). *J. Fac. Radiol. (Lond.)*, 5, 167.
 Whitaker, W., and Lodge, R. (1953). *J. Fac. Radiol. (Lond.)*, 5, 182.