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SEMI-CONTINUOUS LEFT ATRIAL PRESSURE MEASUREMENTS DURING MITRAL VALVOTOMY*

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Several authors have evaluated the immediate results of mitral valvotomies by comparing pressures in the left atrium before and after cutting or fracturing the commissures, but, as far as can be ascertained, few papers give detailed information about the merits of these pressure readings.

In an earlier report from this hospital Pedersen and Tybjærg Hansen (1953) published measurements from the left atrium in 15 cases. In 12 cases of valvotomy for mitral stenosis without significant regurgitation a decrease of pressure was recorded in every instance, averaging 11 mm. Hg (range 1–23 mm. Hg). In three cases of pure mitral incompetence, in which only exploration of the atrium was performed, an increase of pressure was recorded in every instance.

Lee, Ordway, and Gerbode (1954) measured left atrial pressure before and after valvotomy in 26 cases and compared the decrease of pressure with the clinical result assessed six weeks to 14 months after the operation. Three patients with an "excellent" result showed an average decrease of left atrial systolic pressure of 15.3 mm. Hg. The corresponding figures for 13 "good" and 11 "poor" results were 10.7 and 2.7 mm. Hg respectively. Thus the average figures seemed a good indicator of the clinical result, but the figures in their tables show so great a variation in each group that the pressure changes in the individual case would be a poor guide to the clinical result.

Lev, Connolly, Kirklin, and Wood (1954) used a catheter inserted through the left superior pulmonary vein. In 21 cases the left atrial pressure was measured about 10 and two minutes before, and about two and 20 minutes after, valvotomy. In the pre-valvotomy period the average pressure showed a slight increase, but it can be seen from their diagram that in three cases the increase was 14, 8, and 7 mm. Hg respectively. The valvotomy caused an immediate drop in pressure in every instance but one. In the post-valvotomy period the average pressure was maintained with little change, but one case showed an increase of 7 mm. Hg, and two others a decrease of 7 and 5 mm. Hg respectively. These studies indicate a certain instability of the left atrial pressure in the periods before and after valvotomy. On the basis of these studies and of other less detailed reports (Bigelow and Greenwood, 1954; Connolly, Tompkins, Lev, Kirklin, and Wood, 1953; Cooley and De Bakey, 1952; Gerbode, Holman, and Hultgren, 1952; Hurwitt, Bloomberg, Aaron, Jezer, and Young, 1953; McAllister, Fitzpatrick, Powers, Papper, and Krahl, 1953) it seems safe to conclude that mitral valvotomy in most instances is followed by an immediate but varying decline in left atrial pressure. It has not been established that a correlation exists between the magnitude of the decrease and the anatomical result achieved.

With the exception of Lev and others, the authors cited above all used a single measurement before, and a single measurement after, the valvotomy. This method is only valid if the variations in left atrial pressure before and after valvotomy are insignificant in comparison with the changes produced by the valvotomy. During diagnostic cardiac catheterizations the left atrial pressure (actually the pulmonary "capillary" pressure) is stable under basal conditions, but this is not necessarily so during an operation, where several factors, to be discussed later, are at work. One aim of the present study was to take serial pressure readings from the left atrium during the operation and plot them in relation to time; another was to ascertain whether or not there is a correlation between the anatomical result of the operation and the pressure changes recorded.

METHOD

When the pericardium had been opened the pressure was measured in the left atrium by needle-puncture.† The pericardial incision was then extended in T-shape towards the left superior pulmonary vein. A cardiac catheter (20 cm. long, No. 8 French) was inserted through a puncture hole in the vein near the atrium,

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† The needle or the cardiac catheter was connected by a non-expansile silver tube filled with sterile normal saline to a Tybjærg Hansen capacitance manometer recording pressures through a Kayser amplifier on an Elema direct-writing two-channel electrocardiograph.

and the tip advanced 5–10 cm. into the atrial cavity. The entrance in the vein was guarded by a purse string suture. After this the left atrial pressure could be recorded at any desired moment without interfering with the surgical procedure. In two instances the catheter slipped out of the vein. This caused a slight bleeding and a short delay in the operation. No other complications were encountered. Pressure curves were recorded at short intervals, usually every one or two

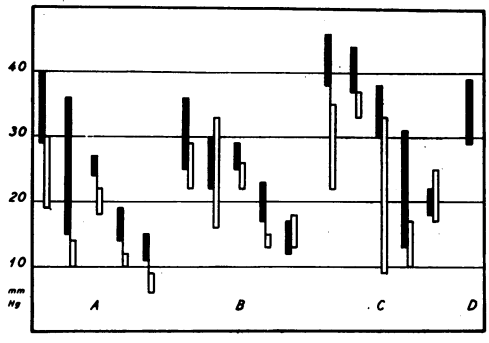

FIG. 1.—Each column represents the range of pressure variation in the left atrium. Black columns: before valvotomy. White columns: after valvotomy. Each pair of columns represents one case. Group A, tight mitral stenosis with none, or only insignificant regurgitation, and result of valvotomy excellent. Group B, as group A, but a less satisfactory valvotomy. Group C, considerable regurgitation before or produced during valvotomy. Group D, only pre-valvotomy values obtained.

minutes, except while the surgeon's finger was kept inside the atrium. The catheter was removed when the auricle had been sutured, and a last pressure reading from the atrium was obtained by needle-puncture just before the pericardium was closed.

Mean pressure data were obtained by visual integration of the curves. The heart rate was calculated from the simultaneously recorded electrocardiogram. The systemic systolic blood pressure was copied from the anaesthetist's chart.

RESULTS

During 15 operations for mitral stenosis the pressure in the left atrium was measured at short intervals in the periods preceding and following valvotomy. In one additional case pre-valvotomy pressures alone were obtained.

The average variation in pressures was 8 mm. Hg, both in the pre- and in the post-valvotomy period. The range of variation before valvotomy was 3–21 mm. Hg, in five instances 10 mm. Hg or more. After valvotomy the range was 2–24 mm. Hg, in four instances 11 mm. Hg or more. The pressure variations in the individual cases are depicted graphically in Fig. 1 in such a way that pressures before and after valvotomy are paired for each patient. It will be noticed that in eight instances, i.e., in more than half the cases, the columns overlap, and a single pressure reading before and after valvotomy would have registered a drop, no change, or a rise in pressure after the valvotomy, according to the time when the readings were done. Even more cases might have been included in this group if the post-valvotomy period of recording had been longer, as Case 151 (Fig. 2) seems to indicate. In this case the post-valvotomy period was extended considerably beyond the usual 15 minutes, because of technical difficulties encountered during the closure of the auricle. It will be seen that the pressure curve does not reach a peak until late in this period.

Returning to Fig. 1, it is evident that in most instances the pressures recorded are lower after than before valvotomy. In Fig. 1 the 15 com-

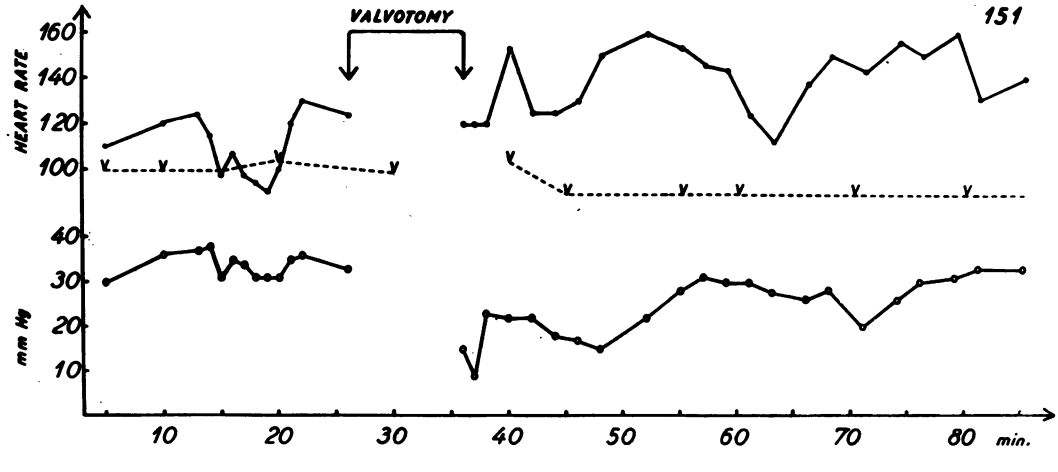

FIG. 2.—Changing left atrial pressure in spite of a very stable systolic blood pressure. ○—○—○=left atrial pressure. ●—●—●=heart rate. V--- V--- V=systolic systemic blood pressure.

plete recordings are divided into three groups each containing five cases : Group A consists of cases of tight mitral stenosis with none, or only insignificant regurgitation, in which a completely successful anatomical result was obtained. In Group B the same type of stenosis was found, but a less satisfactory valvotomy was performed. In Group C considerable regurgitation was present before, or was produced during, valvotomy.

In Group A overlapping takes place in only one instance (Case 154). In this case the commissures were split with difficulty, but the final result was in full accordance with the criteria for the group.

In Group B overlapping was present in all cases but one (Case 164). This case might have been put in Group A. The surgeon reported that both commissures were split, but the orifice did not admit more than one finger and a half owing to a narrowing of the annulus.

In Group C one case (Case 157) does not present overlapping. This case differs from the rest of the group in that the commissures were completely split, and a considerable regurgitation present before valvotomy was found to be slightly diminished. In another case (Case 153) in this group, the " pressure columns " just touch each other, but otherwise the case is in complete accordance with the criteria used for Group C.

In two cases in Group B and in one case in Group C, higher pressures were measured in the left atrium after valvotomy than any measured before. The two cases in Group B had no special characteristics, while the case in Group C was the only one in which a significant regurgitation, not present before valvotomy, was produced.

The material was subdivided into the three groups, A, B, and C, corresponding to the classification : excellent, fairly good, and doubtful valvotomies. This classification is necessarily rough and in a few instances perhaps even misleading, as indicated above in the description of Cases 164 and 157.

The results may be summarized thus. In four of five excellent valvotomies all pressures measured in the left atrium after valvotomy were below any pressure measured before valvotomy. Among 10 valvotomies considered fairly good or doubtful, two cases with an undisputable drop in left atrial pressure after valvotomy were included, and an analysis of these two cases indicated that the result of the operation might perhaps be better than the author's grouping would lead one to believe.

Discussion

Several factors, not operative during a diagnostic catheterization performed under basal conditions, may affect the left atrial pressure during an operation for mitral stenosis.

In the present study no correlation could be demonstrated between the systemic systolic blood pressure and the left atrial pressure. In the majority of the cases the changes in the left atrial pressure took place in spite of a very stable systolic blood pressure as exemplified by Case 151 (Fig. 2). On the other hand, a very stable left atrial pressure was observed during a considerable rise in the systolic pressure in Case 162 (Fig. 3).

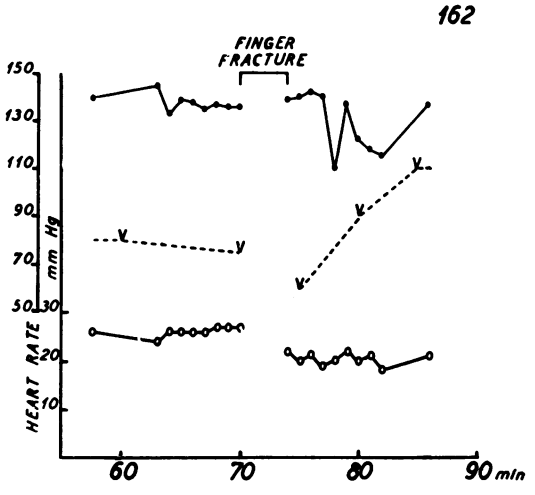

FIG. 3.—Stable left atrial pressure during a considerable rise in systolic blood pressure. (Symbols as in Fig. 2.)

Though not invariably the case (Baden, Fabricius, and Secher, 1955), it is generally conceded that an increase in the heart rate will raise the left atrial pressure when mitral stenosis is present. In this study a clear direct relation between left atrial pressure and heart rate was present in two cases in the pre-valvotomy period, as illustrated by Case 14 (Fig. 4). In four more cases a rough correlation was present, while in the rest of the cases no correlation was found. Case 153 (Fig. 5) is an example of the latter. In the post-valvotomy period, when the stenosis had been relieved, no relationship was demonstrable.

Minor changes in the rate or the force of the intermittent positive pressure ventilation used by the anaesthetist have been shown experimentally by Opdyke, Duomarco, Dillon, Schreiber, Little, and Seely (1948), and clinically by Baden and others to cause only minimal changes in the left atrial pressure.

The effect on the left atrial pressure of manual pressure upon the atrium has been studied by the author (unpublished data). Squeezing and releas-

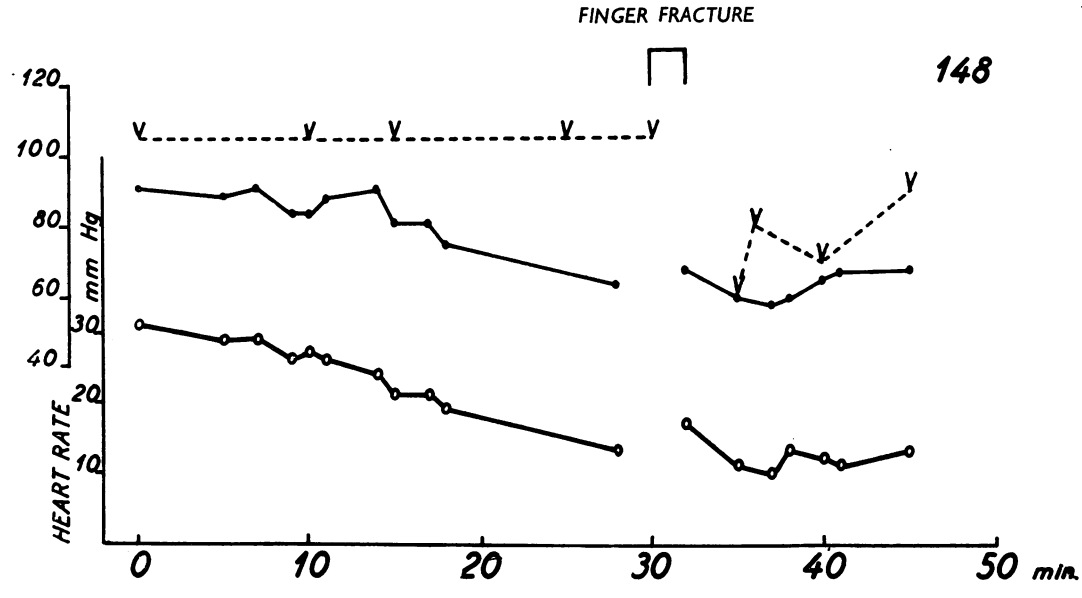

FIG. 4.—Unmistakable direct relation between left atrial pressure and heart rate in pre-valvotomy period. (Symbols as in Fig. 2.)

ing the atrium produce a slight transitory rise and fall respectively in atrial pressure. During maintenance of the atrial compression the left atrial pressure remained unchanged. Accidental pressure on the atrium during the operation will thus cause no appreciable pressure changes in the atrium.

There were only minor changes in the pressure exerted on the left lung under the packings, and the mediastinum was kept very stable by the anaesthetist. Left atrial pressure changes from these two causes are unlikely.

There were no sudden losses of appreciable amounts of blood, and the intravenous blood transfusion was running evenly and slowly throughout the major part of the study. The amount of transfused blood was calculated to replace lost blood millilitre for millilitre, and changes in circulating blood volume must have been minimal and incapable of modifying the left atrial pressure.

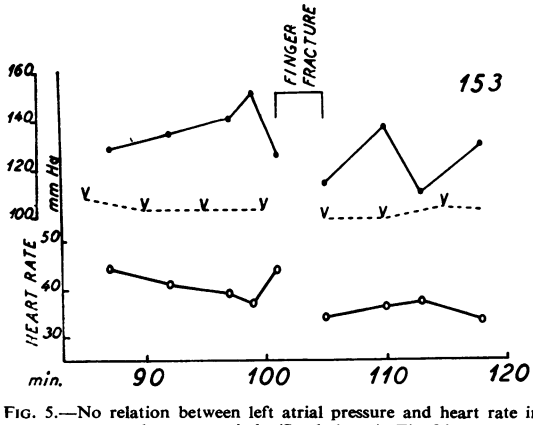

FIG. 5.—No relation between left atrial pressure and heart rate in pre-valvotomy period. (Symbols as in Fig. 2.)

A last factor that might possibly influence the left atrial pressure during a cardiac operation is the condition of the heart. To the factors listed by Wiggers (1952) as "primary coefficients" (factors that affect the physiological condition of the heart muscle directly) one may add "myocardial trauma." Though not mentioned by Wiggers in that connexion, trauma is recognized by the heart surgeon as a prominent reason for poor cardiac function. The primary coefficients cause changes in the initial ventricular tension, and, indirectly, in the left atrial pressure. The trauma sustained by the myocardium during a mitral valvotomy cannot be assessed, but cannot be omitted from the list of factors that might possibly influence the left atrial pressure.

SUMMARY AND CONCLUSIONS

During 16 operations for mitral stenosis repeated measurements were taken in the left atrium by means of an indwelling cardiac catheter. Plotting of the obtained values in a pressure-time system demonstrated that the left atrial pressure in the pre- and post-valvotomy period varied considerably, and rendered a single pressure measurement

before and after valvotomy valueless for an assessment of the operation's effect on the left atrial pressure.

An analysis of the pressure readings showed that, although an anatomically perfect operation in most cases caused a definite decrease of pressure, this was not invariably so. In one of five successful valvotomies a slight overlapping of pre- and post-valvotomy pressures was present. In two less successful valvotomies an unmistakable decrease of pressure was recorded. It must be concluded that even serial measurements of the left atrial pressure add little or nothing to the surgeon's assessment of the result.

The factors that may influence the atrial pressure during operative conditions are discussed. The left atrial pressure had a direct relation to the heart rate in a few cases in the pre-valvotomy period; in the post-valvotomy period no relation was demonstrable in any case. No other known factor bore any clear relation to the left atrial pressure, and the unpredictable course of the pressure curves cannot be explained at the present.

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