

## The Nature of the Disorder of Function in Chronic Postinfarction Aneurysm of the Left Ventricle

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### ABSTRACT

Assessment of left ventricular function in five patients with chronic postinfarction left ventricular aneurysm was carried out at the time of left heart catheterization and compared with that in six normal subjects. One patient was investigated before and after surgical resection of the aneurysm. The presence of the aneurysm placed the left ventricle at a mechanical disadvantage in systole and increased the resistance to diastolic filling (impedance). This was true even in patients with normal cardiac indices who were not badly disabled. Resection of the aneurysm corrected both these abnormalities, and, as well, lowered the time-tension index at a time when calculated left ventricular work was much increased. These differences between normals and patients with aneurysms, and the changes occurring as a result of resection of an aneurysm, show that the presence of the aneurysm places the left ventricle at a mechanical disadvantage in systole as well as altering its diastolic filling characteristics.

### SOMMAIRE

L'évaluation de l'état fonctionnel du ventricule gauche chez cinq malades présentant un anévrisme ventriculaire gauche chronique (post-infarctus) a été faite au moment d'une cathétérisme du cœur gauche et a été comparé à celui de six sujets normaux. Un des malades a été étudié avant et après résection chirurgicale de l'anévrisme. La présence de celui-ci constitue un obstacle mécanique au moment de la systole et augmente la résistance au remplissage diastolique (impédance). Ceci a été vérifié même chez des malades présentant des indices cardiaques normaux et qui n'étaient pas gravement atteints. La résection de l'anévrisme a permis de corriger ces deux anomalies et, en même temps, d'abaisser l'indice temps-tension à un moment où le travail calculé du ventricule gauche était très augmenté. Les différences entre des sujets normaux et des malades présentant un anévrisme et les changements apportés par la résection de l'anévrisme montrent que la présence de l'anévrisme constitue un handicap mécanique pour le ventricule gauche au moment de la systole et modifie les caractéristiques de remplissage diastolique.

**R**ESECTION of a chronic postinfarction left ventricular aneurysm is now possible with a mortality of about 20%,<sup>1,2</sup> and patients disabled by cardiac failure who survive this operation may remain in good health for years.<sup>3</sup> Cooley, Hallman and Henly<sup>2</sup> have shown that pulmonary artery and wedge pressures, which are usually elevated, are returned to normal following this operation. Some patients with ventricular aneurysm, however, have remained well without surgery for some years after discovery of their lesion,<sup>4</sup> one for as long as 29 years.<sup>5</sup> Resnik and Harrison<sup>6</sup> stated that the aneurysm, in most instances, does not alter the prognosis. Rupture of the heart later than three weeks after infarction<sup>7-9</sup> or systemic embolism later than eight weeks after infarction<sup>10,11</sup> is rare, so

that resection of chronic aneurysm should not be advised to prevent these complications. Although patients with left ventricular aneurysm who are in cardiac failure are greatly helped by this surgical procedure, it is not known whether the operation is indicated in the absence of failure. For this reason, we have felt justified in investigating the nature of the disorder of function in patients with chronic postinfarction left ventricular aneurysm, by the techniques of left heart catheterization.

### MATERIAL AND METHODS

Five patients with chronic postinfarction left ventricular aneurysm were subjected to combined, percutaneous retrograde aortic and trans-septal left heart catheterization.<sup>12</sup> Case 1 was catheterized twice before resection, and once after Dr. W. G. Bigelow resected the aneurysm. Left ventricular cineangiography demonstrated the aneurysm in all cases.<sup>13</sup> Pressure tracings were obtained using Statham P23 db strain gauges and an Electronics

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for Medicine photographic recorder. Zero reference level for all recorded pressures was 10 cm. above the level of the catheterization table. Left ventricular function was assessed using the following parameters:

1. The patient's functional status, graded by the New York Heart classification.<sup>14</sup>
2. Cardiac and stroke indices determined by means of the direct Fick principle.
3. Rate of rise of left ventricular pressure (mm. Hg/sec.).
4. Mean left ventricular systolic ejection rate (ml./syst. sec./sq.m. = millilitres per systolic second per square metre).
5. Time-tension index (mm. Hg sec. = millimetres of mercury seconds).<sup>15</sup>
6. Left ventricular minute work (kg. metres/min./sq.m.) =

$$\frac{\text{Mean aortic pressure—Left ventricular end-diastolic pressure}}{\times \text{Cardiac Index.}} \times 100$$

These same parameters were measured in six patients who were considered to have normal left ventricular function but who had been catheterized for other reasons.

RESULTS

All five patients with ventricular aneurysm had well-marked elevation of left ventricular end-diastolic pressure (Table I). The cardiac index was normal in all except Case 4, who was the only

TABLE I.—LEFT VENTRICULAR END-DIASTOLIC PRESSURE (LVEDP) IN VENTRICULAR ANEURYSM

Case	LVEDP (mm. Hg)	Cardiac index (l./min./sq.m.)	Functional grade*
1	35	3.4	II
	25	2.7	II
2	17	3.3	II
3	27	3.0	II
4	32	1.8	IV
5	20	3.9	II - III

\*New York Heart Association.

patient badly disabled or in congestive failure. The parameters of left ventricular function in the six normal subjects and in the patients with aneurysm are shown in Fig. 1. Although the values for normal subjects and patients with aneurysms overlap, in three of the four parameters the differences between the means are statistically significant at the 5% level. Table II and Fig. 2 demonstrate the

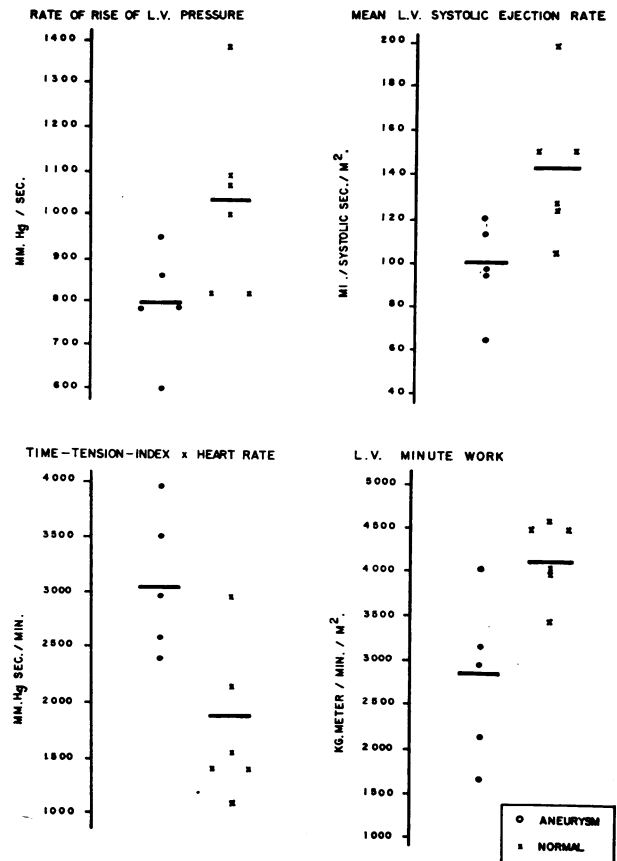


Fig. 1.—Comparison of four parameters of left ventricular function in patients with ventricular aneurysm (circles) with patients having normal left ventricular function (crosses). The horizontal bars represent arithmetic means.

Statistical analysis shows a difference between the means, significant at the 5% level in Mean LV Ejection Rate, Time-Tension Index x Heart Rate, and left ventricular minute work. The difference between the means of rate of rise of LV Pressure, while not statistically significant, approaches significance at the 5% level.

effects of resection of the left ventricular aneurysm in Case 1. The preoperative and postoperative chest radiographs in this case are shown in Fig. 3. It is evident that the presence of an aneurysm impairs left ventricular function and that resection of this lesion improves it.

DISCUSSION

The elevation of end-diastolic pressure observed in all of these patients with ventricular aneurysm is striking, and is present in patients without undue dyspnea or heart failure and with normal cardiac indices. It was returned to normal by resection of the aneurysm in one case, and is thus believed to be due to the presence of the aneurysm. Since end-

TABLE II.—CASE I BEFORE AND AFTER RESECTION OF LEFT VENTRICULAR ANEURYSM

Date	LV end-diast. pressure (mm. Hg)	Cardiac index (l./min./sq.m.)	Rate of rise LV press. (mm. Hg/sec.)	Mean LV syst. ejection rate (ml./syst. sec./sq.m.)	Time-tension index x heart rate (mm. Hg sec./min.)	LV minute work (kg. metre/min./sq.m.)
Preoperative						
November 1962	35	3.4	595	97.4	2348	2204
January 1963	25	2.7	568	94.6	2040	2269
November 1963 (nine months postoperative)	12	3.2	980	122.0	1323	3936

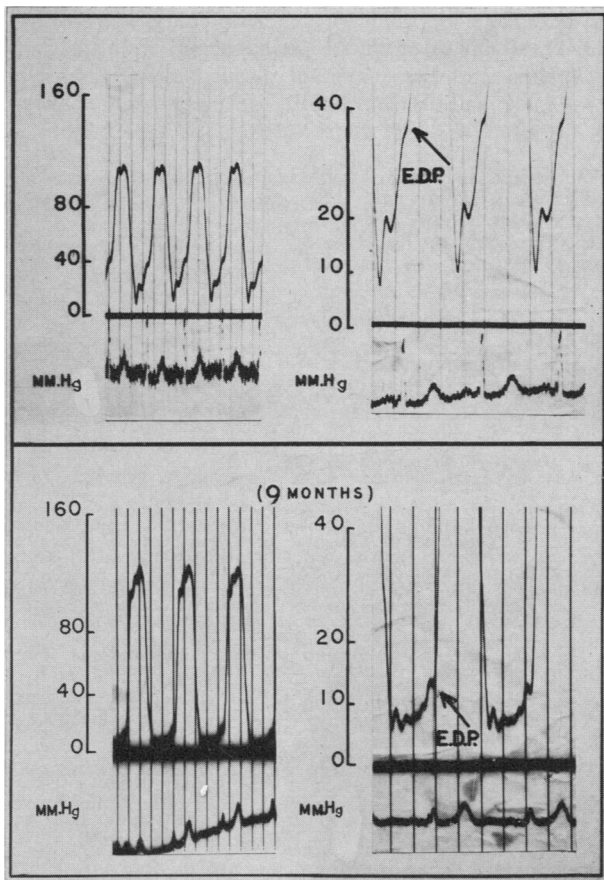
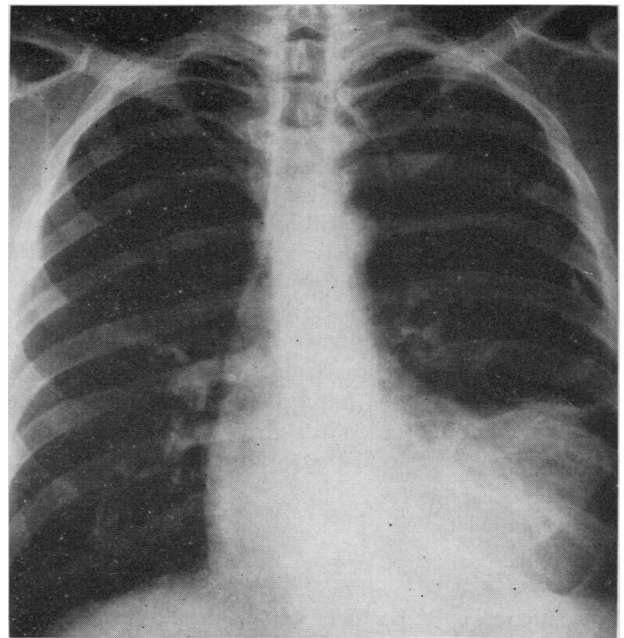


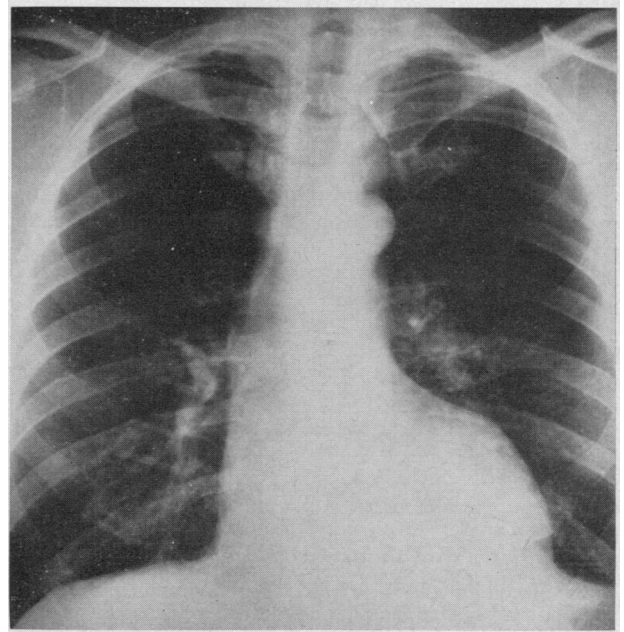
Fig. 2.—Left ventricular pressures (above) before and (below) after resection of aneurysm in Case 1. EDP = end-diastolic pressure.

diastolic left ventricular pressure is just one point on the pressure-volume curve of the left ventricle, it can be raised either by increasing end-diastolic volume or by changing distensibility of the left ventricular wall, or both. The aneurysm, by acting as an expansion chamber in systole, could result in an increase in the end-systolic volume and hence in the end-diastolic volume of the left ventricle. Also, the wall of the aneurysm may be less compliant in diastole than the rest of the wall of the left ventricle. (Meadows *et al.*<sup>16</sup> have used the term "impedance" to describe the increased resistance to ventricular filling that results both from an increase in the end-diastolic volume and a decrease in compliance of the ventricular wall.) The fact that the end-diastolic pressure returned to normal following resection of the aneurysm does not establish which of these two mechanisms caused the original elevation of pressure. Since the degree of systolic expansion observed by cine-angiography<sup>13</sup> may vary greatly, and may even be absent, it is likely that the relative importance of these two mechanisms varies from case to case.

It is apparent that the rate of rise of left ventricular pressure and the left ventricular ejection rate are both higher in our normal subjects than in our patients with aneurysm (Fig. 1), and that resection of the aneurysm was followed by a rise in both parameters (Table II). The time-tension index



(a)



(b)

Fig. 3.—Radiographic appearance of heart in Case 1 before (a) and after (b) resection of the aneurysm.

was lower, and the left ventricular minute work was higher in normal subjects than in patients with aneurysm (Fig. 1). Since time-tension index x heart rate reflects the energy expenditure and oxygen consumption of the heart,<sup>15, 17</sup> a lowering of this index at a time when the external work accomplished is increased (e.g. following resection of the aneurysm (Table II)), would indicate that the presence of the aneurysm resulted in ineffectual energy expenditure during cardiac contraction. This excess in energy expenditure could be due to expansion of the aneurysm in systole and/or be related to the increase in wall tension required to

develop a given pressure when cardiac enlargement occurs.<sup>18</sup>

The preoperative and postoperative data from Case 1, who did not have failure or angina, showed that his heart was working at a mechanical disadvantage small enough that cardiac function was fairly good, and undue dyspnea and angina were not present. It is not possible to state whether one would improve longevity or postpone functional deterioration by resection of an aneurysm in a patient of this type. Even though we know that the aneurysm causes the heart to perform work inefficiently, it seems reasonable for the present to reserve resection for patients who are disabled. If the mortality of resection of an aneurysm of this type became very low, this opinion would have to be revised.

#### SUMMARY

Assessment of left ventricular function in five patients with chronic postinfarction left ventricular aneurysm was carried out at the time of left heart catheterization and the results were compared with those of six normal subjects. One patient was investigated before and after surgical resection of the aneurysm. The presence of the aneurysm placed the left ventricle at a mechanical disadvantage in systole, in addition to increasing the resistance to diastolic filling (impedence). Resection of the aneurysm corrected both of these abnormalities and, as well, lowered the time-tension index at a time when calculated left ventricular work was much increased. These differences between normal subjects

and patients with aneurysm, and the changes occurring as a result of resection of an aneurysm indicate that the presence of the aneurysm places the left ventricle at a mechanical disadvantage in systole as well as altering its diastolic filling characteristics.

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### PAGES OUT OF THE PAST: FROM THE JOURNAL OF FIFTY YEARS AGO

#### WAR NOTES II: AMBULANCE OCEAN

The Queen of the Belgians, who is unwilling to leave her country for any length of time, lives in a villa at one end of the promenade and the King comes and goes from time to time. Dr. Depage, a very well-known surgeon in Brussels, who had a hospital in the Palais there before and after the German occupation, determined to set up a hospital in La Panne directly behind the firing line, and chose one of the hotels, "Grand Hôtel de l'Océan", for his purpose. The Queen was very interested in its organization and, as usual, British money has made the undertaking possible, though I might add that Madame Depage is now visiting Canada and the States to form an American Committee. Work was commenced early in December, and with remarkable rapidity the five storied narrow white building was quickly transformed into what is now one of the best equipped of any of the field war hospitals; and remember it is only a few miles from the firing line. Not a window was forgotten in putting up red crosses and no one could take the "Ambulance Océan" (as it is officially called) for anything but a hospital. It is right on the *digue* and only a few yards from the sea at high tide, and a queer little steam tram line runs right behind it. Central heating, quite an indispensable thing in this climate, and a good system of hot water were installed. The hospital was opened about ten days before my arrival. On the ground floor the café has become the

dining room for everybody, and along the long corridor are the offices, the laboratory, x-ray room, dark room and two splendid operating rooms with very good electric light, washing fixtures and sterilizing room. The next four stories form the wards and the fifth floor is used as sleeping quarters for the nurses. Hotel rooms are not very suitable for patients, and it is a great pity that the light partitions were not knocked out. There are many single rooms but most of them hold two beds, whilst the largest have only four in them. The nursing is rendered very difficult on this account, when it is taken into consideration how ill so many of the patients are. We use a trolley or sort of dinner waggon to take the dressings and instruments from room to room. On the average, each ward has about thirty-five beds. Temporary sheds have been put up as garages. Plans have already been made for two new one-storied buildings and then we shall have four hundred and fifty, instead of about one hundred and fifty beds as at present. Indeed, some of us began to level the sand dunes in the open space beside the hotel, but the sort of thing was only as a form of exercise and the labour at present is being done by Belgian soldiers, and the amateurs merely look on. So far, the "Ambulance" has never been completely filled up, but we are told that, comparatively speaking, there has been very little heavy fighting going on and that spring will see much more.—T. A. Malloch, *Canad. Med. Ass. J.*, 5: 353, 1915.