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INTRODUCING A NEW JOURNAL

Cor et Vasa, a medical journal which we present today for the first time to the medical public, will publish original work in the fields of cardiology, angiology, and other fields associated with the pathophysiology and clinical management of cardiovascular diseases. It will also contain important material otherwise connected with these fields from the countries participating in its publication, such as courses, lectures, etc.

This journal arrives on the scene at a time when a large and increasing number of medical journals occupy the attention of the reader. In Europe alone there are quite a number of cardiological journals, and the question naturally arises as to the correctness of adding Cor et Vasa to this list.

A new journal can defend its right to existence only by the quality of its scientific content, and by presenting truly original matter, and in this regard we hope that Cor et Vasa will be able to present work from the countries represented on the editorial board, and improve possibilities of international contact with the rest of the scientific world. Most cardiological journals are published by national cardiological societies, a few are international but these tend to mirror the scientific production of Western Europe and North America. These latter periodicals, of course, have been generous in accepting for publication articles from Eastern Europe, but we feel that a need exists to present systematically a more organized picture of scientific work in cardiology from Central and Eastern Europe and from parts of the Asiatic continent within the framework of a single publication. Scientific work from the latter countries often remains outside of the active world forum for the simple reason that publication in national journals gives rise to marked language difficulties in imparting this information beyond the borders of this country.

Cor et Vasa will be published in two versions: one in English, French or German, and one in Russian. Although its main purpose is to present work from the countries represented in the editorial board, work from all other parts

of the world will be welcome within its covers. We are very proud to publish Cor et Vasa from Prague under the sponsorship of the Czechoslovak Cardiological Society. Prague has an old tradition in medical science — including such figures as Purkinje — and particularly in cardiology. The Czechoslovak Cardiological Society was founded 30 years ago as one of the first such societes in Europe, and in the intervening years has stimulated a great deal of scientific and organizational work. In 1933 it organized in Prague the first international cardiological congress. It published proceedings of its meeting and conferences. This activity has been increased considerably in the postwar period, and we feel that the publication of an international journal belongs among these activities.

Last, but certainly not least, we earnestly desire that this publication may play a small part in the dual function that even a professional cardiologist may serve — to assist the management of the individual patient, for example, whose cardiovascular system has reacted unfavourably to the tensions within his own micro-environment — and to assist as well, in some small way, in the successful management of the end-results of tension in the macro-environment by enlarging the scope of international contact and cooperation.

Prof. F. Herles

Prague, October, 1959.

COR et VASA — 1 (1) : 3—11, 1959

SOME DISTURBANCES IN LIPID METABOLISM IN HYPERTENSIVE DISEASE

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The study of lipid metabolism in hypertensive disease is of interest because of its frequent association with atherosclerosis. Furthermore, disturbances found in both diseases are mutually related. However, compared with the numerous ideas on lipid metabolism in atherosclerosis, data on lipid metabolism in hypertensive disease are incomplete and contradictory.

According to Westphal (1924), Poindexter and Bruger (1938) and Harris (1949) hypertensive disease is characterised by hypercholesterolaemia. The results of Tareev and Ratner (1938), Mandelboim and Narodovoltseva (1953), and Litvak and Sosnina (1954), however, only demonstrate slight hypercholesterolaemia. Page, Kirk and van Slyke (1936), Elliot and Nuzum (1954) and Waris (1938) report normal blood cholesterol levels. A study of blood cholesterol levels in the development of hypertensive disease made by Myasnikov, Tareev and Ratner (1938) and Rozhdestvensky (1952) revealed increased cholesterolaemia at the transition of this disease from the functional to the sclerotic stage, due to the associated atherosclerotic process.

Fluctuations in cholesterolaemia in various forms of hypertensive disease (cerebral, renal and cardiac), in hypertensive crisis and in myocardial infarction were discribed by Drobov (1948), Tonkonogy (1948), Tsukershtein and Yegorova (1949) and Ratner and Osipenkova (1956).

In the development of atherosclerosis significance is attached not only to hypercholesterolaemia but also to the mutual relation between cholesterol and other blood lipids, mainly the phospholipids which stabilise the colloidal state of plasma cholesterol (Ahrens and Kunkel 1949, Nedzvetsky and Ratnitskaya 1951). A lowering of the phospholipid/cholesterol coefficient to below 1.0 is, according to Schroeder (1953), of atherogenic significance, since this points to an insufficient stabilisation of the colloidal state of blood cholesterol.

Rozhdestvensky (1952) reported a gradual lowering of the phospholipid/cholesterol coefficient in developing hypertensive disease, especially when there are signs of atherosclerosis. However, the significance of the blood phospholipids themselves is as yet unclear although their active role in intermediary lipid

metabolism in the oxidation of fatty acids is known (Sinclair 1935, Ferman 1947).

In recent years changes in the individual stages of intermediary lipid metabolism in hypertensive disease and atheroclerosis have been discovered. Ponomareva (1953) and Sidelnikova (1956) reported a lowering of the blood level of keto-substances in patients with atherosclerosis and sclerotic hypertension. Inhibited ketogenesis was observed by Ponomareva in pronounced hyperlipaemia and interpreted as a consequence of deranged fat splitting.

Kritchevsky, Moyer et al. (1956) point out the significance of unsaturated fat containing dissolved cholesterol in the development of experimental atherosclerosis; increasing saturation of fat enhanced and intensified the development of rabbit atherosclerosis; the administration of highly unsaturated fat irrespective of the cholesterol dose showed the opposite effect.

In the investigation on blood fatty acids in atherosclerosis and diabetes Schrade, Biegler and Böhle (1958) found a lowered ratio of unsaturated to saturated fatty acids.

It has recently been reported (Priss 1958) that the iodine number of blood lipids is lowered in the sclerotic stage of hypertensive disease; this demonstrates an increased proportion of saturated fatty acids.

Bloor (1926) considered desaturation of fatty acids to be an early stage in disturbed lipid metabolism determining the intensity of their subsequent splitting. Kinsell and Michaelis (1958) and Lukomsky (1959) have shown that the administration of highly unsaturated fatty acids causes a decrease in blood cholesterol levels and an increase in serum phospholipids. Furthermore, an improvement in clinical state was observed, chiefly the disappearance of stenocardia.

The present report deals with an investigation of serum lipid changes in various clinical stages of hypertensive disease with special reference to unsaturated fatty acids.

METHODS

Total blood cholesterol and its fractions were estimated by the method of Fedorova, which is a combination of the procedures of Engelhardt and Smirnova with the technique of Kanner. Neutral fat was determined according to Pincussen. The iodine number of the blood lipids was determined by the method of Page as modified by Tsatskis.

RESULTS

Control observations were performed in 35 normal individuals, ranging in age from 18 to 65 years. The following ranges of blood lipid indices were obtained:

a) total cholesterol	125—180 mg%
b) free cholesterol	45— 70 mg%
c) esterified cholesterol	80—122 mg%
d) coefficient of cholesterol esterification	0.55—0.68
e) phospolipids	150—240 mg%
f) neutral fat	50—180 mg%
g) iodine number	340—420 mg%

Deviations from normal values were apparent chiefly in esterified cholesterol. Since data reported in literature concerning esterified cholesterol show considerable variations, the control values were taken as normal.

Blood samples for lipid estimations were taken from patients in the fasting state before breakfast at 70—10-day-intervals. In cases of acute complications blood samples were taken at their climax whenever possible and on the following day. The patients were on a standard diet with limited fat intake.

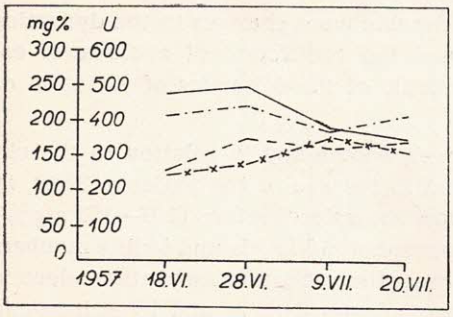

Fig. 1. Dynamics of serum lipid level in female patient B., 45 years (functional stage of hypertensive disease, climacteric hypertension).

———— cholesterol (mg%)
– – – – – – phospholipids (mg%)

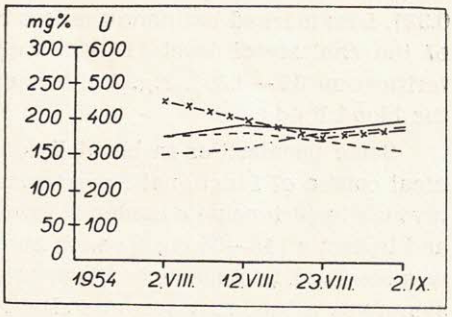

Fig. 2. Dynamics of serum lipid level in male patient L., 57 years (sclerotic stage of hypertensive disease with uncomplicated course).

—·—·—·— neutral fat (mg%)
—×—×—× iodine number (units)

A total of 115 patients with hypertension was observed, 55 of whom were suffering from complications (crisis, myocardial infarction, ictus). Among the remaining 60 patients with an uncomplicated course of the disease 20 were in the stage of functional changes and 40 in the sclerotic stage.

In the group of the patients in the functional stage of uncomplicated hypertension there were 11 men and 9 women, the age of which ranged from 19—45 years, including some patients with juvenile and climacteric hypertension; the range of blood pressure was 190/110—130/75 mm. Hg at rest under the administration of sedatives. In almost all the patients the development of hypertension was preceded by neurological symptoms. Thirteen patients showed slight hypertrophy of the left heart ventricle, in seven there was narrowing of vessels in the fundus of the eye. A deterioration of the clinical state (headache, dyspnoea, stabbing precordial pain) was associated with physical and mental strain.

Cholesterolaemia in this group showed considerable variations (107—228 mg%). Raised cholesterolaemia (185—238 mg%) was observed in 4 patients with climacteric hypertension and in 3 patients with obesity, i. e. in 7 patients. An elevated coefficient of cholesterol esterification to the value of 0.7 was found in 2 patients with climacteric hypertension. The phospholipid level also showed considerable variations (130—205 mg%). A fall in phospholipids was observed in 4 patients two of which had climacteric hypertension.

A rise in neutral fat values (193—258 mg%) was found in five patients three of whom had climacteric hypertension and two had generalised obesity.

A lowering of iodine number to 254—304 (as compared to the normal range 340—420) was found in 4 patients, three of whom had pronounced hyperlipaemia (neutral fat level: 213—258 mg%).

In hospitalised patients with functional hypertension there were considerable variations in the level of all lipids, mainly phospholipids (ranging from 155—45 mg%), neutral fat (15—43 mg%), phospholipid/cholesterol coefficient (0.18—0.32). Less marked but none the less considerable were changes in the dynamics of the cholesterol level (12—36 mg%) and the coefficient of cholesterol esterification 0.1—0.25). Fig. 1 shows an example of the dynamics of variation of the blood lipids.

Some pecularities in blood lipid changes were found in relation to the clinical course of functional hypertension and to the age of the patients. Thus, in juvenile hypertension a tendency towards low cholesterol values (107—151 mg%) and lipaemia (48—96 mg%) with normal phospholipid levels and iodine numbers was observed. In climacteric hypertension regardless the absence of atheroclerotic symptoms a tendency towards slight hypercholesterolaemia and hyperlipaemia and towards lower phospholipid/cholesterol coefficients and iodine numbers was evident.

The group of patients in the sclerotic stage of uncomplicated hypertensive disease was composed of 40 patients (15 men ad 25 women) aged 45—78 years, who had been suffering from the disease for 4—20 years. The majority of these patients were persons with hypersthenic constitution (29 of the 40 patients). Arterial blood pressure ranged from 160/100 to 210/120 mm. Hg, showing considerable stability from the dynamic point of view (especially diastolic pressure).

Hypercholesterolaemia was observed in 29 of the 40 patients with a range of 185—330 mg%, and a slight elevation of blood cholesterol level (185—250 mg%) in 27 patients. In 11 patients normal blood cholesterol levels (156—180 mg%) were found.

Elevated esterified cholesterol levels (125—330 mg%) were found in 27 patients and free cholesterol blood levels were raised in 16 patients (range: 71—83 mg%). An increased coefficient of cholesterol esterification was observed in 15 patients (0.7—0.81).

Phospholipid levels were decreased in 16 patients (112—145 mg.%), in 11 individuals the level was at the lower limit of the normal range (150—165 mg%) and only in 9 patients was the upper limit of the normal range approached (182—207 mg%).

The phospholipid/cholesterol coefficient was lowered in 33 patients to a range of 0.45—0.82. Neutral fat levels were above normal values in 30 of the group of 40 patients (198—344 mg%).

A marked lowering of iodine number (to 203—330) was found in 19 patients with significant hyperlipaemia.

The lipid levels showed considerable stability in their time course (fig. 2) as compared with the functional stage of the disease. A conspicuous stability

was revealed by serum cholesterol levels (variation 5—17 mg%) and the cholesterol esterification coefficient (deviation 0.04—0.1). The range of variation of the phospholipid levels (7—17 mg%) and of blood neutral fat content (18—26 mg%) was somewhat larger.

Fifty five patients with a complicated course of hypertensive disease were investigated. From these, 25 were in hypertensive crisis on admission to hospital and 30 had myocardial infarction and ictus.

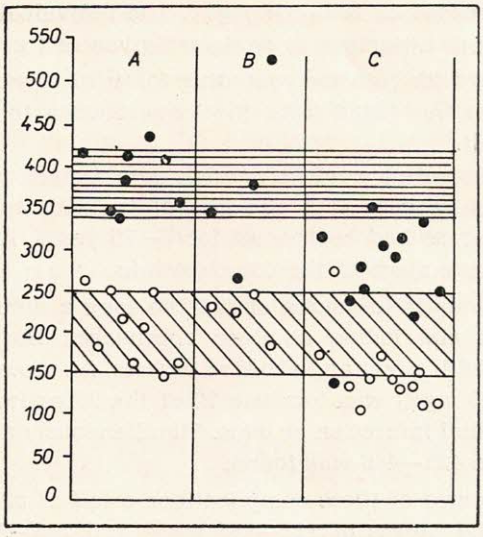

Fig. 3. Serum phospholipid level and iodine number in hypertensive crisis.
A = mild course, B = abortive course, C = severe course, ○ = phospholipids (mg%), ● = iodine number (units), ▨ = normal level of phospholipids, ▤ = normal values of iodine numbers.

Among the patients who on admission to hospital had manifestations of hypertensive crisis with high blood pressure values (190/120—250/150 mm. Hg) 10 were men and 25 women, within an age range of 35—74 years. In 9 patients the crisis was relatively mild and of short duration, in 4 patients the crisis was of short duration although there were severe manifestations of preapoplectic stages (abortive crisis) and in 12 patients there was severe complicated crisis of long duration. Marked atherosclerotic changes were found in these patients.

The levels of cholesterol and the cholesterol fractions were not significantly different from those found in the uncomplicated sclerotic stage of the disease. In 18 of the 25 patients the cholesterol levels varied between 185—312 mg%; an increase in the coefficient of cholesterol esterification to 0.7—0.82 was observed in 16 patients.

The most characteristic changes were found in the levels of phospholipids, neutral fat and iodine number. In 11 of the 13 patients during mild and abortive crises the phospholipid levels were raised from 182 to 275 mg% and the phos-

pholipid/cholesterol ratio was raised to 0.95—1.35. Simultaneously an elevation of iodine number to 430—546 with normal neutral fat levels (48—172 mg%) was observed. Regardless of the relatively severe course of the abortive crisis these changes in lipid levels could be observed in all these patients.

In crises with a severe course and long duration the following changes were observed: phospholipids were lowered to 105—154 mg% in 9 of 12 patients, the phospholipid/cholesterol coefficient was also lowered to 0.36—0.76. A lowering of iodine number (140—337) was found in all patients of this sub-group. Neutral fat levels were increased to 186—381 mg%. The individual phospholipid levels and iodine numbers in hypertensive crisis are given in fig. 3.

When compared with both the preceding forms of crises the duration of the changed lipid values was found to be the longest when the crisis had a severe course (14—26 days).

Of the 30 patients with hypertensive crisis with complications like myocardial infarction and ictus 17 were men and 13 women, with an age range from 52 to 70 years. The disease had be present for 7—15 years. All observations were performed in the acute stage of the complications.

With the relatively mild course of not too long a duration the changes in phospholipid levels and iodine numbers approached the values observed in hypertensive crisis with slight and abortive courses. An elevation of phospholipid levels from 191—265 mg% was found in 12 of the 30 patients regardless of the presence of myocardial infarction or ictus. Simultaneously an elevation of iodine number to the range 425—446 was found.

In the severe course of these complications a fall of phospholipid level and jodine number to the ranges of 112—155 mg% and 203—311 resp. was found. Pronounced changes in neutral fat content were absent; lipaemia showed variations from 75—292 mg%.

A lowering of cholesterol levels towards the lower limits of the normal range (138—147 mg%) was found in some patients with myocardial infarction or with ictus (8 of the 30 patients). In the remaining patients cholesterol levels varied from 192—263 mg%.

An analysis of the results obtained emphasizes the known rule of the elevation of blood lipids with progression of hypertensive disease. In the first (the functional) stage of the disease a lability in the regulation of lipid metabolism is observed being most pronounced in climacteric hypertension.

In the second stage, the sclerotic stage, there is stabilisation of the lipid levels probably due to the associated atherosclerotic process. According to our findings cholesterolaemia in the sclerotic stage of the disease shows a slight but persisting elevation, which is accounted for mostly by an elevation of the cholesterol esters.

In a considerable part of our patients phospholipids were lowered, causing a lowering of the phospholipid/cholesterol coefficient; according to the present results this was due to hypercholesterolaemia as well as to low phospholipid levels. In patients with normal or slightly elevated cholesterolaemia the lowering of the former coefficient was accounted for mainly by low phospholipid levels.

Parallel variations of the phospholipid levels and the phospholipid/cholesterol coefficient in complicated hypertensive disease also points to the relation of the latter coefficient to the phospholipid level.

In the majority of the patients in the sclerotic stage there was elevation of the blood neutral fat level. These findings are in agreement with the results of Ponomareva (1953) and Harris (1949); they do not confirm the findings of Rozhdestvensky (1952) who found normal neutral fat levels in the great majority of patients with hypertensive disease. In nearly half of the patients with uncomplicated sclerotic hypertension the present authors were able to observe a lowering of the blood lipid iodine numbers as compared with the control values in normal individuals of corresponding age. This change points to an increase in the proportion of saturated fatty acids and to a lowering of the proportion of unsaturated acids of the lipids. The most apparent lowering of iodine number as observed in severe complications of hypertensive disease with marked atherosclerotic changes is in agreement with the data of Kritchevsky, Moyer, Tesar et al. (1956), on the atherogenic effect of saturated fatty acids.

With a relatively mild course of the complications a certain activation of lipid metabolism occurs, as can be reasonably expected, and which is possibly of a compensatory nature.

SUMMARY

Tareev, E. M., Priss, I. S. (Therap. Clin., Fac. of Hyg., First Inst. of Med., Moscow). *Some disturbances in lipid metabolism in hypertensive disease.* Cor et Vasa 1 (1) : 3—11, 1959.

1. The serum lipid content in hypertensive disease is a manifestation of profound metabolic disturbances which are closely connected with the dynamics of the development of the disease and the associated atherosclerotic process.

2. Uncomplicated hypertensive disease in the sclerotic stage is characterized by a slight and persisting elevation of serum cholesterol, mainly accounted for by the esterified cholesterol fraction.

3. A lowering of the phospholipid/cholesterol coefficient is, according to the present findings, nor only due to hypercholesterolaemia but also to a lowering of the serum phospholipid level.

4. A tendency towards lowered iodine number pointing to an increased proportion of satured fatty acids, with simultaneously elevated lipaemia in the sclerotic stage of the disease is evidence of disturbed intermediary lipid metabolism (oxidation of fatty acids).

5. In acute complications of hypertensive disease (critis, myocardial infarction) two forms of changes in phospholipid levels, phospholipid/cholesterol coefficient and iodine number were found: a) elevation of these factors in the mild course of the complications, b) persistent lowering of these factors in complications with a severe course.

ZUSAMMENFASSUNG

1. Bei der hypertonischen Krankheit spiegelt der Serumfettgehalt die tiefgreifenden Stoffwechselstörungen wieder, die mit der dynamischen Entwicklung der Krankheit und dem mitlaufenden atherosklerotischen Prozess in Zusammenhang stehen.

2. Für die komplikationsfreien Hypertoniker im sklerotischen Stadium ist eine beständige, mässige Erhöhung des Cholesterinspiegels charakteristisch, die hauptsächlich der Fraktion der Cholesterinester zuzuschreiben ist.

3. Auf Grund unserer Ergebnisse kommt die Senkung des Phospholipid/Cholesterinkoeffizienten nicht nur durch die Hypercholesterinämie, sondern auch durch eine Senkung des Phospholipidspiegels im Blutserum zustande.

4. Die Neigung zur Herabsetzung der Jodzahl, die auf ein Überwiegen des Anteils der gesättigten Fettsäuren in der Zusammensetzung der Lipide bei gleichzeitiger Erhöhung der Gesamtlipämie im sklerotischen Stadium der Krankheit zurückzuführen ist, weist auf eine Störung des intermediären Fettstoffwechsels hin (Oxidierung der Fettsäuren).

5. Bei akuten Komplikationen der hypertonischen Krankheit (Krise, Myokardinfarkt, Insult) konnten zweierlei Veränderungen der Phospholipidindikatoren, sowohl des Koeffizienten Phospholipide/Cholesterol als auch der Jodzahl, festgestellt werden: a) Erhöhung dieser Indikatoren bei leichterem Verlaufe der Komplikationen und b) dauernde Herabsetzung bei schwerem Verlauf.

RÉSUMÉ

1. Le taux de la lipémie des hypertendus reflète des troubles métaboliques graves qui sont en rapport avec le développement dynamique de la maladie, ainsi qu'avec le processus athéroscléreux associé.

2. Une augmentation modérée et permanente de la cholestérolémie, surtout en ce qui concerne la fraction estérifiée, constitue un des signes caractéristiques d'une hypertension non-compliquée dans le stade scléreux.

3. D'après nos résultats, la diminution du coefficient phospholipides/cholestérol ne provient pas seulement de l'hypercholestérolémie, mais aussi d'un abaissement du taux des phospholipides sériques.

4. L'inclination à un abaissement de l'indice d'iode des lipides qui marque une prédominance das acides gras saturés dans la composition des lipides, avec une augmentation simultanée du taux de la lipémie, indique un trouble du métabolisme intermédiaire des lipides (oxidation des acides gras) au stade scléreux de la maladie.

5. Lors des complications aigues de la maladie hypertonique (crise, infarctus du myocarde, insulte), on a pu constater deux sortes de changements des indicateurs des phospholipides, aussi bien du coefficient phospholipides/cholestérol que de l'indice d'iode: a) une augmentation de ces indicateurs lors d'un cours léger des complications et b) un abaissement permanent lors d'une évolution grave.

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THE PERSPECTIVE VECTORCARDIOGRAPHY

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The available methods of spatial vectorcardiography vary from solid wire models[4 13]) and stereoscopy[12 13 14]) to the presentation of three plane projections (frontal, horizontal, and sagittal) of the vectorcardiogram.[5 7 14 18])

The descriptive geometry is the perfect method of presenting three-dimensional figures and it could be reasonably assumed, that it will be good enough for the spatial vectorcardiography, too. The "perspective vectorcardiography" is based on this obvious principle.

The "perspective vectorcardiogram" is a graphic presentation of the spatial vectorcardiogram, performed by means of a simple mechanical device for integrating three synchronous scalar leads, representing a three-dimensional reference system.[10]) The reference system of Duchosal and Sulzer[4]) is preferably used with "positive" sense of the vector[3]) including the transverse (OX), the craniocaudal (YO) and the postero-anterior (OZ) leads.

The spatial structure of the three- dimensional figure is satisfactorily visible in the perspective presentation. The temporal characteristics and the spatial coordinates of the instantaneous vectors are readily obtainable. The magnitude and the angular speed of the vector can be easily estimated by graphic methods of the descriptive geometry. The direct visualization of the space and time relationships give to the perspective construction advantages over the bidimensional, plane projections alone. It is very difficult, for instance, to gain an adequate idea about the rotations of the spatial vectorcardiogram on the base of plane projections only.

The principles of integrating three scalar electrocardiograms into a perspective vectorcardiogram are presented in fig. 1.[8])

Three reference electrocardiograms YO, OZ and OX are seen. The coordinates X, Y and Z (45°) represent the reference systems of the perspective image.

The perspective image of the spatial vectorcardiogram and its horizontal plane projection are constructed in this reference system.

To facilitate the visualisation the coinciding points of the spatial vectorcardiogram and its horizontal projection are joined by perpendicular lines. The sense of rotation of vectorcardiogram is indicated by shadowing. The vector-

cardiogram is additionally provided with arrows indicating the sense of rotation and with time marks of 0,005".

The consistence of the mechanical integration of vectorcardiograms with the cathode-ray vectorcardiograms was carefully examined and no reason was found

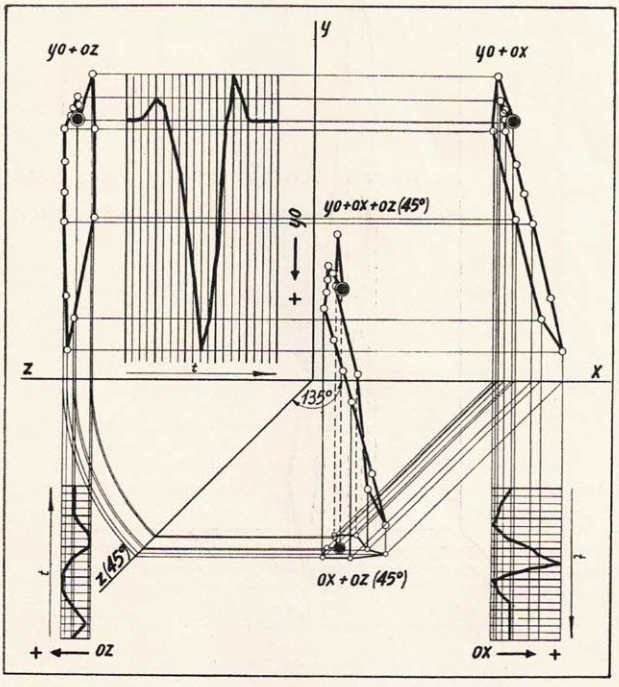

Fig. 1. The integration of a perspective vectorcardiogram. — YO = the cranio-caudal scalar lead. — OZ = the posterio-anterior scalar lead. — OX = the transverse scalar lead. — YO + OZ = the sagittal plane projection. — YO + OX = the frontal plane projection. — YO + OX + OZ (45°) = the perspective image of the spatial vectorcardiogram. — OX + OZ (45°) = the perspective image of the horizontal plane projection.

to claim a superiority of the latter one in respect to the clinical needs.[11]) This experience remains in agreement with results gained by other authors.[1 18])

The advantages of the spatial vectorcardiography can be easily exemplified.

The QRS vectorcardiograms of two individuals in figures 2a and 3a differ essentially, the former being normal, the latter showing right heart preponderance. The correspoding electrocardiograms are almost identical in respect to the QRS complex, except the RS-type in CR_6 lead, visible in figure 3b.

The vectorcardiograms presented in figures 2a and 3a stress the significance of the sagittal component of the electric field of the heart. The visualisation of this component was indicated by Wilson, Johnston and Kossman as one of the fundamental aims of the spatial vectorcardiography.[17])

The electrocardiograms of two individuals in figures 4b and 5b are similar and do not show any essential difference. On the other hand the QRS vector-

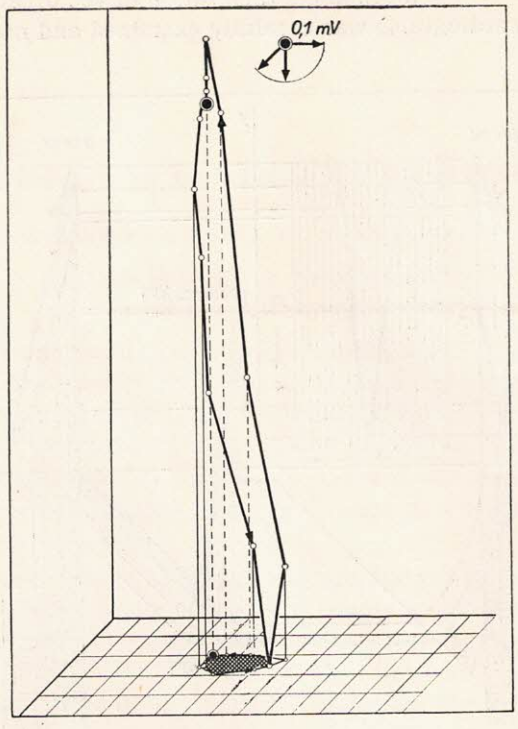

Fig. 2a.

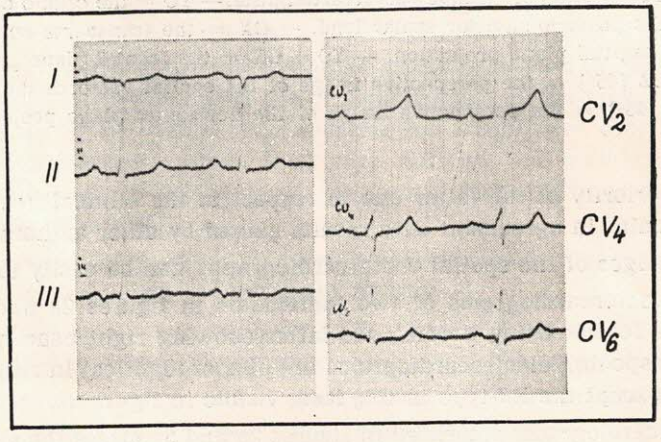

Fig. 2b.

Fig. 2. Woman, 24 years. old. — Dgn: vitium mitrale rheumaticum compensatum. — a) Normal QRS vectorcardiogram. — b) Corresponding ECG.

cardiograms in figures 4a and 5a differ essentially, one of them showing a typical left heart strain pattern, the other one, suggesting a mixed left and right heart lesion.

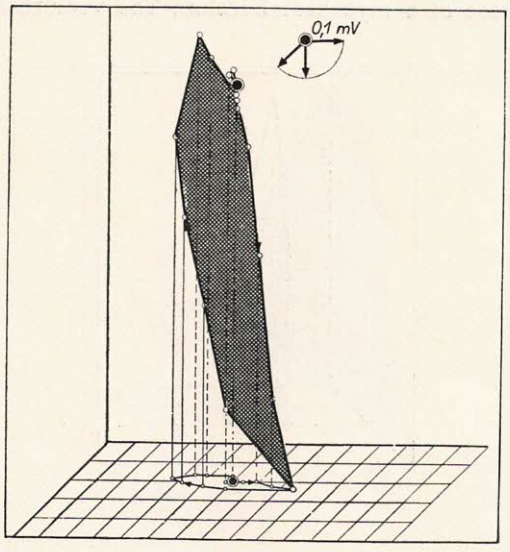

Fig. 3a.

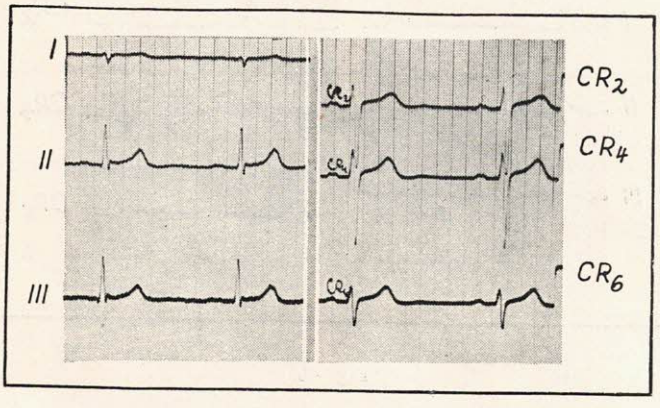

Fig. 3b.

Fig. 3. Male, 36 years old. — Dgn: emphysema pulmonum, cor pulmonale incipiens. — a) Dextrodromic QRS vectorcardiogram with inverse rotation of the vector in the horizontal projection. Note the prominent right S wave in the horizontal projection. — b) Corresponding ECG.

It is the phase shift between the sagittal and frontal components of the cardioelectric field which is chiefly responsible for the difference between both vectorcardiograms. The perspective vectorcardiogram emphasizes the significance

of the phase shift phenomenon which though known principally since 1914[16]) was mostly neglected in the routine electrocardiography.

The figures 6a and 7a demonstrate the value of vectorcardiography when observing the progress of a myocardial lesion. The vectorcardiograms concern

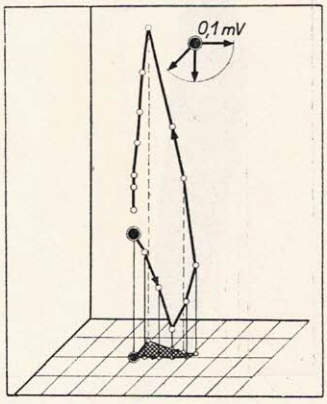

Fig. 4a.

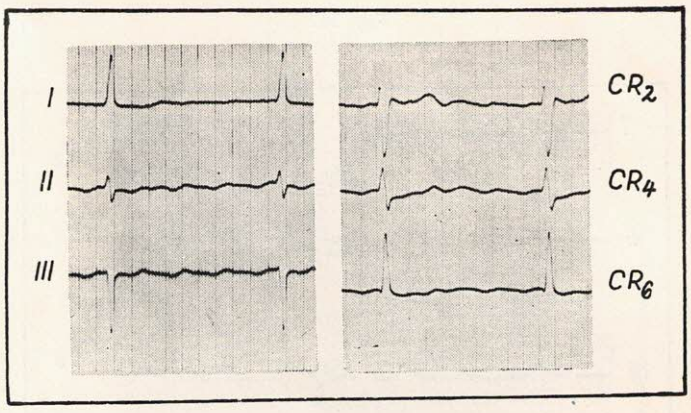

Fig. 4b.

Fig. 4. Male, 73 years old. — Dgn: arteriosclerosis universalis. — a) Levodromic QRS vectorcardiogram with prominent left S wave. — b) Corresponding ECG: fibrillatio atriorum.

a case of Eisenmenger's syndrom observed in the IInd Surgical Clinic of the Medical School in Wrocław.[2]) The lapse of time between the two examinations was 26 months.

During this time the electrocardiogram showed only some unimpressive changes in the lead II. No serious significance could be attributed to this electro-

cardiographic finding. In contrast, the vectorcardiogram entirely changed its appearance. At the first examination it exhibited the signs of the right heart strain. The second examination revealed an impressive "allodromy" indicating the progress of the myocardial lesion. The patient died soon after examination.

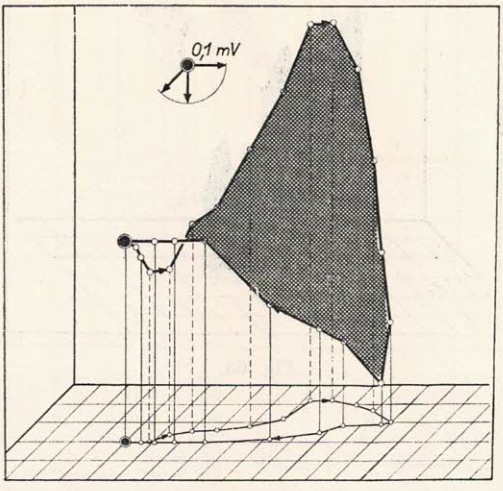

Fig. 5a.

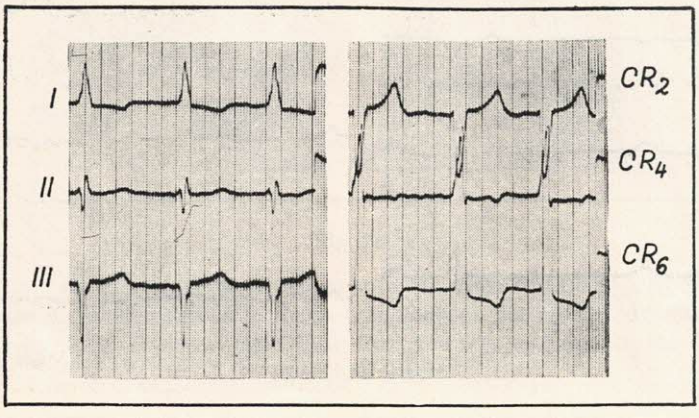

Fig. 5b.

Fig. 5. Male, 52 years old. — Dgn: arteriosclerosis universalis — a) 8 — shaped, prevalently dextrodermic, QRS vectorcardiogram with inverse rotation of the vector in the horizontal projection. Note the prominent left S wave in the spatial image of the vectocardiogram.

Fig. 5b) ECG to fig. 5a).

Owing to the perspective vectorcardiography we have gathered in a relatively short time a fair amount of information on vectorcardiograms in various pathological conditions. We feel that the spatial vectorcardiography contributes much

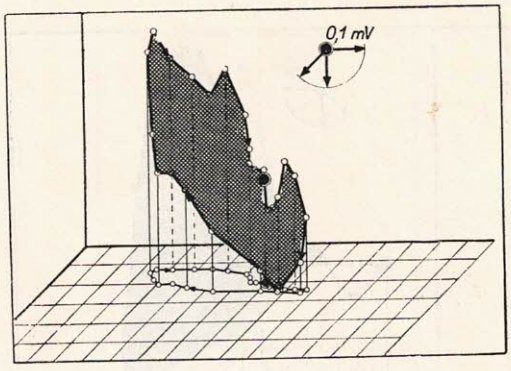

Fig. 6a.

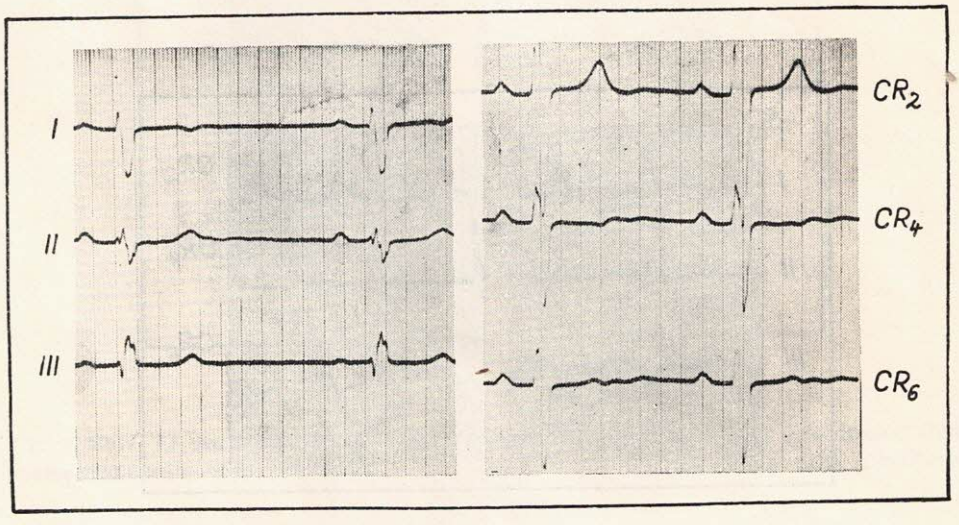

Fig. 6b.

Fig. 6. Woman, 27 years old. — Dgn: Eisenmenger's syndrom (examination in November 1953). — a) Dextrodromic QRS vectorcardiogram with inverse rotation of the vector in the horizontal plane. Note the right S wave in the spatial image of the vectorcardiogram. Fig. 6b) ECG to fig. 6a).

to cardiology. Among the available methods, the perspective presentation of the vectorcardiogram proves to be the simplest and the most effective. Independent clinical work from otherwise is consistent with our evaluation of this method.[1 6])

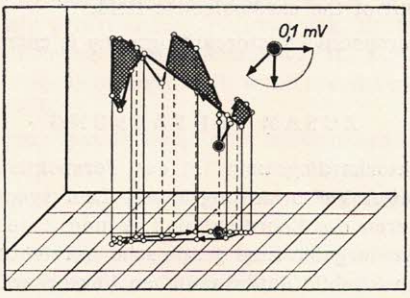

Fig. 7a.

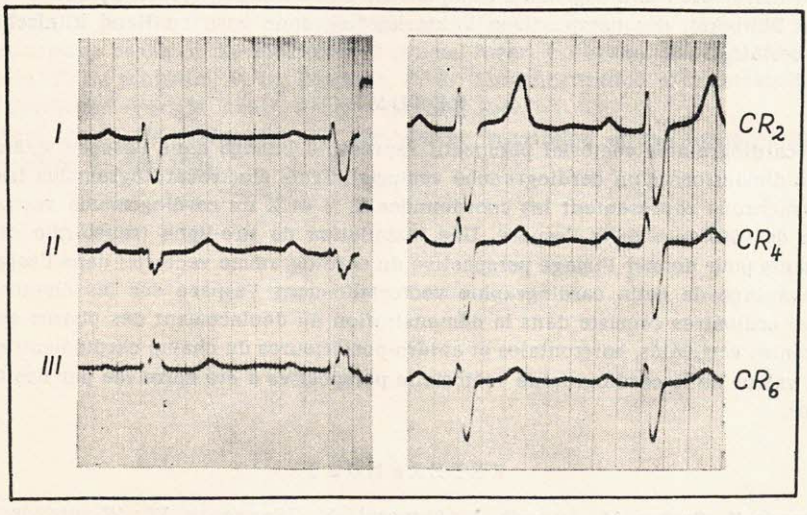

Fig. 7b.

Fig. 7. The same patient as in fig. 6 (examination in January 1956). — a) Same signs of the right heart preponderance as in fig. 6a). In addition multiple, allodromic distortions of the QRS loop. — b) Corresponding ECG. Note the slight change in the QRS complex in II limb lead.

SUMMARY

Kowarzykowie, H. and Z. (Med. School, Wrocław, Poland): *The perspective vectorcardiography.* Cor et Vasa 1 (1) : 12—21, 1959.

The perspective vectorcardiogram is the perspective image of the spatial i. e. of the three-dimensional vectorcardiogram. Three synchronously recorded electrocardiograms represent the X, Y and Z co-ordinates of the vectorcardiogram in the spatial reference

system. A drafting device transforms the three components into the perspective aspect of the spatial vectorcardiogram.

The advantages of the spatial vectorcardiography over the standard electrocardiograms consist in demonstrating the phase shift between the vertical, transversal and antero-posterior component of the cardioelectric field.

The validity of the perspective vectorcardiography is corroborated by clinical work.

ZUSAMMENFASSUNG

Das perspektive Vektorkardiogramm ist das Perspektivbild des räumlichen, das heisst des dreidimensionalen Vektorkardiogramms. Drei synchron registrierte Elektrokardiogramme repräsentieren die Koordinaten X, Y und Z des Vektorkardiogramms im System der räumlichen Wiedergabe. Eine graphische Vorrichtung transformiert die drei Komponenten in das Perspektivbild des räumlichen Vektorkardiogramms.

Die Vorteile der räumlichen Vektorkardiographie gegenüber den Standard-Elektrokardiogrammen bestehen in der Wiedergabe der Phasenverschiebung zwischen der vertikalen, transversalen und sagittalen Komponente des herzelektrischen Feldes.

Die Gültigkeit der perspektiven Vektorkardiographe wird an Hand klinischen Materials bestätigt.

RÉSUMÉ

Le cardiogramme vectoriel perspectif représente l'image dans l'espace, c.-à-d. dans les trois dimensions d'un cardiogramme vectoriel. Trois électrocardiogrammes tracés de façon synchrone représentent les coordonnées X, Y et Z du cardiogramme vectoriel du système de référence dans l'espace. Une installation de tire-ligne transforme ces trois composants pour donner l'image perspective du cardiogramme vectoriel dans l'espace.

L'avantage de cette cardiographie vectorielle dans l'espace sur les électrocardiogrammes ordinaires consiste dans la démonstration du déplacement des phases entre les composantes verticales, horizontales et antéro-postérieures du champ cardioélectrique.

La valeur de la cardiographie vectorielle perspective a été éprouvée par des travaux cliniques.

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COR et VASA — 1 (1) : 22—29, 1959

THE INFLUENCE OF SOME CIRCULATORY CHANGES UPON THE ELECTROCARDIOGRAM IN THE EXERCISE TEST

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It is a common experience that the changes of the ST-T-complex in the electrocardiographic exercise test must be cautiously evaluated. The borderline between physiological and pathological events is not sharp and there is overlapping with a broad zone of uncertain results that can be of "functional" origin.

We have been studying some factors that could produce probably non pathological changes of ST-T-complex in the exercise electrocardiogram, and on other occasions. Immediately after exercise the heart rate increases, the blood pressure changes, modifying the pressure load on the subendocardial layers of the myocardium in the course of systole.

We put the question as to whether these factors exert an influence upon the ST-depression.

For that reason the ST changes after exercise were followed in 50 persons without clinical signs of coronary insufficiency (20 normal and 30 cases of hypertensive disease). Standard leads and two chest leads (cr_4 and cr_5) were registered simultaneously with a five-channel "Elema-Clinic" electrocardiograph before, immediately after, and 1, 2, 3, 5 and 7 minutes following standard exercise. Blood pressure was also measured. We determined the degree of ST-segment depression from its original position in any lead absolutely, not only in relation to the isoelectric line. We excluded the depression caused by the auricular T-wave.

We compared the maximum change of the blood pressure, of the heart rate, and the change of the preceeding R-wave with the simultaneous depression of the ST-segment in the records immediately, or up to one minute at the most after exercise, when the ST changes were the most characteristic. The ST-depression was taken into consideration in that lead in which it was most distinct; as a rule it was in a chest lead.

A highly significant correlation was ascertained between the maximum elevation of the systolic blood pressure immediately after exercise and the ST-depression (fig. 1). A less significant correlation between the maximum depression of the ST-segment and the simultaneous elevation of systolic blood pressure was seen (fig. 2). We did not find any relation between the change of the diastolic pressure and the ST depression (fig. 3). Neither there was any correlation to

the heart rate (fig. 4) nor to the height of the preceeding R-wave. The changes of systolic blood pressure, as well as the changes of the ST-segment, were more marked with hypertensive subjects then with normal ones.

The ST depression and the rise of systolic blood pressure can be related to the effect of the increase of the intraventricular pressure load on the subendocardial layers of the myocardium. The pressure can reduce the blood supply of

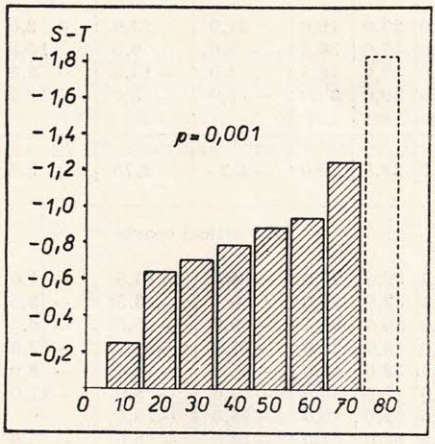

Fig. 1. Maximum increase in systolic blood pressure and S-T depression. — X-axis : systolic blood pressure (Δ mm Hg).

these layers, which as a rule is limited during systole. The subendocardial layers may become ischaemic if the rise of the systolic blood pressure is significant, even though coronary disease is not evident.

The T-wave in the exercise test will vary in height and sometimes in direction even in normal hearts. The changes will be marked two or three minutes after exercise, when the heart rate is slowing down but cardiac output is still high. The changes in this phase of the exercise test were analyzed in 25 healthy persons by the method of ventricular gradient in order to distinguish the intrinsic changes of the T-wave from the secondary ones. The direction of the gradient with regard to the QRS mean axis (so called angle delta alpha) was ascertained before and after exercise. Only the projection on the frontal plane was determined.

The 25 cases were divided into two groups according to the direction of the QRS mean axis in the exercise electrocardiogram (table I). The gradient in the 4 horizontal hearts (with an angle of the QRS axis lesser than 40 degrees) is projected to the right of the QRS mean axis, the gradient in the 21 vertical hearts is projected to the left of it as it will be with normal persons. After exercise the average direction of the ventricular gradient changes in this manner so that in vertical hearts the shift was more to the left, i. e. the gradient kept rather from the QRS mean axis, while in horizontal hearts the movement of the gradient was in the inverse direction again.

Table I. Changes of the mean heart vectors after exercise.

I. Horizontal hearts

Nr.	Age		$\alpha\hat{A}$ QRS		$\alpha\hat{G}$		$\Delta\alpha$		Shift of the gradient ($\Delta\alpha$E − $\Delta\alpha$R)	$\hat{A}_{QRS}$ $\mu Vsec$		$\hat{G}$ $\mu Vsec$	
	♂	♀	R	E	R	E	R	E		R	E	R	E
1		29	2,0	−7,0	23,0	16,0	21,0	23,0	+ 2,0	9,5	9,8	39,0	24,2
2	48		26,0	30,0	17,0	36,5	− 9,0	6,5	+15,5	11,6	8,2	35,9	27,8
3	35		43,0	32,0	39,0	18,5	− 4,0	−13,5	− 9,5	15,6	17,0	40,3	33,4
4		14	56,0	38,0	39,0	33,0	−17,0	− 5,0	+12,0	10,7	12,2	53,6	38,6
∅	31,5		31,7	23,2	29,5	26,0	− 2,25	2,75	+ 5,0	11,8	11,8	42,2	73,2

II. Vertical hearts

5	36		44,5	40,5	30,0	25,0	−14,5	−15,5	− 1,0	17,8	22,6	58,1	45,5
6	32		33,0	41,5	33,0	38,0	0	− 3,5	− 3,5	20,2	10,6	58,8	27,0
7	13		48,0	42,0	39,0	26,5	− 9,0	−15,5	− 6,5	25,0	22,9	51,1	39,6
8		11	63,0	53,0	46,0	29,0	−17,0	−24,0	− 7,0	6,6	8,4	22,5	21,7
9		26	62,5	63,5	52,0	45,0	−10,5	−18,5	− 8,0	23,8	30,6	45,6	26,1
10	14		44,0	66,0	47,0	58,0	+ 3,0	− 8,0	−11,0	13,6	22,3	69,0	73,0
11	10		70,5	67,5	52,0	49,0	−18,5	−18,5	0	12,0	12,3	51,9	40,1
12	15		77,0	72,0	62,0	54,0	−15,0	−18,0	− 3,0	21,4	21,6	69,2	71,7
13		31	70,5	73,0	68,0	71,5	− 2,5	− 1,5	+ 1,0	34,0	31,5	54,0	39,2
14	15		62,0	74,0	41,0	44,0	−21,0	−30,0	− 9,0	17,3	15,3	62,2	56,5
15		17	71,0	74,0	61,0	55,0	−10,0	−19,0	− 9,0	19,2	14,9	50,2	29,7
16	29		66,5	75,0	53,5	54,5	−13,0	−20,5	− 7,5	27,2	34,6	48,2	37,0
17	10		74,5	75,0	46,0	56,0	−28,5	−19,0	+ 9,5	10,7	13,6	36,9	35,8
18		17	81,0	75,5	73,0	69,5	− 8,0	− 6,0	+ 2,0	39,2	38,2	63,6	67,0
19		51	57,0	78,0	36,0	44,0	−21,0	−34,0	−13,0	21,2	31,2	24,8	26,5
20	26		73,5	78,0	57,5	69,0	−16,0	− 9,0	+ 7,0	49,6	37,6	85,0	62,2
21	11		80,0	82,0	57,0	54,0	−23,0	−28,0	− 5,0	20,6	22,8	51,2	36,1
22	13		76,0	85,0	62,0	74,5	−14,0	−10,5	+ 3,5	15,8	12,9	43,4	35,3
23	37		80,0	87,0	54,0	32,5	−26,0	−54,5	−28,5	31,4	22,1	44,7	15,7
24		11	82,0	87,5	46,5	38,0	−35,5	−49,5	−14,0	27,0	19,6	36,1	35,3
25	25		94,0	101,0	67,0	68,5	−27,0	−32,5	− 5,5	31,2	27,5	57,2	32,6
∅	23,2		67,1	71,0	51,6	20,2	−15,5	−20,7	− 5,2	23,1	22,5	51,6	40,6

Note: R = before exercise, E = after exercise, + = clockwise, − = counterclockwise.

A similar phenomenon with the ventricular gradient was observed in healthy people after injection of epinephrine (table II). Here also the ventricular gradient was shifted markedly to the left from the QRS mean axis (it rotated counterclockwise). At the same time the transverse diameter of the heart grew smaller. The reverse occured after injection of sympathicoplegics (dihydroergotamine or hydergine) in patients suffering from hyperkinetic circulatory syndrome on the basis of emotional instability (table III). The transverse diameter of the heart after dihydroergotamine increased, while the ventricular gradient kept farther to the right.

Table II.

	Number of cases	Tr.*) (cm)	$\Delta\alpha\ (\alpha\hat{G}-\alpha\hat{A}_{QRS})$ before epinephrine	$\Delta\alpha\ (\alpha\hat{G}-\alpha\hat{A}_{QRS})$ after epinephrine	Shift of the gradient after epinephrine
Horizontal hearts	5	−0,54	+28,8°	+46,6°	+17,8°
Vertical hearts	10	−0,71	−13,3°	−28,6°	−15,3°

The modification of gradient direction after adrenaline and the opposite change after dihydroergotamine cannot be interpreted by an altered position of the heart within the chest, since the position of the heart was not modified after the injection of the drugs. In the exercise test, however, the electrocardiographic

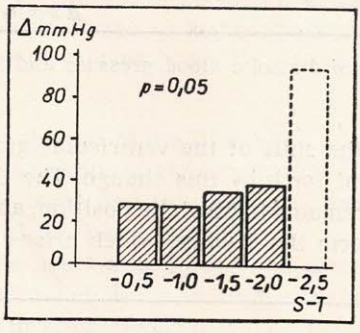

Fig. 2. Maximum S-T depression and the change of the systolic blood pressure.

position of the heart changed a little. The gradient moved in the opposite direction than the QRS mean vector. Such a rotation of the gradient could be brought about by the rotation of the heart along its longitudinal axis, but the resemblance between the exercise changes and those after application of epinephrine points to another mechanism, probably like that after epinephrine.

The electrocardiographic changes after sympathicomimetic drugs were most marked in small hearts and were accompanied by a change in heart size in the

Table III.

The average shift of the ventricular gradient in the frontal projection after sympathicoplegics.

	Number of cases	$\Delta\alpha\ (\alpha\hat{G}-\alpha\hat{A}_{QRS})$ before sympathicoplegics	$\Delta\alpha\ (\alpha\hat{G}-\alpha\hat{A}_{QRS})$ after sympathicoplegics	Shift of the gradient after sympathicoplegics
Vertical hearts	10**)	−33,8°	−19,3°	+14,5°
Horizontal hearts	0	—	—	—

*) Change of the transversal diameter of the heart.

**) Average increase of the transversal diameter of the heart + 1,3 cm.

frontal orthographic projection. The smaller the heart, systolic output being the same or even greater, the greater is the diminution of its size during systole and the more marked is the change from the diastolic to the systolic position of the

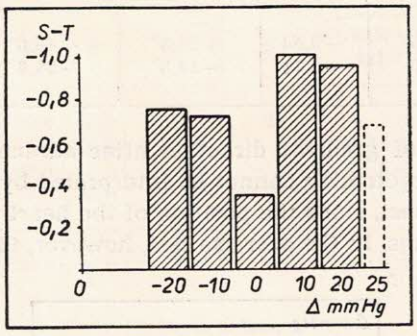

Fig. 3. Change of diastolic blood pressure and S-T depression.

heart. We presume that the shift of the ventricular gradient with regard to the QRS axis might be brought forth by this change. The QRS-complex is registered at a time when the heart remains in diastolic position, and is influenced by cardiac contraction differently form the T-wave, which arises during maximum systolic

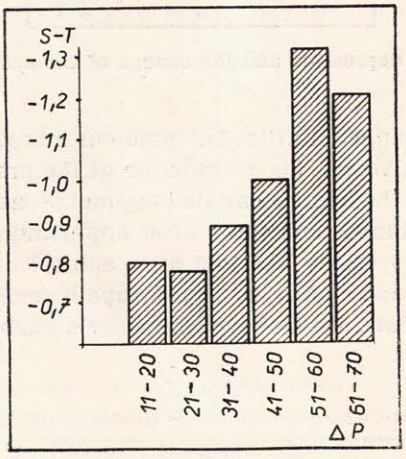

Fig. 4. Maximum increase of heart rate and S-T depression.

deformation of the ventricles. The same accounts for the conduct of the ventricular gradient.

The systolic movement of the ventricles is set by the course of the myocardial muscle fibres, in the first place of the superficial muscles, which are spiral-shaped (fig. 5). If the heart is fixed to the origin of great vessels, it is being

counterclockwise rotated during systole and the apex is lifted. Such a movement would explain the shifting of the gradient to the left absolutely as well as relatively with regard to the QRS mean axis, at least in vertical hearts. The systolic movement of the heart might therefore be a reason for the position of

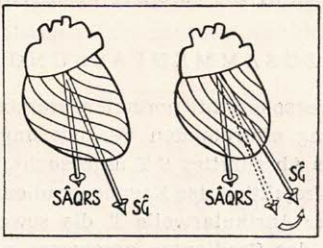

Fig. 5. Shift of the ventricular gradient in the frontal projection after the injection of epinephrine. — Left - before epinephrine. — Right - after epinephrine. — The gradient is shifted counterclockwise after epinephrine. The size of the heart is diminished.

the ventricular gradient to the left of the QRS mean axis in the frontal projection in vertical hearts, and of its continued movement to the left whenever the systolic blood volume is relatively large and the heart not enlarged, i. e. whenever the systolic residual volume of the heart is small.

We did not follow the heart size during and after the exercise test, but it is a well known fact (from Reindell's work for instance) that the heart size diminishes after exercise in the recovery period.

In conclusion, some changes of the ST-T-complex of the electrocardiogram may originate from the instantaneous circulatory conditions. Consequently they may be an physiological event that can simulate pathological conditions or appear simultaneously with them.

SUMMARY

Herles, F., Jarošová, V., Jedlička, J. (Second Med. Clin., Charles' Univ., Prague): *The influence of some circulatory changes upon the electrocardiogram in the exercise test.* Cor et Vasa 1 (1) : 22—29, 1959.

In a group of 50 persons with normal hearts the influence on the S-T segment of blood pressure and pulse frequency changes after exercise was examined. The change of ventricular gradient in the frontal projection was ascertained in 25 persons. Curves with a marked auricular T-wave, making the localization of S-T segment and the determination of the gradient difficult, were not employed. It was ascertained that depression of the S-T segment after exercise is connected with the change of systolic blood pressure, and that it does not significantly depend on the diastolic pressure or on the change of pulse frequency. The greatest depression takes place in persons with high blood pressure, who also show the greatest rise of systolic blood pressure after exercise. The average direction of the ventricular gradient changes after exercise in vertical hearts more to the left from the QRS mean axis, i. e. it rotates counterclockwise. In horizontal hearts the shift was in the inverse direction. A similar change was earlier observed after epinephrine, with simultaneous reduction of the transverse diameter of the heart. The

author supposes that the depression of the S-T segment after exercise results as a consequence of the rise of intraventricular pressure and of physiological ischemia of subendocardial layers of the myocardium during systole. The shift of ventricular gradient may be in connection with the change of the position of ventricles during the systole. These mechanisms should be taken into consideration in distinguishing functional changes of the ECG from those produced by the coronary insufficiency.

ZUSAMMENFASSUNG

In einer Gruppe von 50 Personen mit normalem Herzbefund wurde der Einfluss der nach körperlicher Anstrengung eintretenden Veränderungen des Blutdruckes und der Pulsfrequenz auf die Lage des Abschnittes S-T untersucht. Bei 25 der Versuchspersonen wurde eine Veränderung der Projektion des Kammergradienten auf die Frontalebene festgestellt. Kurven mit deutlicher Aurikularwelle T, die sowohl die Bestimmung der Lage des Sektors S-T als auch die des Gradienten erschwert, wurden nicht ausgewertet. Es wurde festgestellt, dass die Senkung des Abschnittes S-T nach körperlicher Anstrengung mit der Veränderung des systolischen Druckes zusammenhängt, jedoch weder auf den diastolischen Druck noch auf die Änderungen der Pulsfrequenz in eindeutiger Beziehung steht. Die grösste Senkung trat bei Personen mit höherem Blutdruck ein, bei denen auch der systolische Druck nach Anstrengung am meisten anstieg. Der Kammergradient wird bei vertikalen Herzen im Durchschnitt weiter links von der QRS-Achse projiziert, d. h. er dreht sich etwas in der Uhrzeigerrichtung entgegenlaufendem Sinne ab. Bei horizontalen Herzen tritt die Verschiebung in entgegengesetztem Sinne ein. Eine ähnliche Veränderung konnte bereits früher nach Adrenalinverabreichung bei gleichzeitiger Verkleinerung des transversalen Herzdurchmessers festgestellt werden. Es wird die Vermutung ausgesprochen, dass die Senkung des Abschnittes S-T nach körperlicher Anstrengung eine Wirkung der Erhöhung des intraventrikularen Druckes und der physiologischen Ischemisation der subendokardialen Schichten des Myokardes während der Systole darstelle. Die Verschiebung des Kammergradienten kann mit der Lageveränderung der Herzkammern während der Systole zusammenhängen. Man muss diese Mechanismen in Betracht ziehen, wenn es sich um eine Unterscheidung der funktionellen Änderungen des EKG von den durch Koronarinsuffizienz hervorgerufenen handelt.

RÉSUMÉ

L'influence des changements de la tension sanguine et de la fréquence du pouls sur la position du secteur S-T, après un effort physique, a été étudiée dans un groupe de 50 sujets à fonction cardiaque normale. Chez 25 de ces sujets, un changement de la projection du gradient ventriculaire sur le plan frontal fut constaté. Les courbes avec un onde auriculaire T perceptible, ce qui rend difficile aussi bien la détermination du secteur S-T que celle du gradient, ont été éliminées. On a pu constater que l'abaissement du secteur S-T après un effort physique est en rapport avec le changement de la tension systolique et qu'il ne dépend pas, d'une façon significative, ni de la tension diastolique ni de la fréquence du pouls. L'abaissement le plus important a lieu chez les hypertendus, chez lesquels — après un effort physique — la tension systolique elle-aussi présente l'augmentation la plus forte. Après un effort physique, la projection du gradient ventriculaire se déplace plus vers le côté gauche de l'axe QRS chez des coeurs verticaux, c.-à-d. qu'il tourne légèrement en sens inverse aux aiguilles de la montre. Chez des coeurs horizontaux, le déplacement a lieu en sens nverse. Un changement semblable avec rétrécissement simultané du diamètre transversal du coeur avait déjà pu être observé antérieure-

ment, après application de l'adrénaline. Les auteurs discutent l'hypothèse que l'abbaissement du secteur S-T pourrait être provoqué par l'augmentation de la pression intra-ventriculaire et l'ischémie physiologique des couches sub-endocardiques du myocarde au cours de la systole. Le déplacement du gradient ventriculaire peut être en rapport avec le changement de la position des ventricules pendant la contraction systolique. Il faut tenir compte de ces mécanismes lors du discernement des changements dits fonctionels de l'ECG des changements produits par l'insuffisance coronaire.

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THE BALLISTOCARDIOGRAM IN HYPERTENSIVE DISEASE

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By the present investigation we aimed at the elucidation of the ballistocardiographic curves in hypertensive disease. We have examined 120 hypertensive patients (70 women, 50 men), among them:

5	aged	up to	20	years
5	„	„	21—30	„
16	„	„	31—40	„
42	„	„	41—50	„
37	„	„	51—60	„
15	„	over	60	„

As to the stages of their disease 33 patients were in the functional stage, 55 in the initial organic and 32 in the advanced organic stage.

We used a direct longitudinal horizontal electromagnetic ballistocardiograph, constructed according to the principle of Dock-Mandelbaum. Ballistocardiograms were taken, when patients were breathing gently. In reading the curves Brown's classification has been adopted. The duration both of the systolic waves H, I, J, K and of the whole systolic complex H—K has been measured in one part of the patients. Also the beginning of the single waves of the ballistocardiogram after the R-deflection of the electrocardiogram was noted. Ballistocardiographic indices (B. I.) I, J_{min} /I, J_{max} and I, J_{min} /JK_{max} of the same patients were computed.

Among the examined 120 patients we found

36	(= 30 %)	showing	fully	normal	ballistocardiographic curves
5	(= 4 %)	showing	1st	grade	pathologically altered curves,
10	(= 8 %)	showing	2nd	„	„ „ „
32	(= 26.6 %)	showing	3rd	„	„ „ „
37	(= 30.83 %)	showing	4th	„	„ „ „

The relation of the stage of hypertensive disease to the changes of ballistocardiograms is shown in the table I.

In the functional stage of the hypertensive disease the ballistocardiogram of half the patients is fully normal; one-third of them shows however patho-

*) In collaboration with S. Tomov, I. Krushkov et al.

Table I.

Distribution of Brown's grades in dependence on the stage of the hypertensive disease

Stage of the hypertensive disease	Number of patients	Grades of ballistocardiograms according to Brown's classification				
		zero	Ist	IInd	IIIrd	IVth
Functional stage	33	17	1	4	6	5
Initial organic stage	55	17	2	4	18	14
Advanced organic stage	32	2	2	2	8	18

logic changes of the 3rd and 4th grade. Among the patients in the advanced organic stage there are only two of the zero grade against 26 (81.25 %) of the 3rd and 4th grade. On the contrary, in an initial organic stage one can see ballistocardiographic curves as well of the zero grade (30.9 %) as of a trifling or more advanced pathological changes. However, even in such cases the pathological curves are prevailing: 32 (58.1 %) of 55 patients are of the 3rd and 4th grade of pathological deterioration (fig. 1).

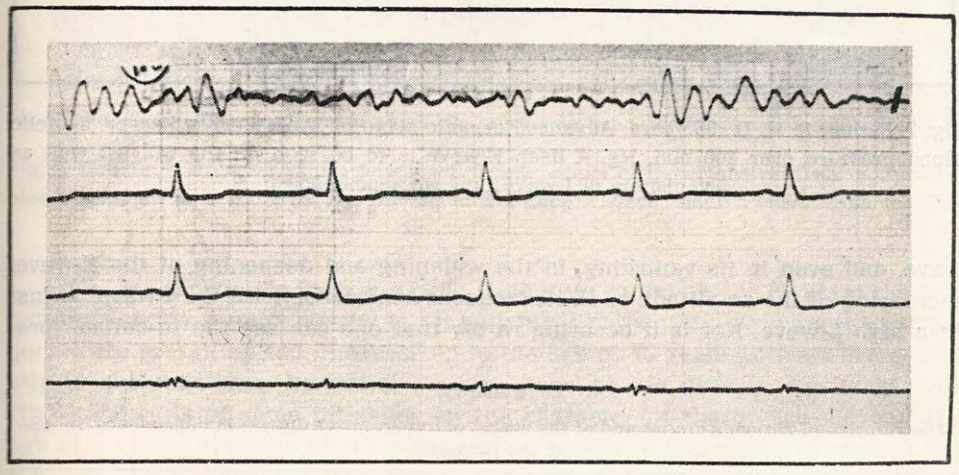

Fig. 1. Patient B. P. V., 52 years: Initial organic stage of hypertensive disease. Systolic blood pressure over 200 mm. Hg. Ballistocardiogram of the 3rd grade according to Brown's classification. In the expiratory phase the waves show decreasing amplitude and cannot be discerned. During the inspiration they appear again.

One can summarize from these data that there is a close relation between the stage of the hypertensive disease and the grade of the pathological change in the ballistocardiogram. As the stage of the disease is advancing, the rate of the pathological curves as well as the grade of the pathological changes are in-

creasing progressively. Tabeau, who investigated the ballistocardiograms of 157 hypertensive patients, found the same data.

Besides the general character of the curve, the form and the amplitude of the single waves are changing too. The changes appear in a rather shallow 1st

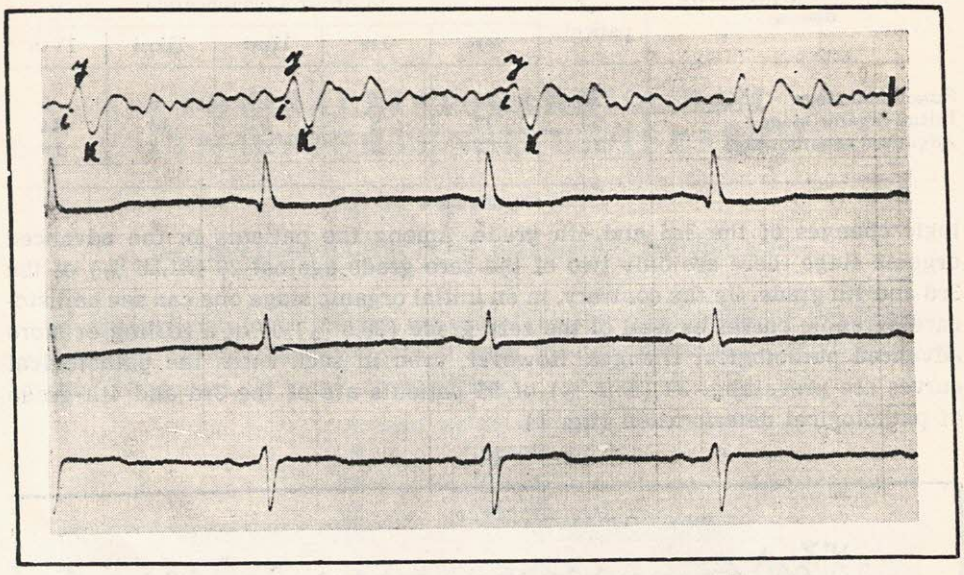

Fig. 2. Patient S. M. D., 65 years: Advanced organic stage of hypertensive disease. Systolic blood pressure over 200 mm. Hg. A deep K-wave is to be seen on the BCG as well as vanishing of I-wave; low wave-complexes.

wave, and even in its vanishing, in the widening and deepening of the K-wave, increasing of the amplitude of H, its frequent confluence with the J-wave, at last in a high L-wave. Nor is it occuring rarely that one can see the so-called "pre-

Table II.

Distribution of Brown's grades and of the stages of hypertensive disease in dependence on age of the patients

Age	Number of patients	Stage of hypertensive disease			Brown's grades of ballistocardiogram				
		functional	organic		zero	I	II	III	IV
			initial	advanced					
11—20 y.	5	5	—	—	5	—	—	—	—
21—30 y.	5	4	1	—	5	—	—	—	—
31—40 y.	16	4	11	1	10	1	—	4	1
41—50 y.	42	11	19	12	8	3	7	9	15
51—60 y.	37	8	15	14	7	1	3	10	16
over 60 y.	15	1	9	5	1	—	—	9	5

mature M". Also ballistocardiograms showing low complexes are often to be seen. In 34 patients we found a shallow first wave or it was none at all. A deep and widened K-wave or only widened was to be seen in 34 patients too, a high L-wave in 11, a premature M-form likewise in 11 patients (fig. 2, 3, and 4).

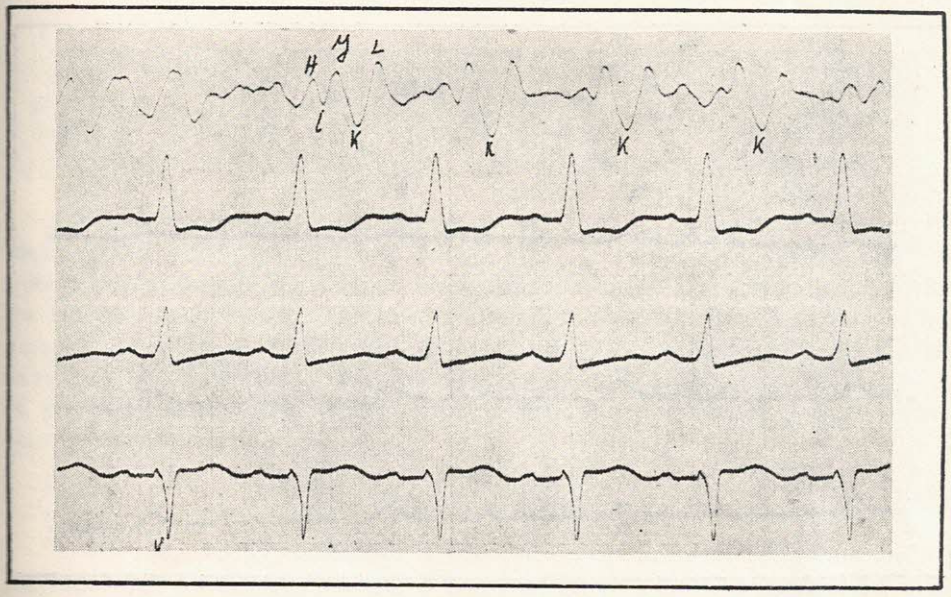

Fig. 3. Patient P. G. V., 42 years: Advanced organic stage of hypertensive disease. Systolic blood pressure over 240 mm. Hg. On the BCG a deep K-wave, small I-wave, high L-wave.

One can summarize from the table II. that up to the age of 30 years the ballistocardiogram is quite normal in all patients. Between 31—40 years the normal curves are prevailing too. However up to the age of 40 years patients are generally in the functional or initial organic stage of the disease. No doubt, this circumstance is of some influence on the character of the curves. Beyond the age of 40 years the rate of the pathological curves is increasing progressively: it makes 73.8 % from 41—50 years, 78.3 % between 51 and 60 years, at last 93.3 % over 60 years.

The importance of the age is striking in the group of patients of the mere functional stage of disease: up to the age of 40 years they all have a fully normal ballistocardiogram, but over this age 15 (75 %) of 20 patients show pathological changes of the same, and only 5 have the zero grade.

According to the changes in their electrocardiograms patients were put into three groups, viz.: 1. indifferent type of electrocardiogram — 12 patients, 2. showing a deviation of the electric heart axis to the left — 43 patients, 3. with strain of the left heart — 65 patients.

Ad 1. Among the 12 patients of this group there were only 3 showing a ballistocardiogram of the 3rd grade, the other 9 having a fully normal one.

Ad 2. About 39,6 % of the ballistocardiographic curves proved to be normal in this group, whilst the remaining 60 % are equally distributed among the 2nd, 3rd, and 4th grade of ballistocardiograms.

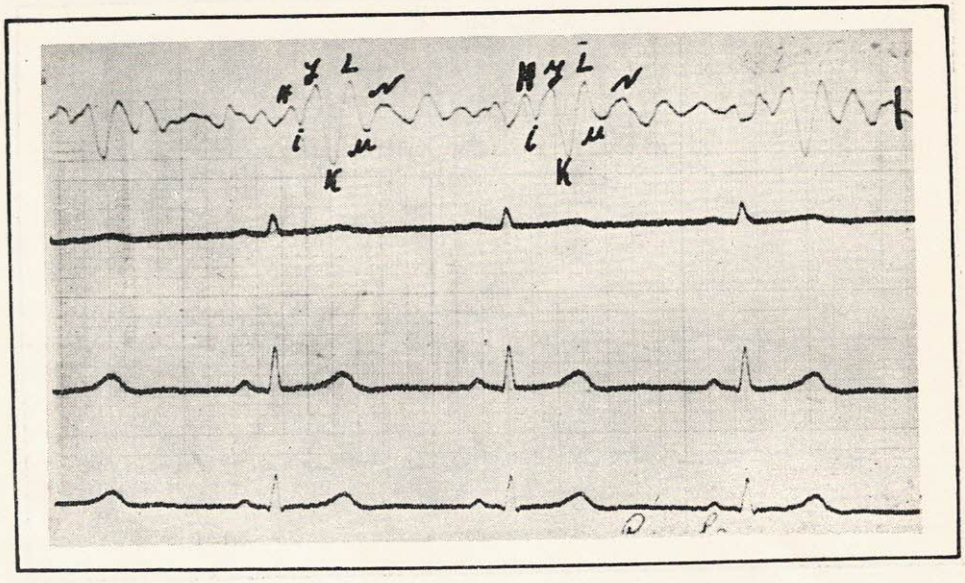

Fig. 4. Patient S. K. P., 60 years: Initial organic stage. Systolic blood pressure up to 200 mm. Hg. On the BCG a small I-wave, deep K-wave, confluence of H with J („premature M"), a high L-wave.

Ad 3. In this group only 15 % of the curves are normal ones, approximately 75 % belong to the 3rd or 4th grade, and 10 % to the first or second grade.

These data suggest that there is some parallelism between the changes of the ballistocardiogram and those of the electrocardiogram. On the other hand it is remarkable that the electrocardiogram is still unchanged in a considerable number of patients, though their ballistocardiograms have altered already. For example among the patients of the 2nd group, where the electrocardiogram shows a deviation of the electric axis of the heart to the left, the ballistocardiograms of the majority of the patients (60 %) proved to be of the 2nd, 3rd, or even of the 4th grade. This is due probably to the greater sensitiveness of the ballistocardiographic method. Other authors too called special attention to this fact.

In 21 patients of the zero grade BCG the duration of the systolic waves and of the complex H-K has been measured. Comparing the results of these measurements with those in healthy persons, one can ascertain that in hypertensive patients the duration of BCG-waves (except for the K-wave) is subject to larger variability both, in respect of the top limit as well as of the lowest one (Table III).

Table III. Duration of the systolic waves in healthy persons and in hypertensive patients.

BCG waves	Duration in seconds		Beginning beyond the deflection of the electrocardiogram	
	1. healthy persons	2. hypertensive persons	1. in healthy persons	2. in hypertensive persons
H	0.06—0.010	0.03—0.09	0.00—0.02″	0.00—0.02″
I	0.06—0.10	0.03—0.12	0.04—0.08″	0.06—0.08″
	0.09—0.15	0.07—0.16	0.09—0.13″	0.10—0.12″
K	0.14—0.20	0.14—0.24	0.14—0.20″	0.13—0.18″
H—K	0.23—0.38	0.24—0.42		

The ballistocardiographic index (B. I.) IJ_{min} /IJ_{max} is oscillating within the limits of 0.50—1.00, whilst the B. I. IJ_{min} /JK_{max} remains within the limits of 0.35—0.69. In healthy persons we have measured 0.47—1.00 respectively, whilst for the second 0.44—0.92. The lower rates of the second index in hypertensive patients are due to the increased amplitude of the K-wave. No peculiar differences in respect of the beginning of systolic waves on the BCG beyond the R deflection of the electrocardiogram could be ascertained in hypertensive patients, when compared with healthy persons.

CONCLUSIONS

1. The most frequent changes of the BCG curves in hypertensive disease are the following: a deep and widened K-wave, a shallow I-wave or none at all, more rarely a high H-wave, confluence of the same with the J-wave, a high L-wave, sometimes the so-called "premature M", low wave complexes, increased respiratory oscillations of wave amplitudes.

2. The ballistocardiograms which we have examined show that there is some relation between the hypertensive disease and the pathological changes of the BCG.

3. In all hypertensive patients up to the age of 30 years the ballistocardiograms proved to be fully normal (zero grade). As age advances, the rate of the pathological curves increases progressively.

4. Our material gives no definitive answer if there is any BCG-curve significative of hypertensive disease, though a deep and widened K-wave and a shallow I-wave are to be seen more frequently.

5. There is some parallelism between the changes of the BCG and those of the ECG too.

6. The BCG index IJ_{min} /JK_{max} shows low rates due to the increased amplitude of the K-wave.

7. The duration of the systolic waves H, I, J, and of the systolic complex H-K shows larger variability, when compared with healthy persons; on the contrary, the K-wave shows increased rates. The same waves offer no peculiar deviations in respect of their beginning beyond the R-deflection of the ECG.

SUMMARY

Malamov, E. (Ther. Clinic, High Med. Inst., Sofia, Bulg.): *The ballistocardiogram in hypertensive disease.* Cor et Vasa 1 (1) : 30—37, 1959.

120 hypertonics (70 male, 50 female) were examined with the aid of the Dock-Mandelbaum ballistocardiograph. An increase in the incidence pathological patterns was observed in advanced age and in advanced stages of the disease. A certain parallelism between ECG and BCG was found. The IJ_{min} /JK_{max} - index in hypertonics was smaller because of the larger amplitudes of the K-wave. The most frequently occuring alterations of the BCG in hypertension were: deep and widened K-wave, shallow or missing I-wave confluencing with the J-wave and a high L-wave. Sometimes there was the so-called "premature M". There were low wave complexes and increased respiratory oscillations of the wave amplitudes.

ZUSAMMENFASSUNG

Der Verfasser untersuchte 120 Patienten mit Hochdruckkrankheit (70 Frauen und 50 Männer) mit Hilfe des Ballistokardiographen (System Dock und Mandelbaum). Die Inzidenz pathologischer Kurven stieg mit dem Alter und dem Krankheitsstadium. Ein bestimmter Parallelismus zwischen dem Elektrokardiogramm und dem Ballistokardiogramm konnte festgestellt werden. Der Index IJ min/JK max war bei den Hypertonikern kleiner wegen der höheren Amplitude der Welle K. Die am häufigsten vorkommenden Veränderungen des Ballistokardiogramms bei Hochdruckkrankheit waren: eine tiefe und breite Welle K, eine flache oder fehlende Welle I, die mit der Welle J zusammenfiel, eine hohe Welle L; manchmal trat ein sogenanntes „vorzeitiges M" auf. Niedrige Wellenkomplexe, erhöhte Respirationsveränderungen der Wellenamplituden.

RÉSUMÉ

L'auteur a examiné 120 malades (70 femmes et 50 hommes) à l'aide du balistocardiographe du système de Dock et Mandelbaum. La fréquence des tracés pathologiques a augmenté avec l'âge et la stade de la maladie. L'auteur a constaté un certain rapport entre l'ecg et le bcg. L'index IJ min./JK max. était plus petit chez les hypertendus, étant donné l'amplitude élevée de l'onde K. Les changements les plus fréquents étaient: l'onde K profonde et large, l'onde I plate ou disparue ou bien jointe à l'onde J, l'onde L haute, parfois londe M „prématurée", les complexes bas et les changements des amplitudes dépendant de la respiration.

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COR et VASA — 1 (1) : 38—46, 1959

INCREASED TRANSLUCENCY OF ONE LUNG AS A SIGN OF PULMONARY VASCULAR ANOMALIES

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In the literature of these last years we find a fairly substantial number of cases with various respiratory complaints, the only common feature of which is the increased transparency of one lung on the X-ray picture; the vascular pattern is diminished on this side without any further alteration of the pulmonary parenchyma. Some authors consider this phenomenon as a basis for an individual syndrome, designated by different names, such as "abnormal transradiancy of one lung" (Macleod), "unilateral emphysema" (Dornhorst et al., Levina), "einseitige helle Lunge" (Teschendorf). According to Uehlinger, it is closely related to the syndrome known under the names of "vanishing lung" (Burke), "idiopathic atrophy" (de Martini) or "progressive dystrophy of the lungs" (Heilmeyer and Schmid). There seems to be a tendency to create a new nosological category and due to the over-estimated radiological picture basically different clinical and pathological entities are mixed up. Thus, valuable and important observations may lead rather to confusion and pathological pseudo-entities, instead of a well-founded anatomical and functional diagnosis. In order to prevent this course of events we would like to try to reconsider systematically the problems involved.

Laur and Wedler, who reported the greatest number of such cases, already pointed out that different kinds of pathological events — inflammation, tumours, congenital malformation and circulatory disorders — may equally lead to increased translucency of one lung. It is advisable to distinguish acquired and congenital forms, as the first may be followed through the course of its development, while the picture of the second remains almost unchanged throughout life.

In the first group we mention only those inflammations and tumours, which cause alterations in the structure of one lung, by amputating and compressing its bronchi and vessels; the primary pathological process being invariably demonstrable with more or less difficulty. Increased transradiancy of the affected side is the rule, though contralateral compensating emhysema may be present exceptionally (Fig. 1.). Less easy to recognise is the syndrome of "vanishing lung" which usually affects only isolated lobes, sometimes, however, it affects one

entire lung. The origin of this slowly progressive disease is unknown. In the course of the reduction of the parenchyma large cavities, with paper-like walls, are gradually formed. Some authors attribute it to an inflation of the lung by bronchial ventilator-mechanism — like those producing bullous emphysema. According to others it is the result of tissue destruction due to endarteritic processes. Neither of these hypotheses are substantially supported by the rather scanty post mortem findings. Diagnosis may be based on the progression, on gradually developing confluent alterations in the lung and on the peculiarity of the X-ray picture, first pointed out by Heilmeyer. This is characterized — in contradistinction to the congenital types to be discussed below — by a knob-like voluminous hilar shadow protruding into the translucent lung-field.

Among the congenital anomalies the differentiation of the big "balloon cysts" is fairly easy (Kartagener). The X-ray picture may show, especially in advanced cases, increased transradiancy of the entire hemithorax and the disappearence of the normal pulmonary structure; however, the widening of the intercostal spaces, the low diaphragm, deviation of the mediastinum towards the healthy side are valuable signs of overdistention by an expansive process. Differentiation from bullous emphysema hardly presents any difficulty if the age of the patient as well as the stationary or progressive nature of the process are taken in consideration. Unilateral transradiancy is not infrequently produced by another congenital anomaly, the absence of a main branch of the pulmonary artery.

Though described by Fräntzel as early as 90 years ago, the literature contains but a few cases diagnosed only at autopsy, up to the most recent years (Lavel, Doering, Müller). On the basis of the peculiar X-ray picture Madoff et al. succeeded first in establishing this diagnosis in vivo, the total number of cases described amounting to about 50 (Emanuel and Pattinson, Scheiderman, Elder et al.). One lung is supplied with blood only from the aorta — via bronchial arteries or additional systemic branches — the X-ray shows reduced vascular markings and increased transparency. Vascularisation on both sides was equal, however, in some cases (Caro et al., Bartel), the unaffected lung was even more translucent in another case (Derrick and Howard). The involved hemithorax is narrowed in many cases (Flynn et al.), the mediastinum deviated to this side (Smart and Pattinson). The clinical picture depends mainly on whether the lack of the pulmonary artery is accompanied by other congenital malformations or not. In about 25 % of the cases this malformation is isolated; these cases are characterized mostly by the absence of the right main branch. Agenesia of the left main branch is usually associated with other cardiac anomalies (Schneiderman): tetralogy of Fallot (Nádas et al., McKim and Wiglesworth, Emanuel and Pattinson), Eisenmenger's syndrome (Reisch and Themel, Steinberg), anomalies of the aorta: dextroposition, ductus Botalli apertus (Steinberg, Caro et al., McKim). In some cases bronchiectasis could be demonstrated on the otherwise normal bronchograms (Steinberg). The ventilation remains unaffected, oxygen uptake of the involved lung is, however, negligible — the intrapulmonary vascular system being intact, but supplied with arterial blood from the aorta, due to the lack of the central part of the main branch (McKim). Unequivocal haemodynamical changes have not been demonstrated in the few cases investigated up to now; the catherer could evidently not be introduced into the pulmonal artery on the involved side; right ventricular and pulmonary artery pressures were normal or increased (Steinberg et al., Caro et al., Flynn et al., Wyman, Dolmer et al., Anderson et al.). Cardiac catheterization gives

only negative results and its diagnostic value is slight. Angiocardiography on the other hand is a most efficient diagnostic tool as proven first by Steinberg et al., who succeeded in demonstrating this anomaly with its aid. Numerous authors have since reported on the reproduction of the typical picture; absence of one main branches of the pulmonary artery and opacification of the intrapulmonary vessels following aortic filling. Schneiderman points out that the abnormal artery originating from the aorta must be demonstrated in every case; this has in itself, however, no absolute diagnostic value, as similar pulmonary branches of the aorta may be present occasionally in cases where the pulmonary artery is normally developed (Findlay and Maier). Functionally this anomaly has the same effect as pneumonectomy: respiration is not substantially diminished as long as the other lung remains intact. Medical treatment is needed only in the rather frequent cases complicated by haemoptysis from the dilated bronchial arteries or from the concomitant bronchiectasiae (Steinberg). Another clinically and radiologically very similar anomaly of the pulmonary vascular system, which is hardly mentioned in the literature (Hornykiewytsch), may also lead to bronchiectasis and haemoptysis: this is the stenosis of one of the main branches of the pulmonary artery. Described first 150 years ago (Maugars), its literature is extremely poor. Two cases of Grosse-Brockhoff et al., the fourth case of Gyllenswärd et al., and the second case of Vermillion et al., where asymmetric main branches and Wood's case in which an additional aortopulmonic fistula was associated with the stenosis of the pulmonary orifice, do not belong immediately to this group. In addition to the child reported 80 years ago by Kessler, Maier reported one, Elder two such cases. Two cases were briefly mentioned during a discussion by Waterman and a further one by Smith.

This scanty material — where functional alterations and the possibility of in vivo diagnosis are hardly mentioned — led to our making a detailed report of our case.

The 29-year-old woman had no complaints until 2 years ago, when in the course of a field investigation she was found to have hypertension. From this time she had frequent headaches, weakness and attacks of palpitation in the course of which her arterial pressure rose further. Recently she developed dyspnoea, her feet became swollen in the evening and she had stabbing cardiac pain on fast walking. On admission, physical examination revealed only mild pathological signs. There were fine wet and dry rales over the left lung base. The heart was not substantially enlarged, there was a soft protosystolic murmur at the apex, the aortic second sound was moderately loud. There was no cyanosis, oedema or hepatomegaly. Blood pressure was 210/140 mm.Hg.

The first scope of our further examination was to find out the origin of her hypertension.

Urine analysis was normal, concentration and dilution were within normal limits and so was the creatinine clearance. During one of her previous hospitalisations, the excretion of pressor-amines had been found to be within normal limits, even immediately following the hypertensive attacks. There was no evidence of increased hydroxytryptamine excretion, this amounting to 5.6 mg./24 hours. (For the estimation we are indebted to A. Fischer M. D., Third Medical Service of the University Medical School, Budapest.) Straight X-ray of the kidneys and intravenous pyelography were normal. Urological examination revealed only a slight urethritis. All these findings pointed to essential juvenile hypertension. The X-ray examination of the chest revealed a more transparent left hemithorax with meagre vascular markings, those of the right side being strongly

accentuated (Fig. 2.). The difference is even more conspicuous on the tomograms (Fig. 3.), the left hilar shadows being markedly smaller than the right and the vascularisation extremely poor especially in the middle and lower part of the left lung.

For closer eluciditation of the character of these vascular alterations the catheterisation of the right heart was performed.

The catheter was easily introduced into the right branch of the pulmonary artery, to pass the left branch however was very difficult and succeeded only after numerous trials. Its pressure was found to be lower than the identical values of the common trunk and the right main branch (Table I.). The pressure difference between the left branch and pulmonary trunk as registered on withdrawing the catheter is clearly demonstrated on fig. 4.

Table I. Haemodynamic findings.

	Blood pressures (mm. Hg)			Oxygen content	Oxygen saturation
	systol.	diastol.	mean	(vol. per cent)	(per cent)
Right atrium	8	−3	3	14.8	78.5
Right ventricle	26	−2	—	—	—
Pulm. artery (trunk)	26	13	19	13.8	73.5
Pulm. artery (right branch)	26	13	19	—	—
Pulm. artery (left branch)	12	5	8	—	—
Femoral artery	170	130		17.6	95.8

Normal atrial and ventricular pressures and O_2 values were found; wedged pulmonary pressure could not be obtained, probably owing to the irregularity of the vascular lumen. The circulation time determined from the cubital vein was very short and there was no difference between the ether and lobelin time; both amounted to 5 sec., pointing to the presence of a right-to-left shunt. Similar results were obtained by determination of the circulation times starting from the right ventricle and from the pulmonal artery. These facts prove the presence of an intrapulmonary shunt.

As to the effect of these vascular alterations on the ventilation, the following facts should be mentioned: vital capacity was low (2,400 ml.), only 65 % of which (1,560 ml.) was expelled in the first second. The maximal breathing capacity was accordingly low: 47 litres. To determine the ventilatory function of the separate lungs, bronchospirometry was performed, for which we are indebted to G. Varga, M. D. (Sanatorium of the Hungarian Railways). The results of this investigation are summarized in table II.: ventilation of the left side is markedly reduced — it should be mentioned however that in the further course of the investigation, the initial 1.3 l/min. value increased to 2.2 l/min. The O_2 uptake was also lower on the left side, the percent of reduction being, however, less than of the minute ventilation. The ventilatory equivalent, i. e. the volume of air breathed to supply 100 ml. of oxygen per minute is thus markedly reduced on the left-affected-side and hence more favourable than in the intact lung.

Diminished ventilation could not be directly correlated with the vascular anomaly; some other bronchopulmonary alteration was therefore presumed. Bronchoscopy left us without any clue, showing no difference between the main bronchial branches of the two lungs. Bronchography however shoved diffuse cylindroid and cystic bronchiectasis in the left lung (Fig. 5.). Most of the cysts were small, with the exception of the wall-nut sized bronchiectasis in the left hilus.

The hypertension of the patient was thus proven — per exclusionem of a renal and hormonal origin — to be of an essential character. The peculiarity of the X-ray picture — translucent hemithorax with narrow vessels — was explained by hypoplasia of the main branch of the left pulmonary artery. This is the first case reported in literature where this anomaly could be diagnosed in

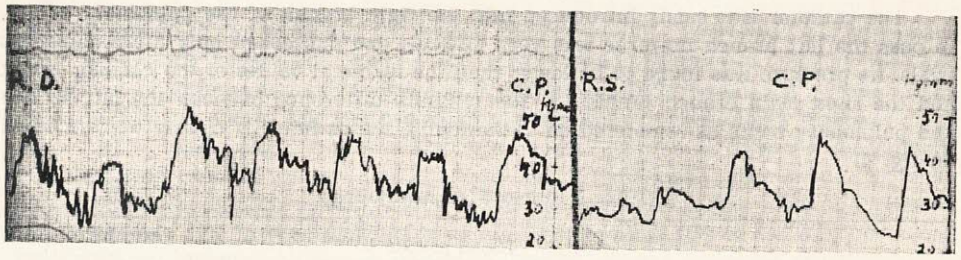

Fig. 4. Pressure tracings obtained by withdrawal of cardiac catheter along the right (R. D.) and left (R. S.) main branch of the pulmonary artery towards the trunk (C. P.). Sudden pressure gradient occurs only in latter tracing.

vivo with the aid of direct pressure measurements: pressure in the left main branch was lower than in the right and the common trunk. The vascular anomaly was not accompanied by other cardiac malformations. Bronchographic investigation revealed diffuse bronchiectasis in the affected lung, the limited extension of which excluded its being responsible for the production of the vascular anomaly, neither can the origin of the bronchial alterations be traced back to the poor vascularisation of the lung, there being no proof of concomitant damage to the bronchial circulation. It is much more probable that bronchiectasis is due to congenital hypoplasia of the hemithorax, as in the cases of complete absence of the main branch. As a rule, the dilated bronchi are surrounded by many arteriovenous anastomoses: these are considered to cause the shortening of the circulation times, the intrapulmonary localisation of the right-to-left shunt having been demonstrated by our investigations. The reduction of the minute ventilation and vital capacity of the left lung — as proven by bronchospirometry — must be related similarly to the alteration of the bronchial system. There is but a slight reduction in the oxygen uptake as compared with cases of complete absence of a main branch of the pulmonal artery, in which no oxygen is taken up by the affected lung, its blood supply being derived entirely from the aorta. The two anomalies, similar in their appearance, differ essentially from the functional point of view. This is very important especially in case of additional damage occurring on the unaffected side.

The lung with a congenitally absent main branch that does not participate in the oxygen uptake is unable to afford any kind of compensation. Findlay and Maier even suggested that the patient may be benefitted by its removal, decreasing thereby the load of the expanded bronchial circulation. In contradiction to this, the lung with a stenotic or hypoplastic main branch preserves, partly at least, its function and compensating potency, which is even accessible to being

increased with adequate treatment of the associated ventilatory disorders (bronchiectasis in our case). The therapeutic and prognostic importance of exact differential diagnosis is hereby clearly shown.

Stenosis and hypoplasia of the peripheral branches of the pulmonary artery does not belong immediately to the topics of our report, as in these cases the

Table II. Bronchospirometry.

	Lung	
	Right	Left
Vital capacity (ml.)	1,260	690
Minute ventilation (ml.)	5,100	1,300
Oxygen uptake (ml.)	240	100
Ventilatory equivalent (L/100 ml.)	2.1	13

X-ray changes only extend to isolated segments or lobes and not to an entire lung. They should be mentioned briefly, however, the findings being related in many respects to those of our case. Such cases have been reported by Möller, Arvidson et al., Belcher and Pattinson, Gyllenswärd. The typical X-ray is demonstrated by one of our own observation (Fig. 6.), in a patient with mitral stenosis and insufficiency, whose right upper lobe was more translucent with narrowed vessels. This anomaly, if extending to several lobes, may lead to pulmonary hypertension due to the increase in vascular resistance (Möller, Arvidson et al.). In contrast to the rather uniform picture in the case of hypoplasia, vascular dilatations may be seen distal to an isolated stenosis. Bronchiectasis has been found in the affected parts in such cases (Belcher et Pattison) and this lends clinical importance to the changes even in cases without pulmonary hypertension.

SUMMARY

Gottsegen, G., Csákány, G., Romoda, T. (Nat. Inst. of Cardiol., Budapest): *Increased translucency of one lung as a sign of pulmonary vascular anomalies.* Cor et Vasa 1 (1) : 38—46, 1959.

The X-ray picture of increased translucency of one lung may be caused by different acquired and congenital alterations of the parenchyma and of the vascular system. "Vanishing lung" is the most important syndrome in the group, characterized by absence, stenosis or hypoplasia of one main branch of the pulmonary artery. One case of this latter type is reported, where the diagnosis was ascertained in vivo with the aid of cardiac catheterization. In spite of the similarity in the clinical and X-ray appearance there are great differences between absence and stenosis of one main branch in respect to the functional capacity. The importance of an exact diagnosis is stressed.

ZUSAMMENFASSUNG

Das Roentgenphänomen einer erhöhten Strahlendurchlässigkeit einer einzelnen Lunge kann durch verschiedene erworbene und angeborene Veränderungen des Parenchyms und des Gefässystems bedingt sein. Die „vanishing lung" ist das wichtigste Symptom der letzteren Gruppe, d. i. Nichtvorhandensein, Stenose oder Hypoplasie des Hauptastes der Lungenarterie. Ein Fall dieses Typs wurde beschrieben; die Diagnose konnte in diesem Falle noch zu Lebzeiten des Patienten mit Hilfe der Herzkatheterisierung gestellt werden. Obzwar eine grosse Ähnlichkeit des klinischen und Roentgenbildes besteht, ist der Unterschied zwischen Nichtvorhandensein und Stenose des Pulmonalishauptastes in Hinblick auf die funktionelle Kapazität gross. Die Notwendigkeit einer genauen Diagnose wird betont.

RÉSUMÉ

L'image radiologique de la translucidité élevée d'un poumon peut être donnée par divers changements du parenchyme ou du système vasculaire acquis ou congénitaux. Le "vanishing lung" est le syndrome le plus important du premier groupe, c'est-à-dire l'absence, la sténose ou l'hypoplasie de la branche principale de l'artère pulmonaire. Un cas de ce genre est décrit. Le diagnostic avait pu être fait du vivant du malade à l'aide de la cathétérisation du coeur. Bien qu'il existe une grande ressemblance entre les images clinique et radiologique, il y a une énorme différence entre l'absence et la sténose de la branche principale de l'artère pulmonaire en ce qui concerne la capacité fonctionnelle. L'importance d'un diagnostic précis est soulignée.

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PERIPHERAL STENOSIS OF THE PULMONARY ARTERY WITH PULMONARY HYPERTENSION

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Since 1953, when peripheral stenosis of the pulmonary artery was reported for the first time [Möller[7]], 29 case reports of this disease have been described in 11 papers in the accessible literature. Peripheral stenosis was either associated with some other congenital heart lesions, most often with pulmonary stenosis, or isolated and accompanied by pulmonary hypertension of lesser or greater degree. The description of these cases added a further cause to the already known causes of pulmonary hypertension. Nearly all the reported diseases were described in infants, although Vermillion et al.[13]) remark that there is no reason why peripheral pulmonary stenosis could not also occur in adults and be compatible with a fairly long life. Some months ago in the report of the 31st meeting of the American Heart Association a hitherto unpublished communication dealing with 30 cases of peripheral pulmonary stenosis appeared.[12]) From this report is already evident that the authors noticed the characteristic physical finding enabling a diagnosis to be made before cardiac catheterisation and angiocardiography is carried out.

In this paper a case of peripheral pulmonary stenosis is described partly because it was found in an adult (the oldest patient with peripheral pulmonary stenosis which has been described up to the present time) and partly because this disease is still rare, and every detailed description may contribute to increasing our knowledge of it.

X. Y., aged 38, a technician, employed in a sugar refinery, was not examined during childhood, had not suffered from rheumatic fever and had been entirely without symptoms. At the age of 23, he was definitely ill with left-sided "pneumonia and pleurisy". Acid-fast bacilli were never found in the sputum either during the illness or afterwards.

After this illness he became dyspnoeic on extertion and often produced blood stained sputum and sometimes even pure liquid blood, maximum amount 50 ml. His shortness of breath was not getting worse, he had never had oedema. Already at the beginning of his illness at 23, a heart murmur was discovered, but he states that the underlying cause was not found. On account of the last haemoptysis the patient was admitted to the Chest department of the University Hospital in Olomouc whence he was transferred to the I. Medical Clinic of the same hospital in Olomouc.

The patient weighed 72½ kg., measured 175 cm. He was not cyanotic. At the left base of the chest there was dullness on percussion reaching to the angle of the left scapula with weakened respiratory sounds. The heart was shifted to the left with diffuse systolic lifting in the precordium. In the right second and third intercostal space near

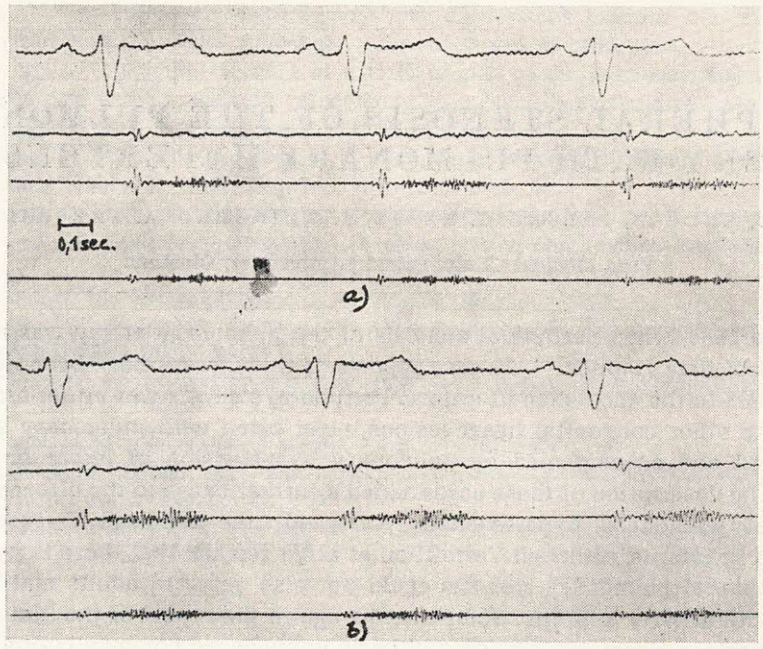

Fig. 1. Phonocardiogram taken in right axilla. — a) expirium, b) inspirium. There is marked increase in systolic murmur during inspiration.

the sternal border there was a systolic cardiac murmur (grade III), which could also be heard as a fine murmur over the carotids. This murmur was heard very distinctly over the whole right side of the chest and definitely increased during inspiration (fig. 1). It was hardly heard over the precordium (fig. 2). The second heart sound was widely split especially over pulmonary area and over the mesocardium and the splitting was considerably influenced by respiration (fig. 3). The veins were not distended, the liver was not enlarged and there was no pitting oedema.

X-ray examination shows enlargement of the right ventricle with a prominent pulmonary artery. The right hilus is formed by the broad pulmonary branches without any conspicuous pulsation. There are no signs of left auricular enlargement. In the left lung there is a marked basal retractive pachypleuritis (fig. 4). Bronchiectasis was excluded by bronchographic examination. The ECG is characteristic for right ventricular hypertrophy (fig. 5).

The preliminary conclusion, before cardiac catheterisation and selective angiography, was that the underlying cause of this clinical picture was most probably pulmonary hypertension with peripheral stenosis of the right branch

G. Gottsegen, G. Csákány and T. Romoda

INCREASED TRANSLUCENCY OF ONE LUNG AS A SIGN OF PULMONARY VASCULAR ANOMALIES

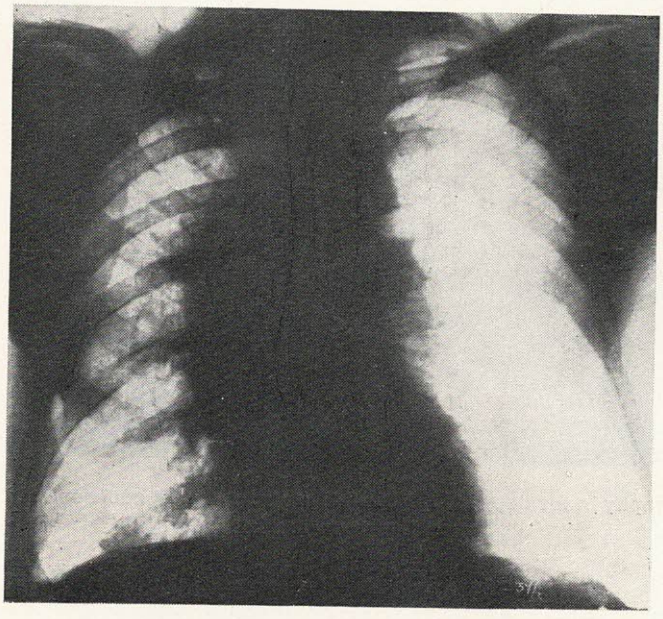

Fig. 1. Bronchial cancer on the right side with increased transradiancy of the left lung.

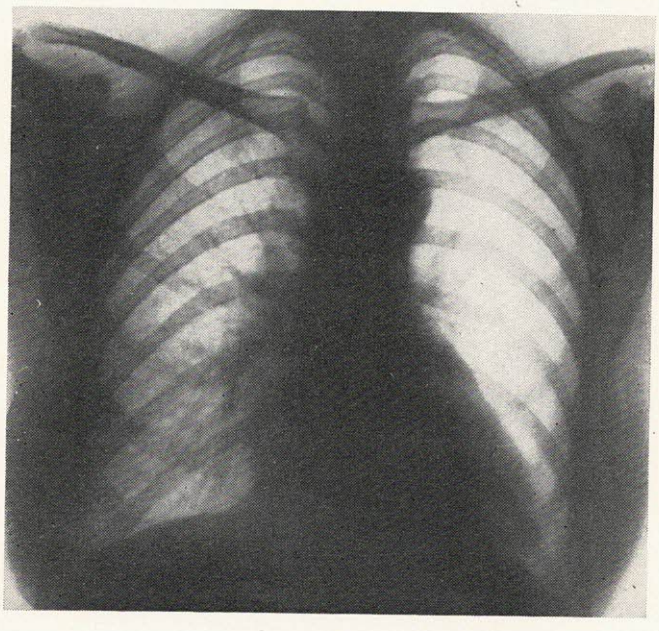

Fig. 2. Posteroanterior X-ray of the chest. There is increased radiolucency of the left lung with faint hilar shadow and absence of vascular markings.

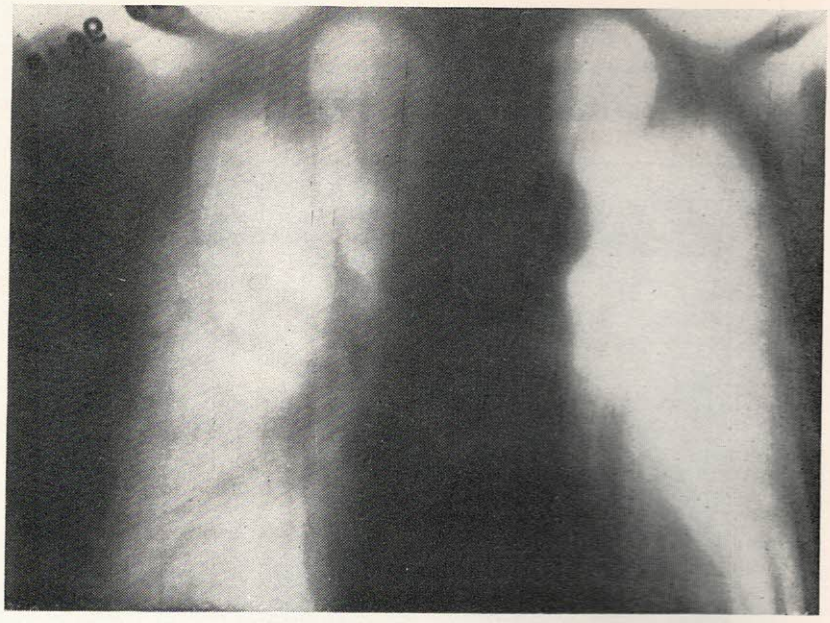

Fig. 3. Tomography in the depth of the hili. Diminished hilar shadow and lack of pulmonary vasculature on the left side.

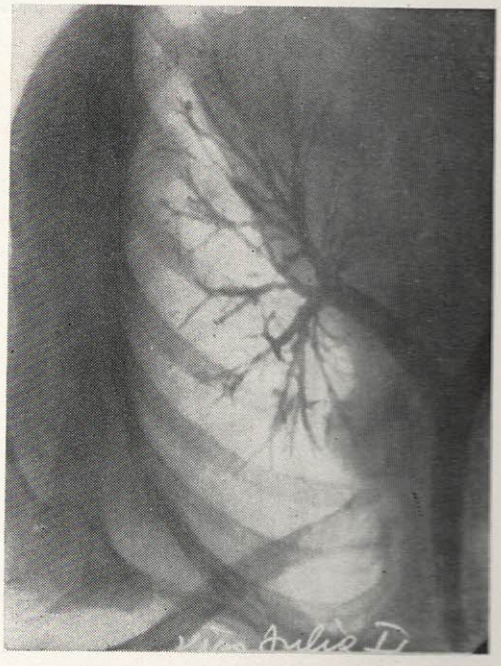

Fig. 5. Bronchogram shows multiple bronchiectasis of the left lung.

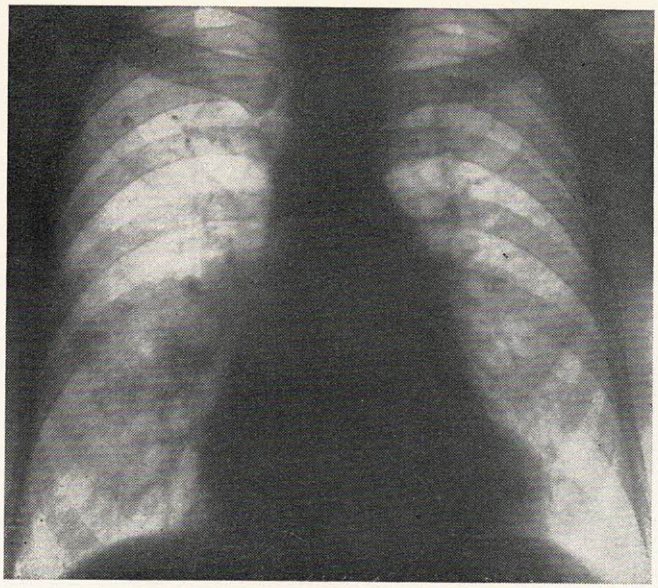

Fig. 6. Posteroanterior X-ray. Increased transradiancy and lack of vascular markings in the right upper field.

Z. Fejfar, F. Zajíc and M. Fejfarová

ALLOXAN INDUCED EXPERIMENTAL PULMONARY OEDEMA

I. Haemodynamic alterations

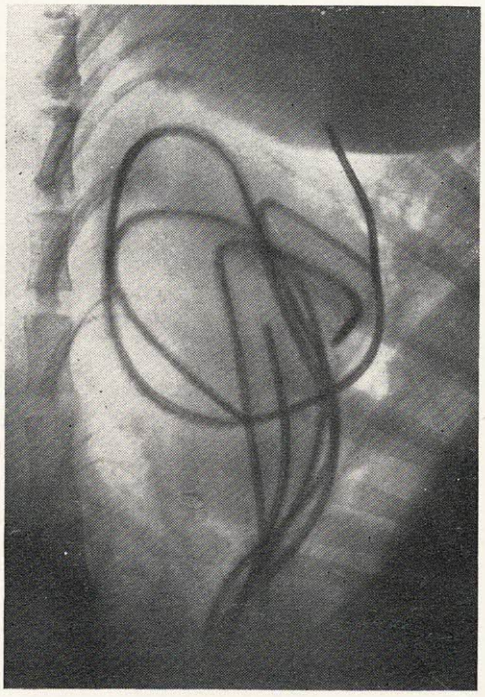

Fig. 1. X-ray picture of thorax — dog no. 60 with introduced catheters. Catheters are inserted into left and right atrium, pulmonary artery, wedged pulmonary artery down to the diaphragm and into sinus coronarius.

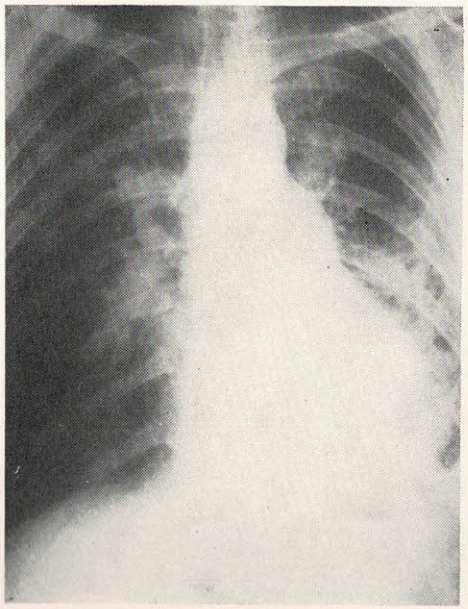

Fig. 4

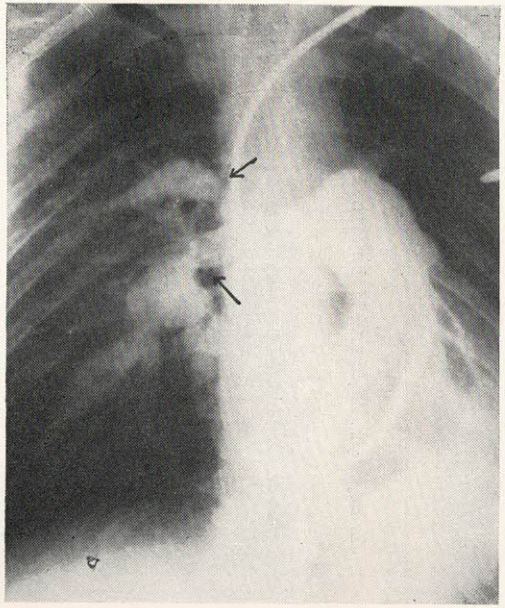

Fig. 7

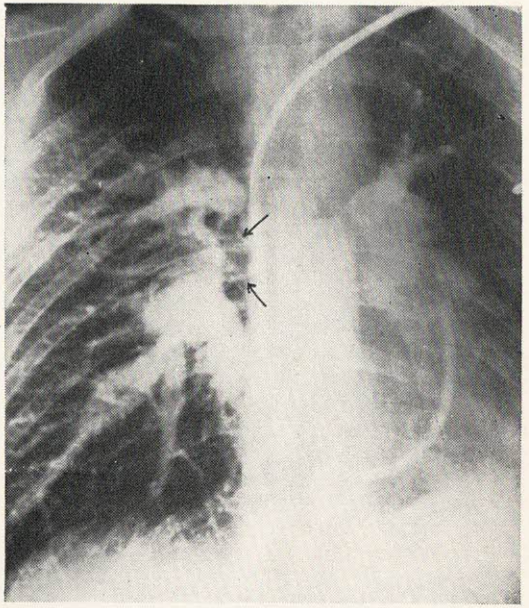

Fig. 8

Fig. 4. Chest X-ray. Prominent pulmonary artery with broad pulmonary hilar branches. Extensive pleural adhesions at left base. — Fig. 7 Angiocardiogram from outflow tract of right ventricle. Marked narrowing of both branches of right pulmonary artery on the right side of the shadow of catheter (↓). Marked poststenotic dilatation of lobar pulmonary branches. — Fig. 8. Later phase of angiocardiogram. Filling of peripheral vessels. Marked poststenotic dilatation of lobar branches. Filling-defect (↓) of right pulmonary artery close to shadow of spine. Defective filling of branches supplying left central and lower lung field

of the pulmonary artery. Cardiac catheterisation revealed a pulmonary hypertension of 132/30 mm. Hg with a mean pressure of 68 mm. Hg. This hypertension was measurable in the main pulmonary artery and in the right branch as far as the region of the right hilus. Before the catheter was passed into the hilar

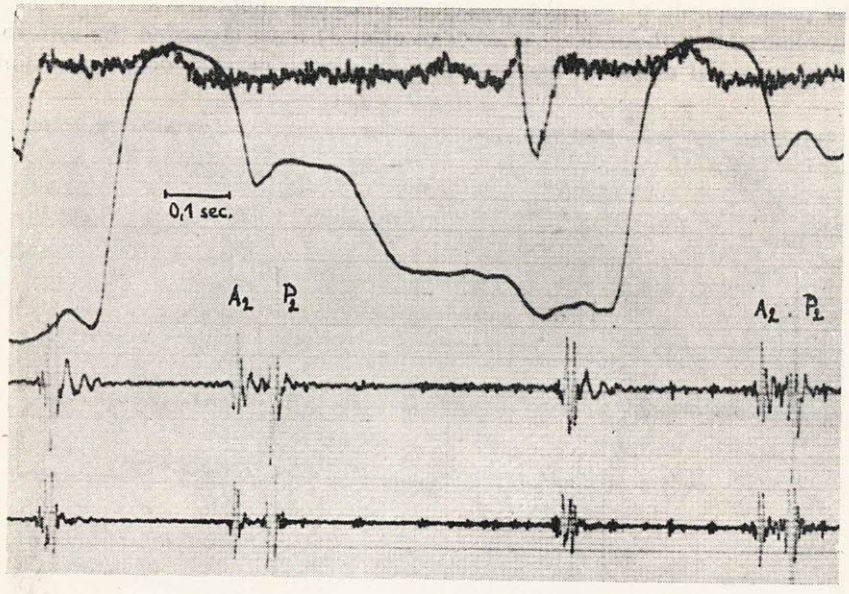

Fig. 2. Phonocardiogram taken from third intercostal space at left border of the sternum with arteriogram from carotid artery. Splitting of the second heart sound (0.06 sec.) with accentuation of pulmonary component (P_2) of the second heart sound.

branches, the blood pressure rapidly dropped to the value of 38/20 mm. Hg. The change in the blood pressure to the original level of 132/30 mm. Hg (fig. 6) could be repeatedly reproduced by withdrawal of the catheter into the right branch of the pulmonary artery to the region between the right hilus and the main pulmonary artery. It was unfortunately impossible to penetrate into the peripheral branches of the left pulmonary artery. A sample of blood was taken from the pulmonary artery and the angiography was performed by infecting the contrast medium into the outflow tract of the right ventricle (fig. 7, 8). The seriogram demonstrated a narrowing of the right pulmonary artery at the site where the pressure gradient had previously been detected together with considerable enlargement of the pulmonary artery peripherally to the stenosis.

The branches supplying the left lower lobe did not fill at all. An attempt to alter the pulmonary hypertension by injecting 2 mg. of acetylcholine in front of stenosis and 1½ mg. acetylcholine peripherally to the stenosis failed (fig. 9 and 10).

The possibility of a shunt was excluded by determining the oxygen saturation in blood samples from different parts of the right heart (table I) and by indicator

dilution curves (fig. 11). In this way the preliminary clinical diagnosis was confirmed and found to be correct by cardiac catheterisation and angiography.

DISCUSSION

The pathogenesis of peripheral stenosis of the pulmonary artery is not yet entirely clear. All authors except Eldridge et al.,[5]) have regarded the syndrome, especially in small children, as congenital. Eldridge et al.[5]) draw attention to

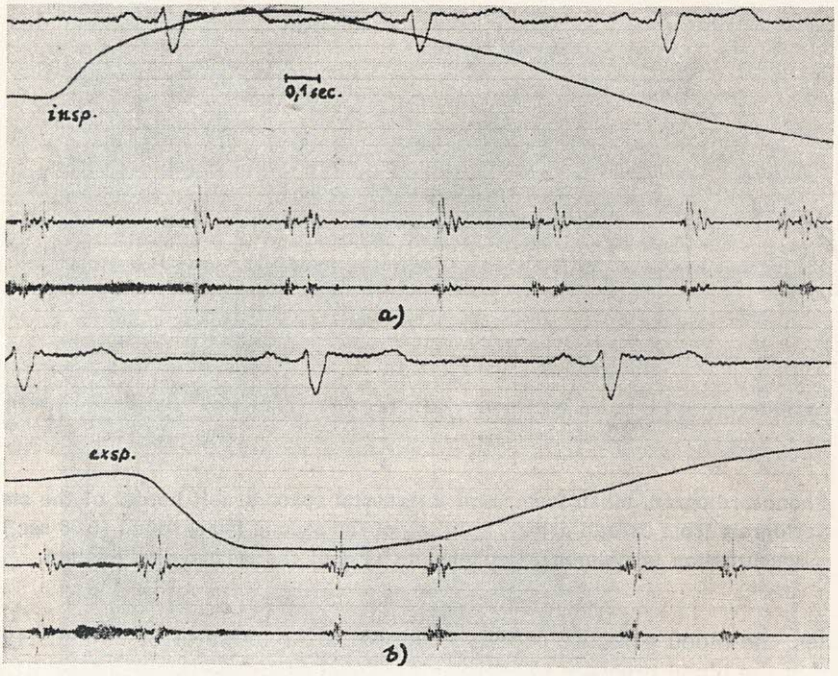

Fig. 3. Phonocardiogram taken from the third intercostal space at left border of the sternum. Dependence of splitting of the second heart sound on respiration is evident. A_2P_2 during inspiration is 0.06 sec. (a), during expiration 0.03 sec. (b).

the possibility of a thromboembolic origin, although they did not find any proof for this conception. In our case we can assume with reasonable probability that the pneumonia at the age of 23 was a pulmonary infarction because the branches of the pulmonary artery supplying the left lower lobe did not fill with contrast medium during angiography (fig. 7 and 8). This would at the same time explain the pulmonary hypertension, because in addition to the demonstrated narrowing in the right branch, there must be a further reduction of pulmonary flow on the left side since without this hypertension could not arise in the pulmonary trunk. Another fact suggesting that the peripheral pulmonary stenosis described above was acquired and of thromboembolic origin is the frequent haemoptysis without

underlying bronchiectasis and especially the completely asymptomatic course until the illness diagnosed as pneumonia in adult life. The angiographic picture of narrowing with a defect in contrast filling at the site of the pulmonary pressure gradient is well compatible with a thromboembolic genesis of the stenosis. In

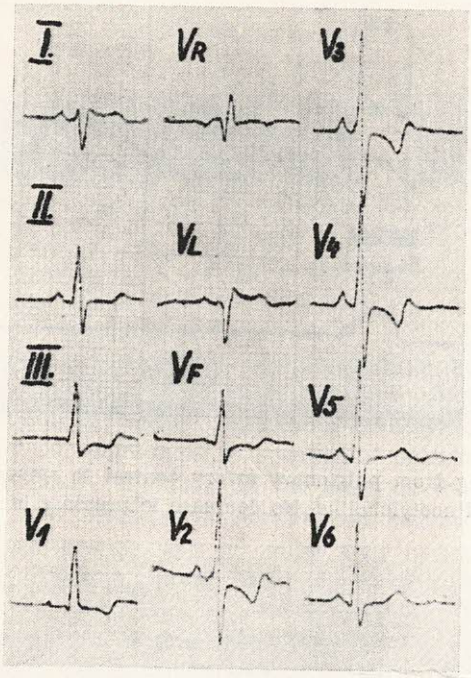

Fig. 5. Electrocardiogram showing marked right ventricular hypertrophy.

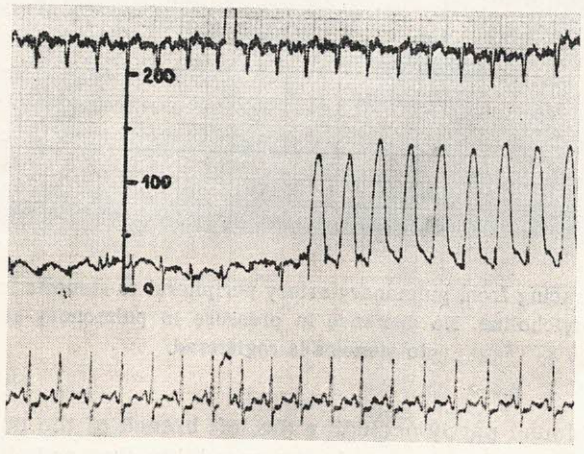

Fig. 6. Pulmonary artery pressure curve showing pressure gradient when crossing the site of peripheral stenosis in right branch.

1954, Dimont and Jones[4]) published a similar case with a murmur audible over the left hemithorax. After angiographic examination these authors concluded that the syndrome was a valvular stenosis of the pulmonary artery. At autopsy

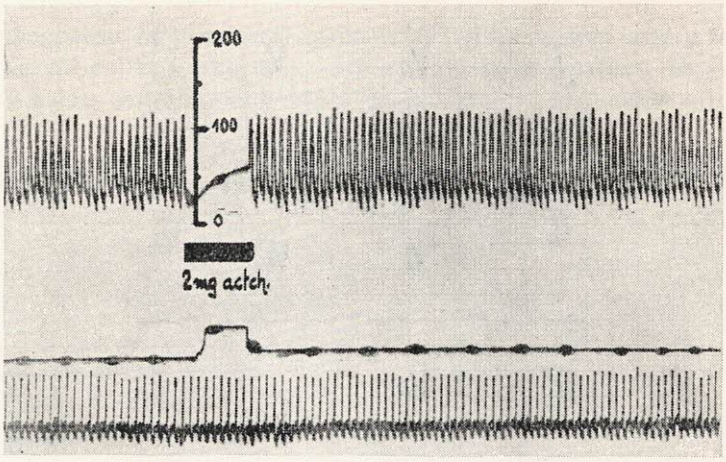

Fig. 9. Pressure tracing from pulmonary artery central to stenosis following injection of 2 mg. of acetylcholine. No decrease in pressure is registered.

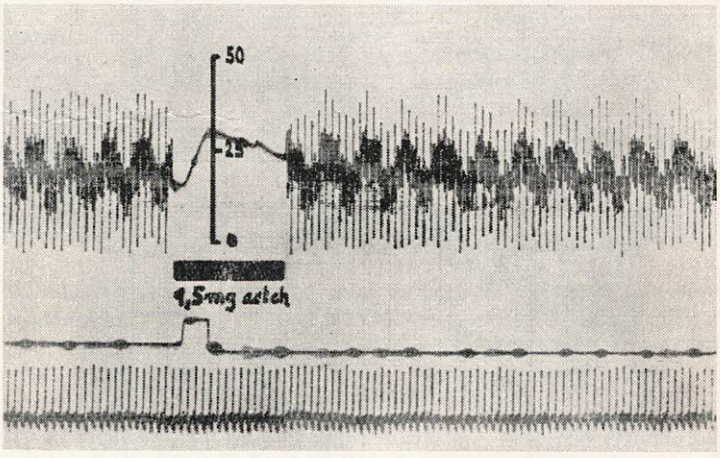

Fig. 10. Pressure tracing from pulmonary artery peripheral to stenosis following injection of 1.5 mg. of acetylcholine. No decrease in pressure in pulmonary artery peripherally to stenosis is registered.

a thrombus was found partly occluding the left branch of the pulmonary artery. It is, of course, impossible to exclude the possibility that embolic complications were only the secondary sequellae of primary congenital peripheral pulmonary stenosis. The final proof of the thromboembolic origin in our case of peripheral

Table I. Values of blood pressure and oxygen saturation during cardiac catheterisation.

	Pressure	O_2 saturation
Superior vena cava	4/—1 mm. Hg	73.5%
Right auricle	3/—2 mm. Hg	76,5%
Right ventricle	125/0 mm. Hg	78,5%
Pulmonary artery	132/25 mm. Hg, mean 68 mm. Hg	78,0%
Pulmonary artery peripherally to the stenosis	38/20 mm. Hg	66.0%
Pulmonary capillary pressure	15/7 mm. Hg	
Femoral artery	125/77 mm. Hg	96.0%
Cardiac index	4.7 l/m.^{2}	
Pulmonary resistance	614 dyn. sec. cm.$^{-5}$	

pulmonary stenosis seems to be the entirely negative response to acetylcholine, especially when injected peripherally to the stenosis, since in the case of pulmonary hypertension due to another cause there would be a drop in blood pressure in this region.[15]) Cor pulmonale as a cause of pulmonary hypertension in this case can be practically excluded on the basis of the normal spirometric values (table II). Without operative or post mortem control the thromboembolic conception of this syndrome remains of course only hypothetic. The source of emboli could not be discovered even after a very thorough investigation of patients history.

The detailed description of this case of peripheral pulmonary stenosis is given because of the rarity of this syndrome. In spite of this rarity it is necessary to keep this possibility in mind when causes of pulmonary hypertension are considered, which is now the daily task of students of the pulmonary circulation. It is the purpose of this paper to show that the syndrome in its typical form is easily recognizable because of pronounced and well-defined pathognomonic physical findings. A systolic or continuous murmur audible over one half of the thorax, especially when more marked over the lung than over the heart, with signs of pulmonary hypertension (accentuation of the second heart sound with

Table II. Spirometry. Values obtained in sitting position.

Oxygen consumption	280 ml./min.
Respiratory rate	21/min.
Tidal volume	500 ml.
Vital capacity	3.200 ml. (82% of predicted normal)
1 sec. vital capacity	2.500 ml. (78% of VC)
Minute ventilation	10.5 l/min.
Maximum breathing capacity	62.2 l/min.
Breathing reserve (MBC/MV)	5.9
Ventilatory equivalent (for oxygen)	3.7

hypertrophy of the right ventricle) in a case without cyanosis and without X-ray signs of arteriovenous fistula of the lung, is sufficiently conclusive for the diagnosis of peripheral pulmonary stenosis. This feature does not seem to have been sufficiently stressed in the literature. Finally, in connection with this syndrome

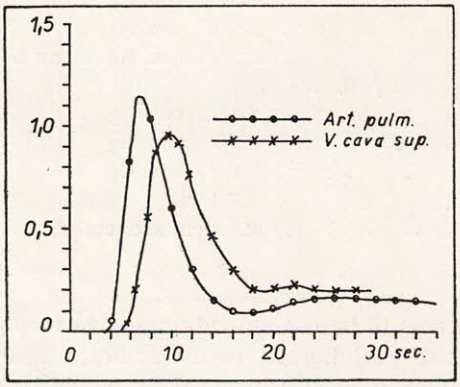

Fig. 11. Indicator dilution curves following injection of 6 mg. of T—1824 dye into pulmonary artery and into superior vena cava. No measurable shunt can be demonstrated by this means.

it is worth while to point out the lasting value and permanent importance of the classical method of auscultation at a time of a rapid extension and general use of complicated instrumental methods and on the other hand to note the contribution of these modern methods to the understanding and quantitative interpretation of changes detected by simple auscultation.

SUMMARY

Endrys, J., Lukl, P., Ressl, J., Weinberg, J., Zmeškal, A. (First Med. Clin., Palacký Univ., Olomouc, Czechoslovakia): *Peripheral stenosis of the pulmonary artery with pulmonary hypertension.* Cor et Vasa 1 (1) : 47—55, 1959.

Peripheral stenosis of the right branch of the pulmonary artery with pulmonary hypertension and marked physical findings, in a patient of 38 years, is described.

According to the history and examination it seems to be an acquired type of peripheral pulmonary stenosis of thromboembolic origin which has not been yet described in this syndrome.

The characteristic pathognomonic auscultatory finding is emphasized and the facility with which a diagnosis can be made even before cardiac catheterisation and angiography, is stressed.

ZUSAMMENFASSUNG

Es wurde eine periphere Stenose des rechten Astes der Arteria pulmonalis mit Hochdruck im kleinen Blutkreislauf und einem markanten physikalischen Befund bei einem 38-jährigen Mann beschrieben. Es handelt sich wahrscheinlich um den erworbenen Typ

der peripheren Pulmonalstenose mit thromboembolischer Genese, die bisher bei dieser Erkrankung noch nicht beschrieben worden ist. Der charakteristische pathognomonische Auskultationsbefund wird betont. Die Verfasser weisen auf die Mühelosigkeit der Diagnosestellung noch vor der Beglaubigung durch Herzkatheterisierung und Angiokardiographie hin.

RÉSUMÉ

Les auteurs décrivent le cas d'un malade de 38 ans atteint d'une sténose périphérique de l'artère pulmonaire droite accompagnée d'une hypertension pulmonaire. Vraisemblablement il s'agit là d'une sténose pulmonaire périphérique acquise et probablement d'origine thrombogène, cas unique dans la bibliographie médicale. Les auteurs soulignent les changements très caractéristiques perçus au cours de l'auscultation et démontrent la facilité avec laquelle on peut faire le diagnostic avant la cathétérisation et l'angiocardiographie.

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COR et VASA — 1 (1) : 56—72, 1959

ALLOXAN INDUCED EXPERIMENTAL PULMONARY OEDEMA*)

I. Haemodynamic alterations

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The blood pressure rise in the pulmonary capillaries and the increased permeability of the capillary walls are the two main factors responsible for the origin of pulmonary oedema (review by Altschule 1954, Drinker 1945, Sova 1958, Luisada and Cardi 1956, Vischer, Haddy and Stephens 1956 and others). In several observations on patients with mitral heart disease and other disturbances it was verified that the attack of pulmonary oedema starts with a sharp blood pressure rise in the pulmonary bed. The fall in arterial oxygen saturation as a manifestation of impeded oxygen diffusion during the escape of fluid from the capillaries, appears later and is of long duration (Fejfar, Fejfarová, Bergmann and Brod 1958). It appears that under such clinical conditions the picture of acute dyspnoea and of pulmonary oedema originates mainly due to the blood pressure rise in the pulmonary capillaries, causing the escape of fluid from the latter.

In contrast to this type of pulmonary oedema the lung oedema elicited by chemical substances of the phosgene type is characterised by increased capillary permeability with the blood pressure remaining unchanged (Gibbon, Bruner, Boche and Lockwood 1948, Vischer, Haddy and Stephens 1956).

The present communication deals with an analysis of the circulatury changes in experimental pulmonary oedema caused by alloxan. This type of pulmonary oedema has been described in cats (Peralta 1945) and in dogs (Gruhzit, Peralta and Moe 1951, Aviado, Walters and Schmidt 1953, Aviado and Schmidt 1957). Aviado and Schmidt consider a local contraction of the pulmonary veins as the main cause of alloxan induced pulmonary oedema leading to an increase in pulmonary blood volume (in the capillary region) and to an enhancement of fluid filtration from the capillaries. This view is based on the finding of increased

*) Presented in abbreviated form at the Third Physiological Session in Brno, Jan. 13, 1959. (Čs. Fysiol. 8 : 185, 1959.)

amounts of red blood cells that had been previously labelled with radioactive phosphorus P^{32} and of plasma tagged with radioactive iodine I^{131} in the lungs, at this stage of pulmonary oedema.

METHODS

All experiments were performed on dogs with closed chest under chloralose narcosis (0.1 g. per kg. weight in 1% freshly prepared solution) without premedication. Heart catheters (no. 7—8) were introduced into the dissected vessels in the neck and under X-ray control guided into the pulmonary artery, the wedged pulmonary artery above the diaphragm, the sinus coronarius and right atrium from both jugular veins (always two catheters in one vein) and into the left atrium resp. down into the pulmonary vein against the blood stream from the left a. carotis — fig. 1). The catheters were flushed with saline containig heparin at a concentration of 1 ml. per 500 ml. of solution (heparin SPOFA or NOVO), i. e. 5000 i. u.

The pressures in all regions were measured with membrane manometers and registered with an optical kymograph. Arterial blood pressure was measured in the aorta after introduction of a polythene catheter via the a. femoralis. The mean blood pressures from all heart regions were read off directly from mercury manometers. The dog was placed on its right side. The horizontal plane passing through the spines of the vertebrae was taken as the phlebostatic plane. It is evident that in this single position neither absolute atrial nor venous capillary pressure in the periphery of the left lobe can be assessed. The values obtained are of significance only in the dynamic assessment of pressure changes in the actual experiment.

In order to gain an idea of intrathoracic pressure changes a catheter provided with a cigar-like balloon was introduced into the oesophagus immediately above the diaphragm. Pressure measurements were performed with a capacity manometer and registered with an optical kymograph (for details see publication no. II).

Pulmonary ventilation and oxygen consumption were measured continuously with a Roth-Benedict spirometer in which valves were obviated by an artificial oxygen circulation (about 100 1/min; for details see our publication No. II). An endotracheal tube did not prove suitable and therefore a glass cannula was always introduced into the opened trachea. A Fleisch pneumotachograph was connected to the tracheal cannula. Blood oxygen saturation was estimated according to Brinkman and Zijlstra (1949) with a Kipp haemoreflectometer. Haematocrit values were determined by the Wintrobe technique on heparinised arterial blood. After 30 minutes centrifugation at 3000 r. p. m. values were noted without correction for trapped plasma between the blood cells. Haemoglobin was estimated photoelectrically.

Cardiac output was estimated directly by the Fick method. Resistance values in the systemic and pulmonary circulations were calculated from the usual formulae.

Following preparatory phases of varying duration, 10 minutes after the start of oxygen respiration corresponding blood samples were drawn at least twice and the cardiac output determined. Within 30—250 seconds a 20% solution of alloxan in saline was injected into the right atrium in amounts of 0.27—0.5 ml. per kg. (i. e. 54—100 mg. per kg. weight). Changes in haemodynamic values and respiratory function were then followed until the death of the animals; immediately afterwards section was performed in order to verify the positions of the catheters and to obtain tissue samples for microscopic examination (heart, lungs, liver, spleen, kidney, pancreas and skeletal muscle).

In some cases the protein content and composition of oedema fluid were determined.

Table I. Control values in narcotised dogs in at least two measurements of cardiac output within an average time interval of 11 minutes. — SD is the standard deviation. The confidence interval for the individual observations denotes the limit of error of the method with a 95 % probability either in percentage or in absolute values.

	Number of dogs	Number of examinations	Average	SD	Range	Confidence interval for individual observations at < P 0.05	
						in %	in original values
Cardiac output ml./min./kg. weight	21	44	171.21	77.17	51.6—388.8	12,03	22.46
Stroke volume ml./min./kg. weight	18	37	1.1142	0.514	0.48—2.58	13,04	0.197
Oxygen consumption ml./min./kg. weight	20	43	9.515	3.92	3.52—17.35	9.77	1.238
Pulse frequency	15	31	153.3	32.4	100.0—239.0	5,48	9.2
A—V dif., vol. %	21	45	5,793	1.318	3.42—7.87	—	0.588
Art. oxygen sat. in % O_2	21	45	97.89	1.62	92.2—100.5	—	2.22
Sat. in sin. cor. in % O_2	10	19	34.76	6.44	24.0—45.0	—	2.16
Sat. of mixed ven. blood in % O_2	20	42	69.6	8.08	51.9—82.0	—	4.02
Oxygen utilisation in %	21	44	28.27	7.62	15.15—46.4	—	3.23
Coronary utilisation in % O_2	10	19	64.04	6.71	53.5—74.8	—	2.16
Haematocrit	7	14	48.33	5.77	57.6—37.4	—	3.39
Pressures in mm.Hg							
A. pulmonalis	15	31	9.46	7.43	−2,0—+33	—	2.94
Capil. venous	14	29	4.95	7.76	−2.5—+28	—	4.16
A. femoralis	18	43	155.52	24.74	105.0—210	—	13.46
Left atrium	17	38	4.92	7.52	−5—+34	—	3.37
Right atrium	18	40	−0.87	3.26	−5—+8	—	2.328
Peripheral resistance dyn sec cm^{-5}	21	39	3,073.5	1,494.3	1,048—8,360	12.62	—
Total pulmonary resistance dyn sec cm^{-5}	20	34	231.32	277.9	24.1—1,520	24.8	—
Pulmonary arteriolar resist. (AP-left atr.) dyn sec cm^{-5}	18	29	98.12	148.5	8.4—761	61.1	—
Pulmonary arteriolar resist. (AP-capil. venous) dyn sec cm^{-5}	15	25	150.46	97.3	14.8—361	55.6	—
Pulmonary ventilation							
Respiratory frequency	15	30	15.9	3.49	10.0—22.0	23.0	2.9
Respiratory volume, ml.	15	30	598.4	183.4	368.0—978.0	13.74	47.7
Transpulmonary resistance	15	30	0.0394	—	—	10.69	—

Oxygen utilisation was calculated as the percentage consumption of oxygen supplied (Fejfar, Fejfarová 1959) from the formula

$$\frac{\text{A—V dif. vol. \%}}{\text{A vol. \%}} \times 100$$

Coronary oxygen utilisation was estimated in a similar manner from the formula

$$\frac{\text{A—V sin. cor. vol. \%}}{\text{A vol. \%}} \times 100$$

RESULTS

Before discussing the course of the individual haemodynamic changes it is necessary to consider the initial, i.e. the control values for catheterised dogs under chloralose narcosis.

Initial values were obtained at least twice in the period in which cardiac output was determined. The time interval between two estimations was on an average 11 minutes (range 4—30 minutes). A survey of measured and calculated values is given in table I. For all magnitudes the confidence interval was calculated for the individual observations at $P < 0.05$. This means that a change exceeding this interval is outside the limits of error of the method. For some values as for example, cardiac output where the individual values in the experimental animals showed considerable fluctuations (cf. the case in man — Fejfar, Fejfarová 1959) changes were expressed as a percentage of control values (marked x). In the case of pressure values absolute deviations (marked o) were considered, as will be stated in the corresponding parts. All significant changes exceeded the calculated confidence interval.

Average values were obtained in 21 experimental animals (table I.). Some dogs are also included in which haemodynamic values were followed after an articially produced pressure rise in the aorta or after a reaction to a sharp fall in oxygen tension in the respired air. The entire group with normal values was intended as a basis for all further experimental work employing a similar technique.

Haemodynamic changes brought about by alloxan were followed in 18 large dogs of an average weight 29.1 kg (range 22—36.8 kg.). Pulmonary oedema that was noticeable at first sight developed in all animals with exception of one which died 30 minutes after the alloxan injection. However, the haemodynamic pattern of this animal resembled the pattern in the remaining animals. In the majority of the animals foaming fluid flowed directly from the trachea. There was extensive atelectasis of the lungs with fluid flowing from them, the lymphatic vessels directed towards the hilus were markedly dilated into broad sinuses. Three dogs had to be injected with alloxan twice since after the first dose haemodynamic changes were temporary and no oedema developed. The alloxan dose was within the range 54—100 mg., the average dose was 72 mg. per kg.

Table II. Survey of experimental material. Three animals were given double injections of alloxan.

Number of dogs	18
Weight of dogs in kg.	29.1 (22—36.8)
Number of alloxan experiments	21
Alloxan dose per kg. weight	72 mg. (54—100)
Death occured after	85.2 min (24—235)
Pulmonary oedema observed	17×, i. e. in 94 %

per dog. Death occured within 24—235 minutes, on the average after 85.2 minute table II.) due to cessation of respiration. Heart activity ceased several minutes later.

The course of haemodynamic changes was similar in all animals except for small deviations in values and in the rate of change. It is thus possible to represent it by an example from one experiment (fig. 2).

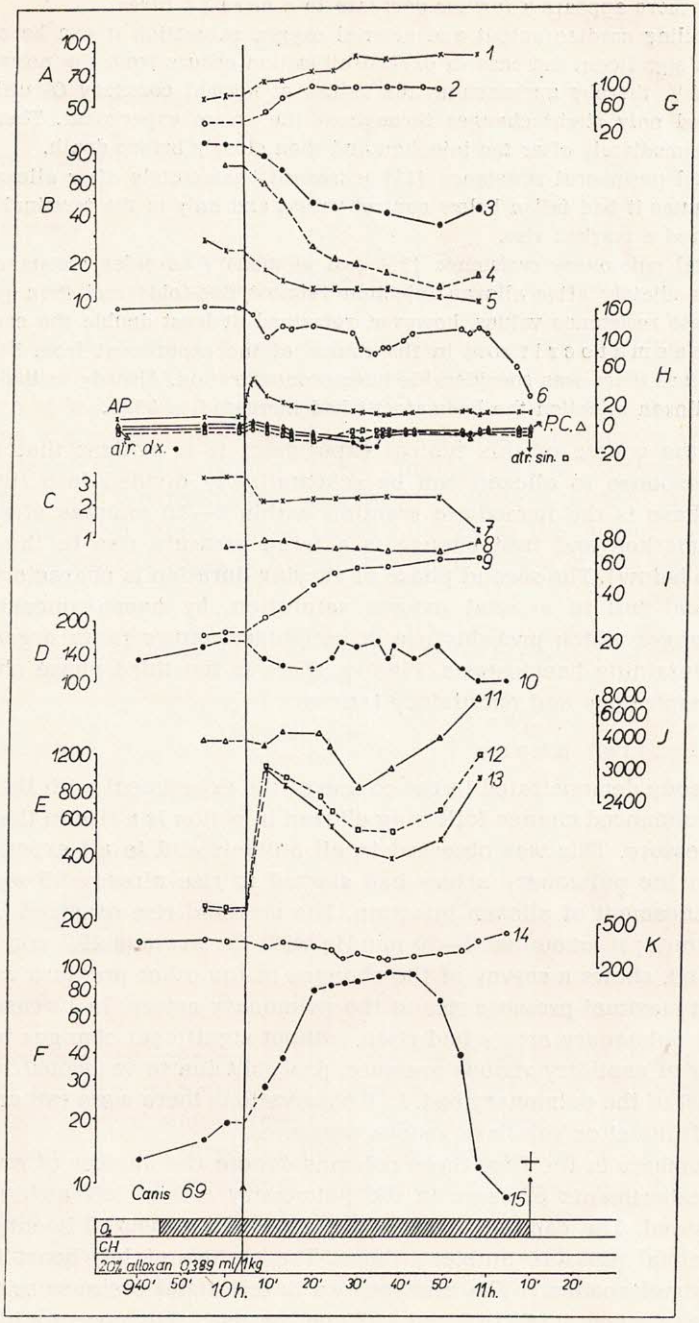
The dog No. 69 was injected with 77.8 mg. of alloxan per kg. into the right atrium. No rales were audible throughout the entire experiment. Cessation of respiration occurred 67 minutes after the start of the injection.

The development of haemodynamic alterations, however, was very rapid. The entire alloxan dose was injected within 30 seconds. Almost immediately (in the 1st minute after injection) a sharp pressure rise occurred in the pulmonary artery; within two minutes it had risen from the original 9 mm.Hg to 46 mm.Hg. In the following five minutes the pressure in the pulmonary artery began to fall and remained at 10—20 mm.Hg until cessation of respiration. As will be shown below the pressure rise in the pulmonary artery was always the first change to be observed. In the case of this dog the sharp pressure rise in the pulmonary artery was not accompanied by pronounced rise in left or right atrial pressure or in capillary venous pressure. The systemic mean pressure decreased in the first minutes following alloxan injection from 160 mm.Hg to 100 mm.Hg; it then fluctuated between 80—120 mm.Hg until the final phase when it sharply dropped to 40 mm.Hg.

The arterial oxygen saturation also significantly decreases from the start of the alloxan effect and gradually falls to below 40 %. The saturation of mixed venous blood falls within the first minutes in a similar manner as the arterial oxygen saturation. The greater fall in the saturation of mixed venous blood in the later phase is reflected in an increase of the arterio-venous difference. In the final phase the saturation of mixed venous blood falls to below 20 %, i. e. the normal values in the coronary sinus which under normal control conditions are the lowest (see table I.). The saturation of blood in the sinus coronarius falls from 26.7 % to a mere 10 %.

Oxygen consumption in unsteady. In the first 15 minutes it falls slightly below the initial values. Later, however, it returns to the initial values and only in the final phase does it fall significantly below control values.

Fig. 2. The course of haemodynamic changes after alloxan injection into the right atrium. Injected dose 77.8 mg. per 1 kg. weight. (Curve 1: Haematocrit; scale A in %. Curve 2: Relative changes in oxygen tension: millivolts increase with decreasing oxygen tension; scale G in mV. Curve 3, 4 and 5: Saturation of blood from aorta, pulmonary artery, and sinus coronarius, respectively; scale B in %. Curve 6: blood pressure in femoral artery, AP—pressure in pulmonary artery, P. C.—pressure in wedged pulmonary artery, atr. dx., atr. sin.—pressures in the right and left atrium, resp. Scale H in mmHg. — Curve 7: Cardiac output; scale C in liters. Curve 8, 9: The coefficient of oxygen extraction from the coronary region and systemic circulation, resp.; scale I in %. Curve 10: O_2 consumption; scale D in ml./min. Curve 11, 12 and 13: Total peripheral (log. scale J in dyn cm.$^{-5}$, pulmonary vascular and total pulmonary resistances, resp. (log. scale E in dyn cm.$^{-5}$) — Curve 14: Tidal volume; scale K in ml. Curve 15: Respiratory frequency/min.; scale F. — CH- rales; abscissa — time scale per 10 min., h — hours. — The duration of pure oxygen respiration is marked by the hatched region. →


A
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atr. dx.
atr. sin.
Canis 69
CH
20% alloxan 0,389 ml/1kg
9 40' 50' 10h. 10' 20' 30' 40' 50' 11h. 10' 20'

The cardiac output significantly decreases already within 5 minutes after alloxan injection (from 3.2 litres to 2.2 litres). It remains at this level until the final phase when there appears a further decrease to a mere 1.2 litres.

With falling cardiac output and arterial oxygen saturation it can be easily understood that a significant increase in oxygen utilisation occurs from the normal values of 22.8 % to 64 % thereby approaching the values of normal coronary O_2 utilisation. The latter showed only slight changes throughout the entire experiment. There was only slight rise immediately after the injection and then closely before death.

The total peripheral resistance (11) increased immediately after alloxan injection; after 10 minutes it had fallen below control values and only in the terminal phase there again occurred a marked rise.

The total pulmonary resistance (13) and pulmonary vascular resistance (12) rose sharply immediately after alloxan injection (almost five-fold) and then gradually decreased; these resistance values, however, remained at least double the control values.

The haematocrit rose in the course of the experiment from 54 % to 86 %. This shows that there was considerable haemoconcentration. Already in the fifth minute following alloxan injection the haematoctit had increased to 66 %.

From the course of this typical experiment it is evident that the haemodynamic response to alloxan can be schematically divided into three phases: the first phase is the immediate reaction within 5—10 minutes after injection. The most marked and first change is a large pressure rise in the pulmonary artery (see below). The second phase of varying duration is characterised mainly by a gradual fall in arterial oxygen saturation, by haemoconcentration and further changes which probably are of secondary nature in an organism which is still maintaining haemostasis. Finally, there is the third phase characterised by acute respiratory and circulatory failure.

The initial phase

As already demonstrated in the course of the experiment with the dog No. 69 the first pronounced change following alloxan injection is a rise in the pulmonary arterial pressure. This was observed in all animals and in all experiments. The pressure in the pulmonary artery had started to rise already 15 seconds after the commencement of alloxan injection. The maximal rise occurred between the 2^{nd}—4^{th} minute; it amounted 3—50 mm.Hg with the average 25.7 mm.Hg.

Table III. shows a survey of the changes in the other pressure values at the time of the maximal pressure rise in the pulmonary artery. In 12 cases the pressure in the pulmonary artery had risen without significant changes in left atrial pressure or of capillary venous pressure, probably due to vasoconstriction in the arterial part of the pulmonary bed. In 9 observations there were rather significant rises in left atrial or capillary venous pressures.

The numbers in the first three columns denote the number of examinations. In all 21 experiments pressure in the pulmonary artery, left atrium and aorta were measured. The capillary venous pressure was measured twenty times and the right atrial pressure nineteen times. The picture of left heart failure thus appeared simultaneously. The average rise in left atrial pressure or in capillary venous pressure was small (4.0 and 2.57 mm.Hg resp.) The pressure in the pulmonary artery, as was shown above, was much higher.

Table III. Mean pressure changes in systemic and pulmonary circulations in the phase of maximal pressure rise in the pulmonary artery.

	↓	0	↑	Average	Range
				in mm.Hg	
Mean pressure in a. pulmon.	0	0	21	25.7	3—50
Capillary venous pressure	0	15	5	2.57	0—16
Pressure in left atrium	0	12	9	4.0	0—18
Pressure in right atrium	0	7	12	5.3	0—20
Mean pressure in aorta	5	6	10	+23.6	0—45
				−30.6	−52—0

The presssure in the right atrium was significantly raised in 12 cases. In nine of these 12 cases this rise appeared when there also was a significant rise in left atrial pressure or in capillary venous pressure. It is probable that in these cases alloxan caused the picture of acute and temporary heart failure in addition to pulmonary arterial vasoconstriction. These findings are at variance with the results of Aviado and Schmidt (1957) who failed to observe cardiac insufficiency at this early stages. No relation of pressure changes in the pulmonary bed and in the heart to pressure changes in the aorta could be found in this work.

Table IV. Changes in some haemodynamic values at the time of the first determination of cardiac output (2—22 minutes after alloxan injection). Numbers denote numbers of individual examinations.

Cardiac output	Minutes after injection	↑	0	↓
Cardiac output		3	6	11
Mean pressure in a. pulmonalis		18	—	2
Pressure in left atrium		4	12	2
Capillary venous pressure	2—22	6	13	1
Arterial oxygen saturation		0	6	14
Pulmonary vascular resistance		20	—	—
Haematocrit		11	3	1

Table IV. shows the pressure in the pulmonary bed and in the left atrium at the time of the first measurement of cardiac output. This was within 2—22 minutes after the start of alloxan injection. The mean pressure in the pulmonary artery at this time was still increased in 18 cases. The picture of left heart insufficiency (inferred from the significant rise in left atrial pressure and in capillary venous pressure resp.), appeared only in 6 cases.

Cardiac output was significantly decreased as compared with control values in 11 examinations, 6 times it remained unchanged and only three times had it risen. It is thus surprising that the pressure rise in the pulmonary artery was in all experiments due to a raised pulmonary vascular resistance (in the capillary

or arteriolar region). In 14 experiments this pulmonary vasoconstriction was accompanied by a fall in aterial oxygen saturation.

The haematocrit of the arterial blood at this stage was measured in 15 cases; in 11 observations it had significantly increased, it remained unchanged in only three observations and in 1 case there was a slight fall. This shows that

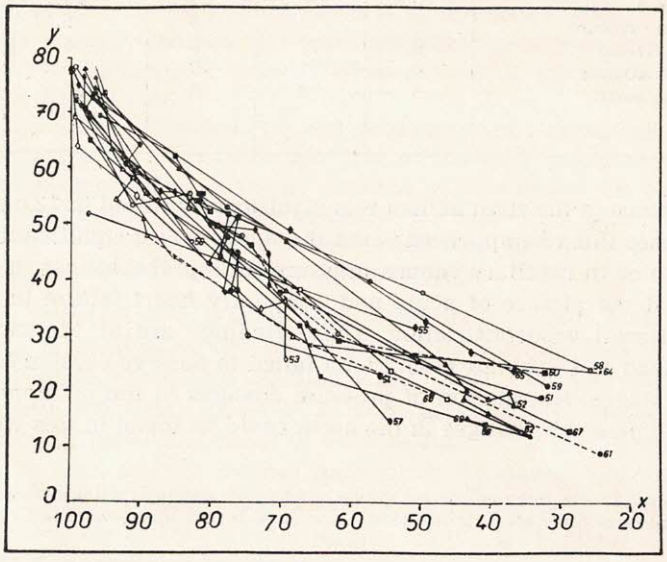

Fig. 3. Mixed venous oxygen saturation (y%) in relation to arterial oxygen saturation (x%). The numbers of the experimental animals with different marks denote the course of the individual experiments.

already in the first minutes following alloxan injection there was escape of plasma from the pulmonary vascular bed in the majority of the experiments.

Respiratory changes will be discussed elsewhere (Zajíc, Fejfar and Fejfarová — in preparation).

In the first minutes following alloxan injection there was thus a sharp pressure rise in the pulmonary artery due to a rise in pulmonary vascular resistance in the region of the capillaries or arterioles. Cardiac output was decreased. There was haemoconcentration due to plasma escape from the pulmonary region; arterial oxygen saturation had fallen.

The second phase

This phase is of varying length depending on the alloxan dose, the initial state and the reactivity of the experimental animal. The basic change in this phase is the increasing hypoxaemia of the arterial blood and the respiratory frequency in the developing pulmonary oedema. The other findings may be secondary reactions of the organism which is threatened by insufficient arterialisation of the blood on the lungs. Circulatory and respiratory changes in the

individual experiments were therefore assessed according to the degree of arterial oxygen saturation. The shaded band always shows the range of deviations in the control values at a confidence interval $P < 0.05$ (see table I.). The latter data were always obtained shortly prior to or at the time of cessation of respiration.

With increasing arterial oxygen desaturation the saturation of mixed venous blood decreases (fig. 3). Oxygen supply to the tissues is secured by enhanced capillary extraction, since oxygen utilisation had increased beyond 66 %. None

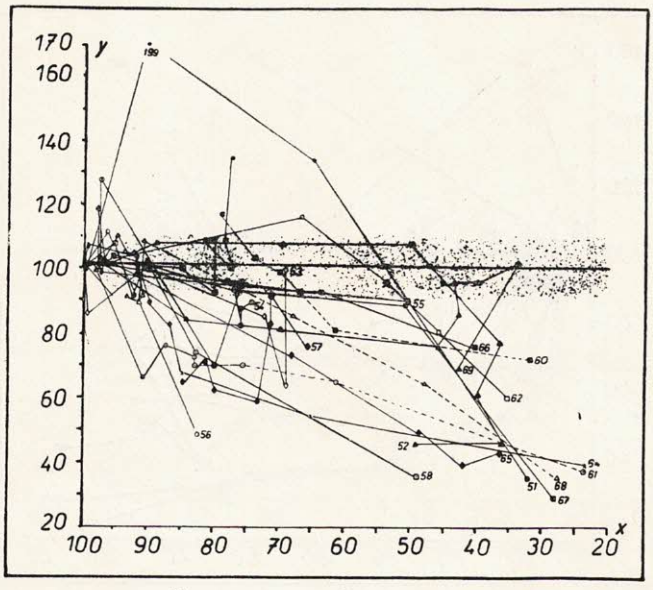

Fig. 4. Oxygen consumption (y%; initial = 100%) in relation to arterial oxygen saturation (x%). The shaded band denotes the confidence interval of the individual observations at $P < 0.05$.

the less the oxygen supply is insufficient since oxygen consumption gradually declines (fig. 4). The usual compensation by accelerated blood circulation is missing here. The cardiac output is in the majority of cases decreased (fig. 5). The oxygen saturation in the sinus coronarius is decreased, however, to a lesser extent, than the oxygen saturation of mixed venous blood. The utilisation of oxygen supplied to the coronary circulation remains unchanged for a long time; it decreases only in the terminal phase.

The fall in cardiac output is not compensated by a proportional increase in peripheral resistance which in the majority of cases remains unchanged and in case of a rise of the latter, its increase is small; because of the fall in cardiac output and in systemic pressure there is a drop in left heart work. But this is hardly due to impaired efficiency of the left ventricle with increasing hypoxaemia, since left atrial pressure was increased only in 4 cases whereas in the remaining experiments it remained unchanged or gradually decreased. Cardiac output rather

declines because of a diminution in the amount of circulating blood. Changes are not assessed in absolute units since oxygen consumption may be partly distorted due to the reduction of the functional residual capacity (Zajíc, Fejfar and Fejfarová — in preparation). A marked increase in arterial haematocrit (up to 90 %) in all observations with the exception of dog No. 59, shows that the majority portion of plasma entering the lungs escapes from the vascular region (fig. 6). This is in agreement with an increased protein content of the fluid leaving the lungs (exceeding 5 % with a composition resembling blood protein).

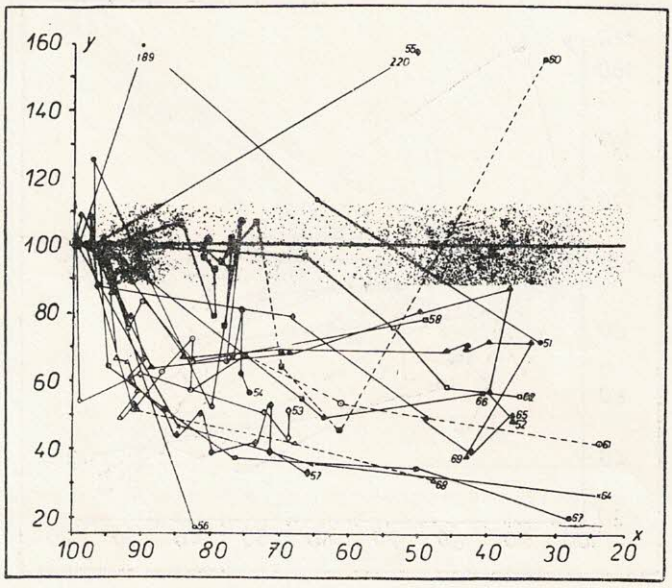

Fig. 5. Cardiac output (y%; initial = 100%) in relation to arterial oxygen saturation (x%).

Since it was found that neither left atrial pressure nor venous capillary pressure were increased it is believed that the escape of plasma from the pulmonary region is manifestation of increased permeability of the pulmonary capillaries. These findings are thus at variance with the conclusions of Aviado and Schmidt (1957).

The pressure in the pulmonary artery reveals a falling tendency after an initial sharp rise. In the majority of observations it remained, of course, above normal values (fig. 7). This rise is caused by a considerable increase in pulmonary arteriolar resistance (fig. 8). This follows clearly from the fall in cardiac output with rising pulmonary arterial pressure while left atrial and capillary venous pressures remain unchanged in the majority of cases; nor is the right atrial pressure pronouncedly increased.

The relation between the pressure in the pulmonary circulation and intrathoracic pressure as well as changes in pulmonary function will be analysed in a forthcoming publication (Fejfar, Zajíc and Fejfarová — in preparation).

The terminal phase

The terminal phase usually starts with a sharp pressure drop in the systemic circulation and a fall in respiratory frequency. This can be seen from fig. 2. This is a manifestation of the breakdown of the compensatory and adaptive possibilities of the organism. The behaviour of the haemodynamic parameters can be seen from the last values in figs. 3—7. It remains to point out that with the exception of dog No. 58, death occurred primarily invariably due to cessation

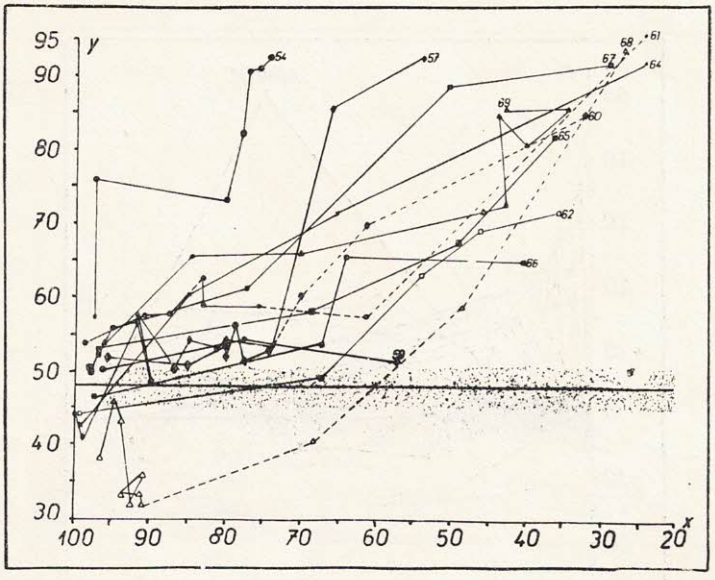

Fig. 6. Haematocrit values (y%) in relation to arterial oxygen saturation (x%).

of respiration and that heart activity ceased several minutes later. From the figures is can also be seen that respiration ceased at varying levels of arterial oxygen saturation (70—20 %).

DISCUSSION

The results described confirm earlier findings (see introduction) of sufficiently large doses of intravenous administered alloxan causing pulmonary oedema in dogs. By the use of doses smaller than the ones applied by Aviado and Schmidt (1957) it was possible to study the course of the haemodynamic changes in the development of pulmonary oedema for longer time periods. It was confirmed that the immediate reaction to alloxan is a pressure rise in the pulmonary artery due to contraction of the pulmonary bed in the region of the arterioles or capillaries. Unlike Aviado and Schmidt the present authors observed in some dogs an immediate rise in left atrial pressure and in capillary venous pressure with decreased cardiac output, i. e. haemodynamic manifestations of acute left ventricular failure.

A further apparent manifestation is a fall in arterial oxygen saturation which was observed although the animals respired pure oxygen. This increasing hypoxaemia was linked with a marked increase in haematocrit (beyond 90 %), i. e. marked haemoconcentration. Since oedema leaving the lungs contained a considerable amount of protein resembling in composition blood protein it can be infered that the major part of plasma gradually escaped from the pulmonary capillaries. The volume of oedema fluid amounted in some cases to 0.75 litres which is a considerable portion of circulating plasma (the amount of circulating

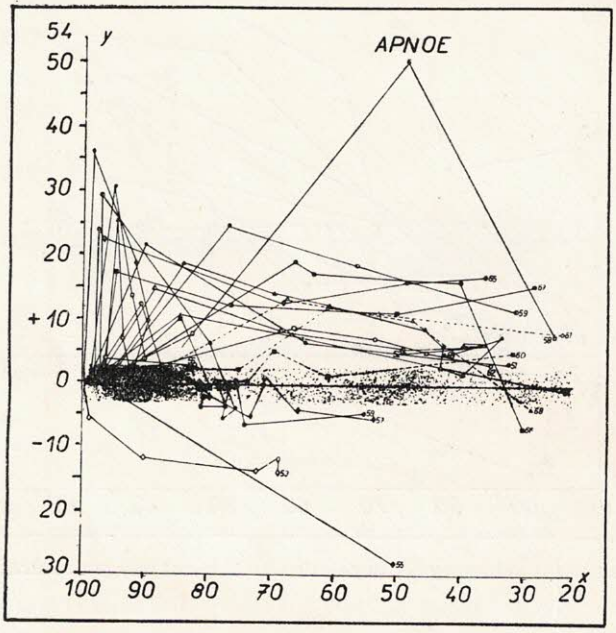

Fig. 7. Mean pulmonary arterial pressure (y mm.Hg) in relation to arterial oxygen saturation (x%).

plasma in a 30 kg. dog may be roughly estimated at 1 litre). Since the left atrial pressure and the capillary venous pressure were not raised (with some slight exceptions) it is felt that the escape of fluid from the pulmonary capillaries is a consequence of increased permeability. This conclusion is at variance with the view of Aviado and Schmidt (1957) who believe that the enhanced filtration of fluid from the pulmonary capillaries is due to raised filtration pressure in the widened capillaries as a consequence of a pressure rise caused contraction of the pulmonary venulae (increased postcapillary resistance). This conclusion was based on an increase in pulmonary radioactivity following injection of plasma protein tagged with radioactive iodine I^{131} and of erythrocytes labelled with radioactive phosphorus P^{32} in the development of pulmonary oedema. Radioactivity was estimated with a Geiger-Müller counter which was applied to the lung surface. The present authors however believe that the increase in pulmonary

radioactivity following injection of the radioactive phosphorus can be accounted for by haemoconcentration whereas the increased radioactivity after injection of the radioactive iodine preparations was due to an accumulation of fluid containing labelled albumin, in the lungs (outside the capillary region).

Alloxan thus causes pulmonary oedema by damaging the pulmonary capillaries (as in the case of phosgene). Alloxan is a substance the dosage of which can easily be controlled; it is thus suitable for model experiments on pulmonary oedema due to primary damage to the pulmonary capillaries.

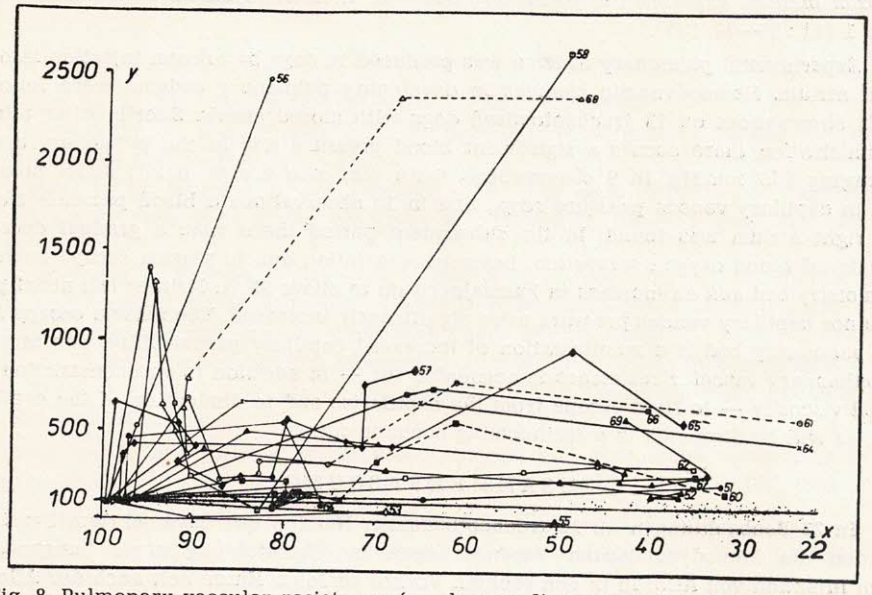

Fig. 8. Pulmonary vascular resistance (y—dyn cm.$^{-5}$) in relation to arterial oxygen saturation (x%).

The mechanism of constriction of the pulmonary bed immediately after alloxan injection is as yet unknown. Aviado and Schmidt (1957) found such a constriction in the isolated lung that was being perfused with a constant amount of blood; it is thus of a local nature. It cannot yet be said whether it is caused by the primary stimulation of the arterioles by alloxan or secondarily as a consequence of primary damage to the pulmonary capillaries (with escape of fluid from them) or perhaps by a local (axon) reflex or the stimulation of the receptors in pulmonary tissue. In this respect the Kitaev reflex is of some interest, i. e. the sharp rise in pulmonary arterial pressure with an increased pressure in the pulmonary veins (Kitaev 1931). This reflex, as has been experimentally demonstrated by van Bogaert et al. (1953) might be elicited by the stimulation of the receptors in pulmonary tissues as well as by the stimulation of the pressoreceptors in the venous wall.

It is necessary to emphasize that pulmonary vasoconstriction was most pronounced immediately after alloxan injection and in the further course it

rather diminished although arterial oxygen saturation gradually decreased and viscosity of blood had increased due to haemoconcentration. This is further experimental evidence that the relation between pulmonary vasoconstriction and hypoxaemia is not yet clear as is borne out by other work recently published (Braun and Eliakim 1958, Ferrer 1958, Pennetti et al. 1958, Widimský et al. 1959).

SUMMARY

Fejfar, Z., Zajíc, F., Fejfarová, M. (Inst. for Cardiovasc. Dis., Praha-Krč): *Alloxan induced experimental pulmonary oedema.* I. Haemodynamic alterations. Cor et Vasa 1 (1) : 56—72, 1959.

Experimental pulmonary oedema was produced in dogs by alloxan injection into the right atrium. Haemodynamic changes in developing pulmonary oedema were followed in 21 observations on 18 tracheotomised dogs with closed chests. Shortly after alloxan administration there occurs a significant blood pressure rise in the pulmonary artery, averaging 25.7 mm.Hg. In 9 observations there was also a rise in left atrial pressure and in capillary venous pressure resp., and in 12 observations a blood pressure rise in the right atrium was found. In the subsequent period there was: a gradual decrease in arterial blood oxygen saturation, haemoconcentration due to plasma escape from the pulmonary bed and an increase in haematocrit up to above 90 %. Neither left atrial pressure nor capillary venous pressure were significantly increased. The plasma escape from the pulmonary bed is a manifestation of increased capillary permeability. The increase of pulmonary vascular resistance is accounted for — in addition to vasoconstriction and blood viscosity — to fluid escape from the capillaries and to diminution of the capillary bed, as will be discussed in a forthcoming communication.

ZUSAMMENFASSUNG

In 21 Beobachtungen an 18 tracheotomierten Hunden mit unversehrtem Brustkorb wurden die hämodynamischen Veränderungen bei Entwicklung eines Lungenödems nach Injektion von Alloxan in den rechten Vorhof verfolgt. Kurze Zeit nach der Alloxaninjektion steigt der Druck in der Arteria pulmonalis signifikant an, durchschnittlich um 25,7 mm.Hg. In 9 Beobachtungen stieg auch der Druck im linken Vorhof, beziehungsweise der kapillär-venöse Druck, und zwölfmal der Druck im rechten Vorhof an. Im weiteren Verlauf sinkt allmählich die Sauerstoffsättigung des arteriellen Blutes, infolge des Austritts von Plasma aus den Lungengefässen tritt eine Blutverdickung auf, der Haematokrit steigt bis über 90 % an. Weder der Druck im linken Vorhof noch der kapillär-venöse Druck erhöhen sich in signifikantem Grade. Der Plasmaaustritt aus den Lungengefässen ist auf die erhöhte Durchlässigkeit der Kapillaren zurückzuführen. Am Anstieg der Resistenz der Lungengefässe beteiligt sich ausser der Vasokonstriktion und der Blutviskosität auch die Flüssigkeit, die aus den Kapillaren ausgetreten ist sowie die Verringerung des kapillären Strombettes, wie in einer weiteren Mitteilung dargelegt werden wird.

RÉSUMÉ

Dans une série de 21 observations, faites sur 18 chiens chez lesquels une trachéotomie sans ouverture du thorax avait été effectuée, les changements hémodynamiques lors du développement d'un oedème pulmonaire après injection de l'alloxane dans l'oreillette droite ont été examinés. Peu de temps après l'injection de l'alloxane, la pression de l'artère pulmonaire augmente sensiblement de 25,7 mm Hg en moyenne. Au cours de 9 observations, la pression de l'oreillette gauche resp. la pression capillaire veineuse

a également augmentée, et 12 fois celle de l'oreillette droite. Par la suite, la saturation en oxygène du sang artériel diminue progressivement, le sang s'épaissit à cause de l'écoulement du sang du réseau pulmonaire, l'hématocrite augmente jusqu'à des valeurs de plus de 90 %. Ni la pression de l'oreillette gauche, ni la pression capillaire veineuse n'augmentent de façon signifiante. L'effusion du plasme du réseau pulmonaire constitue une conséquence de l'augmentation de la perméabilité des capillaires. En plus de la vasoconstriction et de la viscosité sanguine, le liquide qui s'est échappé des capillaires et la diminution du réseau capillaire participent également à l'augmentation de la résistance vasculaire pulmonaire, comme nous allons le démontrer plus en détail dans une communication ultérieure.

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DYNAMIQUE DE LA SYSTOLE CHEZ L'HOMME NORMAL ET CHEZ DES MALADES ATTEINTS D'INSUFFISANCE CARDIAQUE

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Depuis ces dernières années, la cardiologie a fait des progrès considérables dans tous les domaines: clinique, électrocardiographie, hémodynamique, thérapeutique. Ce n'est que l'investigation du dynamique du coeur qui est restée en retard. Depuis longtemps, on a fait des efforts pour mesurer la durée des périodes de la révolution cardiaque, mais les méthodes employées étaient soit si compliquées qu'on ne pouvait pas les utiliser en pratique, soit inexactes.

Au cours des dernières années, plusieurs auteurs ont démontré que la durée de la systole mécanique, la période isométrique et la durée de la période d'expulsion rapide et celle d'expulsion lente (ou réduite) peuvent être mesurées par le ballistocardiogramme. On a révélé que les débuts des différentes périodes de la systole sont synchronisés avec les ondes du balistocardiogramme à l'aide duquel on en registre l'accélération. (1, 2, 3, 4) (Fig. 1.)

Méthode employée:

Pour évaluer la durée des différentes phases de la systole, nous nous sommes servis de la méthode ballistocardiographique.

Dans un de nos travaux précédents, nous avons démontré que le début des différentes phases de la systole coïncide avec certaines ondes du ballistocardiogramme d'accélération (5). Le point G du ballistocardiogramme et le début de la systole mécanique sont synchroniques, car il coïncide avec les vibrations initiales du premier bruit cardiaque (6,7). Le sommet de l'onde L coïncide avec la vibration principale du deuxième bruit cardiaque ainsi qu'avec l'incision du pouls carotidien, il est donc apte d'indiquer la fin de la systole mécanique. La distance entre le point G et le sommet de l'onde représente la durée de la systole mécanique.

Le sommet de l'onde H coïncide avec le début de la montée du sphygmogramme artériel central, ainsi qu'avec la deuxième et troisième vibration du 1er bruit, correspondant à l'ouverture des valvules semilunaires (8). Le sommet de l'onde H correspond à la fin de la phase isométrique ainsi qu'au début de la phase d'expulsion, qui dure jusqu'au sommet de l'onde L. Cette phase est divisée en deux parties: la phase d'expulsion rapide ou maximale et celle de l'expulsion lente ou réduite. Le sommet de l'onde J coïncide

avec le sommet de la courbe du pouls artériel central, ainsi qu'avec l'onde c, indiquant la montée protosystolique de la courbe jugulaire. La phase d'expulsion rapide s'étend du sommet de l'onde H au sommet de l'onde J, et celle de l'expulsion réduite du sommet de l'onde J au sommet de l'onde L.

Les résultats obtenus sont les suivants:

La durée de la période isométrique — c'est à dire la période de la systole pendant laquelle les valvules semilunaires et atrioventriculaires sont fermées — est du quatre à six centièmes de seconde. Elle est constante. Nous ne trouvons

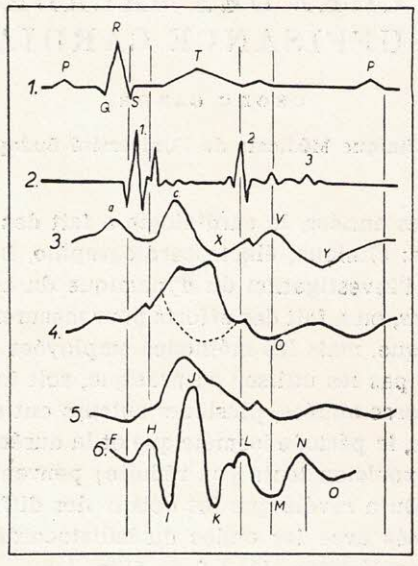

Fig. 1. 1. électrocardiogramme, 2. phonocardiogramme, 3. phlébogramme jugulaire, 4. cardiogramme apexienne, 5. sphygmogramme, 6. ballistocardiogramme.

aucun rapport entre la durée de cette période et la durée du cycle ou celle de la systole.

La durée de la contraction isotonique — c'est à dire de la période d'expulsion — varie entre vingt-deux et trente-quatre centièmes de seconde. La durée de cette période est determinée par celle de la systole; il existe une corrélation stricte entre la durée de la systole et celle de la période isotonique. (Fig. 2.)

On sait que l'expulsion est composée de deux temps: la période d'expulsion rapide ou maximale et la période d'expulsion lente ou réduite. On a démontré que la durée de l'expulsion rapide et celle de l'expulsion lente dépend de la durée de la systole. (Fig. 2.) Avec la prolongation de la durée de la systole, la durée de l'expulsion rapide et celle de l'expulsion lente augmente également et en sens inverse. L'accroïssement de la durée de l'expulsion lente est un peu plus rapide que celle de l'expulsion rapide. Cette différence entre les deux phases de l'expulsion peut s'expliquer par le fait que la relation entre l'expulsion rapide et l'expul-

sion lente reste constante. Nous avons trouvé un rapport de 1 : 1.6 resp. 1 : 1.8. La durée de l'expulsion lente est donc toujours de 60 à 80 % plus longue que celle de l'expulsion rapide.

Tenant compte du fait que les périodes d'expulsion changent avec la durée de la systole, nous avons déterminé le rapport entre les différentes périodes de cette dernière. Dans ce but, nous avons calculé le pourcentage des différentes périodes de la systole. Nous appelons cette durée: durée relative. Nous avons obtenu les résultats suivants:

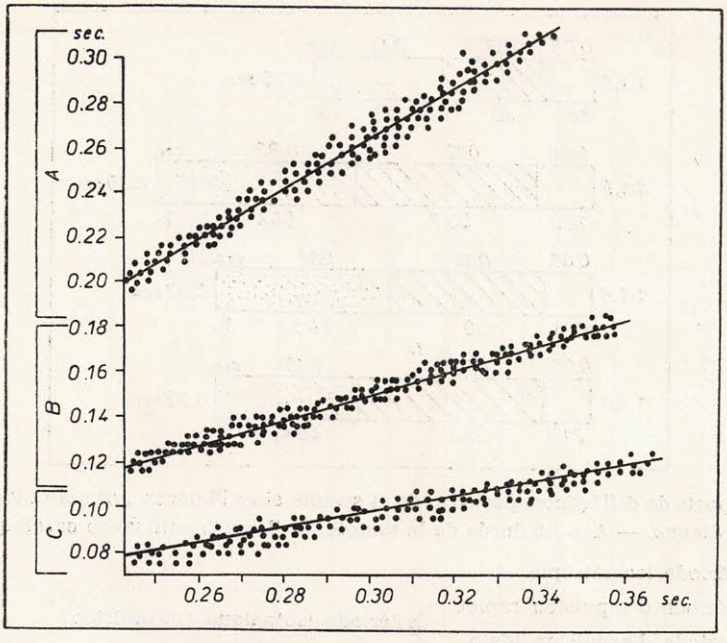

Fig. 2. Rapport entre la durée de la systole totale et ses périodes différentes. La durée de la systole. — A = période isotonique; B = période d'expulsion rapide; C = période d'expulsion lente.

La période isométrique comprend 11 à 19 % de la durée de la systole, la période de l'expulsion rapide 30 à 33 % de la systole et celle de l'expulsion lente 52 à 58 % de la durée de la systole; c'est à dire que la durée de l'expulsion rapide est toujours inférieure au tiers de la systole, et la durée de l'expulsion lente dépasse toujours la moitié de la durée de la systole. (Fig. 2.) (9)

Après avoir exécuté des expériences sur des sujets normaux, nous avons examiné le changement des différentes phases de la systole au cours de l'insuffisance cardiague. Nous avons observé 75 malades. L'insuffisance cardiaque avait des causes différentes. (9)

Résultats obtenus:

La durée de la contraction isométrique était, chez un tiers environ des malades, plus prolongée que chez les sujets normaux. La valeur absolue de la durée

de l'expulsion rapide et celle de l'expulsion lente ne change pas, mais la durée relative de ces périodes montre une altération importante. Notamment, l'expulsion rapide devient plus longue que le tiers de la systole et l'expulsion lente plus courte que la moitié de la systole. (Fig. 2, 3.)

Dans l'insuffisance cardiaque, nous trouvons une altération essentielle et constante dans le rapport réciproque des périodes d'expulsion rapide et lente. Le rapport entre l'expulsion lente et l'expulsion rapide est de 1 : 1.2 resp. 1 : 1.5 (Fig. 4). Cette altération signifie que la durée de la période de l'expulsion lente

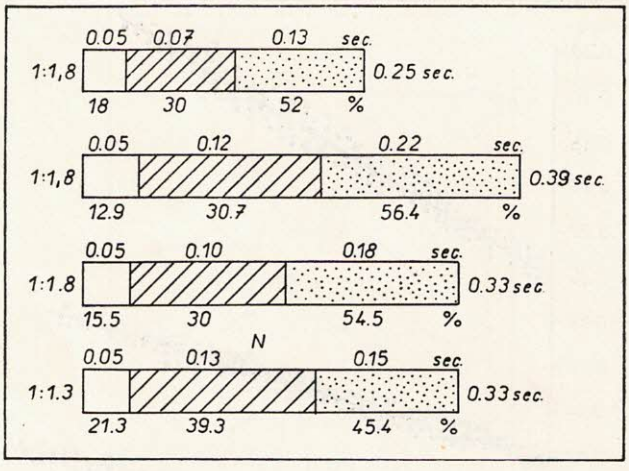

Fig. 3. Rapports de différentes périodes de la systole chez l'homme normal et l'insuffisance cardiaque. — A = La durée de la systole. — B = L'insuffisance cardiaque.

Période isométrique
Période d'expulsion rapide
Période d'expulsion lente
} Période isotonique (l'expulsion)

dépasse seulement de 20 à 50 % celle de la période de l'expulsion rapide, contrairement à ce qui se passe chez les sujets normaux, chez lesquels la durée de la période de l'expulsion lente dépasse de 60 % aux moins celle de la période de l'expulsion rapide.

Il semble que le premier signe de l'insuffisance cardiaque consiste dans la prolongation du temps nécessaire pour l'évacuation d'une même quantité de sang par rapport au coeur normal. C'est pourquoi l'expulsion rapide se prolonge. L'expulsion lente dure jusqu'au moment où la pression à l'intérieur du coeur dépasse celle des gros vaisseaux. Pour maintenir la pression, le myocarde a besoin de déployer ses forces. Le raccourcissement de l'expulsion lente signifie peut-être que le myocarde malade n'est pas capable de maintenir aussi longtemps que le coeur normal la pression dans les ventricules.

Durant le traitement de l'insuffisance cardiaque par la strophantine resp. la digitaline, nous avons observé un changement des différentes périodes de la

systole. Nous avons fait des observations chez 66 malades, dont 60 ont été traités par la strophantine et six par l'Acylanide.

Nous avons fait un ballistocardiogramme avant l'injection de la strophantine, un autre 1 heure après l'injection. Pendant le traitement, nous avons fait un ballistocardiogramme par jour.

Voici les résultats de nos observations:

L'expulsion rapide était plus longue que le tiers de la systole dans 49 cas. 1 heure après l'injection de la strophantine, la durée de l'expulsion rapide se rac-

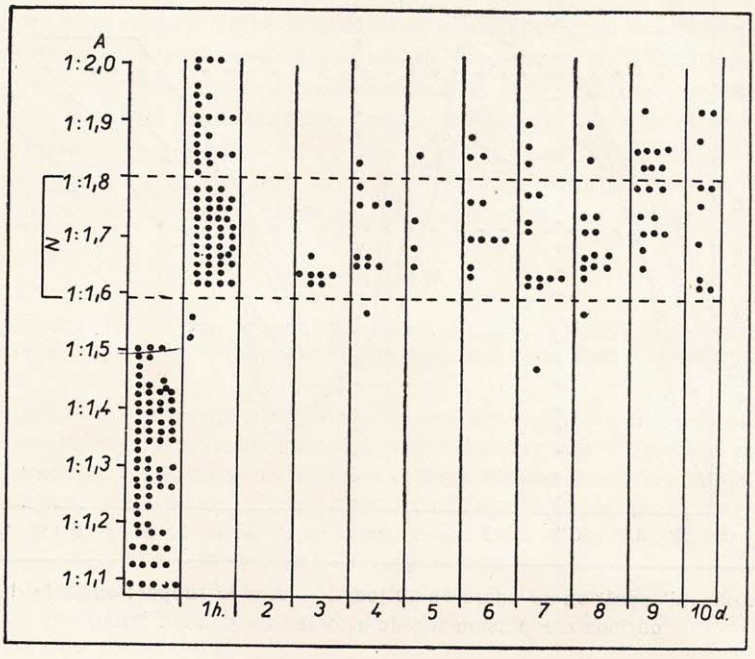

Fig. 4. Période d'expulsion rapide et lente après la strophantine chez l'insuffisance cardiaque. — A = Le rapport entre la durée de la période d'expulsion rapide et celle d'expulsion lente. — N = normal.

courcissait dans tous les cas, à l'exception des six cas où elle restait plus prolongée que chez le sujet normal. Lorsque l'insuffisance avait disparu, l'expulsion rapide était devenue normale (excepté deux cas). (Fig. 4.)

La durée de l'expulsion lente était plus courte que la moitié de la systole dans 45 cas. 1 heure après l'injection de la strophantine elle est devenue normale dans 41 cas. Après l'amélioration de l'insuffisance, la durée de l'expulsion lente devenait dans tous les cas plus longue que la moitié de la durée de la systole. (Fig. 4.)

Le rapport normal entre les deux périodes de l'expulsion changeait pendant l'insuffisance cardiaque. Le rapport entre l'expulsion rapide et l'expulsion lente

est de 1 : 1,2 resp. 1,5. 1 heure après l'injection de la strophantine, ce rapport était devenu normal dans 58 cas sur 60. La proportion normale s'est retablie chez tous les malades dès qu'ils étaient compensés. (Fig. 4.)

Nous avons traité six malades par l'Acylanide. Le premier jour, ils ont reçu à la fois 0,6 mg per os. Puis, selon leur état, 2, 3 ou 4 fois 0,2 mg d'Acylanide par jour. Pendant le traitement, nous avons fait plusieurs ballistocardiogrammes.

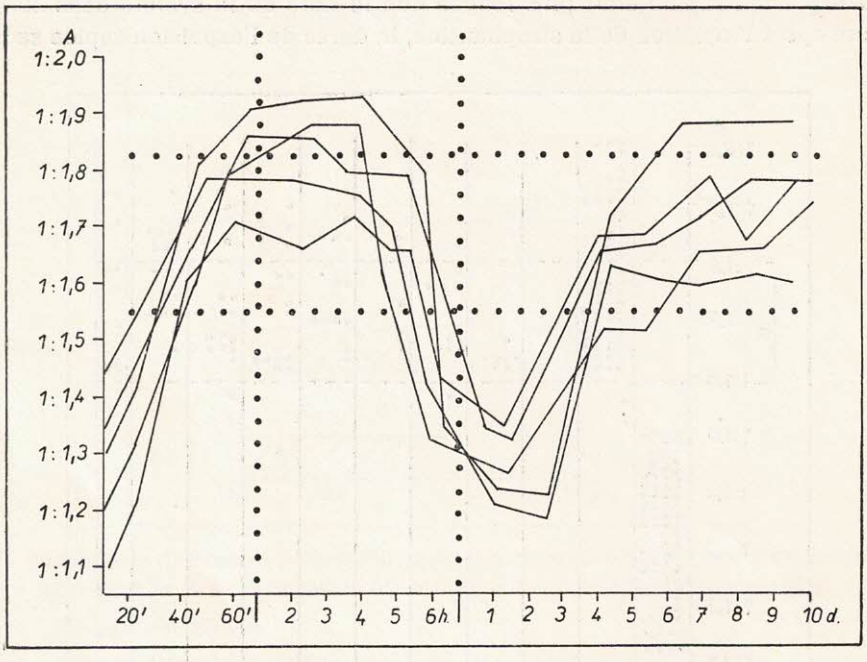

Fig. 5. Périodes d'expulsion au cours de 10 jours. — A = le rapport entre la durée de la période d'expulsion rapide et celle d'expulsion lente.

Résultats obtenus:

40 à 60 minutes après l'application de 0,6 mg d'Acylanide, la durée de l'expulsion rapide et celle de l'expulsion lente était devenue normale chez 5 malades sur 6. Le rapport entre les deux périodes d'expulsion était devenu normal dans tous les cas. Après 5 ou 6 heures, l'expulsion rapide s'est allongée et l'expulsion lente s'est raccourcie de nouveau et ainsi le rapport entre les périodes d'expulsion avait repris un aspect pathologique. (Fig. 5.)

Ces observations prouvent que l'Acylanide agit par la voie digestive au bout de 40 à 60 minutes, et son action dure de 5 à 6 heures. En administrant des doses décroissantes de 4, 3 et 2 fois 0,2 mg par jour jusqu'à ce que le pouls ait atteint environ 60 pulsations, on peut observer que la durée de l'expulsion rapide se raccourcit et celle de l'expulsion lente se prolonge; la proportion entre l'expulsion rapide et l'expulsion lente est de 1 : 1,6 à 1 : 1,8. Chez trois sujets, l'insuffisance cardiaque s'est manifestée de nouveau. Après le traitement par l'Acyl-

anide, l'insuffisance s'est améliorée. A l'aide des ballistocardiogrammes, nous avons pu déterminer le meilleur dosage de la digitaline et l'intervalle le plus convenable entre les cures. Nous avons établi, à l'aide de cette méthode, le traitement individuel le plus convenable: deux fois 0,2 mg d'Acylanide par jour pendant quatre jours, répétés après des intervalles de cinq jours. Chez d'autres: trois fois 0,2 mg d'Acylanide pendant une semaine, puis une semaine d'intervalle. Chez un troisième malade, il était nécessaire d'administrer une fois par jour 0,2 mg pendant longtemps.

La possibilité d'évaleur la durée des différentes périodes de la systole semble être d'une grande importance. Comme nous avons vu, les différentes périodes de la systole et le rapport entre ces périodes changent dans l'insuffisance cardiaque et se normalisent de nouveau après la disparition de l'insuffisance. Cela signifie que l'insuffisance est reconnaissable déjà dans un stade précoce, et ainsi le traitement peut être commencé à temps. Le dépistage de l'altération du rapport entre les différentes périodes de la systole facilite le diagnostic et en même temps le contrôle du traitement. Enfin, l'étude des variations de la durée des périodes systoliques permet l'examen de l'efficacité des préparations digitaliques.

RÉSUMÉ

G á b o r, G. (IIIe Clin. Méd., Univ. de Budapest): *Dynamique de la systole chez l'homme normal et chez des malades atteints d'insuffisance cardiaque.* Cor et Vasa 1 (1): 73—81, 1959.

Les temps de la contraction isométrique et des deux composantes de la contraction isotonique, c'est-à-dire les périodes d'éjection ventriculaire rapide et lente, ont été mesurés chez 250 personnes normales et 66 malades atteints d'insuffisance cardiaque. Chez les personnes saines, le temps de la contraction isométrique était de l'ordre de 0,04 à 0,06 secondes (11 à 19% de la durée de la systole). Le temps de la contraction isotonique était de l'ordre de 0,22 à 0,33 secondes. Le rapport entre la période de l'éjection rapide et celle de l'éjection lente était de l'ordre de 1 : 1,6 à 1 : 1,8. La période de l'éjection rapide comprenait 30 à 33% de la durée de la systole et la période de l'éjection lente 51 à 58% de cette même durée.

Au cours de l'insuffisance cardiaque, la période de l'éjection rapide était plus longue et celle de l'éjection lente plus courte. Chez 49 sur 66 malades, le temps de l'éjection rapide était plus long que le tiers de la durée de la systole et le temps de l'éjection lente plus court que la moitié de la durée de la systole. Le rapport des deux périodes est tombé à 1 : 1,2 à 1 : 1,5.

Après une injection intra-veineuse de 0,6 mg d'Acylanide, la dureé des deux périodes de la contraction isotonique est devenue normale au bout de 40 à 60 minutes, mais 4 à 6 heures après, les valeurs pathologiques se sont à nouveau manifestées. L'auteur a, de la même façon, déterminé des doses les plus appropriées ainsi que leurs fréquences au cours du traitement d'Acylanide par voie bucale.

Selon l'avis de l'auteur, cette méthode permet le diagnostic de l'insuffisance cardiaque et le contrôle de l'effet du traitement cardiotonique.

ZUSAMMENFASSUNG

Bei 250 normalen Personen und 66 dekompensierten Herzkranken wurde am Ballistokardiogramm die Dauer der isometrischen Herzkontraktion und beide Komponenten der

isotonischen Kontraktion, das ist die Periode der schnellen und die der langsamen Herzentleerung, gemessen. Bei den normalen Personen betrug die Dauer der isometrischen Kontraktion 0,04 bis 0,06 Sekunden, 11 bis 19 % der Systolendauer. Die Dauer der isotonischen Kontraktion betrug 0,22 bis 0,33 Sekunden. Das Verhältnis der Periode der schnellen Entleerung zur Periode der langsamen Herzentleerung betrug 1 : 1,6 bis 1 : 1,8, wobei die Periode der schnellen Entleerung 30 bis 33 % und die Periode der langsamen Entleerung 51 bis 58 % der Systolendauer betrug.

Bei Herzinsuffizienz war die Periode der schnellen Entleerung verlängert und die der langsamen Entleerung verkürzt. Bei 49 von 66 Patienten machte die Dauer der schnellen Entleerung mehr als ein Drittel und die Periode der langsamen Entleerung weniger als die Hälfte der Systolendauer aus. Das Verhältnis beider Perioden zueinander verringerte sich auf 1 : 1,2 bis 1 : 1,5.

Nach einer intravenösen Injektion von 0,6 mg Acylanid normalisierte sich die Dauer beider Perioden der isotonischen Kontraktion innerhalb von 40 bis 60 Minuten, nach 4 bis 6 Stunden jedoch traten wiederum pathologische Werte auf. Auf ähnliche Weise bestimmte der Verfasser die vorteilhafteste Dosis und ihre Frequenz bei peroraler Behandlung mit Acylanid.

Nach der Ansicht des Verfassers eignet sich die beschriebene Methode zur Diagnostik der Herzinsuffizienz und zur Kontrolle des Effekts der kardiotonischen Behandlung.

SUMMARY

A total of 250 normal subjects and 66 decompensated cardiacs were ballistocardiographically examined. The phase of isometric heart contraction and both components of the isotonic contraction, i. e. the rapid and slow ejection periods, were measured. In normal individuals the isometric contraction period was found to be 0·04—0·06 sec. or 11—19% of the period of the systole. The phase of isotonic contraction was 0·22—0·33 sec. The ratio of the rapid and slow injection periods was within the range 1 : 1·6 to 1 : 1·8, with the fast and slow ejection periods accounting for 30—33% and 51—58% of the period of the systole, respectively.

In cardiac insufficiency the fast and slow injection phases were prolonged and shortened, respectively. In 49 of the total of 66 patients the phase of rapid ejection exceeded $^1/_3$ of the phase of the systole and the phase of slow ejection was shorter than half the period of the systole. The ratio of the two phases fell from 1 : 1·2 to 1 : 1·5.

After intravenous injection of 0.6 mg. acylanid there was normalisation of both phases of isotonic contraction within 40—60 minutes, however 4—6 hours following injection pathological alterations had again become manifest.

The method employed is considered suitable for the diagnosis of cardiac insufficiency as well as for control purposes in cardiotonic treatment.

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NEWS

BULGARIA

In Sofia in September 1958 a cardiological section attached to the Society of Internists was founded.

On October 22—24 1959 a national conference of internists and paediatricians will be held in Sofia.

The subject of the conference will be: Rheumatism, its clinical picture, treatment and prevention.

CZECHOSLOVAKIA

The Czechoslovak Cardiological Society celebrates this year its 30th anniversary. It is one of the oldest cardiological societies which organized as early as in 1933 the First International Cardiological Congress.

In May 1959 in Luhačovice a National Cardiological Congress on the treatment of cardiac insufficiency was held. The Congress completed a series of three scientific conferences which in recent years were concerned with the metabolism of the failing myocardium and the pathogenesis of cardiac insufficiency. Some 600 doctors took part at the Congress. The proceedings of the Congress revealed new advances and suggestions for preventive and curative practice, research and the pharmaceutical industry.

In 1960 specialists from all over the world will meet in Prague to discuss problems of the pathogenesis of hypertension at the International Symposium organized by the Czechoslovak Cardiological Society. The scientific secretary of the Symposium is Dr. Jan Brod.

In 1961 the first congress of the International Union of Angiology (with headquarters in Paris) devoted to the metabolism of the vascular wall will be held in Prague. Professor B. Prusík, associate member of the Czechoslovak Academy of Sciences, is the president of the Congress. Dr. Z. Reiniš will act as the scientific secretary to the Congress. Address of the preparatory committee: Fourth Medical Clinic, Karlovo náměstí, Praha 2.

HUNGARY

The annual post-graduate course in the well known spa of Balatonfüred took place this year in September, 23—27. The inaugural lecture on the treatment of circulatory failure in infants was delivered by the Academician Prof. P. Gegesi Kiss, Rector of the Medical University of Budapest. Further lectures on problems of normal and pathological circulation were delivered by Professors Fornét, Gömöri, Julesz, Szentágotai and Assistant Professors Bugár-Mészáros, Dobozi and Gábor. Simultaneously, on September 25 and 26, at the same place meets the Society of Hungarian Cardiologists. The programme of each individual session: pathological physiology of circulation, congenital cardiac and vascular anomalies, rheumatic lesions and other acquired heart diseases. Almost 30 lectures treated original research results exclusively.

The Internal Department of the Hungarian Institute of Cardiology was transformed into a Medical Clinic of the Budapest University.

Prof. G. Gottsegen, Director of the Hungarian Institute of Cardiology, was named Head of this new Chair.

USSR

The Cardio-rheumatological Section of the Moscow Scientific Society of Therapeutists (Internists) is carrying on its work in Moscow. Problems of cardiovascular pathology are frequently discussed also at plenary sessions of the Moscow Society of Therapeutists and at sessions of therapeutists in other towns.

In December 1958 the First All-russian Congress of Therapeutists was held in Moscow, its programme being devoted to fundamental cardiological problems and collagenoses. At the Congress new methods of examination and treatment of patients suffering from cardiovascular disorders and collagenoses were discussed in detail.

In March 1959 the tenth scientific session of the Therapeutic Institute of the Academy of Medical Sciences of the USSR, devoted to hypertension and atherosclerosis, was held.

In May 1959 in Jerevan a congress of the therapeutists of the Armenian SSR, devoted to fundamental cardiological problems, was held.

In September 1959 a symposium on the problem of atherosclerosis organized by the Academy of Medical Sciences of the USSR was held.

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