the whole procedure. Fallacious findings will usually be found to be due to faulty technique, or to failure on the part of the patient to follow the instructions. Fallacies due to defective drugs are now practically unknown, but to avoid such a possibility capsules should be bought only from reliable manufacturers. The patient may vomit immediately after taking the capsules; should this occur it is important to inquire whether any of the capsules have been ejected. If pyloric obstruction is present the capsules will dissolve in the stomach no matter how they are coated. The test is said to be contraindicated in elderly people with low arterial tension and myocarditis, and also in subjects of extensive arterio-sclerosis. While these precautions may be necessary for the intravenous test, the danger of severe reaction from the oral method is practically nil.

The following tables have been prepared to show on a percentage basis the confirmation of the x-ray findings by operation, and also an analysis of the surgical findings. The cases to which they refer were examined between January, 1926, and October, 1928. There were 47 males and 90 females. The ages were as follows:

Under 20 years	...	...	...	...	...	3
20-30 years	...	...	...	...	...	13
30-40 years	...	...	...	...	...	36
40-50 years	...	...	...	...	...	30
50-60 years	...	...	...	...	...	40
60-70 years	...	...	...	...	...	12
70-80 years	...	...	...	...	...	3

Total ... 137

TABLE I.

Description	No.	Operated.	Correct.	Per Cent.
Normally visualized	48	12	9	75
Faint shadow	19	10	10	100
Late appearance	11	5	5	100
No shadow	40	25	24	96
Stones	19	12	12	100
Total	137	64	60	93
Total cases reported pathological with or without stones	89	52	51	98

TABLE II.—Analysis of Surgical Findings in Cases Reported Pathological.

Stones	...	...	...	39
Chronic cholecystitis	...	...	...	8
Adhesions between gall-bladder and colon	...	...	...	1
Adhesions between gall-bladder and duodenum	...	...	...	2
Cirrhosis of liver and chronic cholecystitis	...	...	...	1
Normal gall-bladder	...	...	...	1
Total	...	...	...	52

TABLE III.—Faint Shadow—10 Cases. Surgical Findings.

Multiple stones in gall-bladder	...	...	...	5
Stones impacted in cystic duct	...	...	...	1
Adhesions between gall-bladder and colon	...	...	...	1
Adhesions between gall-bladder and duodenum	...	...	...	1
Reported pathological	...	...	...	2
Total	...	...	...	10

TABLE IV.—Late Appearance—5 Cases. Surgical Findings.

Adhesion between gall-bladder and duodenum	...	...	...	1
Multiple stones in gall-bladder	...	...	...	3
Cirrhosis of liver, small adherent gall-bladder	...	...	...	1
Total	...	...	...	5

TABLE V.—No Shadow—25 Cases. Surgical Findings.

Single large stone in gall-bladder	...	...	...	1
Multiple stones in gall-bladder	...	...	...	13
Multiple stones in gall-bladder and ducts	...	...	...	2
Single stone in common bile duct	...	...	...	1
Chronic cholecystitis	...	...	...	7
Normal gall-bladder	...	...	...	1
Total	...	...	...	25

Of the twelve gall-bladders normally visualized (Table I) upon which operations were performed it will be noted that the x-ray findings were incorrect in three cases. One had a malignant liver, and presumably the disease was not so advanced as to prevent the secretion of the bile-stained dye and the filling of the gall-bladder. The gall-

bladder itself was not directly involved. In the other two cases single stones were found in the gall-bladder. These were probably stones of intermediate density (to which type I have already referred), not translucent enough to cast a negative shadow and not sufficiently opaque to cast a positive shadow. Of the twenty-five "no shadow" cases which came to operation, in only one were the x-ray findings not verified. I cannot explain the cause of this failure. The patient was a hospital case, and may have taken food before the first radiograph. It is of interest also to note that in all those cases presenting faint shadows, or in which the shadow was late in appearing, which were submitted to operation, the x-ray findings were verified. This was contrary to what I had expected. In the past my reports upon these cases were made with very great caution, but the result of this study has considerably increased my confidence in the value of these signs. In all operated cases in which stones were visualized, stones were found, but in Table II it will be seen that of all cases reported pathological stones were found in 39, while in only 12 of these were stones demonstrated radiologically. That is to say, 69.3 per cent. of the stones did not cast definite shadows, either negative or positive, which could be recognized as stones.

Conclusions.

1. The oral method of carrying out the Graham-Cole test is reliable and is capable of giving a correct indication as to whether the gall-bladder is normal or pathological in 93 per cent. of cases.

2. Except in the case of visualized stones it is not possible by means of this test to give a precise diagnosis. Different surgical conditions will produce similar x-ray appearances, and therefore in the "no shadow, faint shadow, and late appearance cases" one is only justified in saying that the gall-bladder is pathological.

3. The success of the method depends upon the most careful attention to details in preparation and to correct radiographic technique.

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THE EFFECT OF OBSTRUCTED RESPIRATION ON HEART AND LUNGS: ITS CLINICAL IMPORTANCE IN RADIOGRAPHY.

BY

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DURING normal systole the heart changes its shape, size, and position, and pumps an average charge of 75 c.cm. of blood from each of the ventricles into the aorta and pulmonary artery. The discharge of blood into the pulmonary artery disturbs the size, shape, and position of the pulmonary vascular tree, and the pulmonary arteries are straightened in systole and relatively curved in diastole. Since the pulse wave in the pulmonary arteries is estimated to travel at three to six metres a second, it reaches the periphery of the lung in an interval of time which is probably not greater than one-sixtieth of a second. This indicates that the ideal radiogram of the chest requires an exposure of about one-hundredth to one-sixtieth of a second, so as to eliminate the effect of the propagation of the pulse wave along the arteries. The possibility of obtaining radiograms from such a brief exposure is entirely outside the range of most hospital x-ray equipments. In the majority of cases, with the existing apparatus, an exposure of less than half a second cannot be employed with any measure of success.

Apart from the movements in the lung vessels due to each cardiac cycle, the slower rhythm of inspiration and expiration also leads to a change in size, shape, and position of the bronchial and vascular tree. In inspiration the trachea, bronchi, and bronchioles become lengthened and revert to their original length in expiration. The movements of the respiratory apparatus in the subject who is being screened can be voluntarily controlled to some extent, but the involuntary cardiac movements cannot be controlled except to a slight extent by the voluntary control of respiration or by the voluntary assumption of the extreme erect attitude of attention. It is essential that all routine radiograms of the chest should be taken under strictly defined standard conditions in a particular phase of inspiration or expiration, and, if possible, in a particular phase of the cardiac cycle. So far one of the most successful attempts in this direction has been made by MacPhedran and Weyl¹ of the Henry Phipps Institute, Philadelphia. They have applied a tambour to the area of carotid pulsation on the neck of the patient, and the excursions of the tambour are employed to deflect a beam of powerful light on to a photo-electric cell of the vacuum type. This in turn is connected by way of an amplifier to a relay which operates the switch of the x-ray tube. In this manner a radiogram can be taken not only in a given phase of respiration but also in a given phase of the cardiac cycle with an exposure of one-twentieth of a second, and a minimum lag of one-twenty-fifth of a second between cardiac systole and the actual commencement of the exposure.

Both in the routine teaching of the normal radiographic appearance of the chest to students of anatomy and physiology, and in observing the varied symptoms of patients who have been screened or radiographed in the erect attitude, it has been noted that the subject may exhibit symptoms of distress ranging from dizziness to fainting. It was evident that in certain cases the respiratory mechanism was influencing the circulation of the blood to an inordinate extent. On viewing two radiograms of the chest of a certain subject it was observed that there was considerable variation in the appearance of the root shadows, and it was thought that this might be due to some alteration in the amount of blood present in the heart and lungs at the moment the photographs were taken. It was therefore determined to vary the amount of blood reaching the heart and lungs by repeating the classical experiments of Valsalva (1740) and Johannes Müller (1838) and to take radiographic records of the chest under the varying conditions obtainable. In Valsalva's experiment, after a deep inspiration is taken, the glottis is immediately closed and a strenuous and prolonged expiratory effort is made, but without allowing the air to escape. Such pressure is exerted on the heart and intrathoracic vessels that the movements and flow of blood are almost entirely arrested. "Pronounced swelling of the veins, visible principally in those of the neck and face, evacuation of the vessels in the pulmonary system, and surcharge of the systemic circulation, cessation of cardiac sounds, and disappearance of the arterial pulse can all be witnessed" according to Luciani.² In Müller's experiment the glottis is closed at the end of expiration and an attempt is made forcibly to inspire. "The heart and all the intrathoracic vessels fill to such an extent that the arterial pulsations cease owing to the surcharge of the lesser, and comparative evacuation of the greater circulation" (Luciani). These experiments are not devoid of risk in old age and in patients suffering from cardiovascular disease.

Standard radiograms of the chest of a healthy male, aged 33, of hypersthenic build, were taken under the varied conditions of intrapleural pressure which are produced in the experiments of Valsalva and Müller. The pressure of the air in the lungs was recorded by means of a mercury manometer connected to a tube in the mouth of the subject, care being taken to keep the glottis open, the nose being clipped, during the reading of the pressure. The standard conditions for the radiograms were a tube distance of two metres to minimize distortion, Coolidge tube of universal type, and an exposure of half a second at 110 kilo-volts,

the patient standing erect with the screen immediately in front of him. Such a series of radiograms demonstrates the effect of changes of pressure in the pleural cavity on the volume of blood reaching the heart, and the variations in the size of the cardiac shadow within the physiological limits of respiration.

Fig. 1 shows the chest at the end of normal inspiration. The pressure of the air in the lungs is in equilibrium with that of the atmosphere. Assuming that the pressure due to the elasticity of the lung substance is 15 mm., the intrapleural pressure is 745 mm., so that there is a virtual negative pressure in the pleural cavity of $(760-745)=15$ mm.

Fig. 2 shows the chest at the end of normal inspiration, when an extreme effort is made to force expiration against obstruction, as in Valsalva's classical experiment. The radial pulse could not be detected, though the heart could be seen beating feebly on the fluoroscopic screen. The pressure of the air in the lungs rises to 850 mm. Allowing 15 mm. for the elasticity of the lung substance, the intrapleural pressure is 835 mm., or a positive pressure of $(835-760)=75$ mm. This increase of the intrapleural pressure prevents the return of venous blood to the heart from the great veins of the neck and abdomen. The result is clearly indicated by the marked decrease in the size of the cardiac shadow and the extent of uncovering of the lung roots. On ceasing the effort at forced expiration the face of the subject was suffused with blood, and a sudden sensation of dizziness developed. It must be repeated that this experiment of Valsalva is not without its dangers in the unfit.

Fig. 3 shows the chest at the end of normal inspiration, when the subject attempts to inspire still further against obstruction. The pressure of air in the lungs is reduced to 680 mm. Allowing 15 mm. for the elasticity of the lung substance, the intrapleural pressure is 665 mm., or a negative pressure of $(760-665)=95$ mm. The flow of blood into the heart is suddenly increased, as shown by the size of the cardiac shadow, which is greater than that shown in Fig. 1, and still greater than that in Fig. 2. The increased density at the lung root in this experiment is marked, and may easily lead to errors in radiographic reports in relation to conditions at the hilum. The increased density of the shadow is due to marked engorgement of the pulmonary vessels.

In addition to three experiments with radiographic records (Figs. 1-3) at the end of inspiration, three corresponding experiments were performed at the end of expiration. Fig. 4 shows the chest at the end of normal expiration. The pressure of the air in the lungs is 760 mm. The pressure exerted on the contained air by virtue of the elasticity of the uninflated lung is approximately 5 mm., so that the pressure within the pleural cavity is 755 mm., or a negative pressure of $(760-755)=5$ mm. Fig. 5 shows the chest at the end of normal expiration when the subject forces expiration still further against obstruction, as in "bearing down" or "straining at stool." The radial pulse could barely be detected at the wrist. The pressure of the air in the lungs was 835 mm., the pressure within the pleural cavity, allowing 5 mm. for the elasticity of the lung substance, was 830 mm. This yields a positive pressure of $(830-760)=70$ mm. The diminution in the volume of blood reaching the heart, as evidenced by the reduced size of the cardiac shadow, is most marked. The decrease in the size of the cardiac shadow is not so marked as in Valsalva's experiment (Fig. 2). The differences between Figs. 4 and 5 are of the same kind, but not of the same degree, as those between Figs. 1 and 2.

Fig. 6 was taken at the end of normal expiration, the subject making an effort to inspire against obstruction, as in Müller's experiment. The pressure of the air in the lungs is 675 mm. The intrapleural pressure is 670 mm., or a negative pressure of $(760-670)=90$ mm. The size of the heart is distinctly greater than in Fig. 5, and in contrast to Fig. 2, with the minimal cardiac inflow, is most marked. The heart in Fig. 6 is receiving the maximal inflow of blood that can be brought about by voluntary change of intrapleural pressure. The clinical picture corresponds closely to that seen in the attempt at inspiration against obstruction after a series of expiratory coughs in whooping-cough or in some phases of the dyspnoea of asthma. The density of the shadow of the lung roots should be compared with that in Fig. 2, when the cardiac inflow was at the minimum. The subjective disturbance in this experiment of Müller is not so marked or so easily produced as that in Valsalva's experiment.

The Significance of the Dead Spaces of the Chest.

As in the neck, so in the chest, certain spaces of great pathological significance are never seen in the routine dissection of the formalin-fixed cadaver. The textbook diagrams of fascial planes in the neck and of lines of pleural reflection in the chest do not emphasize the existence of those "dead spaces" filled with loose areolar tissue

which permit considerable distension of certain viscera, such as the pharynx and oesophagus, and of extreme distension of the veins in any condition involving severe physical effort or pathological venous congestion. In the thorax it is important to realize the extent of the fascial spaces in the posterior mediastinum and in relation to the lung roots, for those "dead spaces" not only allow room for expansion of engorged veins, but also determine the direction of expansion and spread of enlarged lymphatic glands and mediastinal tumours. The root of the left lung is almost encircled by the relatively resistant arch of the aorta, with a marked condensation in the surrounding connective tissue, whereas the root of the right lung is almost encircled by the dilatable vena azygos major and superior vena cava. The enlargement of glands, whether of the carinate group at the bifurcation of the trachea, or of those in the hilum of the right or left lung, is therefore directed towards the right side of the thorax. It is this tendency for the glands to enlarge on the right side which accounts for the phenomenon of right-sided paravertebral dullness, which has been so rightly emphasized by Riviere.³ Similarly the conduction of the whispered voice from the third to the fifth dorsal spine on the right side, as described by d'Espine, is another manifestation of the enlargement of the glands to the right. Opie has emphasized that the common calcium-bearing glandular lesions, distinguished by the deposition of calcium salts, are right-sided irrespective of the side in which the pulmonary and intrapulmonary glandular lesions occur. In fatal infantile disease the calcium-bearing mass of glands often extends as far as the right side of the bodies of the vertebrae. Opie⁴ has also stressed that the commonest demonstrable site of calcification, either radiographically or at necropsy, is in that lymph node which sits to the right of the trachea just above the bifurcation and above the arch of the vena azygos major.

Furthermore, the mediastinal pleura of the right side, above the level of the lung root, covers over a dead space extending from the superior vena cava anteriorly to the trachea and oesophagus medially, the right vagus lying somewhat freely therein. Enlarged glands in this area are frequently seen, and it is the perifibrosis thereof which so frequently leads to a strange "bruit de diable" over the right apex and neck, and renders the clinical signs in this area equivocal. The lowest gland in this space, just above the arch of the vena azygos major, is the one which most frequently displays a lesion, as mentioned above.

In order to obtain an instructive radiogram of the chest by freeing the right and left lung root from the shadow of the heart and great veins, it is essential to take the radiogram in that phase of respiration which fills the lungs with air and at the same time empties the heart of blood to the maximal extent. This is best accomplished by pinching the nostrils of the patient at the end of inspiration, either digitally or by a clip, and asking him to expire forcibly (Fig. 2), as in Valsalva's experiment. If the condition of the patient is such that Valsalva's experiment is dangerous, then the radiogram should be taken at the end of expiration, with forced expiration against obstruction, as in "bearing down" (Fig. 5). The information thus gained adds greatly to the value of the radiogram, and saves the expense of two or more oblique radiograms. Although with routine work with a Coolidge tube it is difficult to determine the size of those glands at the hilum which are enlarged but uncalcified, it should be noted that the gas tube often gives information of the degree of enlargement of both the calcified and uncalcified glands. This is well seen during and after an attack of measles or whooping-cough.

The repetition of the classical experiments of Valsalva and Müller, with the visible aid afforded by the x-ray screen and photography, clearly demonstrates the wide variation in appearance of the thorax in the same individual, and shows the need for further standardization in routine radiography of the chest. A given individual under different phases of respiration may simulate "cor bovinum" or "cor pendulosum." A brief study of the six radiograms presented indicates the need for the reconsideration of many of the terms used by the radiologist. Such terms as "dilated heart," "peribronchial

fibrosis," and "increased hilum shadows" may have to be abandoned.

With the growth of knowledge accurate diagnosis is coming to depend, even in greater measure than it has in the past, on considerations of exact anatomy and physiology applied with understanding to the concrete pathological problem presented by each individual patient.

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THE DEEP SUBMAXILLARY LYMPH GLANDS.

BY

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THE submaxillary lymph glands have for long been recognized as a chain of glands occupying the groove between the lower border of the mandible and the superficial surface of the submaxillary salivary gland. The number of glands is variably given, but three large ones are considered fairly constant. The biggest of these is usually in the centre of the chain, lying below the facial artery as it turns upwards on to the mandible. Other glands, placed one anteriorly and one posteriorly to this, complete the trio. There may be additional smaller glands in the chain, or one of the main three may be absent, particularly the posterior one. These glands lie beneath the superficial layer of deep cervical fascia, but outside the capsule of the submaxillary gland. Occasionally one finds mentioned deeper lymph glands beneath the salivary gland or inside its capsule, but no very exact account of observations on which such statements are based can readily be found.

It is well known that lymph glands are to be found actually embedded in the substance of the parotid gland. So intimate is the relationship between the two that, as Neisse demonstrated, salivary acini are to be found invading the interior of some of these intraparotid lymph glands. It does not yet seem to have been determined whether such interrelations exist between the submaxillary salivary and lymphatic glands, although Poirier and Cunéo make the positive statement that "contrary to what we have noticed in the case of the parotid, there do not appear to be any lymphatic glands included in the submaxillary salivary gland."

In 1903 von Brunn addressed himself to this problem. He specially wished to find out if metastases in the submaxillary salivary gland occurring in cases of labial or lingual carcinoma were to be explained by the presence of lymph glands inside the salivary gland. He gives, as surgeons will do, a black list of the standard anatomy textbooks of his time, which threw no light upon his problem. Even the voluminous Sappey failed him. Turning to more specialized works, mostly studies of the lymphatic drainage of the tongue, he found that although one or two investigators who had injected the lymphatics of this region did not find any deep submaxillary glands, others made passing mention of small glands inside the submaxillary gland capsule or even enveloped by the gland. But these last did not give satisfactory accounts of work on which their statements were based. Von Brunn, therefore, himself examined 61 submaxillary salivary glands, which he cut into sections 2 or 3 mm. thick. The sections were examined unstained, and his drawings at any rate are only naked-eye views. Of the glands, 15 were removed at operation from 9 cases of cancer of the lower lip or tongue. One or two of those contained carcinomatous nodules, but there were lymph glands in none. The remaining 46 submaxillary glands were taken from 23 subjects of all ages, dead of conditions other than disease of this region. In two only, from different individuals, were lymph glands found. In each case a single small gland was seen embedded in connective tissue prolonged into the submaxillary gland as

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FIG. 1.—CHEST AT END OF NORMAL INSPIRATION. Breath held, but no effort made to force expiration.

FIG. 4.—CHEST AT END OF NORMAL EXPIRATION. Breath held, but no effort made to inspire.

FIG. 2.—CHEST AT END OF NORMAL INSPIRATION (Valsalva's Experiment). Breath held, and extreme effort made to force expiration against obstruction. Pulse could not be detected at wrist, but, when screened, the heart was seen to be making slight movements. Positive intrapleural pressure=75 mm.

FIG. 5.—CHEST AT END OF NORMAL EXPIRATION. Breath held, and extreme effort made to force expiration against obstruction. Pulse could barely be detected at wrist.

FIG. 3.—CHEST AT END OF NORMAL INSPIRATION. Breath held, and extreme effort made to inspire against obstruction.

FIG. 6.—CHEST AT END OF NORMAL EXPIRATION (Müller's Experiment). Breath held, and extreme effort made to inspire against obstruction. Pulse easily detected at wrist. Heart seen to be beating forcibly when screened. Negative intrapleural pressure=90 mm.