impressed by the functional importance of the region of the apex. The chief terminal arborescences of the A.V. bundle end in the trabecular network of the apical region. Dr. Thomas Lewis⁷ has demonstrated that the apical region is the first to pass into contraction with the onset of ventricular systole. When we open the ventricles we see that their internal musculature—columnae carnaeae and muscoli papillares—commence in the apical region and divide into two sets. The larger set terminates in the auricular or movable base, the smaller or septal set in the fixed or aortic base. When we examine the outside of the ventricles we find the same arrangement in the spiral fibres. They commence in the vortex of the apex and divide into two sets—an extensive one which ends in the auricular movable base, and a less extensive, which ends in the fixed aortic base. Between these outer and inner sets is placed the great middle driving muscle of the left ventricle; its spirals are so closely pressed together that they give the appearance of being purely circular; we may speak of them as the circular set. The circular musculature, acting by itself, would diminish the circumference and at the same time lengthen the lumen of the ventricle the elongation is antagonized by the internal and external apico-basal musculature. We know that, at least in the earlier phase of ventricular systole, the auricular base approaches the apex and therefore the circular fibres are more than antagonized; in the later stages of ventricular systole the opposite is the case; the circular fibres become dominant and press again on the auricle, raising the intra-auricular pressure. The apico-aortic fibres are purely sustaining in function; they neither shorten nor lengthen in systole.

In several respects the structure and mechanism of the right ventricle is peculiar. There is incorporated in the infundibulum of the right ventricle a chamber—the pylorus of the primitive cardiac tube—an element which has completely disappeared in the left ventricle. The pulmonary orifice does not serve as a fixed point for the ventricular musculature; the infundibular septal bands of the right ventricle act from the aortic base. Further, the right ventricle has only one wall—the lateral; its septal wall—the interventricular septum—is part of the left ventricle; it takes only a passive share in expelling blood from the right ventricle. On the other hand, the right ventricle is provided with a highly developed internal musculature passing from its apex to the auricular base. The systolic movement of that base is more marked on the right side than on the left side of the heart. Hence we find in the lateral wall of the right auricle a well-developed opponent set of muscles—the muscoli pectinati. In auricular systole the muscoli pectinati elongate the apico-basal fibres of the right ventricle; in ventricular systole the opposite occurs.

I noted, when investigating those hearts in which Sir James Mackenzie first observed that the auricles had ceased to functionate—from auricular fibrillation, as was afterwards proved—that a condition was present similar to that which occurs in a limb when a set of muscles undergoes contracture from paralysis of the opponent group. In such cases the lateral wall of the right auricle had become elongated and stretched, while in their opponents—the apico-basal fibres of the right ventricle—an extreme degree of shortening had occurred.

I have merely touched on some of the unsolved problems relating to the structure and mechanism of the heart. I am content if I have succeeded in showing that Harvey's methods of investigating anatomical problems are still the best that we anatomists can adopt.

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- ¹ Sir Thomas Barlow, *BRITISH MEDICAL JOURNAL*, 1916, II, p. 577.
² See D'Arcy Power's *William Harvey*, in the *Masters of Medicine* series, 1897.
³ See Proceedings of the Anatomical Society of Great Britain and Ireland, November, 1902 (appended to *Journal of Anatomy and Physiology*).
⁴ *Journ. of Physiol.*, 1891, vol. xii, p. 438.
⁵ See Chauveau and Marey, *Mém. de l'Acad. de Médecine*, 1863, vol. xxvi, p. 313; Haycraft, *Journ. of Physiol.*, 1891, vol. xii, p. 438.
⁶ The best account of the arrangement of the muscular fibres of the heart is that given by the late Professor Bell Pettigrew (*Phil. Trans.*, 1864, p. 445). The late Dr. John Bruce MacCallum also gave an excellent account in *Johns Hopkins Hospital Reports*, 1900, vol. ix, p. 307.
⁷ Professor Franklin Mall added very important embryological facts (*American Journ. of Anatomy*, 1912, vol. xiii, p. 249). For an introduction to the older literature see the chapter on the heart in Poirier's *Traité d'anatomie humaine*, 1899, and Quain's *Elements of Anatomy*, 1892. My statements are based on dissections carried out between 1901 and 1907, and will be published in full at some future date.
⁸ Croonian Lecture, *Proc. Roy. Soc.*, 1917, S. B, vol. lxxxix, p. 560; *Lectures on the Heart*, 1916.

THE TOLERANCE OF PHYSICAL EXERTION, AS SHOWN BY SOLDIERS SUFFERING FROM SO-CALLED "IRRITABLE HEART."

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It is now two years since we introduced at the Military Heart Hospital, Hampstead, a system of graded drills, arranged from exercises in the army exercise book, and employed these both remedially and as means of grading soldiers returned to us for the condition known as "disorderly action of the heart," "irritable heart," etc. We have repeatedly contended that the surest means of gauging capacity for physical endurance is to test the men upon drill, the highest grades of which should approach in their severity the tasks which will be set to these men when they return to their dépôts. The test of capacity for work should be the observed reaction to work. That this thesis has been justified fully is shown clearly in an article published recently elsewhere,¹ in which the after-histories of 239 graded out to duty categories by this system are compared with the recommended categories of discharge. This comparison is reviewed in the subjoined table:

Recommendations.	Disposition within 11 Months.
Fit for general service 72	Full duty overseas, 79: Known to reach firing line (of whom 26 make good) 35 Not known if in firing line 23 Known not to have been in firing line 21
Likely to be fit for general service within 3 months 47	In provisional units 30 Full duty home service 8
Light duty; unlikely to be fit for overseas within 3 months 20	Light duty overseas 7 Labour companies (H.S.) 23
Light duty, but unlikely ever to be fit for service overseas 68	Light duty (H.S.) 33 Sedentary duty 16
Sedentary work at home 32	Under treatment 5 Discharged permanently unfit 38
239	239

This system and its results have aroused a good deal of interest, and a large number of military hospitals both at home and abroad have adopted it; others are following suit. Since the recent removal of the heart hospital to Colchester we have continued to receive numerous inquiries as to the details of our method. In part these have been described in previous publications.² In the present article the work of the medical officer's examination room is described, his method of prescribing exercises, and his method of judging the toleration of exercises so prescribed.

The drills now in use are termed B 15, C 15, BC 30, C 30, and D 30,* the letter indicating the stiffness of the exercises, the number the duration of the drill in minutes. B 15 consists of simple movements, and calls for no considerable expenditure of energy; D 30 includes many of the stiffest exercises of the army exercise book, and entails thirty minutes' hard work.

Seeing that most of our patients are recently from France, all those cases to whom drills are prescribed start on the easiest drill, and progress from this to those of higher grades, according to tolerance. A few days or a week upon the two 15-minute drills suffices; a week is usually spent on each of the three 30-minute drills. Men who promise well may be kept a week or so longer on the highest grades of drill to harden them. It is a rule of the hospital that patients upon 15-minute drills are to be considered unfit to leave the hospital premises except under escort; those on 30-minute drills are given afternoon passes freely. This rule has the advantage of stimulating the men to accomplish the 30-minute drills. All men on exercise C 15 and BC 30 go regularly for route marches in the early afternoon; these are short marches of one or two miles in the immediate neighbourhood of the hospital, and at slow time. Men in classes C 30 and D 30 are taken for longer marches of four to five miles in the

* Two of our original drills, A 15 and AB 30, have been discarded.

country at a brisk pace. The exercises and marches are supplemented by outdoor games. At suitable intervals all men are examined as they come from drills or marches. It is understood that any man who feels his drill or march to be beyond his power is to report at once to his medical officer. The drill instructors are ordered to report upon men who seem to them to tolerate exercise badly, and, on the other hand, upon any men who fail to make reasonable effort. Co-operation between the medical officers and the instructors is a very essential feature of our system, and much is left to the instructor's discretion. It is the habit of most medical officers to see each man immediately after he has taken the first drill of each grade; other officers prefer to raise the grade more automatically, and to await complaints from such men as feel themselves hard pressed. At the examination, whether it be at the dictation of the medical officer or drill instructor, or at the wish of the man, questions of a general nature only are asked; the rule is to allow the man to tell his own story; it is inadvisable for the officer to introduce any symptom into the conversation. Notes are kept on simple forms provided for the purpose; each symptom complained of is entered, as are corroborative signs and readings of pulse-rate, etc. This sheet forms in the end a summarized history of the work accomplished and the reaction to it. In the average one or two examinations of each man are made weekly directly after exercise. Medical officers are careful to conceal so far as possible the particular symptoms or signs upon which they judge tolerance.

SIGNS AND SYMPTOMS AFTER DRILL.

The chief complaints of the men as they come from drill are of breathlessness, precordial pain, palpitation, giddiness, and fatigue. It is essential that objective evidence of symptoms should in each case be found before a complaint is allowed to weigh. Most patients emphasize a single symptom, and emphasize it constantly; a changing symptomatology can rarely be corroborated by outward signs, and is to be distrusted. Some men complain on all occasions and in equal degree from the lowest to the highest exercise; others complain little. The medical officer has ever to be on his guard against those who exaggerate their sensations, and equally on his guard against those who are reticent. The tolerance of exercise is to be judged by physical signs, and not by symptoms; symptoms are chiefly of value in directing the attention quickly to physical signs. It has happened more than once that a medical officer has laid recognizable emphasis upon a particular symptom, and that it has led to a corresponding epidemic in his service.

Facial Expression and Breathlessness.

The facial expression when it exhibits genuine distress is generally that associated with breathlessness. The accessory muscles begin to be called into play, the alae

nasi are expanded, the tendons of the sterno-mastoid lift, and the lips part a little; where there is greater distress the alae nasi are active, the eyebrows are drawn together, furrowing the forehead vertically and yielding an expression of anxiety or actual pain; the mouth opens wider, its angles droop, and the breathing is more audible. If questions are asked, the breathing is ill-regulated during the replies, the flow of words is interrupted by inspiratory movements. Not infrequently, and especially where there is fatigue, a slight but distinct dusiness develops under or around the eyes; pallor or sallowness of the whole face is not unusual. The facial traits deserve careful observation, for they cannot be simulated; rapid breathing is by itself a scarcely sufficient evidence. In a few patients in whom distress has been frequent and has been experienced for long periods, the altered facial expression is maintained at rest.

Photograph of a patient, aged 28, admitted for long-standing and severe "D.A.H." The photograph was taken immediately after fifteen minutes' easy exercises (B 15), and shows the tension of the sterno-mastoid, slightly opened mouth, and dilated nostrils. The eyebrows are depressed, the forehead furrowed (the central furrow is permanent). The face expresses fatigue and the anxiety of early breathlessness.

Precordial Pain.

This is a common complaint after exercise; it is to be checked by physical examination. With the chest stripped, the hands of the examiner are placed outspread symmetrically on the axillary and sub-mammary regions and pressure is exerted as though to steady the chest or to bring the patient to a more convenient position. This simple action may be sufficient to disclose hypersensitiveness; in some patients, indeed, the slightest pressure on the left precordial region and a wide surrounding area is resented. In others it is necessary to slip the hands higher, bringing the thumbs over the borders of the pectoral muscles and pressing again, or to proceed further and while interrogating the patient, to grasp the pectoral folds with increasing firmness between thumbs or fingers. Where the muscles are sensitive on the left side the patient winces, the left shoulder is depressed, the facial expression alters, or the reply is momentarily interrupted or actually broken off by a movement or expression of protest. When no

hypersensitiveness of the left chest wall is detectable after exercise, the plaint of pain may usually be neglected. In extreme cases hyperaesthesia is found beyond the chest area and exists in the skin of the upper arm; not infrequently it also involves the tendons of the sterno-mastoid muscles. Tenderness of the anterior border of the trapezius muscle suggests a closer examination for signs of early tuberculosis. Patients should not be asked, Is this or that region sensitive?

Palpitation.

A complaint of palpitation is to be neglected as such, but is serviceable as a guide to persistent or excessive tachycardia. The usual rate of the heart's action while a patient is up and about, and especially after set test exercises, is of much importance. It may be normal, raised, or very high. To give actual rates might create a false impression. Heart-rate cannot be used by rule of thumb; rates vary too much with circumstances, and in

general it is impracticable to render these uniform. However, the conditions pertaining to a particular service may be maintained sufficiently constant for different patients and at repeated examinations of the same case. It is essential that heart-rates should be regarded broadly, and particular emphasis is to be laid upon consistency of separate readings. Thus, a patient who reports himself as disturbed by a given drill, will usually show uniform high readings after that drill if distress is genuine; and these high readings will be foreshadowed by raised rates after drills of lower grade. Equally important is consistency between these drill rates, the routine ward rates, and the rate obtained by test exercises.*

Giddiness.

This is a common complaint, but one which is given for the most part in the initial stages of treatment. It consists of transient dizziness or dimness of vision, and is often described as a cloud before the eyes. Rotation of surrounding objects is not experienced. Giddiness may be felt after the patient has stood quietly for some while, immediately at the cessation of effort, or on rising to the upright position abruptly. As a prognostic sign it has little value.

Fainting.

Although nearly 3,000 patients sent to us with diagnoses of "D.A.H." or "V.D.H." have now been submitted to graded drills, there has been no single accident of consequence. Where several hundred men are drilled each day, a fainting attack on drill is less than a monthly incident. The chief form of attack, and one which may always be regarded as genuine, is that accompanied by a feeble and slow heart action (30-50). It may be preceded by a short interval of giddiness, by a sense of weakness or unsteadiness. Consciousness is lost, and the fall is sudden, but rarely heavy. Pallor and sweating are present. Involuntary movements are slight, and usually confined to the face and arms; a general rigidity may be developed; the tongue is not bitten, neither is the urine passed. Nausea or vomiting may be present. The attack lasts from a few seconds to a few minutes, and is followed by lassitude and headache. A history of earlier attacks is common; these are associated usually with emotion (sight of blood, etc.), long standing at attention or the cessation of sudden effort; they do not occur in recumbency. Recovery is always complete, and an attack should not break the routine of drill for more than forty-eight hours. Attacks which are inconsistent with this picture are to be viewed with suspicion unless they may be ascribed to epilepsy.

A complaint of *fatigue* or *exhaustion* is rarely unaccompanied by other complaints, and may be disregarded unless often repeated and accompanied by signs, such as pallor, or by uncontrollable tremor of lips or limbs, or by signs of breathlessness, as the grade of exercise is raised. Stiffness of the limbs or trunk muscles, accompanied by tenderness, is experienced by some unpromising cases to an unusual degree as an after-effect of short exercise. Pain in the axillary region, back, or limbs is usually related to a particular action during drill, and as a general rule does not endure.

Simulation.

If it were wise it would be impossible to hide the meaning of the exercises or their use for sorting purposes from the patients, and they come to understand the significance of any deliberate special examination. We believe that complaints of distress, where absolutely no distress exists, are on the whole rare. Such complaints do not deceive; the manner of their presentation awakens doubt; they are unaccompanied by objective signs or the signs are incompatible with the complaint.

The over-emphasis of symptoms actually experienced is somewhat more difficult to recognize and is undoubtedly common; it is recognized by the same careful comparison of the objective and subjective. Medical officers will be well advised to guard against wilful efforts to produce or to exaggerate signs of distress. A man returning from exercise to the medical officer's room will from time to

time sprint on the flat, dash upstairs, or perform vigorous exercises before opening the door and presenting his wrist for examination. But such attempts are not easy to maintain, and repetition is essential to their success. The man must repeatedly risk detection by a member of the staff, or, maybe, fails to find his opportunity; in the last case his observed reaction is out of harmony with former reactions. The genuineness of a sudden increase in the reaction to exercise is to be tested by visiting the man while he is at drill, or by imposing simple exercise tests in the examination room or ward. The constant supervision of drill by medical officers has been abandoned as both unnecessary and inexpedient; the men work better and more uniformly when left to the drill instructor. No doubt the voluntary production of distress is overlooked from time to time in individual cases, but it cannot long be concealed from the man's comrades, and many of these at once resent the deception. If less gross, the deception may be contagious, and comes to be practised by small groups of men; its early discovery is from that time certain. When discovered, it is met at once by placing the man upon a higher grade of drill without comment.

The other and brighter side of the picture is the man or men who steadily refuse to complain; these tax the medical officer's power of discrimination most of all. Medical officers who get to know their men, who can win their confidence, who treat them tactfully and fairly, experience little difficulty. By far the larger part of our patients desire only full examination and consideration, and recognize the justice of the final decision, understanding for themselves that they are judged for grade of service according to their proved tolerance for work.

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¹ *Lancet*, February 2nd, 1918. ² BRITISH MEDICAL JOURNAL, September 23rd, 1916; Medical Research Committee, Special Report Series, No. 8.

NOTES ON RHEUMATOID ARTHRITIS.*

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I FIRST had the opportunity of making a special study of rheumatoid arthritis and allied conditions when working at Buxton several years ago. Much has recently been done in investigating its nature, and means for its relief or cure. It is in reference to these sides, and to the differential diagnosis, rather than to the clinical types, that I wish now to allude.

Rheumatoid arthritis has been defined as a progressive degeneration of joints of a special kind, accompanied by atrophy of some structures and hypertrophy of others, but it is really no more than a name given to a number of conditions the exact cause of which is unknown. It is probable that there is more than one disease to account for the different types. The course is variable, but is usually towards irrevocable damage to structures involved. It is a disease of great antiquity, and although it has long received much attention, there is perhaps no other disease in which such confusion exists as to its pathology and place in medicine.

During the last few years bacteriological researches have to a great extent modified former ideas and given light from a new direction. Joints have been aspirated and the fluids so obtained examined microscopically and by cultivation, and it is stated by some observers that a specific organism has been isolated.

Crowe considers that in the majority of cases one particular organism, which he calls the *Staphylococcus deformans*, is concerned; he states that he is able to cultivate it from the urine in about 90 per cent. of all cases of the disease, and that the same organism is recoverable from the urine in many cases of obscure neuritic trouble; he holds that there is a close connexion between neuritis and acute rheumatoid arthritis. Fuller believes that many cases are due to a streptococcus, and that in a very large number of male cases this streptococcus is derived from post-gonorrhoeal infection of the

* The test exercise is employed in all patients on admission as part of the routine examination, and consists of walking briskly up forty steps. The pulse-rate is taken before, immediately after, and two minutes after this test. As an alternative test, we have suggested hopping twenty times on each foot, raising the shoulders approximately nine inches at each hop. In health the pulse will rise to 110 or 120 per minute, but will fall to normal usually within one minute.

* An extract from the Presidential Address on "Some of the affections connected with the war ('shell shock,' 'trench fever,' and 'rheumatoid arthritis')." delivered before the Gloucestershire Branch of the British Medical Association at Cheltenham.