short, spare, and somewhat delicate in appearance, was employed in a cap-manufactory, in a department which was not trying to the sight. Her general health was said to be good. A fortnight before I saw her, she first noticed dimness of the *left eye*, which continued ever since, but was said to vary in degree. On the morning of Dec. 19th, she observed the appearance of a star before this eye in rapid rotatory motion, which had not been seen before. The *right eye* was healthy. Examined with the ophthalmoscope, the pupil partially dilated, a filmy minute globular opacity was distinguishable in patches, obscuring the view of the disc, and rendering vision dim, especially of objects situated beneath the level of the pupil. This patient was also put upon a tonic plan of treatment—cinchona, with the liquor hydrargyri bichloridi; also an occasional alternative pill, and the cold affusion, as in the former case. She very soon began to improve in sight; and on January 27th, 1868, when examined with the ophthalmoscope, the opacity was found to have entirely disappeared, the disc was distinctly visible, and vision was stated to be as good as ever.

The next two cases may be briefly disposed of, as I cannot speak as to the result of the treatment employed.

CASE III.—May 1867. Mrs. R., aged 26, about medium height, pale complexion, dark hair, and feeble aspect, said that she felt weak, and had suffered a good deal of mental anxiety. Her father died of consumption when she was an infant. Her sight had been failing for several months past, and all objects appeared as if seen through a smoky medium. Vision with the *left eye* (which, I presume, was the only one affected, although it is not stated in my notes) was so defective that she could not distinguish my features. Examined with the ophthalmoscope, the pupil dilated, the disc was distinctly visible through a fine gauzy film, which presented the appearance as of dust sprinkled upon a transparent surface. At the inner side of the disc, close to the base, there was a small linear-shaped black opacity. For this patient I prescribed the citrate of iron and quinine, three grains thrice daily, and good diet, with some wine; rest of the eyes, especially at night; avoidance of fatigue; and the use of blue tinted glasses. As I did not see her again, I hope the means employed were beneficial.

CASE IV.—Nov. 1866. Henry Reid, aged 33, engineer, and married, of medium height, moderately stout, light hair and eyes, rather feeble aspect, said that he had fever in Calcutta four years ago, and was ill for about two months, but did not think that his sight was affected after he recovered. However, he had never felt so well since. A little extra work made him "nervous and shaky, out of breath, and fatigued." He did not appear to have had any venereal affection, or to have taken mercury. He complained of dimness of sight in the *left eye*, of one month's duration; but said that it attained its present condition in the course of a week. Placed with his back to the light, he saw me rather indistinctly with this eye; there was a general cloud over the field of vision, darker towards his left hand. He was able to make out the heading of a newspaper, but nothing more, the letters appearing as if seen through a gauzy veil. In looking at the sky, he observed numerous dark specks gathered round a form which moved slowly about, and the same appearance was noticed in looking at a white surface, as paper. Examined with the ophthalmoscope, the disc in the left eye was very dimly discernible through a gauzy veil, with opaque striae crossing it, and some opaque spots upon it. I gave this man cinchona, with liquor hydrargyri bichloridi, but cannot speak as to the result, not having seen him again.

CASE V.—March 24th, 1868. Joseph Austin, aged 36, a tailor, had been a fortnight under treatment in the Eye and Ear Infirmary. He was of medium height, spare habit, and rather exhausted appearance. He said that he had been a good deal addicted to the intemperate use of strong drink and tobacco; and, during the last six months, had often been without a sufficient supply of food, from inability to work at his trade. He had never been able to see well with the right eye; the pupil was contracted, irregular, and filled with lymph, to which the iris was adherent; and he merely distinguished a very bright light. Vision had been in this state for ten or twelve years past. About four years ago, on getting out of bed one morning, he found the sight of the left eye to be indistinct, and he was unable to thread a needle. He had been indulging in strong drink for some days previously. The sight continued defective for about a year, so that he was unable to work, when it partially recovered, and he resumed his trade during four months, when it failed again, and he was idle from necessity during five or six months. After this, vision again improved, and he worked for some weeks; but during the last six months he has not been able to use his eye for more than one or two hours at once; after this, the sight became confused, and he missed his stitches. He had noticed numerous muscæ, of a dark colour, floating in the air. Examined with the ophthalmoscope, in the left eye, the pupil dilated, the same gauzy film was observed, partially obscuring the view of the disc. Since his admission to the

infirmary, on March 10th, he had been treated with tonics, and put upon a good diet with porter. He improved much in health and strength; and, when examined with the ophthalmoscope, three days ago, the film was found to be materially thinned and dispersed, and he was able to make out printed letters, which he could not do on admission. All objects now appeared clearer to him, the misty cloudiness that formerly obscured them having become much lighter.

Appended to one of these cases, I find a note stating that another example of the same ophthalmoscopic appearances had presented itself to me at the infirmary, affecting both eyes, but in different degrees. It occurred in the person of a workman, who had indulged much in strong drink and tobacco; but there is no further record regarding it.

And now, to sum up the matter: I do not claim very much for these cases; they have at least been faithfully narrated, and may be taken for what they are worth by those whose acquaintance with the ophthalmoscope renders them competent to judge. To me they are interesting, from the relation which they seem to indicate between a general condition of the system and a local change of structure; and I have no doubt but that, as the use of the ophthalmoscope becomes more general among the members of the profession, and a greater number of competent observers in consequence arise, we shall find these relations multiplied as regards the eye. Diseases, and deviations from health of lesser moment, which exercise a constitutional influence, and have not yet been recognised as affecting the structures of the eyeball, will probably be found to do so in a greater or less degree, and to imprint unmistakable evidence of their existence upon the delicate and many-tissued organ of sight.

NOTES AND OBSERVATIONS ON DISEASES OF THE HEART AND LUNGS.*

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IN the preceding papers, the sounds and murmurs emitted by the heart and arteries, viz., the audible effects of the several vibrations induced by the movement of the blood and by the disturbance and sudden arresting of its even flow, have alone been referred to. It is now proposed briefly to consider those vibrations which more particularly reveal themselves to, and are familiarly appreciated by, the sense of touch; viz., the recurring impulses and palpitations of the heart, and those recurring shocks, therefrom resulting, experienced throughout the arterial system. The impulse or beat of the heart, which, in a healthy and fairly nourished person, under circumstances of repose and in the recumbent position, is inappreciable to the touch, immediately becomes perceptible, on assuming the perpendicular position, in the space between the fifth and sixth ribs about an inch and a half to the left of the sternum. The phenomenon thus developed, though partly due to a slight tilting forward of the apex, is mainly affected by a change of shape in the heart itself, whereby it becomes rounded during the spiral contraction of its fibres. The amount of impulse, as well as the rhythmical action that characterises it, is liable, under a great variety of circumstances, to considerable and sometimes immediate modifications. The almost imperceptible beat may present the characters of an obvious blow or sharp shock, and, instead of being limited to a narrow space, may be diffused over a large amount of the parietes of the left chest. So, likewise, its rhythmical action may be notably accelerated or interrupted.

These variations in the force and rhythm of the heart's impulse are, however, in their general occurrence familiar to the observer of the action of this organ; and, as they will necessarily require much careful consideration in the sequel, when speaking of some of its disordered conditions, they need not be here further referred to. It is now proposed to pass on to a consideration of the vibrations felt throughout the arterial system, which we familiarly recognise and understand under the designation of the "pulse." When disease, with its several phenomena, is presented to us, we usually separate for special study and notation the modifications in the circulation of the blood, as evidenced in the frequency and character of the pulse. If this can be said of disease in general, it may more emphatically be said of diseases of its moving power, the heart itself; and hence, to a certain extent, the pulse has been regarded as one mode of interpreting the condition and action of this organ.

Before the adoption of the more modern means now employed in the investigation of the diseases of the heart, this was especially the case. Indeed, volumes have been written to show that the true appreciation of the pulse was an infallible means, not only of indicating the morbid

* Continued from page 287 of JOURNAL for March 16th, 1867.

conditions of the heart, but of discriminating the locality and extent of almost all other diseases. Though we may not, in the present day, thus dogmatise upon the pulse, nor attribute to it that perfect indication of diseased action, which was attempted heretofore, yet we fully appreciate the value and importance of duly observing the departures from its healthy standard, and of considering how far these may be indicative of diseased action, whether this be in the heart or in the system generally.

In considering the phenomena and the rationale of the pulse, the physical agencies whereby the blood is transmitted from heart to heart have, since the days of Harvey, been often investigated with much assiduity; and various theories in explanation have been advanced. The difficulties attending these investigations may be appreciated by the varying and contradictory conclusions arrived at.

To some of the more prominent of these theories reference will now be made. It is not, however, necessary to enter into any minute detail of them, especially as they are to be found fully set forth in several elementary and other works. A careful consideration of the bearing of these theories will show that they may be classified under distinct heads.

1. Those that regard the pulse as due to the distension of an elastic artery, whereby its diameter is increased.
2. Those that regard the arteries as inelastic, and the pulse as due to an extension in its length, whereby a displacement or locomotion takes place.
3. Those that refer the pulse to distension of the artery, with an active contractile power superadded, so that it has a systole and a diastole of its own.

It will be observed that the above refer solely to the proximate cause of the pulse; but, in referring to the theories themselves, it will be seen that they generally comprise within these terms the remote cause also. Thus in one the pulse is stated to be due to the "impulse of the left ventricle being communicated along the arterial tube and the column of blood which it contains." (A. Thomson, *Cyc. Anat. and Phys.*, Art. Circulation.) In another the circumstances are stated somewhat more precisely, and the pulse is said to be due "to the alternate dilatation and contraction of the artery, from the impulse and comparative retardation of the wave of blood-corresponding with the systole and diastole of the left ventricle of the heart." (Haller, Richerand, Hales.)

In examining these several theories, we first see that the general weight of authority lies with the opinion that the arteries are endued with the property of contractility, and that this property is excited to action by the force of the left ventricle; and then that, with one exception, they set forth that the impulse from the heart communicates itself to the column of blood contained within the arteries. Nevertheless they differ materially as to the mode by which this is effected; thus, according to one theory a temporary dilatation of the artery is induced at each recurring influx of blood; according to another, this dilatation is followed by an active state of contraction; according to others, neither of these conditions is admitted; while one attributes the phenomena of the pulse solely to a locomotion in the artery itself. All the above recognise the moving column of blood as the medium in which is developed the phenomena of the pulse, whilst the artery is only the containing tube acted on by this medium. The theory, which is an exception to this general view, is that which refers the pulse solely to a contractile power in the arteries themselves. These several theories, as before observed, comprise both the proximate and the remote causes of the pulse; the latter being almost universally attributed to the contractile agency of the heart itself, while the former has not only been also referred to this, but likewise to other and very different agencies.

It will be useful to look particularly to these, so as to separate and define them; and in doing so we will first refer to the immediate phenomena of the pulse, and those circumstances which belong to its proximate origin, and then consider separately its remote cause, so as to ascertain the precise value, in reference thereto, of the contractile agency of the heart. In considering the nature of the pulse we may, for the sake of argument, discard all questions about the causes inducing the circulation, and look solely to those peculiar phenomena to which the term "pulse" has been given, occurring normally and periodically in the arteries; in the capillaries, under conditions of excitement or inflammation; in certain veins normally, and in others under certain forms of disease (*varix*).

Before going further it may be as well to define what, according to the best recognised authorities, the pulse is, and see if these definitions comprise all the phenomena belonging to it. The usual definition is, that it is "the stroke or beat of an artery, as recognised, for the most part, by the finger applied to the integuments lying over it" (Bostock, Allen Thomson). Other and somewhat differing definitions are that it is "a jetting movement of the blood, whereby, by dilatation and elongation (which latter is the greatest) is effected the pulse." (Kirkes, Carpenter); and "a succession of impulses or distensions alternating with

the reaction or subsidence of the vessels, and felt throughout the body wherever the arterial ramifications penetrate" (Dalton).

If we regard the pulse as comprising the whole of the phenomena that take place from beat to beat, the above definitions are found to be neither descriptive nor distinctive, in as much as they do not accurately portray the whole of the periodically recurring phenomena attendant on the circulation of the blood through the arteries. Nor do they refer solely to the shock. Assuming the correctness of the recognised theory of the cause of this shock, and which also sets forth and accounts for that continuous wave, whereby the progress of the blood is effected throughout the whole system, they are notably incomplete. The definition of such a pulse should include the whole series of phenomena; viz., the undulating wave, the shock or sudden vibration, and the pause. The short sharp stroke or vibration occurring almost simultaneously throughout the whole column of blood is, however, peculiarly that portion of the series to which the term "pulse" is given, and to which doubtless it is not only convenient, but, as I trust in the sequel will be seen, truthful to restrict it.

In a former number of this JOURNAL (No. 296, 1st Sept. 1866), I ventured to advance the theory, that the pulse was divisible into three phenomena: 1, the filling of the artery by successive waves, through the agency of the ventricular system; 2, the vibration in the column of blood throughout the whole arterial system, caused by the sudden closure of the semilunar valves (the pulse); and 3, the contraction and collapse of the arteries during, but not caused by, the ventricular diastole. It will be the purport of the following remarks to support and illustrate this view.

The differences which characterise the above several phenomena of the circulation of the blood through the arteries, are in health sufficiently recognisable, while in disease they often become strongly marked, and thus offer indications of the utmost value in diagnosis. Following, as they do, a natural order, they occupy in their relations to each other definite proportions of time. This rhythm of the arterial circulation may be divided into five periods—one being occupied by the wave; one by the shock (pulse); and, three by the pause.

As generally confirmatory of this position, I would refer to the figures of arterial action delineated by aid of the sphygmograph (*vide* Foster, Sanderson, etc.) Though the sphygmograph may probably not be so perfect an instrument as the educated finger, it shows, by its written diagrams, sufficiently accurately the increasing tension of the onward wave, occupying one-fifth of the rhythmical time, and which culminates in the sudden vibration or shock; and it also notes the decadence of the arterial tension immediately succeeding the shock. It appears to me that, in the diagrams of the normal pulse, the period, nay, the existence of the shock (pulse) is not distinctively marked; no alteration nor sudden variation occurring in the gradually increasing tension of the onward wave, till the period of the collapse, which ensues after the tension has attained to its greatest height. The sphygmograph, under such circumstances, really marks less the pulse than the other phenomena of the arterial circulation. In certain instances of disordered circulation this exclusiveness may, however, not be so marked. By a reference to the diagrams, where the shock or pulse proper is interfered with, its rhythmical duration can, perhaps, be appreciated; and, as such, these diagrams are so far confirmatory and illustrative of the theory which I desire to propound; and they will, in the sequel, be again referred to.

Before the true nature and origin of the phenomena which constitute the pulse can be fully appreciated, it is necessary that the physical qualities of the arteries, and of the moving column of blood, in relation thereto, should be duly estimated, they being the physical media in which this peculiarity of the circulation takes place, and by which it is transmitted. As regards the arteries the questions immediately arise: 1, are they endued with elastic and with contractile powers? and 2, are they liable, where not sufficiently bound down, to displacement by the force with which the contained fluid is moving within them?

It will not be here necessary to revert to the experiments and arguments of the several exponents of each of the above views; it will be sufficient to state generally there are grounds for assuming that the arteries may be in certain positions subject to displacements by the active force of the blood, and likewise endued with elastic and contractile powers, whereby a tension of the vessel is maintained, and thus enjoy the function of "reproducing a force proportional to the degree in which they are extended beyond their natural dimensions" (Young, vol. i, p. 519). Yet it cannot be assumed that both or either of these accidents of their existence, are sufficient to explain the occurrence of the pulse. The pulse may, in fact, be originated and transmitted irrespective of any such qualities.

Is the onward wave of the blood, then, the cause of the pulse? It is to be borne in mind that this and the previous questions, notwithstanding it be admitted that an active vitality exists both in the arteries and in the blood, are to be decided by the ordinary laws which determine the phenomena of mechanical motions, in as much as the vibratile motions of

the blood and of the arteries, though taking place within an animal frame, are regulated by the same general laws as the motions of inanimate bodies. Hence, though the blood, in accordance with the properties of fluids, when forced through the arteries by successive waves, exerts an amount of lateral pressure equal to that which rules its onward course, yet, it having been also granted that the artery is endued with the quality of elasticity, there exists precisely that condition, viz., the onward current of a fluid, proceeding by successive waves through an elastic tube, which militates against the wave of the onward current being transmitted as a pulse; a condition which not only interferes with the tactile appreciation of the wave of the onward current, but really tends to equalise and obliterate it. It represents, in fact, the very mechanical apparatus adapted for effectually counteracting the disturbing effects of an unequal flow, and to which all tubes which are the subject of a supply *per saltum*, without such elastic quality, would inevitably be liable. Moreover, the velocity of the transmission of the impulse, whereby a fluid is propelled through elastic tubes, is diminished by an increase of tension. Doubtless this law holds good as regards the wave flow of the blood itself, while there is no evidence that the pulse is thereby obscured or retarded; on the contrary, the greater the tension, the more decided and pronounced the pulse. Hence, we may assume that the agency of the wave, which effects the onward current of the blood, does not entirely account for all the phenomena observed in the pulse.

It has been assumed, when describing and defining the pulse, that there are evidences of a wave-like expansion and of a sudden shock or recoil, and then of the temporary, though not entire, subsidence of undulation and vibration. The arteries are, undoubtedly, the means whereby these undulations and vibrations are transmitted and made manifest, and the blood contained within them is as unquestionably the seat of them. Again, so much as the arteries are elastic, or locomotive tubes, so much may they be influenced by the pressure exercised by the fluid they contain; hence, they reveal the varying tension caused by the onward wave of the blood. Supposing this onward wave to have induced that amount of lateral pressure which places the artery in a state of tension, there then exists that condition which qualifies the artery to be the sensitive transmitter of other vibrations than those of the onward wave, which may occur amongst the particles of its contained fluid, in as much as the vibrations of a fluid within a tube will be less interfered with when the containing tube is inelastic; or if elastic, when, by means of extreme tension, it is so completely filled as to represent one that is inelastic.

In the elasticity of the artery there exists the conditions, not only of resisting injury from the sudden pressure of the onward wave, but likewise of facilitating its transmission, while in its full and tense state, when this wave is at its summit, it offers conditions of being the ready transmitter of such vibrations, other than those of the onward wave, which may take place in its contained fluid, and this fluid, as being incompressible and inelastic, is the easy recipient of any vibrations to which it may become subject. It is not improbable that, as regards the artery and the blood (separate from the moving power, the heart), the above comprise the only conditions really necessary for the perfect development and transmission of any vibrations which may take place in the one, or be revealed by the other.

The artery then presents the conditions both of an elastic and an inelastic tube—the one, capable of equalising the sudden propulsions of the wave of blood, and the other, of transmitting vibrations occurring in its contained fluid other than those of its propelled wave; while the blood presents, on the one hand, a wave-flow, and, on the other, enjoys the usual qualities of a fluid, of being the easy recipient of vibrations. We will now briefly examine how far the phenomena, observed to take place during the rhythmical flow of the blood, are referable to either or to both of these conditions.

The obvious properties of the heart are its systole and its diastole, and it is to its systole that the circulation of the blood through the arteries is immediately due. By this function the whole, or perhaps only a certain portion, of the blood contained in the ventricle is expelled into the artery; and it is assumed that the moment at which this takes place corresponds with the pulse in the artery. Be this as it may, the propulsion of the blood through the arteries is associated, either at the moment of the systole of the ventricles, or at some other moment, with certain obvious phenomena to which the term "pulse" has been given.

Doubtless, the systole of the ventricle and the emission of blood thence proceeding, satisfactorily accounts for the circulation; but does it as conclusively account for all the phenomena of the pulse? It has generally been assumed that it does; and Young, in his learned and elaborate paper on the functions of the heart and arteries, seeks to show from the experiments made by himself, Hales, Poiseuille, and others, that such an assumption may be demonstrated as a mathematical truth. In the course of his observations (p. 519), he says:—"The successive transmission of the pulsations of the heart through the length

of the arteries, is so analogous to the motion of the waves on the surface of water, or to that of a sound transmitted through the air, that the same calculations will serve for determining the principal affections of all these kinds of motion; and, if the water which is agitated by waves is supposed to flow at the same time in a continued stream, and the air which conveys a sound to be carried forward also in the form of a wind, the similitude will be still stronger."

It will be observed that, in the above, Dr. Young refers to two sets of phenomena, viz., flow, and vibration superadded thereto; and it is to this distinctness of phenomena taking place throughout the arterial system, during each rhythmical movement of the blood, that investigation is now directed. Though the phenomena of the circulation and of the pulse are coexisting, it does not follow, arguing *a priori*, that they are necessarily due to the same cause, or have precisely the same identical origin. The free circulation of a fluid through a tube, whether it be *per saltum*, or not, may be effected without being accompanied by the phenomena of a pulse. Hence, the circulation of a fluid is not dependent on the causes that induce the pulse. As regards the cause of the occurrence of this latter, several questions present themselves, the more prominent of which are:—Is the pulse a phenomenon, attendant upon and caused by the onward wave in a moving fluid? or is it a vibration only through its several particles? or is it a vibration superadded to, or distinct from, the onward wave? or, can it be produced without this fluid being a circulating or moving one? It has already been shown, when referring to the physical qualities of the arteries and of the blood, that there exist grounds for concluding that the vibrations of the onward wave do not comprise the whole of the vibrations that take place within the artery. In examining the above questions, it will be necessary to ascertain if this really be the case.

It has generally been considered, that the wave of blood discharged at each systole of the ventricle fully accounts for the pulse; and there have been many experiments made and much argument adduced, to prove that it is so. Those of Dr. Young are the most comprehensive. "It may be supposed" (he says, p. 214) "that the heart throws out, at each pulsation, that is about seventy-five times in a minute, an ounce and a half of blood; hence, the mean velocity in the aorta becomes eight inches and a half in a second; and the velocity in each of the succeeding segments must, of course, be smaller in proportion, as the joint areas of all the corresponding sections are larger than the area of the aorta." In another place, he says (p. 519), "that the velocity of the pulse must be nearly the same as that of an impulse transmitted through an elastic tube, under the pressure of a column of the same height as that which measures the actual arterial pressure: that is, equal to that which is acquired by a heavy body falling freely through half this height. In man, this velocity becomes about fifteen feet and a half in a second, to which the progressive motion of the blood itself adds about eight inches; and with this velocity, of at least sixteen feet in a second, it may easily happen that the pulse may appear to arrive at the most distant parts of the body, without the intervention of any very perceptible interval of time." In considering the above, we see that two circumstances are detailed; the one, the progressive motion of the blood, which in the aorta is estimated as having a mean velocity of eight inches and a half in a second; and the other, the mean velocity of the pulse, which is estimated at about fifteen feet and a half in a second.

Assuming the correctness of the above, it is obvious that the circulating wave of the heart is not sufficiently rapid to account for the simultaneous pulse exhibited throughout the arterial system. The one, or may be two, ounces of blood forced into the arteries at each contraction of the ventricle is obviously, *per se*, inadequate to effect so universal and instantaneous a vibration. Nevertheless, it is here necessary to state that there is a great discrepancy between the calculated, and, from experiment, the inferred velocity of the calculation. Hering inserted prussiate of potash in one jugular vein of the horse, and detected it in the other in twenty seconds, and hence inferred that the whole circulation of the blood only occupied this short space of time. This experiment, the more especially as the viscosity of the blood exhibits a resistance four times greater than that of water, offers evidence of a most mysterious fact in the ordering of the animal economy, but, as regards the physical origin of the pulse, it has little or no bearing. Though the blood may traverse the system in this incredibly short space of time, it would not account for the production of the pulse, synchronous as this is throughout the whole course of the arteries.

Moreover, in the history of the circulation, there exist a large number of facts which show the pulse to be a measurer neither of the quantity nor of the speed of the blood; for often, most often indeed, the frequent and throbbing pulse is associated with an enfeebled circulation, and a lessening in the amount of the blood circulated: nor is it an indicator of the *vis a tergo*—of the force of the heart's action; for the pulse may be feeble while the action of the heart is violent and excessive. The

position that the pulse is a measurer neither of the speed nor quantity of blood circulated, nor of the power of the heart, is most evident when, assuming that the ventricle discharges the whole of its blood at each systole, it is considered that a pulse at 120 would, over a pulse at 60, exhaust the labour of the heart by the square of the result. That the onward wave of the circulation does not constitute the pulse is evident, from the fact that, if a ligature be applied to an artery, the vibration of the pulse is felt both at the proximate and the distant ends of the vessel, where so tied, though the blood at these points forms no longer a portion of the moving fluid. The circulation is arrested, but the pulse continues.

The pulse is also felt more extensively in some cases in which the circulation is materially diminished, as where the blood becomes inspissated; or it may be even rendered more obvious and largely diffused, though the onward wave must be, comparatively speaking, disguised, or even lost entirely, as in an aneurismal dilatation. Here a fibrous mass, which may scarcely admit a flow of blood through it, communicates on every side a hard and exaggerated pulse. The same may be observed when an artery is ossified, or overlaid by a dense material, as also in those circumstances where elasticity compensates for, and obliterates, the shock of the onward wave; as occurs in the trunk artery and its larger branches, which offer but little external evidence, by expansion, of the onward wave, but freely communicate the vibrations of the pulse. The vibrations of the pulse are otherwise seen to be independent of the forward wave, for velocity in this may differ in different arteries, while the pulse retains its synchronous action. Again, where inflammation has induced a state of local congestion, the pulse may be, in the arteries concerned, more markedly felt. The above instances show conclusively, that the peculiar circumstance of pulsation, in whatever they may consist, is, in effect, separate from the blood-wave; and therefore it may be inferred it does not owe its immediate origin to that mechanical power or force which originates the circulation of the blood.

The blow which the heart makes against the ribs—the *ictus ventriculi*—and which does not occupy the period of the ventricular contraction, but only its concluding act, is neither a pulse nor the cause of it; not only are they not synchronous, but they bear little or no uniform relation in force to each other; the former may be violent, the latter weak. Moreover, the various observations which have been made on the circumstances of the circulating wave, show it not to be the result of a violent or spasmodic contraction of the originating power, such as might be inferred to be the case if it were the result of an action producing a violent rush of blood, and this so sudden as to be ejected at a single moment, and also to produce the vibration of the pulse. The experiments of Hales may be particularly referred to, in confirmation of the above; as also the absence of recoil in the distal arteries, and the absence of any bursting effect when, in an aneurism, the distal vessel is tied.

After fully considering the whole question, we can not but conclude that the circulating wave and the pulse are two separate and distinct operations, and therefore, as taking place in the same medium and transmitted by the same tubes, not due to the same cause. Doubtless, the contraction of the ventricle causes the projection of the column of blood, and this column traverses the arterial system by successive waves; while the pulse is a vibration taking place simultaneously through the whole particles of this, as it were, solid column of blood. The vibrations which constitute the pulse obey the same laws as sound transmitted in bodies, or as those vibrations which, when a blow is struck on one end of a log of wood, are felt distinctly by a hand applied to the other, although there be no visible locomotion. The pulse is, in fact, similar to that tangible shock which "is conveyed through a fluid without any apparent accumulation of it, or change of velocity. Thus, the working of a water-pump may be discovered at great distances through iron pipes, or even through elastic pipes of leather, as those of a common fire-engine, from which the water is spouting nevertheless in a uniform stream," (*Arnott*).

What, then, is the cause of those vibrations which constitute the pulse, as separate from the circulation? In the course of the preceding argument it has been shewn that, in the arteries and in the moving column of fluid within them, the physical conditions exist for the ready transmission of vibrations occurring in this latter; and in a former paper it has been shewn, that the mechanism of the heart is well adapted for the production of these vibrations. (*BRITISH MEDICAL JOURNAL*, 12th May, 1866, No. 288, p. 486.)

Having reference to that general law of hydraulics, which enunciates that the momentum of a liquid in motion is as great as that of a solid, and, hence, that anything which opposes or arrests this momentum, will receive as severe a blow as if from a solid, and cause within it the same disarrangement of particles, we see that, as the blood in circulation is a moving column, and its motion be opposed or arrested, there then exists the conditions for producing those vibrations, within the columns, similar to those which would take place in a solid. It has also been shewn

(*vide* previous paper) that, in the sudden closure of the semilunar valves, the mechanism for thus opposing and arresting the circulation exists.

It is probable, considering the elastic properties of the arteries, that, were it not for the closure of the semilunar valves during the diastole of the ventricle, whereby the momentum of the column of blood is arrested, the supply *per saltum* would have been equalised in these vessels, so that there would not only have been a pulseless wave, but one rendered tolerably even in its flow. As it is, the onward wave is, both in its origin and in its effect, independent of the vibrations which constitute the pulse, as also of the cause of these vibrations; while, on the other hand, these vibrations are, in their origin, independent of the cause of the circulating wave. They are, in fact, dependent for their development on that valvular mechanism, whereby the onward wave is suddenly arrested. It has been stated, that the passage of the blood through the arteries is characterised by three phenomena: 1. the filling of the artery by the onward wave; 2. the pulse; and 3. the gradual cessation of vibration (*vide ante*); and looking to what has now been set forth, these phenomena may be thus explained. The moving wave, whereby the circulation of the wave takes place, is accounted for by the systole of the ventricle; then the sudden vibrations taking place simultaneously throughout the whole moving column of blood, and which constitute the shock or pulse, are accounted for by the momentum of this moving column being arrested by the sudden closure of the semilunar valves; and the succeeding pause is that period during which the momentum of the wave is temporarily arrested, and before it again has re-established its even flow.

As regards the relations of the pulse to the sounds of the heart, in respect of time, it may be stated that the onward wave commences simultaneously with the first sound; the vibrations that constitute the pulse are synchronous with the second sound; and the pause occupies the time between this and the first sound. The reading of the sphygmograph shows an ascending line; this commences synchronously with the first sound, while the highest point of this depicted line is synchronous with the second sound, and the fall or wave-like decadence from this highest point, represents the pause or period between the second and first sounds. The explanation of all this is, that the ascending line of the sphygmograph depicts the expanding of the artery by the onward wave of the blood forced into it by the systole of the ventricle; its highest point, which is synchronous with the pulse-vibration, and with the second sound, represents the instant when the momentum of the onward current is arrested; while the fall in its line represents the period between the second and first sounds, and before the systolic action of the left ventricle has re-established the onward wave-flow.

Before concluding this paper, it may not be out of place to observe, that the theory of the pulse now set forth explains many peculiarities of the circulation observable in disease, and which, without it, are not, as it appears to me, easily to be explained; such as the violent beat of the heart with a feeble pulse; the absence of the true pulse-vibrations where valvular disease is confirmed; the undulations without pulse of the venous pulse; shock; etc. These will, however, be more particularly referred to when these diseased conditions are the especial subject of remark.

REMARKS ON OBSTRUCTION OF THE BOWELS: WITH CASES.*

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CASE XXXVI.—Miss B., a delicate girl, about 19 years of age, had been complaining now and then, for several weeks, of pain or uneasiness in the right iliac region, and was subject to constipation. About a week before I saw her she ate a good many nuts, and continued to eat some for two or three days afterwards, when she was suddenly seized with severe pain in the situation of the ileo-cæcal valve, and became sick and faint. After this she had no satisfactory relief from the bowels, although treated actively by her surgeon, and I was summoned on May 14th, 1863, in consultation. I found her at 5 P.M. with a depressed countenance, small rapid pulse, dry tongue, and considerable thirst. The abdomen was tumid and hard over the right iliac region, and tender; but there was no general peritonitis. She had vomited several times, and neither aperients nor enemata had answered. I advised a discontinuance of the purgative plan; and we agreed to give her at once a large injection of soap and water and castor oil, to cover the abdomen with a bran poultice, and to give her a grain of the watery extract of aloes and a quarter of a grain of opium every three or four hours; soda water and milk to drink, and a little mutton broth occasionally, if not

* Continued from page 169 of vol. i for 1861.