PASSAGE OF THE RED BLOOD-CORPUSCLES THROUGH THE WALLS OF THE CAPILLARIES IN MECHANICAL CONGESTION.*

By H. CHARLTON BASTIAN, M.A., M.D.,
Professor of Pathological Anatomy in University College, London.

IT is my intention to exhibit to the members of the Society to-night Dr. Cohnheim's most interesting experiment illustrating the effects of venous stasis, and the passage of the red blood-corpuscles through the walls of the capillaries in this condition; but, before describing what is to be seen in this experiment, I may state that mechanical congestion is not the only pathological state in which this same diapedesis is known to occur. Dr. Cohnheim had shown previously that, in the process of inflammation, at the same time that the white corpuscles penetrated the walls of the veins, so did the red corpuscles make their way through the walls of the capillaries.† After this, Stricker of Vienna first (*Journal de l'Anatomie et de la Physiologie de Robin*, No. 6, 1867), and then his pupil, Prussak (*Wiener Acad. Sitzungsber. Math.-Naturw.* Cl. 2, Abth. LVI, 13-23), showed that, by injecting a small amount of a ten per cent. solution of chloride of sodium beneath the skin of a frog, an artificial scorbutic condition was produced, in which extravasations of blood took place, not only into the web of the frog's foot, but also into the various internal organs. The same extravasations of blood took place in rabbits similarly treated; and such effects seemed to result from the administration of chloride of sodium only, other salts having been tried without the same result. On microscopic examination of the frog's web after such an injection, it was clearly ascertained that the hæmorrhagic maculæ in this situation resulted from the greater accumulation in certain spots of red blood-corpuscles, which had passed out individually through the capillary walls. The passage of these through the capillary walls could be seen with the greatest ease; and, such being the case, it seemed only fair to infer that the hæmorrhagic effusions into the internal organs and other situations had a similar mode of origin. These experiments I have repeated on the frog; and I am able, so far, to endorse the statements of Stricker and Prussak.

Turning now to Dr. Cohnheim's experiment (*Virchow's Archiv*, xli), which I have also repeated several times, I will briefly describe its principal features. A frog having been previously narcotised by the subcutaneous injection of woorara, the femoral vein is tied with a piece of twine (including a portion of muscle, so as to facilitate the subsequent cutting of the ligature), and soon the capillaries and veins become gorged with blood to an increasing extent. Serum is gradually poured out into the web also, causing this to become notably œdematous. After a time, a distinct oscillation of the blood takes place in the vessels: much of what is driven forward during the systole of the ventricle into the capillaries and veins is returned into the arteries by elastic recoil during the diastole of the ventricle. The red blood-corpuscles gradually arrange themselves crossways in the capillaries; and already, in the space of about fifteen or twenty minutes, complete stasis may be seen to have taken place in certain capillaries, the corpuscles in which appear to become fused into a homogeneous mass, interrupted here and there by the presence of a white corpuscle. This stasis now quickly extends to other capillaries, and later to the veins themselves. In the space of about forty minutes, it may be seen that capillaries which before presented an even cylindrical appearance begin to exhibit projections from their walls, which go on increasing in number and size till these assume an utterly irregular bosselated outline. Some of the projections afterwards separate themselves, and may be seen in the adjacent tissue as unmistakable red blood-corpuscles. But that they are really such, may now be seen more satisfactorily by cutting the ligature on the femoral vein, when, in a very short time, the homogeneous and apparently fused mass in the capillaries again becomes resolved into individual corpuscles, and the circulation is restored throughout the web. Then there may be seen, in addition to the red corpuscles which have passed completely through the capillary walls and are lying imbedded in the tissue around, numerous others in all stages of their outward passage—some showing only a small projection outside the capillary-wall, whilst the major part of the corpuscle is within; the two portions being united by a threadlike part actually in and constricted by the capillary

wall; others showing half of the corpuscle out and half within the vessel; and still others, where three-fourths or more of the corpuscle may be without, and only the smallest portion (separated by the constricted part within the vessel wall) lying in the interior of the capillary itself. Thus the corpuscles are actually seen through the capillary walls, in all stages of their outward passage.

In explanation of this phenomenon, Dr. Cohnheim adopts the view first advanced by Oedmanson (*Centralblt.*, 1863, p. 868), that the capillaries are formed by the juxtaposition of a number of flat epithelial cells, in the angles of union of which certain stomata exist: through these, he thinks, the corpuscles are forced by reason of the increased pressure in the vessels, favoured by the transverse position previously assumed by the corpuscles themselves. This view as to the structure of the capillaries is based upon the appearances presented by these vessels after staining with a weak solution of nitrate of silver, when the ordinary brown lines are said to be produced, such as exist between pavement-epithelium in other situations. This conception as to the structure of the capillaries is, however, completely rejected by Stricker (*loc. cit.*), who seems to have made careful observations on their structure and genesis. He maintains that, even though such markings are to be met with after staining with nitrate of silver, it is not fair to infer from this as to the mode of genesis of the capillaries; and that their formation by the juxtaposition of epithelial cells is directly negatived by observations which he has himself made upon the subject. He believes them to be composed of a yielding, homogeneous, and contractile protoplasm, which, in harmony with the properties of this substance generally, has the power of developing processes or outgrowths. These Stricker says he has seen developing from the walls of the capillaries; and he maintains that they subsequently become channelled, and unite with other similar processes, so as to form new capillaries. His explanation (and also Prussak's) of this passage of the red blood-corpuscles is, not that they are forced through certain pre-existing pores in the capillary walls, but that they pass out by virtue of some "active condition" of the capillary wall itself. From what I have myself observed, I am unable to endorse the explanation given by either of these observers; and my own opinion is, that the corpuscles pass out in all these conditions—whether in inflammation, in the artificial scorbutic state, or in mechanical congestion—by virtue of certain active *ameboid* movements, to which the red blood-corpuscles have been excited owing to alterations in the nature of the blood-plasma, having an irritating effect upon them; in fact, that they effect their outward passage by dint of certain obscure ameboid movements, such as the white blood-corpuscle has been long known to exhibit, and by means of which they readily make their way through the walls of the veins, as shown by Dr. Cohnheim, and as I hope to demonstrate to the members of the Society on a future occasion.

I was led to adopt this view for the following reasons. I observed first, whilst watching the phenomena of inflammation in the frog's foot, that, in certain capillaries beyond the region where this process existed in its greatest intensity, and in capillaries through which the blood was still flowing, certain red corpuscles seemed occasionally to linger by the side of the capillaries, applying their flat surface against its walls. Sometimes these were swept away by the blood-stream passing over them; and occasionally, before they were completely separated from the capillary wall, I have seen them adhering to this for a moment or two by means of a small thread-like process, as though adhesion had taken place to some portion of the capillary wall, which had only been overcome by the blood-stream after the drawing out of a taglike projection from the yielding substance of the corpuscle. Other corpuscles which had applied themselves to the capillary wall in the manner above described were not swept away; and, in the space of about fifteen or twenty minutes, a distinct projection of the corpuscle was to be seen on the outer side of the capillary wall, which went on increasing until the whole of the corpuscle was within the tissue outside the vessel. This took place whilst corpuscles and blood-plasma were still freely circulating through the capillary. Precisely similar phenomena may be seen after the subcutaneous injection of chloride of sodium—the corpuscles passing out in the same manner. And, in repeating Dr. Cohnheim's experiments on mechanical congestion, I have almost invariably seen that the first corpuscles which penetrate the walls of the capillaries are not those situated in the vessels whose contents have undergone complete stasis and have become fused together, but rather those contained in capillaries in which an oscillation of blood-plasma and corpuscles is still taking place. Here also individual corpuscles apply themselves to the capillary wall by one of their surfaces, and after a time the process of perforation takes place. Occasionally considerable numbers of corpuscles pass out in this way from capillaries in which there is no stasis, and that, too, somewhat earlier than the similar exodus of corpuscles from the capillaries in which complete stasis has occurred. Therefore, because

* Read at the Pathological Society on April 21.

† Dr. Sharpey has been kind enough to draw my attention to the fact of the existence in the *Philosoph. Magazine* for 1846 of a paper by Dr. Augustus Waller, entitled, "Microscopic Observations on the Perforation of the Capillaries by the Corpuscles of the Blood, and of the Origin of Mucus and Pus-Globules." To this I shall refer more fully on a future occasion.

the corpuscles seem to pass out indifferently at all parts of the wall of the capillary, and with no approach to anything like a regular arrangement such as one might expect to occur if they were extruded through pre-existing stomata at the junctions of epithelial cells; because the increased tension in the vessels seems adequate to account for the passage outwards of fluid from them, but not of corpuscles contained in this fluid, which, by the ordinary laws of fluid-pressure, would be pressed upon equally in all directions, unless one of their surfaces were absolutely in contact with the wall of the vessel; and, lastly, because the mode in which the corpuscles are observed to become applied by their flat surfaces to the capillary walls is the very reverse of that indicated by Dr. Cohnheim as the favourable position* which the corpuscles assume for forcible extrusion through pre-existing pores—for all these reasons it seems to me that his explanation is untenable. With regard to Stricker's supposition, that the corpuscles are passed through by virtue of some "active" condition of the capillary wall itself, I have been able to observe nothing either for or against it; it seems a pure hypothesis, with not much to be said in its favour. And I think the evidence adduced points rather to the passage of the corpuscle outwards by reason of some active condition which the corpuscle itself assumes, its adhesion to the wall of the capillary being produced by the throwing out of a small amoeboid projection, which tends to adhere to and commence the perforation of the elastic and yielding capillary wall. This view is favoured also by the fact that, when more than half of the corpuscle is lying outside the vessel, this portion has often the most irregular shape and sometimes appears more or less subdivided.†

Having formed this opinion from observation of what takes place in these processes, I afterwards found a paper in a recent number of Virchow's *Archives* (Ein Beitrag zur Lebensgeschichte der rothen Blutkörperchen, xli, pp. 396-411), by Dr. Friedrich of Heidelberg, fully describing certain remarkable changes of form, also protrusions of processes and subdivisions which he had seen taking place in red corpuscles found in the concentrated bloody urine of a patient suffering from renal disease; and also notable alterations of shape of red corpuscles taken from a patient supposed to be suffering from leukaemia. These phenomena he believed to be vital rather than physical, and excited by certain abnormal irritative conditions acting upon the corpuscles. Max Schultze (*Archiv für Mikrosk. Anat.*, bd. i, 1865, s. 25) also, and Dr. Beale (*Trans. of Microscop. Soc.*, 1864), have observed notable alterations in the shape of red blood-corpuscles when subjected to a high temperature; but these, as the respective observers conjectured, were probably changes occurring after the life of the corpuscle had been destroyed. Dr. Beale hints, however, that similar changes of form may occasionally take place during life. Bearing in mind, also, two characters of the red blood-corpuscle, as described by Dr. W. Roberts (*Proceed. of Roy. Soc.*, 1862), after the action of magenta and tannin respectively, it seems well that the attention of future observers should be directed to these peculiarities, and to the particulars above mentioned, in order to determine more certainly than has yet been done how far amoeboid movements and contractions do take place in the much-examined and much-written-about red blood-corpuscle. Presuming that these corpuscles do pass through the walls of the capillaries in the manner I have indicated, it seems to me that they may be made to assume this active condition either by changes in the nature of the blood-plasma, or by some unknown action of the tissues outside the vessel upon the corpuscles within, such as has been assumed to exist in inflammation. In the scorbutic condition and in the state of mechanical congestion, I should imagine that changes in the nature of the blood-plasma would be the most potential—such changes in these two conditions being perhaps not altogether dissimilar. Certainly I have noticed in both these conditions, that most of the corpuscles which can be seen to penetrate the walls of the capillaries present an easily appreciable and similar alteration from their normal structure. This consists in the presence of from two to four small clear spots, looking like vacuoles, in each red corpuscle. What significance the existence of these may have, as pointing to an abnormally active co-existing condition of the corpuscle, must be left for future observation to determine.

I have two specimens to exhibit to the Society: one in which the femoral vessel remained tied for about four or five hours yesterday; and one in which the femoral vein is at present tied, and in which almost complete stasis of blood exists throughout the web.

* Though I cannot myself think that this cross position of the corpuscle in the capillary would be at all favourable for its forcible extrusion by increase of fluid pressure: the tension of fluid would be equal on each side of the corpuscle, and the lateral tension would produce an equivalent pressure of fluid against the walls of the capillary, though not of the corpuscle contained in this fluid.

† Since this communication was made to the Pathological Society, I have seen (April 27th) pretty rapid and most manifest alterations in shape of many red blood-corpuscles after they had passed out of the capillaries and were lodged in the mesenteric tissue of the frog.

ON ACUTE TUBERCLE.

By E. L. FOX, M.D. Oxon.,

Physician to the Bristol Royal Infirmary, etc.

WHILST we owe much to the minute investigations of microscopical observers, there is some danger lest diseases should be divided too finely for any practical purpose, if we depend on these investigations alone, without taking other points into consideration. This seems likely to be the case in the present line of thought on the subject of phthisis; and I venture, therefore, to submit the following suggestions. If scrofula and tubercle be such totally distinct diatheses, is it not remarkable that more than a third of the adults who suffer from tubercle have been subject to swollen or suppurating cervical glands at an earlier period of life; that miliary tubercle of the lungs, or meninges, is associated, as a rule, with cheesy degeneration of the bronchial glands; and that tuberculous ulceration of the intestines, especially in cases that so closely simulate typhoid fever, is constantly accompanied by a similar degeneration of the mesenteric glands?

Niemeyer states that this comparatively frequent coincidence of tubercle in the lungs with the presence of cheesy products in other organs, cannot be regarded as accidental. "The eruption of tubercle," he says, "usually occurs at the time the cheesy knots begin to soften. Tuberculosis is, in most cases, a secondary disease, originating in an unknown manner through the influence of cheesy morbid products upon the organism."

Again, acute tuberculosis differs from chronic phthisis merely in the intensity of symptoms. The pathological appearances in the brain, lungs, and intestinal canal, are identical, saving only the difference due to the more or less rapid formation of a cavity. The symptoms of acute tubercle, and of those acute exacerbations, so common from time to time in the progress of a case of chronic phthisis, are extremely similar; notably in the high temperature, which constantly may sink four, or even six, degrees in twelve hours, and rapidly recur to its former height without any evident cause. I have observed this pretty often in acute tubercle, and in ordinary phthisis with a more chronic course; and Dr. Sidney Ringer's published cases bear evidence to the same fact. If, as I am inclined to believe, every acute disease has its own special scale of temperature, which, within certain limits, is diagnostic; this fact is of no slight importance in establishing an identity of nature between the two conditions. The intestinal ulcerations is very similar in both, and seems, as in typhoid fever, to be due to an attempt of nature to get rid of the poison from the system. Hereditary influence appears, also, to be as frequently connected with the history of the one as of the other. Of course, it is a matter of constant experience that the acute form is less amenable to treatment than the chronic. If, then, this be so, it is at least open to question whether so great an identity of symptoms does not establish an identity of nature between two diseases that just now are being considered as very distinct.

HÆMORRHAGE INTO THE PONS VAROLII.*

By ISAAC HARRINSON, Esq., Reading.

I HAD been attending Mrs. D., a spare woman, aged 39, for attacks of vomiting, to which she had been liable for some years, and which were supposed to be bilious. At my visit, December 11th, 1867, she was in bed, and while there she began to retch and strain hardly. After one desperate effort she exclaimed, with a face livid with turgidity, and with an expression stamped with alarm, "What's that?" "What a noise?" putting her hand to her right ear. She nodded assent to the question whether she had pain there, fell back, and never spoke again. During the first hour there were frequent, curious convulsive, and twisting movements of the body. The left arm was turned quite round and inwards. In the intervals the left leg was paralysed, and the face and pupils were unaffected. The vomiting, or rather the effort to expel mucus, which rapidly collected, and which she appeared unable to swallow, continued. She moaned, with a peculiar appearance of restlessness and distress, and her eyes were open; her aspect was not heavy, stupid, and comatose; her breathing was quick, not laboured. After the first hour, relaxation of the whole muscular system gradually supervened and increased, and she died in six and a-half hours from the attack. From the first she was unable to swallow, and no treatment was attempted.

* Read at the Reading Pathological Society, March 1868.