ON
THE MINUTE ANATOMY
OF
THE EMPHYSEMATOUS LUNG.

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THE form of emphysema which furnishes the subject of the following details is that which is called "Vesicular Emphysema," and the specimens of this disease, which have been selected for minute examination, are of the ordinary kind.

The subject from which the greater part of the preparations illustrating the facts described in this essay, and from which the drawings accompanying it were taken, was about forty years of age, and the general aspect of his lungs, especially in the vicinity of the emphysematous part, was healthy. There were, however, in some parts of the lung, a few small tubercular deposits.

Before the abnormal condition of the structures entering into the composition of the lungs, as they appear in emphysema, is described, a few observations on the normal state of these parts may advantageously be premised; and, the air-cells being the seat of this disease, these observations will be confined to them.

The only two structures entering into the composition of

the air-cells, distinguishable by the microscope, are capillary vessels, and the membrane by which they are invested and connected together. The capillaries are known by the minute oval spots on their coat, generally considered to be the nuclei of cells, as well as by the extremely faint outline of the coat itself. In the uninjected subject this coat can with great difficulty be distinguished, especially when the capillaries have no blood in them; but in the injected lung it is sufficiently evident in those vessels which contain only a small quantity of injection. Nerves are not recognizable in the air-cells, although it can scarcely be imagined that no nerves exist in these parts.

If a portion of injected lung, magnified twenty or thirty diameters, be viewed by reflected light, it is seen to be made up almost entirely of irregularly-shapen cavities—the air-cells—differing very much both in size and form, but for the most part cuboidal. The dimensions of the air-cells differ greatly in different parts of the same lung, being the largest in those parts the most remote from its centre. They are frequently so large at the margins and extremities of the lobes, that these parts of a lung, retaining a good deal of air after death, are sometimes considered to be emphysematous when they are perfectly healthy. The walls of these cavities appear by reflected light to be formed entirely of a dense plexus of capillaries, consisting only of one layer of these vessels, which is so situated with respect to contiguous air-cells that the same layer forms a part of the two cells between which it is situated, one side of it bounding one of these air-cells, and the other side the adjacent one.* The air-cells communicate by large circular openings through which the air can pass freely from one into another. An indefinite number of these air-cells, surrounded by areolar tissue, and supplied by a branch of the pulmonary vessels, constitutes a lobule. The larger branches of the pulmonary artery and vein run in the intervals between the lobules, while the smaller ramifications run between the air-cells themselves, and send off

* See Plate IV. fig. 1.

branches in different directions to the nearest plexuses, in which they anastomose very freely with the radicals of the pulmonary veins, and also with the ultimate ramifications of the neighbouring pulmonary arteries.

The membrane connecting the capillary plexuses—"pulmonary membrane"—is very thin, almost transparent, and made up chiefly of an irregular interlacement of extremely delicate fibres, which are most distinct around the openings of communication between the air-cells, where they appear to be somewhat circular. This membrane, whilst in a healthy state, is devoid of any regularly-formed corpuscles; the appearance of minute cellules may occasionally be observed in some parts of it, but these are so very rare, their form and size so irregular, and their situation so uncertain, that they cannot be regarded as an essential part of its structure, and may therefore be considered either as accidental or abnormal. The pulmonary membrane lines the air-cells, and in passing from one cell into another encloses the plexuses of capillary vessels between the two cells: hence between each two contiguous air-cells there is one layer of vessels and two layers of membrane. This membrane has no regular covering of epithelium, the ciliated form of epithelium ceasing with the bronchial membrane, which extends no further than the termination of a bronchial tube in a bronchial inter-cellular passage.*

The office of the pulmonary membrane is to connect and support the capillary plexuses, and to form the immediate boundary of the air-cells. It appears to be the seat of disease in emphysema, as hereafter will be shown.

Having premised these observations on the minute structure of the air-cells, it will be more easy to render intelligible the changes which they undergo in the disease now under consideration.

If a very thin section, or even a mere fragment of emphysematous lung, especially if it had first been minutely injected, be examined by a lens of one-quarter inch focus, by transmitted light, the pulmonary membrane will be seen

* See Medico-Chirurgical Transactions, vol. xxviii. p. 581.

to be perforated, or cribriform. The perforations in this membrane are generally well defined, of an oval or circular form, of various sizes, and more or less numerous, according to the progress of the disease.* In very thin sections of lungs in other respects normal, I have occasionally met with an opening or two through this membrane, corresponding to the areolæ of the plexuses, but these are so few, and their existence so uncertain, that they may probably be regarded as accidental, or perhaps in some cases the result of incipient disease, as I have not found them in lungs which I have known to be perfectly healthy, and which I have examined expressly for the purpose of determining the normal state of the pulmonary membrane. These openings cannot be confounded with those by which the air-cells open one into another, or by which the air-cells open into the intercellular passages, the latter being surrounded by a circle of anastomosing vessels. The next point to be noticed is that the pulmonary membrane in the vicinity of these perforations, as well as in many parts not yet cribriform, is studded with brightish spots, generally of a circular form, which vary in number and size, but in many instances are about the magnitude of the nuclei observable in the coats of the capillary vessels, and might possibly be mistaken for them, did they not occur in situations where there are no such vessels, as in the areolæ of the plexuses.† These spots exist either singly or in clusters, and I have no doubt precede the formation of the perforations above observed, the latter having the form and occupying the same parts of the membrane as the former. The size also of the perforations accords with the size of the spots, being either that of an individual one or of several aggregated together. This appearance, by a careful examination, is seen to be due to the presence of oil in the tissue of the membrane, or upon its surface. In some parts the oil appears to be so intimately blended with the substance of the membrane as only to increase its transparency, and thus to produce the appearance of bright circular

* See Plate IV. fig. 2.

† See Plate IV. fig. 3.

spots; in others, where it is less intimately blended with the tissue of the membrane, it exists in the form of numerous minute globules, and of others of larger size, apparently due to the coalescence of these. This latter form presented by the oil occurs chiefly in those parts where the pulmonary membrane is thickest. If now a very small portion of the membrane thus affected be dried, then pressed between two pieces of glass, and gently heated, small particles of oil will be left upon the glass, distinctly visible by the microscope; or if it be digested in sulphuric æther, all the minute globules before discernible upon it will have disappeared. From these facts it seems obvious that, owing to a change induced by some cause or other in the nutrition of the pulmonary membrane, the materials of which it is composed pass into a different state of combination, and are converted into oil, and that in consequence of this change the texture of this membrane in the part of the lung affected is in some places weakened, and in others wholly destroyed;—a condition which cannot fail so to impair the mechanical function of the membrane, as to render it incapable of supporting the capillary plexuses, and of furnishing that resistance to the pressure of the air contained in the air-cells which is necessary for maintaining the several parts of the lung in their proper situation; and a condition, therefore, sufficient to account for those changes in the form and size of the air-cells, and their subsequent breaking up, which constitute the more obvious derangements in the structure in the lungs in emphysema next to be described.

The pathological appearances now to be noticed are those observable in the disposition and condition of the blood-vessels. To determine the abnormal state of these parts satisfactorily, and to its fullest extent, the vessels of an emphysematous lung must have been injected prior to examination.

If those parts of an injected emphysematous lung, in which the air-cells are merely dilated, be examined by reflected light, the capillaries in their walls are seen to be smaller than

natural, whilst the spaces circumscribed by their meshes are much increased in size.* These changes in the vessels are proportional to the extent of the dilatation in the air-cells. They seem to indicate that the membrane, previously to its giving way, had been in a state of great extension. This extension may have arisen either from an undue pressure of the air in the air-cells upon the membrane, in consequence of some impediment to its free passage from the lungs, the membrane being in a perfectly healthy state; or from the pressure of the air in ordinary respiration, the membrane being weakened, and rendered more yielding than natural by some disease. In the case under consideration, I am not aware that there was any impediment to the respiration which can account for the changes which existed in the membrane and vessels of the lungs; whilst there seems to be sufficient cause for the elongated and attenuated state of these parts, in the process of fatty degeneration going on in the membrane, whose function it is to preserve all parts of the lung in their proper situation. I believe, therefore, that the dilatation of the air-cells and the changes in the capillary network were produced by the extension of their walls, which being weakened, as before described, have yielded under the pressure of the air within them, and caused the vessels to become elongated, their calibre diminished, and the areolæ of the plexuses to be enlarged. In parts where a visible lesion of the membrane between the air-cells has taken place, and several cells have become united so as to form one cavity, fragments of cell-walls are seen within it, containing extremely elongated capillaries and portions of plexuses, in which the vessels are very much contracted, and the areolæ enlarged but mostly in length.

The extremely attenuated state of the vessels, prior to their division, seen in the injected emphysematous lung, is worthy of notice, as this state, together, perhaps, with a certain degree of retraction of their coats at the instant the division takes place, may be regarded as the reason that

* See Plate IV. fig. 4.

hæmorrhage never occurs in emphysema of the lungs. After the disease has advanced still further, and the emphysematous cavity become large, and situated near to the pleura, all vestiges of the air-cells which were broken up to form it have in a great measure disappeared, and its sides are then held together by fibrous bands of various degrees of strength extending across it. These bands are the remains of the inter-lobular tissue, and they, like the pulmonary membrane, after sustaining a certain amount of elongation, give way. Their broken ends are distinguishable in these cavities in the form of irregular nodulated masses, produced by the retraction of the chords after their rupture.

The inter-lobular cellular tissue being gradually condensed during its elongation, becomes more compact and less capable of inflation; consequently the rupture of the bands into which it had been drawn out is not followed by extravasation of air between the lobules, and the occurrence of inter-lobular emphysema. When the emphysematous cavity has arrived close to the pleura, being separated from it only by the external wall of the most superficial cells, with the sub-pleural vessels and areolar tissue, the pleura in this part becomes thickened, and the sub-pleural vessels very much developed, though without exhibiting the appearance of injected vessels going to an inflamed part. These changes in the structure of the pleura and sub-serous cellular tissue are rendered necessary to support the pressure of the air, to which they are now exposed in consequence of the destruction of the air-cells lying immediately above them.

A review of the facts above stated seems to prove that the form of emphysema here described originates in a morbid process going on in the pulmonary membrane, by which the elementary substances entering into its composition are made to pass into that state of combination which is necessary to form oil—a process very common in other structures and organs of the body, and which of late years has been described under the title of “Fatty degeneration.”

EXPLANATION OF PLATE IV.

- Fig. 1. Exhibits a portion of healthy lung injected, to show the dense plexuses of vessels situated around the air-cells, and the minuteness of their meshes in relation to the capillaries enclosing them.
- Fig. 2. Exhibits a portion of emphysematous lung, in which the membrane connecting the vessels, the pulmonary membrane, is perforated by numerous foramina, and also studded with minute bright spots, occurring, some in clusters, others singly.
- Fig. 3. Exhibits another portion of pulmonary membrane, rather thicker than the former, from the same lung, in which, in addition to the parts above noticed, a multitude of oil-globules of various sizes is seen.
- Fig. 4. Exhibits a portion of emphysematous lung injected, to show the elongated and contracted state of the vessels, the enlargement of the meshes of the plexuses, especially in the direction in which the parts appear to have been stretched, and cavities produced by the breaking up of the walls of the cells.

Fig. 2.

Fig. 4.

Fig. 1.

Fig. 3.