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The
Reciprocal Relation
between
Heart and Lungs
in
Health and Disease
by
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Calls for no special remarks being
a very simple detail of the physiology
of the circulation & respiration - &
a correct account of the manner
in which the principal symptoms
of heart & lung disease are pro-
duced

To one who carefully investigates the material world around us, made up as it is by a number of heterogeneous constituents, which are classed into the three great Kingdoms of Nature, there is seen to exist a mutual relation and an intimate bearing of one part or integral portion upon another. We observe that there are certain laws which guide and govern these relations, and if they are violated or departed from, confusion exists, and the balance of Nature is disturbed. This is well observed in the relation that exists between the vegetable and Animal Kingdoms in regard to the formation of Carbonic Acid by Animals & its consumption by vegetables which in their turn set free the Oxygen again to be used up by Animals. Here as we find plants and Animals are entirely depending on each other, for the constituents in part of their support, and the continuance of their existence. So when we come to consider the subject more intimately under our observation at present, the mutual dependence of the several parts is seen in a still more marked degree that exists in the Animal organism itself. It is found to be divided into systems each of which pursues its own end and purpose, but in its turn is depending on the others to a certain degree without which it could not perform

its function or continue in existence, and in like manner the others are depending on it. These systems are not made according to the caprice, or to please the views of the anatomist or physiologist, but are made by the design of nature to serve the great functions and ends of animal existence. All the attainments that have been reached or ever will be made in science, only serve to demonstrate the functions and purposes served by these systems. There are many systems more or less connected with, and all indispensable for, the different requirements of the higher organisms but those which are absolutely necessary to animal existence are three in number, and have been aptly called the tripod of life; they are the vascular, nervous, and respiratory, the centres of which respectively are the heart, brain, and lungs. These are all dependent on each other, in a marked degree, for integrity of their various parts, and proper performance of function.

In attempting this thesis it is my design to take into consideration the mutual dependence and relation that exists between two of the great central organs in the animal economy, viz. the heart and lungs; but to a certain extent owing to the intimate relation between these and other organs, they will come under our consideration as we proceed with the subject.

In proceeding with this subject it is necessary that a subdivision of some kind should be made. And as the following, although not unobjectionable, appears to embrace the entire relation of these two organs to each other we prefer it:-

- 1st The physiological relation between heart and lungs:
- 2nd The Analogous symptoms produced by disease of one or other organ as manifested by the lungs:
- 3rd The results and diseases of a similar ^{nature} in other organs and tissues of the body, produced by functional or organic disease of either heart or lungs:
- 4th How disease of the heart operates in producing consecutive disease of the lungs:- And,
- 5th How disease of the lungs operates in producing consecutive disease of the heart.

As stated above this subdivision is objectionable because there are certain conditions of these organs ^{each one} that might be viewed as a disease in itself or as a symptom of disease existing in the other organ; thus take for example haemoptysis. If we view it merely as a symptom of both heart and lung disease then it comes under the second division; but if we consider the condition of the lung in which haemoptysis occurs, which is produced by an affection of the heart, as a disease in itself, then that disease would come under the fourth division. And there

hemoptysis would be treated of as one of its symptoms. However, as a general rule, in every subject there can be no classification, or division, that is not open to objection, we will retain the one we have made, and treat of those subjects that might be discussed under two heads under the one which we consider them more particularly to belong.

Before proceeding to give the reciprocal relation between heart and lungs in disease, it is absolutely necessary that ~~the~~ the relation between these two important organs, while performing their respective functions in a state of health, should be understood, and this will enable us to explain the manner in which one operates when in a diseased condition on the other and under the matter more fully understood; therefore we begin with 1st The physiological relation between heart and lungs in a state of health.

Both these organs cooperate in the important function of supplying the blood to the different textures and parts of the body in due quantity and proper quality. So long as they continue mutually to perform their respective functions, the balance of health is maintained, provided there be no other cause as mechanical violence, introduction of morbid poisons into the system &c. to produce disease, but if the action of one or other of these organs should

become impaired in the due performance of their functions, disease must inevitably be the result, provided the cause of derangement continue long enough in action. It is necessary that the blood should be kept constantly moving through the body as it has to convey nutritive material to the different parts of the organism, and bring from these parts the debris that has served its purpose in the economy, and carry it to the different excretory organs where it is separated from the mass of circulating fluid and thrown out of the system. It also requires that the blood should be exposed during its circulation to the atmospheric influence in order that it may part with impurities of which Carbonic Acid is the principal and imbibe Oxygen. For this end man and all warm-blooded animals are provided with lungs through ^{which} the blood has to pass when it returns from the different parts of the body to the heart, before it is again sent through the system. This is accomplished by means of the great central organ of the circulation, which may be viewed as a double forcing pump through whose agency a pulmonary and systemic circulation is constantly maintained. Although there are spoken of as two circulations they may be viewed as one complete circle divided into two parts as each compartment of the heart has its arteries and veins

so fitted that the blood. After it has passed through one side must pass through the other before it again reaches the one from whence it set out.

The force required to propel the blood through its course is principally situated in the heart whose muscular substance by its contractions and the valves being guarded by palves, drives the blood onward in its course and prevents regurgitation. The other subordinate assistant forces are the elasticity of the arteries, the pressure caused by muscular contraction on the veins, the selective influence of the tissues, and the movements of the chest during respiration. In order that the blood may be propelled in the proper direction valves are placed in appropriate localities whose office it is to prevent reflux of the blood. The valves are placed in the heart between each auricle and ventricle, at the orifices of the main arterial trunks as they spring from the ventricles, and also in most of the veins, at least where they are required in these vessels.

The alternate and successive contraction and dilatation serves to propel the blood onward. The auricles contract together and so likewise the ventricles and the contraction of the former appears to pass gradually into that of the latter. During the long pause that precedes the first sound of the heart

the Auricles are gradually being filled; the right by the blood carried to it by the large systemic veins, and the left by the pulmonary veins. At the same time the ventricles are being partially filled by the blood passing into them from the Auricles through the Auriculo-ventricular orifices which are now open owing to no backward pressure being on their valves. When the Auricles get distended they contract, and this immediately precedes the first sound of the heart, by which they force their contents into the partially distended ventricles which being now completely filled contract and drive the blood onward.

The contraction of the Auricles is quick and sudden commencing at the entrance of the great veins passing downward to the Auriculo-ventricular orifices and finally loses itself in ventricular contraction, as has been before remarked. The Appendices are the last parts of the Auricles to contract. From what has been described it might be expected that the blood would regurgitate into the large veins as ~~it~~ it does to a certain extent, but we may expect that the veins will contract more or less and prevent partially this occurrence but it is completely prevented when it reaches the valves that exist at the junction of the internal jugular and subclavian veins, while the Eustachian valve may partially prevent regurgitation into the

inferior vena cava, and the coronary vein is supplied with a complete valve that prevents it in that direction.

The ventricles contract much more slowly than the auricles and draw together their walls in every direction so completely as to empty themselves entirely of blood. During the ventricular contraction the auriculo-ventricular valves are brought accurately together by the combined action of the pressure caused by the blood and the contraction of the musculi papillares which cause the chordae tendineae to become tense and resist the force of the blood in driving the cusps of the valves past each other. By these means none of the force of the ventricles during their contraction is lost but is all directed to the onward propulsion of the blood. After the blood is driven into the aorta and pulmonary arteries, these contract by their elasticity which tends to drive the blood backwards into the heart, but this is prevented by the semilunar valves situated at the orifice of each of these arteries, consequently from the pressure exercised upon it an onward current is maintained.

As soon as the cavities of the heart contract they begin to dilate, and the auricles being the first contracted are the first dilated, and so the blood begins to flow into them as described above, and

when the ventricles begin to dilate, the blood from the Auricles flows into them, then the Auricular Contraction Completely fills them, when they Contract, so that the same Continuous Alternate Dilatation and Contraction is Carried on. The Auricles being the first Contracted begin to Dilate During the ventricular Contraction And are thus getting filled with blood, which is Completed long before the ventricles are filled, but by the systole of the former Chambers the latter are Completely distended as before.

The integrity of the valves of the heart Constitute an important point in preserving the sound working Condition of the organ and preventing disease in itself in the lungs and other organs as we will have to show. The Cusps of which they are made up come together and close the Orifices which they guard at the time when the reflux of blood would pass in a stream Contrary to the Circulation, thus During the Auricular Contraction the valves situated at or near the mouths of the systemic veins are Closed. During the ventricular systole, the Auriculo-ventricular valves are Closed, And During the Diastole of the heart the semilunar valves of the Aorta and pulmonary Artery are Closed, All the openings into and out of the heart have valves more or less Complete, except the mouths of the

pulmonary veins in which they are entirely wanting
and the superior vena cava, but although there are
some in the latter situation those in the veins
at the foot of the pedicle prevent reflux.
Owing to the mechanism of the valves they do not prevent
the free onward current of the blood, although
they prevent its reflux, for we find that they
freely open at the required moment which is during
the systole of the cavity lying immediately behind
them in the course of the circulation or during
the diastole of the cavity immediately before them.

We have now considered the function of the heart
and its valves, and have seen that by the muscular
contraction of its walls the blood is driven out of its
cavities in an onward direction, while reflux is
prevented by the valves situated at the mouths
of most of the great vessels between the
auricles and ventricles, by which means the end in
view is completely obtained. This mechanism
serves to propel the blood through the pulmonary
and systemic circulations where in its course through
the former it is to be exposed freely to the influence
of the air in the lungs and in the latter it is
to supply nourishment to the different tissues
and organs of the body.

We will now proceed briefly to detail the

function of the lungs and see how the blood in passing through them is exposed to the atmosphere, in order that it may undergo the necessary changes fitting it for the support of Animal existence. While the blood is passing through the Capillaries in the vascular tissues of the body it parts with a certain amount of its nutritive constituents and becomes changed with the effete matters of these tissues and it is therefore necessary for the health, nay for the very existence of the Animal, that this should be effected. And an amount of nutriment added. How the latter object is attained by Digestion and Absorption or the former by the different Excretory organs we will not stop to inquire but confine ourselves to the changes that are effected in the lungs.

The principle impurity that is removed by the lungs is Carbonic Acid while in these organs the blood is supplied with a fresh quantity of Oxygen. In order that this interchange of constituents of the blood may take place in the lungs it requires that it should be minutely divided in their tissues and freely exposed in small quantity to the influence of the Atmospheric Air. This is accomplished by the Air-tubes becoming gradually divided and subdivided until they at last are microscopically small, and then on the minute ramifications of the bronchial

tubes small pouches called Air Cells are developed in a ~~specialized~~ manner. All the large divisions of the Air tubes are composed of Cartilaginous rings, complete or incomplete, varying to the length to which the subdivision has gone, which serve to hold the tubes open, Circular muscular fibres that give them some power of contraction, besides elastic tissue that is placed in a longitudinal direction, and lastly their internal surface is lined with mucous membrane covered by fibrillate ciliary epithelium. As the bronchi become smaller in size they gradually lose their different constituents that are contained in the larger tubes until they come to consist almost entirely of a tough elastic membrane lined by a mucous surface and perhaps traces of fibrous and muscular tissue. The Air Cells are composed of fine membrane lined by a layer of pavement or tessellated epithelium. Around these cells the capillaries of the pulmonary artery are distributed in such a manner that nothing intervenes between the air in the cells of the lung and the blood in the capillaries, except the thin membranous walls of each. By this arrangement the changes that take place in the air and blood during respiration are carried on with facility owing to the power of gases to transude through moist membranes.

We have now seen something of the manner in which the heart and lungs cooperate in maintaining life and health, and I must say that I have not gone minutely into the physiology of either of these organs, nor was it my intention to do so only so far as might illustrate the reciprocal relation between the two organs. In order more fully to show the function of the lungs it will be well to observe the more marked changes that take place in the blood and respired air while passing through their tissues.

One of the most marked changes, unimportant in itself, except in so far ^{as} ~~that~~ it informs us that other less marked but more important, have occurred, is the change of colour the blood undergoes in the lungs from the dull ~~crimson~~ of that in the veins to the bright scarlet of that in the arteries. It is here that the blood parts with its Carbonic Acid which is thrown out of the system with the respired air. This has been proved by experiment, and not only that, but the quantity has been estimated. The amount exhaled varies with the purity of the air, period of the day, external temperature, respiratory movements, together with age, sex, and many other diversifying circumstances. The oxygen of respired air is always less than it is in the air before respiration. We might think that the amount of oxygen taken from the air in the lungs would be contained in

the expired air in the form of Carbonic Acid, but we are told by Valentin And Branner, as the result of their experiments, that it is not. It is supposed that this oxygen unites with hydrogen to form water and thus contributes to the generation of animal heat.

Watery vapour is also exhaled from the lungs during respiration, and its quantity varies according to modifying circumstances, so the time that the air is retained in the lungs, the temperature of the expired air, ^{the} quantity of watery vapour contained in it before expired and the volume of air expired.

There are other less important changes that are found to have taken place in the air during respiration, as the presence of ammonia, uric acid, and salts of soda, in that which has been expired; upon which we will not enter.

In speaking of the changes that the air undergoes in passing through the lungs we have had occasion to mention some of the more important changes that take place in the blood. Of these one of the most important that fits it again for traversing the system and carrying life and energy to every tissue of the body, is its parting with Carbonic Acid which we have seen is found in the expired air, and its receiving oxygen by which it is rendered capable of nourishing the different tissues and parts of the body.

We have already referred to the Change of Colour in the blood After it has passed through the lungs. If an Artery be opened, we find that the blood contained in it is bright scarlet (the pulmonary Artery excepted) while on the contrary if a vein be opened the contained blood will be found dark crimson (the pulmonary vein excepted). These two kinds are commonly known as Arterial and venous blood. The change of colour as we have remarked (the cause of which is not perfectly understood) is not so much a matter of importance as the fact that a change of Chemical Composition and nutritive power has occurred in the blood along with the change of colour. That Carbonic Acid exists both in venous and Arterial blood is admitted but it is found to exist in greater quantity in former than the latter. Its presence may be proved in the blood by agitating the blood with oxygen or other gases when the Carbonic Acid will be separated.

It is not necessary to state how the oxygen behaves when it meets with the blood in the lungs. There are some who hold that it enters into Chemical union with constituents of the blood others that it is merely held in solution. But ^{we} think it sufficient to say that the blood must be exposed to its influence or Asphyxia and death will be the inevitable result.

From these few remarks it will appear evident

that the heart and lungs must continue to cooperate in the process of purifying for and sending the blood to the different tissues of the body, if health is to be maintained. The heart acting like a forcing pump must continue perfect in all its parts. Its walls must be able to contract with the necessary force to propel the blood through the entire arterial circulation.

Observing this organ we may admire the wisdom of nature when we see how she adapts the means to the end.

In this complicated apparatus there is nothing found that could be dispensed with and nothing wanting to render it perfect. The right Cavities, because their work is less having only to carry on the pulmonary circulation, has thinner walls than the left which require strength to propel the blood to the most distant parts of the body. Again the Auricles, because they have only to force the blood into the ventricles, are not supplied with so thick or strong walls as the latter Cavities which directly send it through the circulation.

The lungs again owing to their histological structure are well fitted for the performance of the duty incumbent upon them. The pulmonary artery being minutely divided permeates their entire substance: and in like manner the purification of the bronchi are everywhere distributed throughout their entire texture. By this arrangement the capillaries of the former and

the Air Cells of the latter are brought in actual contact where the changes we have described are carried on with the greatest facility. Thus we find that for the maintenance of health the blood must be constantly sent through the entire organism, and not only that but be freed of its Carbonic Acid and receive Oxygen. The former of these requirements is accomplished by means of the heart, and the latter by the lungs. And as we have observed that the blood from the right heart passes through the lungs before it reaches the left heart to go through the systemic circulation, we can understand how it requires both these organs to perform their respective functions with integrity. Otherwise disease or death must result. In little manner it is easy to understand how if the function of one be impaired the other will and must in one way or other participate in the derangement and suffer as a result. As we proceed these derangements and their mode of production will be pointed out when the mutual relation between these two organs in a state of disease will be fully understood.

Before quitting the physiological relation between heart and lungs it may be well to give a familiar illustration that will show the reciprocal relation and dependence of these two organs on each other for the performance of their respective functions.

Every one knows that brisk exercise will cause the heart to beat quicker and the breathing to become more rapid than they normally are when in a state of repose. In this every day occurrence, ^{we observe} that the lungs accommodate themselves to extraordinary duty imposed on them by the requirements of the system through the heart. The heart owing to the greater amount of blood received into it in consequence of the exercise that induces the circulation of the blood more rapidly in the veins toward its right side has a greater amount of work to perform. In consequence of this its ^{in order} contractions become more rapid and powerful to rid itself of the imposed load, and therefore the dark venous blood reaches the lungs in increased quantity. On its arrival there in larger amount than normal, the lungs endeavour to discharge their function, and more rapid play of the organs is called into action for that purpose; hence the rapidity with which respiration is performed. Here is observed the most illustrative example that could be advanced of the mutual relation between these organs. In this, as in other cases, we find nature making provision for exigencies and not adding anything superfluous, or imposing an excess of functional activity without an absolute and imperative demand being made for it in order.

to maintain the standard of health and prolong the existence in a state of ease and comfort, so far as is attainable under the circumstances.

We now proceed to the second division of the subject: The Analagous symptoms produced by disease of one or other organ. ^{As manifested by the lungs} The symptoms that are alike, produced either by disease of the heart or lungs are Cough, Dyspnea (along with which we will treat of Asthma as being merely a form of Dyspnea) and hemoptysis.

Cough is produced by closing the glottis and then making a sudden and powerful expiration. It may be either voluntary or spasmodic. The sound is produced by the confined air in the lungs being forced rapidly through the narrow chink of the glottis.

Cough, as a symptom of heart disease, is quite different not in its mode of production but in its exciting cause, from cough as a symptom of lung disease. In heart affections ~~it is always~~ it is always an indirect symptom of the malady produced through the agency of the lungs. This depends on the intimate relation that exists between these two organs in the due performance of their respective functions. Thus, when we have hypertrophy of the heart, there will be cough, although not usually in the early stage of the malady.

The reason of this probably is that the hypertrophy when in existence for some time produces serous infiltration into the lung tissue, by which an irritation is produced owing to the internalization of the blood being interfered with. Hope tells us that "When the hypertrophy is confined to the left ventricle the cough is milder and later in its appearance, than when the right ventricle is affected." This is what might be expected because hypertrophy of the right ventricle is usually caused by a lesion on the left side of the heart which prevents the return of the blood freely from the lungs. In this case the force behind being augmented, and the onward current ~~through~~ the lungs being partially impeded, congestion and serous exudation is the result. But when this is compared with hypertrophy of the left ventricle as a cause to produce the same effect, it is found to be ^{much} ~~greatly~~ more potent. The left ventricle when hypertrophied exercises its augmented force not on the pulmonary but on the systemic circulation; and this accounts for the little effect it has in causing cough.

Dilatation of the heart produces cough, but here it is the left ventricle that is principally in fault. The blood is not freely transmitted from the left side of the heart, and consequently it accumulates in the lungs, and gives rise to the same mechanical

results as described above producing the same symptoms.

The explanation here given is only on mechanical principles; yet I think it is produced in many cases in quite a different manner. Both heart and lungs receive the greater part of their nervous supply from the same source viz. the pneumo-gastric. Owing to this anatomical reason, there must exist a physiological sympathy between these organs so that an irritation of any kind applied to, or occurring in the one will manifest itself in the other. From this we can infer how organic disease or functional derangement of the heart may operate in producing cough;

As a symptom of lung disease cough is always produced directly by a lesion of some kind in the lung tissue. Its purpose is the dislodgement of mucus or some other irritating material from the bronchial mucous membrane. It occurs in most, if not all ~~the~~ diseases to which the lungs are liable for we find it present in bronchitis, pneumonia, phthisis &c.

Dyspnoea—In introducing this symptom we will proceed, as with cough, to inquire what it is, and how produced. By a healthy adult the act of respiration is performed about eighteen times per minute; and that almost unconsciously, or at least without any voluntary effort whatever.

Again about seventy pulsations in a minute is something like the ordinary standard of the heart's action. That would give us about four pulsations for one act of respiration. In several diseases this proportion may be materially altered and unusual slowness or quickness may exist, ^{or} a voluntary effort may be required for the due performance of the function of the lungs. - this constitutes Dyspnoea. It is produced by an altered proportion between the amount of blood sent from the right side of the heart to the lungs, and the amount of air received into the latter organs. Respiration although an automatic movement is ^{partially} subject to the control of the will, and therefore to a certain extent voluntary. Dyspnoea exists when this voluntary effort is required during the performance of respiration.

Dyspnoea as a symptom of cardiac affections is like the preceding symptom - Cough - of an indirect nature produced through the agency of the lungs. On the contrary when a symptom of pulmonary disease, it is direct in its nature, or produced in the organs affected. Either hypertrophy, dilatation or any affection of the heart that interferes with the circulation of the blood through the lungs, will produce Dyspnoea. Any disease of the heart will cause it that materially alters the quantity of blood sent

to the lungs or that prevents its free return fr^{om} the organs. The mode of production by the quantity of blood sent to the lungs admits of easy explanation. Thus, supposing the normal quantity of air required to Arterialize the normal quantity of blood, can gain a free admission into the lungs, quiet breathing exists provided the amount of blood be not increased. But if hypertrophy, or any affection of the heart exists that will cause it to send more blood to the lungs than usual, a larger amount of air will be required to Arterialize it, and consequently embarrassed breathing will be produced. The amount of air received into the lungs, if deficient in quantity, will also produce it, the amount of blood at the same time remaining unaltered. The ways are numerous by which this deficiency of air to the lungs may be caused. They all operate by preventing the blood from being Arterialized; and the dyspnoea is an effort of nature to accomplish this end.

In all diseases of the lungs in which their tissue is gorged with inflammatory products, or permanently destroyed exten^{si}o paribus, dyspnoea will be found to exist. In a similar manner disease of the heart causes it by producing oedema of the cellular tissue of the lungs. While in croup and all other affections that prevent the free admission of air into the lungs difficulty of breathing will always be found to exist.

Again, though it may and does occur without the heart or lungs being present, is mostly a symptom of disease in these organs. It may be defined a paroxysmal difficulty of breathing in which respiration is performed with a wheezing sound, accompanied by the expectoration of mucus or sputum. From this definition we may safely conclude that Asthma is Dyspnea, but it does not follow that in all cases Dyspnea is Asthma.

It appears that some altered condition of the circulation through the lungs is necessary for the production of Asthma. Probably during the spasm, the blood accumulates in the lungs and leaves the surface of the body. In proof of this coldness of the extremities, and of the surface generally is found to obtain, ~~while~~ while there is a feeling of want of breath during the paroxysm. True the latter symptom can be accounted for by the theory of Asthma being a spasmodic contraction of the air tubes.

It is principally connected with emphysema of the lungs and changes in the structure of the heart and great blood vessels that Asthma is found to exist.

Many Asthmatic patients whose lungs are slightly diseased are able to perform the function of respiration with ease under ordinary circumstances, while an additional demand on the lungs in the performance

of perspiration will produce a spasm of the
Aorta. This additional demand may be made by
any cause that excites the action of the heart. We
must admit that the nervous system has a large
share in the production of Asthma. If it had
not, then, in all cases where the lungs are diseased,
Asthma might be expected to exist which it does not.
Bringing this nervous influence along with us, we
can the more readily understand how any extraordinary
tact on the heart, when in a diseased condition,
and barely able to perform its function, will
operate in causing an attack of the malady.

Hemoptysis is another of the symptoms that
may result either from disease of the heart or lungs.
As a symptom of lung disease it is like the preceding
ones, produced directly by some lesion in these organs.
In pulmonary consumption it is mostly present during
some period in the history of the malady. It may
be the first symptom to attract the patient's at-
tention, and then the physician, on making a
careful examination of the respiratory organs may
detect the presence of tubercles although they were
previously unsuspected. In consumption, it may result,
though rarely, from an arterial branch of some
size being laid open, during the process of softening
and extension of the tubercular deposit in the lungs.

in outline, most commonly arising from the capillaries around the tubules being laid open by the absorptive or ulcerative process caused by the tubules in the surrounding lung tissues.

There are many other diseases of the lungs that might be mentioned in which hæmoptysis is a symptom; but I think it is not necessary as all I intend to show is that the same symptom may arise from disease in either the heart or lungs.

In heart disease hæmoptysis is like the symptoms previously mentioned; an indirect manifestation through the lungs of the lesion in the central organ of the circulation. It is mostly caused by some impediment in the left side of the heart that prevents the free return of the blood from the lungs. How this can produce it is evident if we consider the manner in which it will operate on the circulation. It will throw back a column of blood on the pulmonary veins and through them on the minute veins ~~and~~ and finally on the capillaries of the lungs. Here the pressure exercised on the latter vessels (which have extremely fine walls) will cause their rupture and produce the extravasation of blood into the air tubes and cells. From this locality it is dislodged by the act of coughing, and then the symptom, concerning which we are speaking, is produced.

Of all impediments to the circulation that can
exist in the heart contraction of the mitral valve
is the most likely to produce hæmoptoei, in the
manner I have described. The engorgement we have
seen extends backwards (indeed it may be taken as a
general rule, that the bad consequences of all changes
in the orifices of the heart whether contraction or
dilatation are produced in a course contrary to
that of the circulation) and the blood vessels of the
lungs are ruptured by the pressure to which they
are subjected. In this case it is not only the impediment
to the circulation on the left side of the heart that
causes the lungs to suffer, but its secondary result
on the right side of the heart. This is produced by
the pressure of blood being thrown back through
the lungs on the right side of the heart, which
causes hypertrophy of the right ventricle. It then
labours with increased force to perform the increased
amount of work imposed upon it, but this we
know ~~it~~ is impossible for it to accomplish as
long as the lesion remains in the left side of
the heart. The lungs being placed between these
two forces, a retrograde one before and a direct
one behind them in the course of the circulation
must inevitably suffer, and rupture of the blood-
vessels is the result.

This powerful pressure to which the ill-supported vessels of the lungs are exposed, causes I think, in most cases, an attempt to unload themselves by passive exudation or excretion of watery mucus. This accounts for the occurrence of expectoration as a symptom of heart disease. But when the blood vessels of the lungs fail to unload themselves in this manner then they rupture blood escapes, and haemoptysis is the result.

I think from what has been observed, concerning hypertrophy of the right side of the heart in the manner it operates in aggravating the tendency to haemoptysis when another cause is present, we might safely conclude, that in itself it would be capable, to produce the result if there were no other cause in existence. In this case the haemoptysis is caused by the force with which the right ventricle sends the blood into the lungs, rupturing their blood vessels.

Insufficiency of the mitral valve is another lesion of the heart that may cause haemoptysis. This lesion permits the blood to regurgitate into the left auricle during the systole of the ventricle; and there being no valves at the orifices of the pulmonary veins, the backward current extends to the lungs. The pressure of the blood then operates in a similar manner as we have seen it to do in contraction of the mitral orifice; but in a less powerful degree.

Under the third Division, The periths And Aneias of a similar nature in other organs And tissues of the body, produced by functional or organic Aneias of either heart or lungs: we intend to confine our observations to Dropsy, hamorrhage, from the intestine, And hepatic Congestion.

Dropsy as a symptom of Aneias existing in the lungs although it may sometimes supervene, yet so far as I am aware is of rare occurrence. Why this is the case may probably, to a great extent, depend on the mode of treatment to which patients are subjected, in the acute forms of pulmonary disease, as they ^{are} subjected to depletion by general and local bloodletting combined with diaphoretic And cathartic remedies. We may probably account for its rarity in Chronic pulmonary disease, if we only consider how these affect the system by lessening the quantity of blood circulating in the vessels And thus preventing the ~~mechanical~~ Congestion to which in these cases the serous effusion owes its production. In plethitis And other Chronic Aneias of the lungs, Aemhaa expectoration And nocturnal sweats keep a constant drain on the system, And thus lessen the amount of fluid in the vessels. When these Aneias exist frequently they are complicated by Affections of the Abdominal organs; such as ulceration of the glands of the

intestines, infiltration of the mesenteric gland, with tubercular matter &c, that prevent the proper nutrition of the body from being carried on; These all operate by lowering the quantity of blood, and consequently prevent the occurrence of Dropsy.

Whenever it is a result of some lesion of the lungs, they operate by producing mechanical congestion by causing an impediment to the free circulation of the blood. This is easily accounted for, as for example in pneumonia, when a portion of one or perhaps both lungs becomes impervious to air, in consequence of which the blood does not pass freely through the lungs. By this means a column of blood presses on the right side of the heart and through it on the entire venous system. Then the loaded veins and capillaries allow a serous exudation through their walls owing to the pressure to which they are subjected, between the retarded column of blood on one side and the onward current through the arteries on the other.

Of all affections of the lungs pulmonary emphysema is the most likely to cause Dropsy or Anasarca. The reason of this is because in this affection the nutrition of the body is carried on vigorously, as in health, but owing to the number of bloodvessels of the lung that become obliterated, the free passage of the blood is

prevented, and consequently it is thrown back on the right Chambers of the heart which it tends to dilate and from it on the venous Circulation by means of which the Anasarca or Dropsy is produced.

Disease of the heart causes Dropsy by placing an impediment in the way of the free return of the venous blood, as may be observed by the dilated jugular veins that are usually an accompaniment of Dropsy depending on this Cause. One symptom that we will usually meet with when there is Dropsy existing in these cases is Dilatation of the right side of the heart especially the Auricle. This Dilatation is not the Cause of the Dropsy but only a sign like the Dropsy itself of the Cause of Arrangement in existence. When we have Anasarca depending on Disease of the heart, there will mostly be present those signs that indicate Dilatation of the right side. Of these we may mention the sounds of the heart being heard, and the organ felt to beat beyond the precordial region, fluttering palpitation, and dyspnoea, on slight exertion. Some of the symptoms are blueness and lividity of the lips and coldness of the extremities that will mostly supervene. After what I have said concerning the manner in which Dropsy is caused from Disease of the lungs connected with the changes it produces in the heart, it will be,

Almost superfluous to say anything of its mode of production from disease of the heart as in both cases an impediment to the circulation is the cause, and ~~the~~ dropsy is the effect. The impediment may exist on the left side of the heart in the form of mitral valve; contraction or dilatation, either of which will throw a backward pressure on the circulation through the lungs and will cause ~~the~~ dropsy by its mechanical action.

Hypertrophy of the heart might at first sight be thought a very efficient cause of dropsy owing to the pressure that it would cause on the veins through the arterial system. This we find does not in reality occur if the free return of the blood through the heart and lungs is not interfered with. Indeed such a condition as simple hypertrophy without the existence of some impediment to the circulation, is not likely to occur except in the case of those who are busily engaged in manual occupations when it is a compensating phenomenon in order to supply the blood in the large amount in which it is required; just as we see a large and strong pump in cases where a small and weak one would not be able to perform the requisite amount of work.

Hypertrophy with contraction of the Cavities of the heart, concentric hypertrophy, as it is called, would

readily give rise to Dropsy, at least on theoretical grounds it is easily accounted for. In these cases the free transmission of the blood through the heart would be prevented by the smallness of the Cavities and thus give rise to mechanical pressure on the venous circulation, and cause the symptom in question. However this state or lesion of the heart is said not to exist by many Competent Authorities. Dr. Budd has carefully investigated the subject and come to the conclusion that during life such a state did not exist. Spurzheim, however, was the first to point out the fallacy of concentric hypertrophy and described it as a post mortem appearance, depending on the mode of death. We can understand how observers might be deceived in examining a heart when death was caused by copious hemorrhage, in which the Cavities would appear almost obliterated by the firm contraction of the organ. The walls in a case like this would also appear thickened owing to the shortening of the muscular fibres that enter into their composition.

Hemorrhage from the intestines and hepatic Congestion will be treated of together, as they are both produced from heart or lung disease in a similar manner. Both of these are caused by an impediment to the free return of blood from their tissues. After what has already been said of the way in which

Disease of the heart or lungs operates in causing, other diseases by their mechanical means it would be only a recapitulation of former statements to enter minutely into the way that the operate in these cases under consideration. Suffice it to say, that in hepatic Congestion the free return of venous blood is prevented from the liver. Here the pressure of the Column of blood is carried from the right side of the heart through the inferior vena cava into the hepatic vein. In hemorrhage from the intestines this pressure is carried through the liver into the portal vein, hence to the intestines. This causes the capillary vessels to rupture and the blood becomes extravasated on the intestinal mucous membrane.

We now proceed to the fourth Division. How Disease of the heart operates in producing consecutive Disease of the lungs. We will mention two diseased conditions of the lungs, ^{frequently} caused by heart affecting viz. Pulmonary Apoplexy and Oedema of the cellular tissue of the lungs.

Both of these Diseases are produced in a manner similar to two Affections that have been previously treated of, and will therefore not detain us long. Pulmonary Apoplexy is caused by the means that come into operation in the production of hæmoptoeis.

It differs from hemoptysis only in the respect, that in the latter the extravasated blood is dislodged from the air cells and tubes, and is spat up, while in the former the blood coagulates in these structures and is retained. There is a circumscribed and a diffused form; in the one, the blood coagulates in small hard masses in the substance of the lungs; in the other it is scattered through the broken down pulmonary tissue. Disease of the heart causes this disease and particularly of the mitral orifice, but it may depend on some affection of the lungs.

Edema of the cellular tissue of the lungs only requires to be mentioned as it does not differ in its mode of production from edema of other organs depending on heart disease. And as there have been described under the head of dropsy, no further notice will be taken of the way in which diseased heart operates in this case.

The fifth division upon which we now enter will require to be treated of in more detail. How disease of the lungs operates in producing consecutive disease of the heart.

I believe it might be almost laid down as a general rule, that when disease occurs in the left side of the heart, in either ⁱⁿ the form of contraction or dilatation of the mitral valve, or of the cavities

of the organ, it either commences in the heart as a primary disease, or has its causation in some impediment in the arterial system. Again disease of the right heart, hardly if ever, is primary, but is caused by preexisting disease in the left side of the organ, or in the lungs.

Dilatation and hypertrophy are the ^{altered} only conditions of the heart that can be produced by disease of the lungs. The existing causes of these two conditions connected directly or indirectly with the lungs as enumerated by Hope are "pneumony acute or chronic; emphysema; hydrothorax; chronic catarrh; emphysema; phthisis; narrowness of the chest, either congenital or occasioned by curvature of the spine &c.; encroachment of the diaphragm on the cavity of the chest, from the pressure of tight stays, of the gravid uterus, of abdominal dropsy, aneurism &c."

Whether dilatation or hypertrophy results from any of these causes depends on the condition of the heart itself, and therefore it may be advisable to consider what are its conditions that favour one or other of these occurrences. Either hypertrophy or dilatation may be produced by the foregoing enumerated causes, owing to circumstances connected with the organ itself, or with the system in general that favour the production of one or other. When the mechanical impediment to the circulation exists, the blood is accumulated within the heart, where

function, it is to drive it onward, in the course of the circulation. And as we know that it is an established law in physiology, organs which are embarrassed in the performance of their functions make an attempt to discharge their duty with increased force and vigour. In consequence of this law under these circumstances the action of the heart becomes more powerful. Then the increased work requires increased nourishment to meet its demands and therefore the coronary arteries supply more blood to the heart than normal. By this arrangement the heart receives not only the amount of blood required for its support under ordinary circumstances, but the amount required to enlarge and strengthen the organ for the performance of the greater amount of work and so hypertrophy is the result. When once this state has been established it has a tendency to increase, owing to the more powerful action of the heart - the cause and effect now operating together.

The left ventricle is more apt to become hypertrophied than the right, and this again more so than the auricles. Why such should be the case is easily explained. And this explanation to a certain extent informs us why hypertrophy does not always result when similar exciting causes exist. The different chambers of the heart being viewed as

separate hollow muscles, we observe a great difference in the thickness of their walls, and that the tendency to take on hypertrophy increases with the strength of the walls, while the thinnest are least liable.

Now as powerful muscles by their action have a more stimulating tendency on the arteries to supply blood than weak ones have, it follows from the above explanation that the order we have enumerated would be the most likely for hypertrophy to occur.

We may next proceed to inquire why hypertrophy does not always occur when a mechanical impediment to the circulation is in existence. Although the hypertrophy does not always result yet it generally more or less accompanies the dilatation we are about to describe. As has been before remarked, dilatation of the heart is a result of an impediment; it meets in the free performance of its function. When such an obstacle exists and other causes predispose, the dilatation results in a pre-eminent degree over the hypertrophy. This is caused by anything that imposes on the heart an amount of work which in its present condition it is not able to perform, and as a matter of necessity it yields to the over extending force of the blood contained within its cavities. And here we may expect that the extending force, overcoming

the peristalsis would result in dilatation; and it is so. Not only that but we find the Cavities that are thinnest to be the most ready to take on dilatation while the thickest are least likely, in other words the Auricles dilate more frequently than the ventricles and of the latter Cavities the right more frequently than the left.

Dilatation like hypertrophy requires a long continued exercise of the exciting Cause for its production, and accordingly we find that of the foregoing enumerated Causes the more permanent are most likely to give rise to it. For supposing the distending force to be only temporary, then the organ owing to its muscular elasticity will recover itself. But when the distending force is long continued the muscular fibres being unable at any time fully to recover themselves, they become permanently stretched, and dilatation is the result. It requires this dilating force to act in a powerful manner, or otherwise the heart to be weak so that it cannot overcome the impellent, or otherwise hypertrophy, and not dilatation, would be caused.

I have said above that dilatation of the Auricles is more common than the ventricles. This is only what we might expect in theory but is not what in reality we find. Probably this depends on the Auricles

being defended from the pressure of the blood by the Annulo-pentacular valves.

Having thus ^{glanced} cursorily at a few of the Analogous symptoms in heart and lung disease, and also at the way in which heart disease operates in producing Analogous lung affections, we will go on to consider how the two affections of the heart before mentioned are caused by disease of the lungs. When the mutual relation between the two organs is established, a number of the causes connected with the lungs that are enumerated by Hope, require little else than mention in order that their modus operandi may be perfectly understood. These act not internally, but external to the lungs; thus emphysema, hydrothorax, narrowness of the chest all operate by their mechanical compression on the lungs, and thus preventing the free admission of air and blood into these organs.

As we have seen that the same causes operate in producing both dilation and hypertrophy of the heart the difference of result depending on some other circumstance, we will treat of each cause separately with the view that either contraction of the heart may be the result.

Emphysema of the lung, according to the opinion of most writers, will cause consecutive disease,

of the heart, And this admits of being readily explained, owing to the condition of the lung which we will now describe; the blood does not pass readily through its tissues.

There are two forms of Disease or Conditions of the lung described by Laennec under the name of emphysema. One he designates peculiar, and the other interlobular. The peculiar form consists of dilatation of the air cells frequently misshapen which may be caused by the dilatation extending in the direction of a weak part of the cell wall, or by the partition between two or more cells becoming obliterated. The interlobular form deserves the name of emphysema of the lung more properly. It consists of the admission and permeation of the cellular tissue of the lung with air. Either of these conditions evidently destroys to a certain extent varying with the amount of the disease the function of the lung and consequently prevents the free arterialization of the blood and retards its onward progress. Such being the case, the blood becomes accumulated in the chambers of the heart, and causes dilatation probably combined with hypertrophy of that organ. This satisfactorily accounts for the heart disease but we may inquire into the manner in which the emphysema itself is caused. Professor Gardiner considers that the emphysema and the disease of the heart both

result from pulmonary collapse, or whatever else tends to destroy a portion of lung substance or to render it impervious to air. He concludes that when a portion of the lung is only capable of expansion and another portion collapsed, or rendered solid that the sound part during inspiration in trying to follow the receding thoracic walls and fill the cavity of the chest is stretched beyond its normal degree of expansion and consequently enlargement of the air cells or their dilatation is the result.

An objection might be raised against this theory, because emphysema is not observed as a complication of pneumonia, and other affections of the lung in which a portion becomes impervious to air. This is easily met when we consider that in these diseases there is more solidification, and the bulk of the organ is not decreased because the engorgement or inflammatory products tend to prevent a decrease in the size of the lung. On the contrary, in collapse the portion of lung is gradually emptied of air (and consequently of blood) without anything taking its place; therefore it becomes decreased in volume, and equal increase of volume is required in the sound portion to prevent a vacuum from being formed between the lung and thoracic walls.

Owing to the manner in which respiration

is performed. A moment's Consideration will suffice to prove to us that this theory must be correct. The reception of Air into the lungs is not depending on any Active part these Organs take; but upon the expansion of the Chest when the Air rushes into the lungs to fill the vacuum thus made. Here as a matter of necessity the sound portion of lung must become emphysematous, if another portion be prevented from expanding; because the Atmospheric pressure will cause the space left vacant by the increase in the capacity of the Chest to be filled and therefore it over-expands the portion Capable of expansion.

Paricular Emphysema Causes dilatation with or without hypertrophy of the right side of the heart owing to the impediment that it causes to the Circulation through the lungs. The smaller blood vessels around the Air Cells become gradually obliterated in the progress of the Disease; and thus the passage of the blood through the lungs in the normal quantity is prevented. This renders the heart unable to empty itself with its usual ease and facility, and then the internal strain on its walls causes the dilatation from the gradual stretching of the muscular texture. The hypertrophy is caused by an effort of nature to overcome the obstacle therefore it is a complimentary growth. Perhaps the expansion of the Chest when a

portion of lung is collapsed may have a tendency to cause dilatation of the heart in order to fill the empty space in the thorax. But let this have an effect on the heart or not, it is evident that the obstruction to the pulmonary circulation is capable in itself to cause the effect.

Phthisis although mentioned by Hope does not as he acknowledges produce disease of the heart, in so marked a form as we might be inclined to think, from the great embarrassment it causes to the circulation through the lungs. This probably is accounted for by the constant drain on the system from diarrhoea or night sweats which have a tendency to remove the watery constituents of the blood, and consequently lessen the amount of circulating fluid, and therefore take the burden of the heart. It may here be asked if the blood in phthisis owing to its watery constituents being removed, is richer in solid ingredients than normal blood? Certainly not, because being but imperfectly aerated, and the system imperfectly nourished, it is quite inconceivable that it could be richer, but much more probable that it will be poorer in red corpuscles. In the early stage of the disease, before night sweats &c, commence to act as a drain on the blood while the tubercles are yet crude, the latter

occupy but little space in the lung and therefore but little embarrass the circulation and thus we see how at every period of the disease the heart is but little affected.

Mr. Louis does not consider, so far as I am aware, that phthisis takes any active part in the production of disease of the heart, or if any, it has a tendency to cause atrophy of the organ. He says that under his observation a far greater number of hearts were below the natural size than were above it of those who died of phthisis. He also says that when enlargement did exist it was found on the left, and not on the right side, as it would be if depending on engorgement of the lungs from an impediment to the circulation. There is an account of seven cases given by him of thickening of the pericardium in which hypertrophy occurred, six times on the right, and only once on the right side, which is reverse to what it would be if the cause depended on the condition of the lungs. Again he only observed thickening of the pericardium twice on the right side and four times on the left in his experience. At the time he wrote; so that, as he observes, the cavities of the right side of the heart appear to retain their natural character much more frequently than those

of the left," quite contrary to what would occur if the lungs were the cause of the change. However Hope says that in most cases the right ventricle is found more or less dilated, and he quotes Mr. Louis and Dr. Williams as his authors, but from what I have remarked from the former author, it does not appear confirmatory of this statement, and the views of the latter I have not had the opportunity of seeing on the subject.

I have now concluded all the observations that I intend to make on the "reciprocal relation between heart and lungs in health and disease". Perhaps it may be said that such an extensive subject was briefly dispensed with - if so, grant it, but it was not my intention from the commencement to enter minutely into the details of these two organs, and if I have established their mutual relation, I am satisfied, and my intentions are fully accomplished.