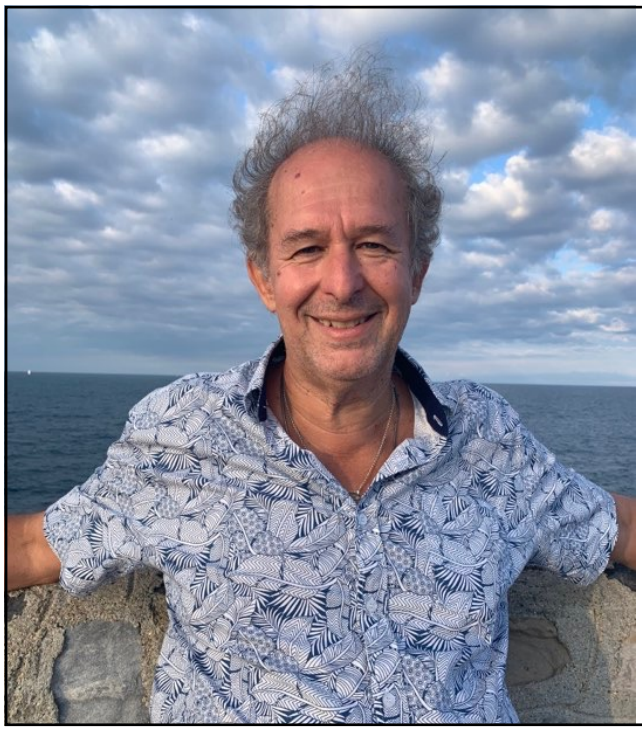


lesser-known aspects of diaphragm physiology

1

Cellular nutrition is intricately linked and dependent on digestion, respiration, and circulation.

Blood plasma provides cellular nutrition. Blood flows through blood vessels, while interstitial plasma collects in the intercellular spaces.

2

Immediately after transudation, arterial plasma undergoes osmotic exchange with cellular plasma and returns with venous blood to the right side of the heart, carrying toxic waste products.

Circulation, by distributing blood uniformly and continuously to all the body's organs and tissues, eliminates waste and harmful substances from the blood, thus ensuring the consistency of its composition and volume.

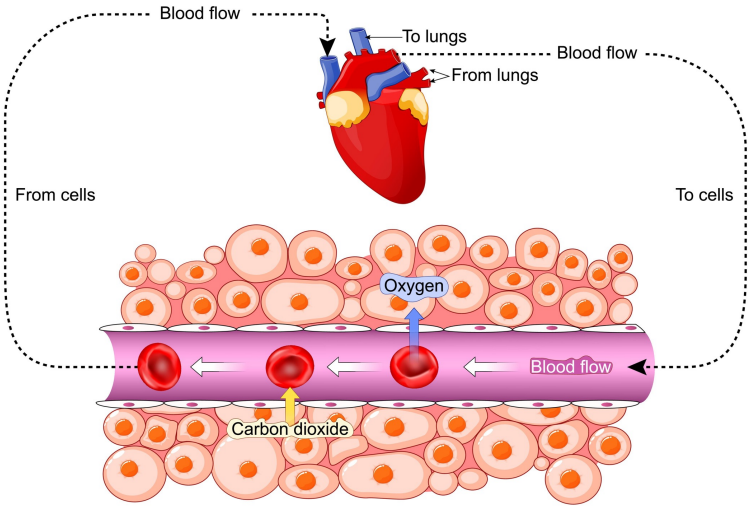
3

This rapid renewal of interstitial fluids allows all the body's cells to constantly receive the nutrients and energy essential for their life and various functions, as well as for their growth, development, and multiplication.

It also allows the body to eliminate catabolic waste products generated within the body and waste products introduced from external sources.

4

GAS EXCHANGE



5

Gas exchange

An average of 5 liters of blood conains around 45% of Red Blood Cells:2,25 liters

One Red Blood cell contains 280 millions of hemoglobin molecules.

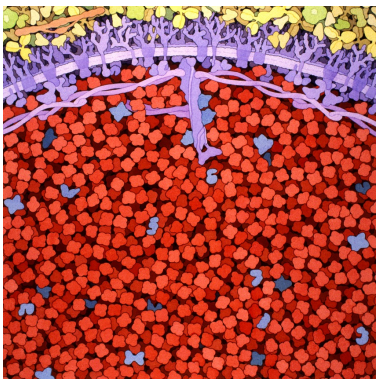
One hemoglobin molecule contains 4 molecules of O_2 and 4 iron atoms➔ One RBC= 1120 millions of O_2 an of iron.

One mm^3 of blood contains around 5 millions of RBC => 2,25 liters of blood contains : 5.10^6 x 10^3 x 2,25 x 1120 x 10^6 oxygene molecules and same amount of iron atoms: 126 000 000 000 000 000 000. ($12,6 \times 10^{18.}$)

For a proper heath, all this dioxygene has to be delivered to all the body cells and to be renewed on the following inspiration.

6

A RED BLOOD CELL



7

When the flow of interstitial fluid slows, the various cells of the body's organs immediately cease to receive the quantities of oxygen and nutrients essential for their life and good health.

Since cellular metabolic waste is no longer properly eliminated, this results in a disruption of nutrition, biochemistry, and overall function.

8

Thus, the slowing of interstitial plasma flow appears to be a primary cause of premature aging and dystrophies in the human body.

Because humans often misuse or malfunction their nutritive functions and respiration, they cause a profound disruption of their autonomic functions, damage their organs, and lead to disease.

9

The proper circulation of interstitial fluids and their immediate and uninterrupted renewal through the appropriate return of venous blood to the right side of the heart constitute the fundamental factor in tissue nutrition.

As we will see, optimizing the return of venous blood to the right side of the heart improves the subject's health and longevity.

10

We will study these three main functions to better understand their interactions and functional associations.

11

1 - Digestion

The cells and tissues that make up the various organs of the digestive system, like those of other tissues, are nourished by the interstitial fluids of the systemic circulation.

For digestion to occur harmoniously under a proper diet, the prerequisite is that general cellular nutrition, through the interstitial fluids, is adequately and optimally achieved.

12

Digestion

Normal digestion, **which occurs unconsciously**, requires normal respiration and circulation so that the interstitial fluids nourishing all the body's organs, and in particular those of the digestive system and its glands, are perfectly and constantly renewed and enriched with oxygen and nutrients, and freed from toxic and metabolic waste.

This allows for the perfect functioning of each organ and the coordination of the entire system.

13

2 – Respiration

Respiration is the only one of the three functions of vegetative life (digestion, circulation, respiration) that, while autonomous like the other two, **can also be controlled and directed by the will**, as we have already mentioned.

14

Respiration

This has considerable implications: indeed, the anatomical and functional interaction and interdependence linking circulation and respiration being absolute, any voluntary modification of one's breathing will unconsciously exert a direct and powerful influence on the circulatory process and, consequently, on tissue nutrition, thus giving it considerable power to affect one's health.

15

Respiration

It is easy to understand that these same mechanisms will be at work during unconscious disturbances of human respiration, such as during the misuse of lung capacity, whether due to a sedentary lifestyle, malformations of the respiratory system, respiratory pathologies in particular, or prolonged emotional distress, thus creating the conditions for pathologies, as we have seen earlier in this work.

Nowadays, sedentary work in front of a computer is one of major factors of respiratory acidosi.

16

3 - The Ventilation-Circulation System: anatomical and physiological review

The ventilation-circulation system, along with the functions it performs, **is the fundamental system related to cellular respiration**, which is the very principle of life, upon which all vital processes depend, directly or indirectly.

17

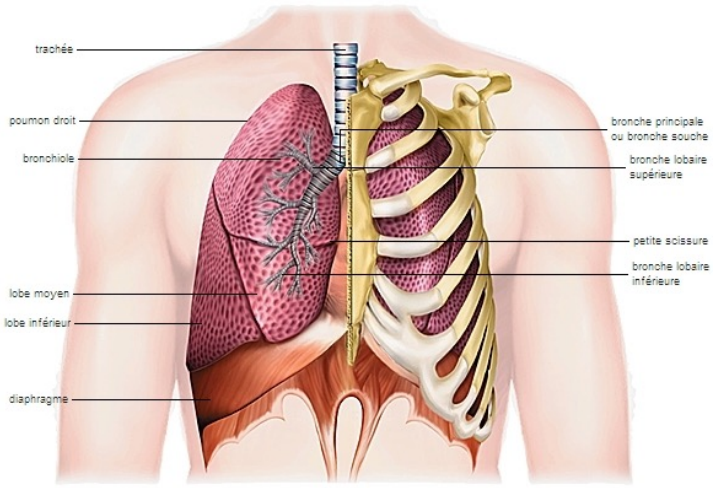
This system is based on three elements:

- A respiratory system that fuels cellular respiration and cellular life;

- A system that animates and regulates circulation;

- A circulatory system.

18



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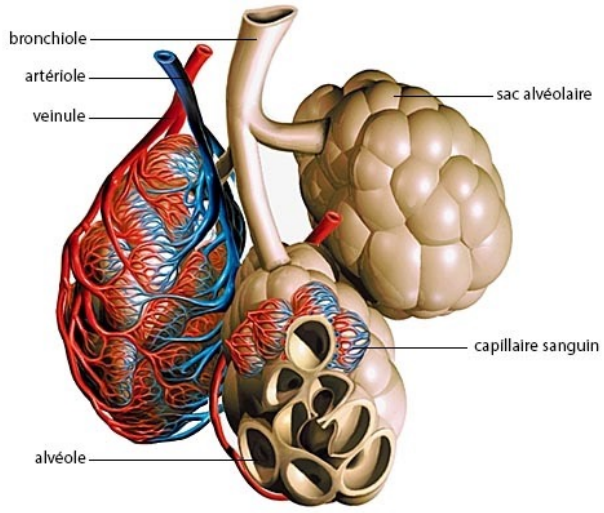

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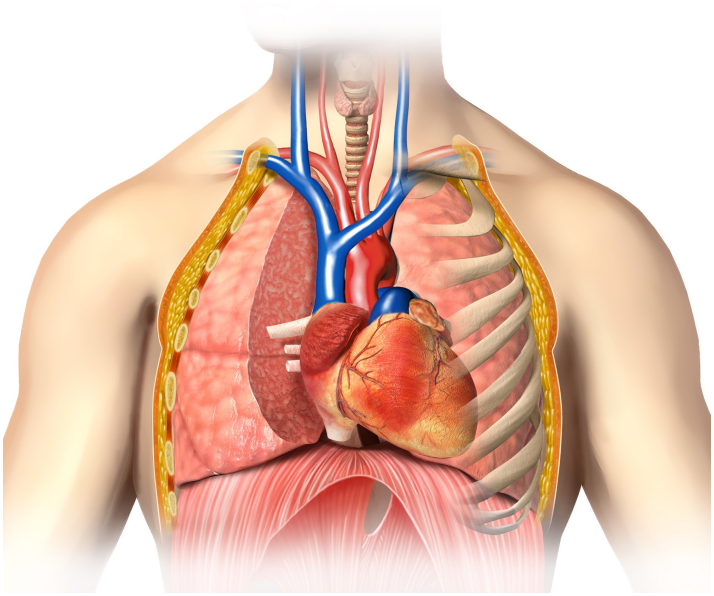

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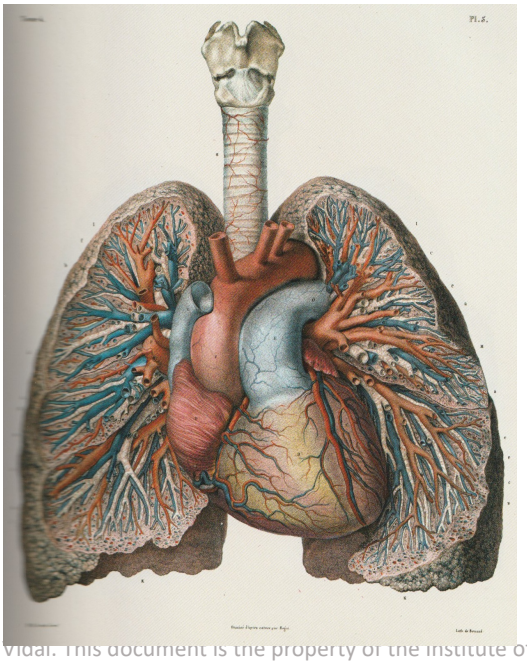

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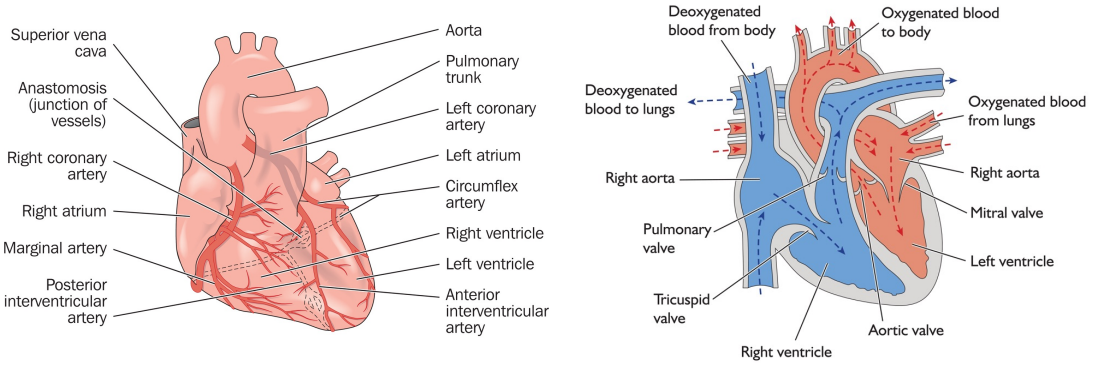
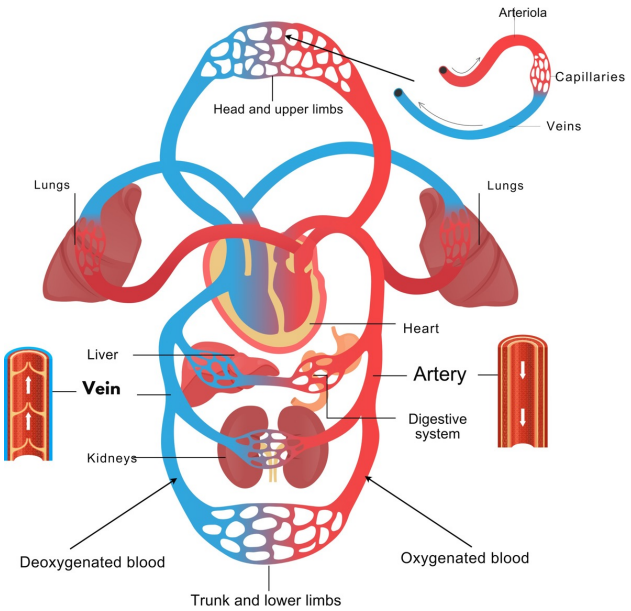


23

The entire life force of the organism resides in the power of the left ventricle's propulsion of fluid into the systemic circulation. This requires optimal muscle function, optimal fluid supply, and optimal circulatory pathways.

The supply of oxygenated blood is delivered via the pulmonary veins, and the quality of this oxygen delivery determines the overall quality of the body's respiration.

24



25

The left side of the heart contains the blood that provides cellular nutrition, while the right side contains the blood that, after being depleted by tissue nourishment, must return to the lungs to be re-arterialized and acquire its nutritive properties.

26

Once pumped by the left ventricle, the blood flows through the aorta and its branches to the peripheral tissues.

Upon reaching the capillaries, a portion of its plasma transudates, carrying oxygen and nutrients to form the interstitial fluids—or internal environment—in which all our tissues are bathed and nourished.

Having become venous blood, it returns to the right side of the heart via the venous system, where chyle provides a continuous and constant supply of new nutrients.

27

After this, the right ventricle pumps the now-dilated venous blood through the pulmonary arteries to the capillaries of the alveolar walls, where the venous blood loses its carbon dioxide and becomes oxygenated (through the respiratory process of hematosis), thus regaining all of its physical and biochemical properties.

Once arterialized, the blood then flows successively to the left atrium and ventricle, resuming its continuous circulation throughout the body.

28

Therefore, the air entering the lungs must be distributed to as many alveoli as possible within fractions of a second.

These alveoli must continuously release oxygen into the passing blood, ensuring that perfectly oxygenated, perfectly red blood, with a maximum oxygen concentration, is delivered to the left atrium.

29

The left atrium is important because it allows the mixing of the blood: it is at this level that the oxygen O_2 still present in dissolved form in the blood will finish being integrated into the hemoglobin system.

30

It is also very important that the two atria are perfectly coordinated, because if they are out of sync, the mixing process is not complete.

Hence the necessity of rhythmic balance and its functional role, as all heart pathology depends on this aspect.

The blood leaving the left ventricle flows into the systemic circulation and towards the brain.

31

Venous blood from the organs and the brain returns via the two venae cavae to the right atrium, where the mixing of these venous bloods must occur correctly.

32

The blood that then goes to the lungs will release its CO_2 in the lungs and, most importantly, provide us with the alkaline reserve, which is then transferred back into the blood that will arrive in the left atrium.

The alkaline reserve is therefore built up with the returning venous blood, occurs in the right atrium, and is balanced and replenished in the lungs.

33

a) The Respiratory System

The base of the thorax is formed by the diaphragm, a powerful, flat, hemispherical muscle.

Its dome occupies a large part of the thoracic cavity and descends during inspiration to the eighth rib on the right and the ninth on the left, and rises during expiration to the fourth rib on the right and the fifth on the left, like a powerful piston moving within its cylinder.

34

The lung, the site of respiratory gas exchange, is composed of two systems joined together by elastic tissue:

- one consists of the bronchi, bronchioles, and alveoli;
- the other of the pulmonary arteries, arterioles, capillaries, venules, and veins, constituting the pulmonary circulation, an integral part of the heart's pumping action and the organ of gas exchange.

35

The lung also contains lymphatic vessels for its own nourishment and arteriovenous vessels independent of the pulmonary circulation, which receive blood from the systemic circulation via the bronchial artery and vein.

The lung, an elastic organ, does not have the capacity to expand by its own means to draw in ambient air and venous blood from the right ventricle, thus preventing the transformation of venous blood into arterial blood.

36

The expansion of the thoracic walls during inspiration ensures lung expansion, and if this thoracic dilation is ample, the lung can expand uniformly, allowing for adequate ventilation of the bronchial tree as well as distension of the pulmonary vessels along their entire length.

37

This ensures normal gas exchange and preserves the integrity of the lung parenchyma synchronously.

During inspiratory thoracic expansions, the pulmonary elastic tissue, uniformly attached around the bronchi and vessels, synchronously opens their caliber, allowing for adequate oxygenation.

38

However, the pulmonary elastic tissue simultaneously exerts a crucial, yet often underestimated, hemodynamic circulatory action.

39

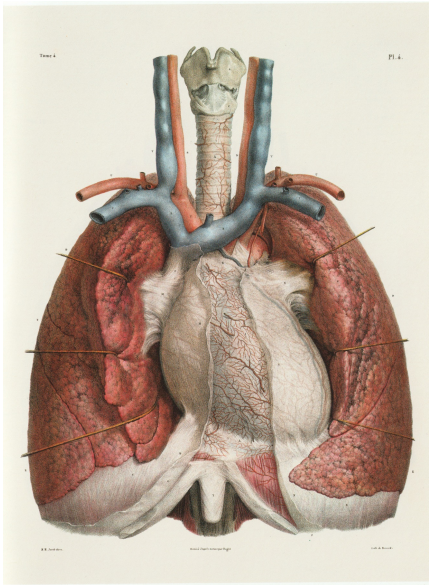
The lung, an elastic mass with a volume significantly smaller than the thoracic capacity it must fill, is simultaneously hermetically sealed and attached (by the vacuum of its pleural layer) to the inner surface of the thoracic walls and to the outer surface of the pericardial sac and mediastinal vessels.

40

It is therefore in a state of permanent tension between these two surfaces and constantly tends to bring them closer together and close the thoracic cavity.

In this way, the lung is forced to faithfully and obediently follow the movements of the thoracic walls.

41



42

During inspiratory expansions of the thorax, the tension of the lung tissue increases, causing the pericardial sac to distend parallel to and with equal force to that of the thoracic walls.

This tension is transmitted to the walls of the heart, which is also tightly pressed against the pericardial walls by its serous membrane.

43

However, since the myocardium is not extensible, all the traction exerted by the pericardial walls on their contents is transferred to the two atria and their large venous trunks.

These trunks, increasing considerably in capacity, **exert a powerful suction on the blood vessels upstream**.

44

By virtue of this double suction exerted by the two atria, venous blood from the systemic circulation is drawn into the right side of the heart, and venous blood from the pulmonary circulation into the left side.

Thus, as soon as the gas exchange achieved through thoracic expansion is complete, the inspiratory contraction of the diaphragm and rib cage muscles ceases, and the thoracic bellows closes spontaneously due to the elasticity of the lung tissue, which pulls the costal walls inward and the diaphragm upward.

45

The thoracic ribs, also being elastic, return to their resting position and complete the expiration, without the expiratory muscles needing to intervene during ordinary breathing.

As soon as blood oxygen is exhausted, a new inspiratory impulse is triggered, and respiration continues its uninterrupted rhythm.

46

It is the balance between the two opposing forces of the inspiratory muscles, which open the thorax on the one hand, and the pulmonary elasticity, which constantly tends to close it on the other, that maintains the rhythm, extent, consistency, and harmony of their work.

47

When the lungs expand properly, the elastic tissue uniformly attached around their periphery dilates the air and blood vessels of the lungs, enabling them to forcefully draw in ambient air and blood from the right side of the heart, according to the body's oxygen and blood requirements, thus ensuring constant and adequate gas exchange.

48

It is because the lungs synchronously draw venous blood from the right side of the heart into the vessels of the pulmonary circulation that inspiratory lung expansion promotes the work of the right myocardium, ensuring harmonious function of the heart as a pump and high-quality blood supply to our tissues.

Unfortunately, it is often observed that humans breathe shallowly, leaving large areas of the lungs incompletely ventilated.

49

As previously mentioned, the diaphragm and pericardium are fundamental factors in the return of venous blood and interstitial fluids to the right side of the heart.

50

The pericardium contains and envelops the heart in a manner similar to that of the thorax containing the lungs, and thus plays a role in circulation as important as that of the thorax in respiration.

If circulation controls the fulfillment of nutrition—and, in so doing, all the acts of life—where circulation fails, life ceases.

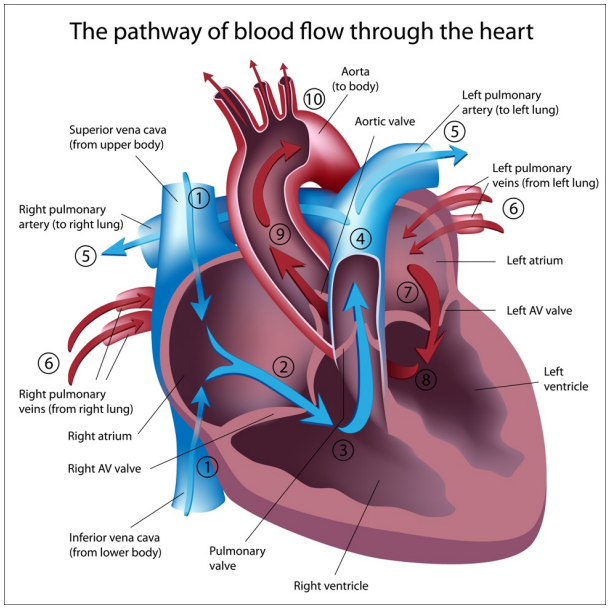
51

b) The Heart's Functioning System

The heart is composed of two halves separated by a central septum. Each half is further subdivided into two chambers: a lower chamber called the ventricle, made up of an exceptionally powerful muscle, the myocardium; and an upper chamber, the atrium, with thin, flaccid walls.

The atrium and ventricle, which are superimposed, are connected by an opening equipped with valves that direct blood from the atrium to the ventricle: the tricuspid valve on the right, the mitral valve on the left.

52



53

Now, these atria, which in a cadaver appear as inert sacs incapable of any mechanical action, acquire in a living person a mechanical importance comparable to that of the ventricular myocardium in the heart's pumping action.

54

Indeed, the two ventricles, the two atria, and their large arteriovenous trunks are contained within the pericardial sac and are held firmly against its walls by the vacuum of its serous membrane, identical in every respect to that of the pleura connecting the lung to the walls of the thoracic bellows.

55

The lung, an elastic mass incapable of performing the slightest unfolding movement on its own, acquires considerable expansion force because it is constrained by the pleural vacuum to slavishly and faithfully follow the movements of the thoracic walls;

Similarly, the heart, placed within the pericardial sac under the same conditions as the lung in the thorax, by virtue of the serous membrane of the pericardium, is compelled to faithfully follow the separation of the pericardial walls.

56

But since the ventricular myocardium is not distensible, all the distension exerted on the walls of the pericardium is transmitted exclusively to the atria and their large venous trunks, transforming these anatomically inert and flaccid sacs into powerful mechanical suction organs.

57

During deep inspiration, the pericardial sac, and consequently the atria, are caught between two opposing forces: pulmonary elasticity and the suspensory ligaments of the pericardial sac pull its upper periphery upwards, while the downward movement of the diaphragmatic dome pulls the base of the pericardial sac downwards.

This results in a considerable increase in the capacity of both atria, transforming them into powerful suction pumps.

58

The right atrium thus establishes a powerful vacuum, forcefully drawing the contents of the systemic venous system, from the venous system to the inter-tissue capillary branches, through successive columns forming rhythmic, undulating negative waves.

It therefore synchronously draws in all the fluids destined to enter the bloodstream via the venous and lymphatic systems.

59

Indeed, the base of the pericardial sac containing the heart rests on the central tendon (the diaphragmatic dome).

The periphery of the pericardium—solidly connected to the lung by the pleural space of the mediastinal surface of the lung—is also attached by its suspensory ligaments directly to the third thoracic vertebra, the sternal notch, and the first pair of ribs, and indirectly by the deep cervical fascia to the base of the skull.

60

And the arterial blood propelled by the left ventricle reaches the tissue arterial capillaries, lets its nourishing plasma transudate to form and renew the interstitial fluids thus feeding the cell groups of the body; then thanks to the powerful aspiration of the contents of the venous vascular system of the large circulation by the right atrium, continues its journey towards the right heart with the food chyle and all the circulating fluids that must enter the bloodstream via the venous route.

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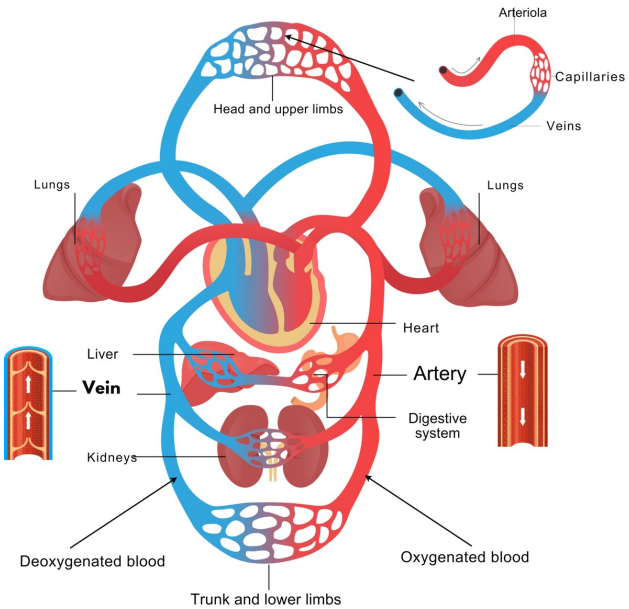

62

Simultaneously, venous blood from the right side of the heart, propelled by right ventricular systoles into the pulmonary arterial system, reaches the alveolar capillaries of the lungs, undergoes gas exchange, and returns to the left side of the heart as arterial blood to continue its ceaseless circulation throughout the body.

63

We can therefore understand that, while the left ventricular thoracic screw propels arterial blood to the right side of the heart and the regulation of capillary vasomotor activity by the autonomic nervous system ensures the transudation of arterial capillary plasma and tissue nutrition, it is also the proper return of the contents of the systemic venous system that, by clearing the pathways for the left arterial blood to flow from the left to the right side of the heart, allows it to progress easily, without encountering abnormal resistance.

64

The harmonious functioning of the heart as a pump depends on the synergy of several organs: the lungs, the pericardium, the rib cage, the atria, the aorta, the elasticity of the lung tissue, the rib elevator muscles, and the diaphragm.

65

Two of these play a crucial role in the heart's function:

- The lungs, through their pulmonary circulation and elasticity, ensure the synchronous operation of the pulmonary circulation and the two atria, thus becoming an integral part of the heart's pumping action.

- The diaphragm, the driving force that activates all the aforementioned organs.

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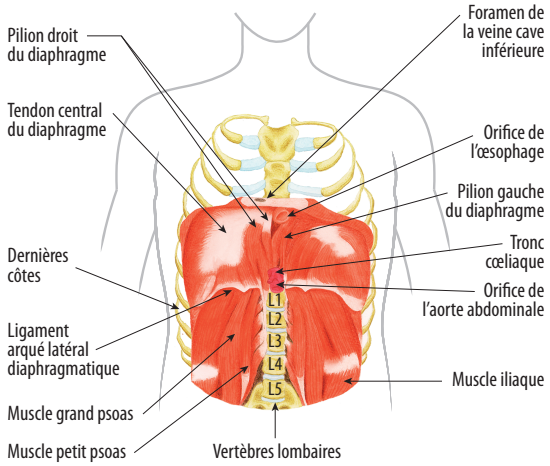

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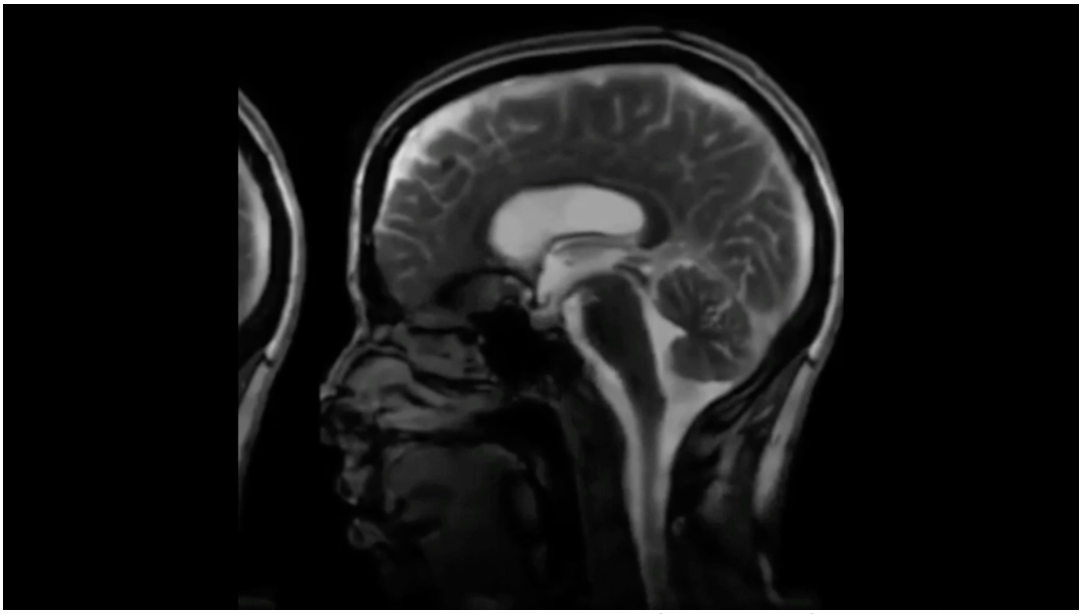

68

The total lenght of blood vessels in an adult is estimated at 100 000 Kms (2.5 times the circumference of the Earth) and their total surface area at 800 to 1000m^2 (more than 3 tennis courts).

69

c) The Circulatory System

The Systemic Circulation

The path from the left ventricle to the right atrium, passing through the entire body, constitutes the systemic circulation. The nutrition of the entire body is carried out exclusively and in minute detail by the systemic circulation.

The systemic circulation receives arterial blood propelled by the left ventricle at an average pressure of 160 mmHg and carries it to its terminal branches (arterioles and arterial capillaries) where the pressure has dropped to only 30 mmHg.

70

At this point, the arterial blood divides into two streams:

- one flows directly from the arterioles into the venules and veins of the venous system, without contributing to tissue nutrition;
- the other flows into the arterial capillary system, where it transudates its arterial plasma through the capillary endothelial walls and fills the intercellular spaces, forming the interstitial fluids in which all the body's cell groups are bathed and live; from there it flows into the venous system where it rejoins the directly transfused arterial blood.

71

Thus, the volume of plasma that transudates into the intercellular spaces during each ventricular systole, relative to the volume of arterial blood that passes directly into the venous system without participating in plasma transudation, depends on the pressure of the previously transudated interstitial fluids that fill the spaces.

It is the pressure of these interstitial fluids and the downstream venous system that regulates circulation in the various sectors of the body's entire vascular and tissue system.

72

As long as the drainage of interstitial fluid occurs efficiently, either via the venous system of the systemic circulation to the right side of the heart or via the lymphatic vessels, the pressure in the intercellular spaces remains consistently lower than that of the arterial capillary system, and plasma transudation from the capillaries to the spaces continues to occur normally and effectively.

73

If, however, the return of venous blood to the right side of the heart is impaired, the pressure in the venous system and in the insufficiently drained spaces increases. Consequently, capillary transudation and the direct passage of arterial blood to the venules and veins will be delayed; therefore, all circulation in the upstream arterial system will be slowed, forcing the heart, and especially the myocardium, to work harder, and blood pressure will rise.

The role played by the return of venous blood to the right side of the heart is therefore a crucial, yet unfortunately often overlooked, circulatory factor.

74

Considering the complexity and significant volume of the fluids entering the bloodstream via venous blood at the right side of the heart, and the considerable force required to propel these fluids into the bloodstream and deliver them to the right side, it becomes clear that the initial ventricular shunt, whose arteriolar pressure is now only 30 mmHg and which becomes zero at the intercellular spaces, is powerless to push arterial blood beyond these spaces, through the tissues, and back to the right side of the heart via venous blood.

75

Therefore, there is necessarily another suction force that opens the vascular pathways and allows the natural progression of blood and plasma columns.

This force is provided by the pulmonary elastic tissue and the pericardial sac during inspiratory diaphragmatic contractions.

76

The diaphragm is the primary agent of venous return, drawing the contents of the venous system through the pulmonary elastic tissue, the pericardium, and the atria. This allows the ventricular thoracic screw to function, which could not continue to operate without this suction.

It simultaneously allows the absorption of the various circulating fluids in the body into their respective vascular circuits.

77

The coordinating action of the autonomic nervous system on the harmonious functioning of capillary circulation depends on the proper use of the diaphragm and adequate pulmonary ventilation, which, by ensuring proper oxygenation and waste elimination, allows for optimal function.

78

The pulmonary circulation

The path from the right ventricle to the left atrium through the lungs forms the pulmonary circulation.

Its primary function is respiratory and circulatory : while the alveolar capillary system facilitates respiratory gas exchange, its large arteriovenous trunks make it an integral part of the heart's pumping action.

Furthermore, it completes the circulatory system between the two hearts, which is interrupted by the median cardiac septum.

79

Thus, the lung possesses a circulatory system originating from the descending aorta (bronchial artery and vein) which nourishes the lung tissue, and another circulatory system, consisting of the vessels of the pulmonary circulation, which is responsible for the final oxygenation and arterialization of the blood.

Through inspiratory dilation, the lung simultaneously facilitates the passage of venous blood from the right side of the heart to the left atrium.

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80

It is important to remember that the blood and humoral mass constitutes two-thirds of the body's weight and is composed of arterial blood, venous blood, intercellular plasma fluids, chyle, lymph, glandular secretions, and all the fluids introduced into the body.

81

This mass permeates our entire body, extending into the smallest recesses and flowing through the vessels and interstitial spaces. This flow rate of blood and interstitial fluids allows all organs to continuously and appropriately receive the necessary nutrients and energy, and to be cleansed of waste products, thus enabling their complete restoration and harmonious functioning

82

As previously mentioned, this flow rate of interstitial fluids and venous blood regulates the resistance that ventricular systoles must overcome to allow and maintain the normal progression of arterial blood, and the pressure under which this progression occurs.

If this flow slows for any reason, the resistance that the myocardium must overcome increases, as does blood pressure, eventually leading to cardiac hypertrophy associated with fatigue.

83

d) Hemodynamic Action of Diaphragmatic Breathing

A median septum closes off all communication between the right and left sides of the heart. The continuity of the interrupted circuit is restored by the arteriovenous system of the pulmonary circulation, which, together with the bronchoalveolar system of the airways and the elastic tissue connecting these two systems, forms the lung.

It is through the vessels of the pulmonary circulation that venous blood from the right side of the heart can reach the left side of the heart via the lung, thus completing its arterialization.

84

Furthermore, during inspiratory lung expansion, the pulmonary elastic tissue, uniformly attached around the periphery of the pulmonary vessels, increases the caliber of these vessels, which can then forcefully draw venous blood from the right side of the heart into the lung.

When it contracts during expiration, the caliber of these vessels decreases, and the aspirated blood can thus be forced back into the left side of the heart.

85

Acting in this way as a suction and force pump, the lung supports the work of the right myocardium and becomes an integral part of the right heart's pumping action.

Without its contribution, the myocardium would be unable to perform its automatic circulatory function.

86

But let us also remember that the elastic pulmonary tissue, attached by the pleural vacuum simultaneously to the inner surface of the thoracic walls and the outer surface of the pericardial sac, strongly pulls on the walls of the pericardial sac during inspiration, distends the sac cavity, and opens, through its walls, the cavities of the two atria, hermetically sealed within the pericardium by the vacuum of the pericardial serous membrane.

87

Through this distension, the right atrium forcefully draws venous blood from the systemic circulation into the right side of the heart, and the left atrium draws pulmonary blood from the pulmonary circulation into the left side of the heart.

88

Through the powerful suction exerted by this synchronous dilation of the vessels of the pulmonary circulation and both atria, the vascular and inter-tissue pathways, having been emptied of their contents, in turn draw, step by step, from the downstream atrium to the tissue periphery, the columns of blood propelled upstream by the left ventricle (systolic wave).

This allows for easy blood flow and harmonious function of the myocardium. Without this support, the myocardium would hypertrophy and eventually fail.

89

The hemodynamic role played by the lungs in the circulatory system is therefore paramount.

The diaphragm can be considered the fundamental factor in life, health, and longevity because:

90

- it triggers, through its inspiratory depressions, the cardiopulmonary synergy,

- it synchronously opens and closes the vessels of the pulmonary circulation and the two atria to allow for gas exchange, as well as the harmonious functioning of the heart as a pumping and depressor mechanism,

91

- it thus ensures the propulsion of ventricular systolic waves under normal blood pressure conditions,

- it ensures adequate nutrition of the myocardium, its constant and autonomous repair, and its preservation.

92