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Mini Review

Implications of the New Starling Paradigm in the Administration of Replacement Solutions

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Abstract

The clinical situations that occur with loss of large amounts of blood volume are frequent in daily practice, so that knowledge of the most novel main aspects of physiology, such as changes in the Starling statement, can be the difference between a Resuscitation with secondary complications and an effective one without them. The purpose of this mini review of the literature is to describe how changes in these specific laws can influence the re-discovery of endothelial glycocalyx during the administration of vascular replacement solutions. For this, a search of the bibliography published in Infomed indexed databases such as Hinari, Ebsco, Scielo, Pubmed, Cubmed, Cochrane; in Spanish and English. Aspects such as the composition of the endothelial glycocalyx, its functions and causes of endothelial dysfunction were reviewed. The original statement of the Starling laws, changes in the Starling laws paradigm, goal-guided resuscitation, and the association between it and the vascular endothelium were also studied. In addition, the different liquids used during resuscitation, as well as their effects on different cell compartments.

Keywords: *Replacement Solutions; Resuscitation; Microcirculation; Endothelial Glycocalyx; Starling Laws*

The human organism is constituted in 60% of its volume per water, which is distributed between three anatomical and functional spaces: water from the intravascular spaces (3L), interstitial space (12L) and the intracellular space (30L). Water, unlike ions, molecules and proteins, passes freely from one space to another, with the purpose of maintaining homeostasis.

All this complex mechanism occurs in the microcirculation of tissues, where the arterial circulation system joins the venous system, through arterioles and venules, with the production of a filtrate to and from the intravascular space. In 1896, Frank Starling described the forces that govern this process, taking shape in 1963 for the work done by Landis and Pappenheimer, which was called the "Starling Law".

The classic statement includes four forces that work on both sides of the vascular endothelium, capillary hydrostatic (PHc) and interstitial (PHi) pressure and interstitial (POi) and capillary oncotic or colloid osmotic pressure (POc). These sn opposing forces with a determined value and sense, where filtration in the arteriolar end is favored if the PHc is greater than the Poc, and on the contrary, the absorption in the venular end is favored if the POc is greater than the PHc, taking into account that the first depends on the serum protein concentration. The rest of the forces have little significant values.

At the beginning of the 20th century, different investigations were carried out that reviewed the classic statement of these laws with the aim of obtaining a model that offered greater precision on the distribution of liquids, and that becomes very important during its administration in resuscitation situations where intravascular volume loss as in hemorrhagic shock is large.

This was possible due to the rediscovery of the endothelial glycocalyx, membrane attached to the vascular endothelium composed of different glycoproteins and proteoglycans, which provide structure and determine its functions, which are closely related in the determination of vascular permeability to plasma proteins.

Among the aspects of relevance that were observed are that between the vascular endothelium and the glycocalyx there is a space that was called the endothelial sub glycocalyx, which is the determinant of the oncotic pressure delta and not the Poi; that both PHi and oncotic pressure of the endothelial sub glycocalyx (Posg) are dynamic and change according to the flow of acute from or into the interstitium; that the increase or decrease of water in this space is what determines the filtration and absorption processes, which serves as negative feedback for the homeostatic regulation of this process, knowing that both exist at the arterial and venous ends of the capillary.

The fact that filtration is the rule becomes very important during intravenous administration of replacement solutions. It is known that the sub glycocalyx stores approximately 1500 ml of liquid. During the administration of crystalloid solutions such as dextrose, rapid distribution to all three compartments is observed equally; 0.9% sodium chloride is distributed with some speed to the interstitial space; and only colloid solutions remain for a longer time, between 3 and 36 h within the intravascular space. When colloid solutions are administered, a drag of the fluid from the endothelial sub glycocalyx into the intravascular space occurs and does not come from the interstitial as previously thought, which has limited clinical utility especially in patients with edema or ascites to name a few examples, being restored in a short time filtration as a rule and with the worsening of the clinical condition.

What happens in patients with hemorrhagic shock? Elements such as overhydration and surgical trauma are the main causes of endothelial dysfunction, which is characterized by loss of balance between the formation of prothrombotic and antithrombotic substances, vasodilators and vasoconstrictors, dysregulation of enzymatic processes, hyperglycemia, which ultimately damage the permeability of the endothelium with the exit of liquids into the extracellular space, giving cavity to the production of the fatal complications that can accompany this clinical situation.

During arterial hypotension that distinguishes hemorrhages, there is a decrease in PHc, which allows a 500 ml autotransfusion of liquids, which does not return the balance to normal because until the blood leak is corrected. It is the reason why a restrictive and objective-guided hydration is suggested, which allows maintaining the biological integrity of the glycocalyx and therefore the vascular endothelium, avoiding in many tissues and organs the phenomenon of ischemia and reperfusion.

In the end, the idea during the resuscitation of patients with bleeding, the important thing is to maintain a capillary hydrostatic pressure layers to perfuse the main organs, without decreasing the Posg and giving the lymphatic drainage system chance to eliminate excess fluid in the interstitial space [1-4].

Conclusion

It is concluded that the rediscovery of the endothelial glycocalyx and the space of the sub glycocalyx marked important guidelines in the reanimation of intravascular volume with the different replacement solutions due to the possibility of redefinition of Starling's laws on the processes of filtration and absorption of water in the capillaries of microcirculation.

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