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Rheohaemapheresis of ophthalmological diseases and diseases of the microcirculation

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Abstract

Blood rheology was considered to be of limited clinical importance, until extracorporeal technologies enabling the treatment of cellular and plasmatic hyperviscosity syndromes were introduced. However, a wide range of applications, mainly referring to rheologically determined diseases of the microcirculation exists but has so far hardly been taken into consideration. The extension of indications was due to modern technical developments leading to different approaches of secondary separation such as precipitation, ad- or absorption and filtration. Based on 18 years of experience with different separation technologies the combination of some centrifugal devices applied for cell – plasma separation with secondary filtration (Rheohemapheresis) appears to be the most efficacious and economical approach for such extracorporeal treatments. The sequence and frequency of rheohaemapheresis treatments depends on the measurement of rheological measurements in combination with clinical – chemical data which are related to the distribution kinetics and synthesis rate of both blood cells and plasma proteins. Standardised treatment protocols proved the efficacy of initial therapies and were applied for controlled trials whereas long term therapies may need more flexible treatment approaches. So far an increasing experience exists for the treatment of ophthalmologic diseases, otologic disorders, diabetic complications and cardiological diseases. Rheohemapheresis was shown to be a safe treatment approach, if a careful risk assessment prior to the initiation of the therapies is performed. The treatment cannot cure diseases but enables a substantial improvement of the quality of life in patients without treatment alternatives.

Keywords: Rheology; Extracorporeal rheotherapy; Age related macular degeneration; Diabetic complications; Sudden deafness; Microcirculation; Apheresis technology

1. Introduction

The term Rheohaemapheresis derives from two roots: Rheology as a field which investigates e.g.

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blood fluidity and applies the results of such research to clinical practise of pathological alterations of the microcirculation and related disease. Alternatively, Haemapheresis using different technologies of extracorporeal blood separation is used as a tool to improve and extend the achievements in the treatment of such diseases with rheological relevance. In the past either field was considered of limited importance in medicine. This was due to the restricted efficacy of conventional treatment techniques and a rather narrow knowledge mainly of Rheology which left the application of haemorheotherapy mainly to transfusion medicine, intensive care (shock treatment) and angiology. In contrast, Rheology plays an important role in many technological areas as for instance with liquids (oil industry, motor technique, construction industry e.g., concrete, bitumen, tar), gases (liquid nitrogen, liquid oxygen etc.) and even powders.

2. History

The history of applied medical rheology dates back to the year 1904, when it was first described that certain drugs were able to influence the blood viscosity [1]. Whereas basic general physical aspects of fluids such as viscosity date back to Newton (1642–1727), defining the relation between energy and the flow, the term blood rheology was introduced by Copley [2,3] using terms such as "blood vessel organ". In physical terms, blood as a non-Newtonian fluid is a complex emulsion of blood cells and blood plasma (which is closely related to a Newtonian fluid). Thus, the flow behaviour of whole blood differs from that of a Newtonian fluid and has to take other variables such as shearing forces, time and blood cell aggregation (generally that of erythrocytes) into account. However, for a simplified consideration, the rheology of blood appears to be determined mainly from the concentration of blood cells (erythrocytes, leukocytes and platelets) and the plasma viscosity. Thus, when discussing the diagnosis and the pathology of blood rheology, one has to take mainly the roles of the cells and the plasma into account.

Subsequently, due to the expansion of rheological research in biology, mainly haematology, conventional haemorheotherapy was developed and isovolaemic haemodilution and infusion therapy were the most frequently applied treatment approaches.

The development of blood cell separators was initiated approximately in 1965 [4–6] and continued since then. Between 1975 and 1980 the treatment of cellular and plasmatic hyperviscosity syndromes using cytapheresis or plasma exchange was introduced. The separation of plasma from cells using membranes was initiated approximately in 1967 [7,8]. From 1981 until now with ongoing development secondary differential separation techniques such as precipitation, double filtration and Rheohaemapheresis were used for extracorporeal haemorheotherapy [9–12].

3. General determinants of organ perfusion

Organ perfusion is related to the blood flow, which is determined from the blood vessels and the rheology of the blood both related to each other. In younger individuals with normo-elastic vessel walls the width of the blood vessels is the major determinant for the organ perfusion, whereas in the elderly rheology gains importance due to the decreased vessel wall elasticity.

The major variables regulating the blood vessel dependent organ perfusion relate to the function (adaptation to the appropriate diameter), the architecture (the length and the surface of arteries, arterioles, capillaries, venoles, veins), the structure and function of the endothelium, the blood pressure and the pathology of alterations (e.g. arteriosclerotic plaques).

Blood rheology as related to whole blood viscosity is mainly determined from the blood cells and the plasma. An increased amount of red blood cells as determined from the haematocrit, a considerably elevated number of leucocytes (mainly granulocytes) or even of platelets may influence the viscosity. Structural changes mainly of erythrocytes determining the aggregation, the membrane flexibility and the membrane rotation are also known as rheological determinants. Alterna-