BLOOD RHEOLOGY AND ITS ALTERATION IN VARIOUS PATHOPHYSIOLOGIC STATES

ESSAY

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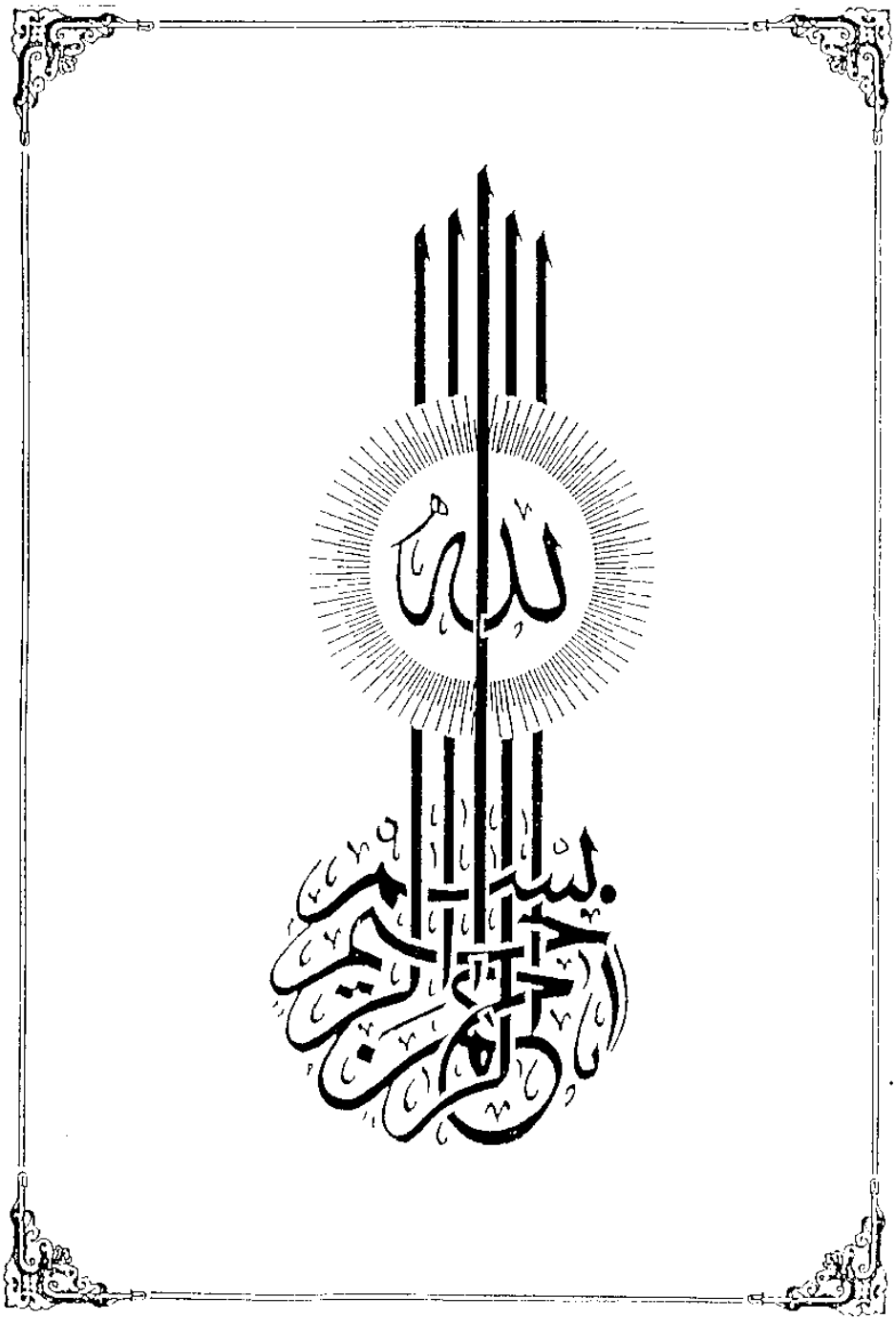

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List of Abbreviation

$^{o}/_{o}$	percent
μ	Micron
α	alpha
/ul	Per unit liter
A	Angestrom
Ca	Calcium
cm	centimeter
DI	Deformability index
EDTA	ethylen diethyl tetra acetic acid
ESR	erythrocyte sedimentation rate
g/L	gram/ litre
Hbs	Sickle Hemoglobin
IgA	immunoglobulin A
IgE	immunoglobulin E
IgM	immunoglobulin M
K	Pottasium.
m pas	millipascal
MCHC	Mean corpuscular Hemoglobin concentration
mL	milliliter
MM	Multiple Myeloma
PCV	Packed cell volume
RBCs	Red blood corpuscles.
RCA	red cell aggregate
Um	micro meter
Um^2	Unit squaremeter
WM	Waldenstrom's macroglobinaemia
ZSR	Zeta sedimentation ratio

Introduction

INTRODUCTION

The science of haemorheology; the flow properties of the blood under physiologic & pathologic conditions has been introduced recently to explain some of the very common human disasterous diseases. Disturbed haemorheology has been considered to play a primary etiologic role, not only in a classic disease like polycythaemia or sikle cell anaemia but also in conditions like hypertension and diabetes mellitus and others. ***(Le rche 1989)***.

Haemorheological abnormalities may also play a role in arterial thrombosis in general and frequently accompanied in many cases by athero sclerosis and hyperlipidaemia. These hemorheologic abnormalites may be the determinant factors in death of patients with these diseases. ***(Dormandy, 1983)***

In the microcirculation where cells must deform to pass through narrow capillaries, cellular rheology (The deformability of individual cells) is the major determinant of resistance to flow. This ability to deform is also a determinant of the cell's survival time in circulation. The deformability of the red cells is essentially linked to its structure (cellular geometry, membrane properties and cytoplasmic viscosity). Thus structural abnormalities as found in some haematological disorders can be expected to affect blood flow in the microcirculation and or red cell life ***(Stuart & Nash , 1990)***.

Rheology is a relativerly new discipline as applied to the practice of haematology. Rheological methods now have sufficently good sensitivity & specificity for their appliction to a wide variety of clinical disorders ***(Fedrova et al, 1989)***.

Aim of the work

Is to review various aspects of hemorheology; its determinants and measurements together with the description of rheological alterations in various pathophysiologic states.

Chapter I
PHYSIOLOGY OF BLOOD RHEOLOGY

Blood rheology

Blood rheology is the science of deformation of blood flow through the heart and blood vessels. Measurement of flow behaviour of blood & plasma in vitro can be performed mainly for one of two reasons; for diagnosis & or monitoring of disease. Haematological determinants of blood rheology are of great importance to know normal physiology and then pathophysiology of certain disease. ***(Koblar , 1992)***.

Blood rheology is complex & mainly determined by variables such as blood viscosity (plasma viscosity, haematocrite & temperature) white cell rheology where the white cells represent a temporary obstacle to microcirculatory perfussion and red cell rheology where red cell deformability is the main determinant.

A- Red cell rheology

1- Definition:-

Erythrocyte deformability is defined as those geometric and physical characteristics which permit a cell whose greater diameter normally ranges between (7.2 - 7.6 μ) to pass through normal capillaries which range in diameter from (3 to 13μ) diameter ***(weed, 1970)***. These characteristics helps the red cell to resist shearing forces across the aortic valve and survive passing through the spleen and other reticular endothelial organs. The capacity of the red cell to deform is also partly responsible for the fall in the viscosity of the whole blood at higher rates of flow and also for the fact that blood remains liquid even at red cell concentration of over 95%, ***(Reid et al, 1985)***.

2- Factors Affecting Erythrocyte Deformation:-

The extent of erythrocyte deformation depends on outside forces and intrinsic properties of the cells. The outside forces are the stresses produced by the flow on the membrane. The intrinsic deform ablity of the erythrocyte depends on the structure of the membrane and the protein network forming the cytoskeleton. Among these protein a fundamental role must be ascirbed to spectrin which froms the major bulk of the network, actin which binds spectrin fibres together and ankyrin which keeps the cytoskeleton attached to the erythrocyte membrane. ***(Reinhart W.H, 1995)***.

3- Microrheological Aspects of Deformability:-

In parallel with biochemical parameter related to red cell cytoskeleton, three major microrheological parameters have been characterized: Internal viscosity, volume / surface ratio and the membrane viscoelastic properties.

a) Internal viscosity:-

The internal viscosity of red cells is recognized as a major determinant of red cell deformability. An important determinant of internal viscosity is the mean cell haemoglobin concentration (MCHC) because the filtarability of red cells falls with increasing (MCHC) ***(Evan et al, 1984)***.

The concept of internal viscosity of the red cells must include both the interior of the red cell and the contribution of the red cell membrane. When the membrane is rigid the cell will behave as rigid particle ***(Dintenfass et al, 1975)***. Inclusion bodies also in crease internal viscosity and decrease deformability including malarial parasites, nuclear fragments

in reticulocytes, Heinz bodies and post splenectomy in clusions.*(Athanassiou, 1994)*.

b) Geometrical factors (Volume/surface Ratio):-

Numerous theoretical & experimental investigations have attempted to account for the specific shape of the red blood cell. It appears that the erythrocyte shape is the result of a complex equilibrium between a large number of parameters such as surface tension membrane thickness, cytoskeleton structure, hydrostatic pressure through the membrane and surface change *(chien, 1977)*. Alternation of these variables by chemical agents *(Meiselman, 1980)* or in haemolytic disorders result inloss of deformability *(Lowe, 1987)*.

Calcium determines the solubility and hence the flexibility of spectrin, reduction of intracellular calcium improves erythrouyte deformability *(La celle et al, 1973)*. Adenosine triphosphate functions as a chelating agents capable of regulating interaction of inter cellular calcium with inner cell membrane. In senescent RB C's the relatively low ATP concentration lead to increased calcium membrane interaction with resulting reduction of membrane cation permeability & decrease deformability *(Marcel 1981)*.

4- Erythrocyte Deformability And Tissue Ischaemia:-

There is a viscous circle between tissue ischaemia and decreased red cell deformability *(Dormandy, 1983)*.

Local changes in ischaemic tissue such as hypoxia, hyper osmolarity acidosis and accumulation of metabolite have all been shown to impair the deformability of red cells, which in turn further impairs the circulation& increase the severity and extent of the

ischemia. This hypostasis explain the strong prognostic significance of early changes in red cell deformability following acute tissue infarction ***(Dormandy, 1983)***.

5- Effect of Red cell aggregation on blood rheology:-

Aggregates have important influence on blood rheology increasing blood viscosity at low shear rates & being largely responsible for the visco elastic properties of blood. Aggregation of erythrocyte is though to endow blood with a yield stress which may influence microcirculatory flow. Aggregation formation occurs only in static or slow moving blood because the adhesive forces are generally small when there is rapid flow. High shear stresses swamp the ad hesive cellular interactions & break up aggregates. The extent of aggregate formation depends on the nature and concentration of the aggregating proteins present, the plasma viscosity, erythrocyte deformability and erythrocyte surface charge density. ***(International committee for standardization in haematology 1988)***.

6- Relationship Of Red Cell Rheology To Plasma Proteins:

Plasma proteins have great action on red cell aggregation. Red cell aggregation results from the action of long large plasma protein which form bridges between adjacent red cells and overcome their mitual repulsion due to negative surface charges, resulting primarily from sialic acid residues. ***(Lowe, 1987).***

Short molecules such as albumin (length about 15 . A) are not long enough to allow their adssorption onto red cells and separation of the cell's surfaces at the same time. Longer molecules such as fibrinogen (650 - 700A) can cause aggregation since an increasing length of the end of the molecule can be adsorbed on the cell, while