Commentary

Of hemorrhagic shock, spherical cows and Aloe vera

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Abstract

The central question explored in this commentary is whether the beneficial effects of an Aloe vera derived drag-reducing polymer during hemorrhagic shock is due to its O_2 radical scavenging properties or to changes in blood rheology.

Keywords blood flow, hemorrhagic shock, ischemia-reperfusion, microcirculation, oxygen radical species

Some time ago, the citizens of a country, whose livelihood depended on exporting dairy products, pooled their resources and hired a world-famous engineering firm to help them increase milk production. After several months of field measurements, calculations, and at great cost to the inhabitants, the consultants produced a much anticipated report that began, “Our calculations show that milk production by cows is physically impossible. Based on the assumption that cows are spherical….” The moral of the story is that the application of physical principles to complex living organisms often requires assumptions *ad absurdum*.

The idea of using small volumes of fluid for the initial resuscitation of victims after major blood loss is of great interest to emergency personnel, medics in the armed forces and, unfortunately, to first responders treating mass casualties from terrorist attacks. In a recent study by Macias and colleagues [1], rats subjected to profound hemorrhagic shock were resuscitated with small volumes of a solution containing a drag-reducing polymer (DRP) derived from Aloe vera. When compared with saline-resuscitated rats, the DRP-resuscitated rats showed greater survival rates and higher mean arterial blood pressure.

Severe hemorrhage impairs the delivery of oxygen and nutrients to the tissues and produces a state of shock. Rapid decreases in blood volume result in the release of catecholamines and antidiuretic hormone. Atrial natruretic receptors respond to the perceived loss of volume by arteriolar vasoconstriction and increases in heart rate [2]. The aim of these compensatory mechanisms is to maintain perfusion pressure and the preferential distribution of circulation to organs with high metabolic requirements.

At the regional level, adenosine, prostaglandins, and nitric oxide lower regional vascular resistance, further refine the redistribution of blood flow and increase the number of open capillaries in proportion to the degree of tissue hypoxia. Capillary recruitment helps maintain tissue O_2 flux at a lower capillary partial pressure of oxygen (PO_2) by shortening diffusion distances and increasing capillary surface area available for O_2 diffusion [3].

The therapeutic goals for hemorrhagic shock are to stop bleeding and to restore intravascular volume, goals usually accomplished by the infusion of large amounts of intravenous fluid, be it crystalloid or colloids [4]. Some studies have questioned the concept of initial aggressive resuscitation of hemorrhagic shock [5]. It seems that excessive fluid resuscitation may be associated with increased bleeding and greater mortality, if done before surgical hemostasis has been achieved. Conversely, small amounts of hypertonic saline during resuscitation from severe hemorrhage show improved survival in animals when compared with controls resuscitated with normal saline or dextran [6]. Thus, it is reasonable to assume that resuscitation with small amounts

avDRP = DRP compound derived from Aloe vera; DRP = drag-reducing polymer.

of compounds that enhance circulatory redistribution might improve survival.

The preliminary findings of Macias and colleagues [1] using a DRP compound derived from Aloe vera (avDRP) are intriguing. Not clear from their experiments, however, is whether the improved response to avDRP resulted from changes in capillary blood flow and red cell drag or from a direct effect of Aloe vera.

Aloe vera (*Aloe barbadenis*) is a member of the lily family, found in African deserts and in the islands of Aruba and Barbados. The gel extracted from the leaf of Aloe vera has been used since ancient times to treat burns, sunburn, insect bites, and scrapes. Aloe is a common ingredient in cosmetics and hand lotions. It is said that Cleopatra and Nefertiti used Aloe vera to accentuate their legendary beauty and that Alexander the Great carried it to battle as a treatment for wounds.

More recently, Aloe vera has been touted as a folk remedy with near-mystical properties. Aloe vera contains hundreds of different ingredients, including salicylates and a carboxypeptidase that inactivates bradykinin [7]. The gel form of Aloe vera, ingested twice daily for 4 weeks, seems to have therapeutic effects in inflammatory bowel disease [8]. The latter is perhaps the result of the antioxidant effects of Aloe vera, a known scavenger of anions generated by xanthine oxidase, or to the inhibition of cyclo-oxygenase-2, prostaglandin E_2, and interleukin-8 [9].

The circulatory effects of DRPs in blood are poorly understood. Drag is defined as the force exerted by the motion of a fluid through a tube. Fluids are characterized as compressible (gases) or incompressible (water). Moreover, incompressible fluids can be viscous or inviscid. Complex fluids are those with particles floating within them. Blood is a complex, incompressible, viscous fluid flowing in a pulsatile fashion through elastic tubes. The rheology of blood becomes even more difficult to characterize for flow through a capillary, where the proportion of solid to fluid approaches a one-to-one ratio. Here we have a stochastic system in which chance, as red cells move through bifurcations, plays as much of a role in determining blood flow as the physics of motion. In the capillaries we also must account for central and wall flow, plug flow with discrete eddy currents, and the development of stagnant fluid layers around the red blood cells. Given the enormous complexity associated in defining the dynamics of capillary blood flow, to attribute systemic hemodynamic changes to decreases in vascular frictional forces is a meaningless exercise – in other words, a spherical cow.

It may be that during a condition of ischemia–reperfusion, the beneficial effects of avDRP are related not so much to changes in blood rheology as to the antioxidant effect of an Aloe vera-derived compound. Whatever the mechanism(s) that resulted in improved survival from severe hemorrhage, the findings of Macias and collaborators [1] are indeed exciting!

Competing interests

The author(s) declare that they have no competing interests.

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