DID THE EMERGENCE OF BLOOD GROUPS WEED OUT CANNIBALISM? A NEW TAKE ON A PERSISTENT CONUNDRUM

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Abstract – It is proposed that the emergence of different blood groups – whether in humanoids or their predecessors – served as a strong deterrent to the mixing of blood from different individuals. Cannibalism is the most likely activity in which such mixing would have been inevitable. In fact, the immunological significance of the blood groups may be overblown, as a correspondence between antigen and antibody is not always apparent in them. These conclusions also raise intriguing questions about the consumption of animal meats and blood by humans, with interesting implications for currently held views on diet and disease.

INTRODUCTION

The discovery of blood groups in the early 1900's represents a landmark event in modern biology, both for its theoretical implications concerning evolution and for its practical implications in terms of life-saving procedures. Interestingly, the early studies unearthed two blood groups that remain the most widely used even today (ABO and Rh), although further work since then has led to the discovery of the more than thirty blood groups known now.

However, despite their revolutionary impact in improving the safety of blood transfusions, the existence of blood groups has remained enigmatic: clearly, they did not evolve in anticipation of the modern era of transfusions! Currently, blood groups are believed to possess an immunological significance, essentially representing a possible defence against invading pathogens. These suppositions are apparently driven by the fact that blood groups are based on interactions of the antigen-antibody type (although this is by no means incontestable, *vide infra*).

This paper explores the possibility that blood groups indeed emerged to discourage the mixing of human blood, although in an ancient setting in terms of evolutionary history. These arguments impinge on the essence of intra-species relationships and interactions, and

ultimately on the evolution of communities and indeed of civilization itself. The discussion below follows a general style and draws upon freely available sources (*e.g.* Wikipedia), as the essential facts about blood types are apparently well established and disseminated. (The reader is particularly referred to a recent popular article by Carl Zimmer published in 'Mosaic' on 24 April 2017, which may be accessed at: http://www.sciencealert.com/why-do-we-have-blood-types.)

DISCUSSION

General background. Human blood is composed of blood cells (40%) and plasma (60%). Whilst blood cells are either red (involved in oxygen transport) or white (involved in immune function), the plasma is mostly water (90%) but also contains essential proteins (*e.g.* antibodies), hormones, wastes, etc.

Blood grouping is based on the observation that the mixing of human blood from different individuals often – although not always – results in a characteristic coagulation. This was subsequently traced to a reaction between the red blood cells (RBCs) in one source with certain plasma proteins in the other. In fact, this involved certain structural elements on the surface of the RBCs termed 'antigens' and 'antibody' proteins in the plasma.

The terms 'antigen' and 'antibody' in the above context is perhaps unfortunate, as they indicate a purely immunological function. Although this is not wholly inaccurate, there are apparent departures from the normal rules governing the immune response, as discussed below. The earliest studies unearthed four types of blood group, termed A, B, AB and O. This was followed by the discovery of a second type of grouping based on the presence or absence of an 'Rh factor', and indicated by a + or – sign.

Current transfusion practice employs both these groupings for enhanced safety, as is indeed well known to any informed lay person. However, this article confines itself to the above ABO system, for the sake of simplicity and also because the essential arguments do not involve any particular system *per se.*

The ABO blood grouping system. This classifies human blood types into four different groups labelled A, B, AB and O, based on the antigen borne by the RBCs and the antibody present in the plasma. Blood from different individuals can be mixed only if they belong to compatible groups (*vide infra*), thus avoiding coagulation *via* the antigen-antibody reaction mentioned above. A broad theoretical framework with a practical set of rules has emerged, as follows.

TABLE 1

Entities	Group A	Group B	Group AB	Group O
Antigen(s) on RBC	A	B	A and B	None
Antibodies in plasma	Anti-B	Anti-A	None	Anti-A + Anti-B

The A and B type RBCs possess distinct antigens on their surface, the AB type possesses both of these, but the O type bears no antigen at all. The plasma of the A and B blood types carry B and A antibodies respectively, the plasma of the AB blood type carries no antibodies, but the plasma of the O blood type carries both A and B antibodies. These characteristics are summarised in Table 1.

The presence of the various types of antibody in three of the cases is noteworthy and indeed intriguing, as they are apparently generated without the corresponding antigen being present at all! In fact (and understandably), the generation of an antibody which is incompatible with the antigen on the RBC is apparently suppressed. However, the antibody can also be generated – presumably in much larger quantities – upon the introduction of the inducing antigen, which is indeed the greatly enhanced *in vivo* version of the coagulation observed *in vitro.*

The presence of both A and B antigens on the AB type RBCs clearly rules out the presence of any antibodies in the plasma (self-coagulation is thus avoided). Conversely, the absence of any antigen on the O type allows for the presence of both A and B antibodies in the plasma (anti-A and anti-B respectively). Thus, the AB type is unable to generate antibodies whilst the O type is unable to induce the generation of antibodies.

In terms of transfusion practice, these considerations mean that the AB type is a universal acceptor and the O type is a universal donor. Also, this implies that the small quantities of antibodies always present in the A, B and O types do not lead to an adverse coagulation reaction (otherwise there would be no universal acceptor or donor). (The adverse reaction becomes significant only in the case of an *in vivo* transfusion, when large quantities of antibody are produced in response to the introduction of a corresponding antigen.)

Evolutionary implications. The existence of blood groups apparently remains enigmatic even over a century after their initial discovery. Informed speculation has veered towards the possibility that they represent a defence against external pathogens, perhaps specifically

directed against the RBCs. However, this would explain the antibody response but not the presence of the antigens on the RBCs unless, of course, the antigens have some other function not involving an immune response.

The idea that antibodies serve as a defence against pathogens also assumes that the different blood groups evolved in different geographical locales and time periods, each with a distinctive pattern of pathogenic challenge. Thus, blood group A evolved under conditions when external pathogens were sensitive to anti-B, and group B evolved under conditions when the pathogens were sensitive to anti-A. This then implies that the AB group faced no pathogenic challenge but that the O group needed to ward off both types of pathogens. The latent levels of antibody present in the A, B and O cases possibly indicate an advanced preparedness, well before the major spurt *via* induction by the antigen occurs.

In fact, antigens and antibodies possibly represent two levels of defence against a pathogenic assault (the ultimate target being the RBC). This explains why the AB type produces no antibodies (it has double the normal antigenic defence) and the O type produces two types of antibody (it has no antigenic defence). Apparently, the ability of the antigen to induce the production of the corresponding antibody is merely consequential, hence a particular blood type produces an antibody different from the antigen. In other words, if both an antigen and an antibody are needed for optimal defence, the antigen and the antibody need not (indeed cannot) correspond to each other.

In the absence of firm evidence, all the same, these arguments remain interesting rather than compelling. Although they cannot be ruled out, it would be worthwhile seeking alternative explanations without supplanting the existing arguments. In fact, an interesting explanation is almost hiding in plain sight, considering the fact that the blood groups essentially serve to prevent the random mixing of human blood from different sources.

A circumstance that may be envisaged under which such mixing would have necessarily occurred involves the ancient practice of cannibalism. Now considered abhorrent in civilised societies, cannibalism is known to have been practised by primitive tribes, and has indeed been sporadically reported even up to contemporary times. In fact, cannibalism is likely to have occurred during brutal confrontations between rival communities, or following ritual human sacrifices for whatever esoteric purposes.

Such events would indeed have been accompanied by the copious flow of blood of all the involved participants. Clearly, the admixing of blood would have been inevitable under such

circumstances. It is also likely that these acts would have involved the consumption of the raw flesh and blood of the victims. The evolution of incompatible blood groups would have strongly deterred these practices, in view of the adverse reactions that would have certainly ensued.

It is, of course, possible that the blood groups emerged primarily as a defensive shield against pathogens, but also served to discourage cannibalism. Thus, evolution appears to have commandeered the blood groups to serve a higher purpose! Indeed, the ending of cannibalism would have set in train the evolution of the higher sensibilities in humankind, particularly relating to tolerance and cooperation, leading to the formation of viable communities and ultimately to civilised societies.

It would thus appear that the absence of a lower instinct (cannibalism, in select individuals) induced the evolution of the more sublime instincts valued by modern man, in a compensatory sense. Thus, traits that fortified the continued absence of the lower instinct deterred even temporary retrogression to an earlier barbaric condition. This implies the rapid extinction (by cannibalism) of communities which failed to evolve in this manner.

Intriguingly, the consumption of animal meats and blood by humans needs also to be considered in this light. Such consumption is generally regarded by the civilised majority as a *sine qua non* of good health, although it is opposed by those propounding vegetarianism. All the same, the possibility of adverse reactions between the animal antigens and antibodies on the one hand, and their human counterparts on the other, cannot entirely be ruled out. Thus, a link between the consumption of meat and certain diseases – at least in the case of sensitive individuals – then needs to be investigated. (This is rather reminiscent of a controversial theory linking a person's blood type and their preferred diet, proposed in recent decades.)

CONCLUSIONS

The origins and evolutionary significance of the existence of the various blood groups are intriguing, and remain an interesting topic for informed speculation and conjecture over a century after their discovery. The view that blood types represent a defence against invading pathogens is interesting although perhaps lacking in firm evidence. This view also leads to a simplistic antigen-antibody relationship between the reacting entities on the red blood cell surface and the plasma. Although such a relationship may well have existed at an early period in evolutionary history, the phenomenon may have been commandeered to serve the purpose

of strongly deterring the random mixing of human blood, inevitable during acts of cannibalism. This may have been a critical prelude to the evolution of traits of tolerance and cooperativeness, which would lead to viable communities and ultimately to civilised society. As an aside it is noteworthy that these observations may have intriguing implications for the (human) practice of consuming animal meat and blood, as this also involves the mixing of blood, although to a minor extent and in a different sense.
