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BLOOD TRANSFUSION AND ATHLETICS

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" In 1976, the Medical Commission of the International Olympic Committee formally condemned the practice of blood transfusion for athletes in good health. As of this writing, however, blood doping has not been explicitly forbidden.
The Author discusses important and controversial questions such as: does blood transfusion afford world-class athletes a substantial competitive advantage? Is this practice safe? Is it ethical to use blood as a recreational drug? "

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Recently, the U.S. Olympic Committee revealed that 7 members of its 24-member Olympic cycling team, including 4 medallists had received blood transfusions in an effort to enhance their performance in the Los Angeles Olympic games. Ironically, public disclosure took place during National Blood Donor Month and at a time when blood shortages were being reported in southern California and elsewhere in the country. According to team officials, the athletes were given transfusions of whole blood, collected from both relatives and from unrelated donors, in a motel room. Details of the collection, storage, and compatibility and safety testing have not been released.

Much of the initial reaction to the report of "blood doping" centered on the possible disqualification of the athletes and on expected political repercussions; pertinent scientific, medical, and ethical questions received less attention. To its credit, the American medical community has spoken out forcefully *against* the practice and with a single voice. However, emotions run

high where Olympic medals are concerned, and reaction from the general public has ranged from heated defense of the athletes to disappointment, resentment, and indignation. It would be unfortunate if the sensationalism surrounding an Olympic scandal were to overshadow other important and controversial questions, such as these: Do blood transfusions afford world-class athletes a substantial competitive advantage? Is this practice safe? Is it ethical to use blood as a recreational drug?

Is it effective?

Rumors have circulated for almost two decades that various national teams use blood transfusions to improve their athletes' performance in international competition. The extent of this practice, colloquially referred to as "blood doping," "blood boosting," or "blood packing," is unknown. However, there is a sound physiologic basis for believing that it may work. The capacity to perform sustained muscular activity depends on the ability to transport oxygen to the contracting muscle cell. More than 50 years ago, physiologic studies related exercise capacity to the maximal oxygen uptake (Vo_{2max}), and Vo_{2max} remains a widely accepted measure of physical fitness (1). Transfusion increases oxygen delivery to exercising muscle by increasing the amount of the carrier protein haemoglobin. Red-cell mass and Vo_{2max} are generally well correlated (2). As long as the metabolic limit of muscle is not exceeded, an increase in the haemoglobin concentration should result in increased oxygen consumption and muscle performance (3).

The elevated haemoglobin concentration induced by hypoxia is one rationale for the widely accepted technique of high-altitude endurance training, although such training probably increases the oxidative capacity of muscles as well (4). Transfusion would seem least likely to benefit the sprinter, whose muscles generate energy primarily by anaerobic metabolism, and most likely to benefit endurance athletes, such as marathon runners, skiers, and cyclists, whose work capacity depends on a ready supply of transported oxygen.

It has been surprisingly difficult to document the benefits of blood transfusion in experimental exercise protocols. One explanation is that the increase in the oxygen-carrying capacity of blood is partially offset by elevated blood viscosity and reduced blood flow. However, viscosity effects are probably small at hematocrit values of 50 per cent or less (5). Some of the contradictory findings are related to difficulties involved in obtaining sufficiently reliable measurements in a physiologic model as complicated as that of the exercising athlete. Changes in regional blood flow, ventilatory drive, and internal temperature and pH may be as important as the haemoglobin concentration.

In dogs, transfusion results in increased peripheral vascular resistance and decreases in both cardiac output and venous return, which again are more marked at higher hematocrit values (6,7). These changes should affect performance adversely. Studies in human beings have proved inconclusive, primarily because of improper controls, the training effect in subjects, and the failure to achieve sufficient elevation in the haemoglobin concentration after

transfusion (8). Finally, despite years of debate, the question remains whether the limiting factor in exercise capacity is oxygen delivery, or whether it is some other factor, such as the oxidative capacity of muscle. The arguments are thoroughly reviewed elsewhere (9).

The most convincing evidence that athletes benefit from transfusion comes from a double-blind, sham-controlled, crossover study of 11 highly trained competitive runners. Athletes underwent extensive treadmill testing before and after phlebotomy with reinfusion of 900 ml of autologous red cells that had been frozen and stored (10). In these subjects, elevation of the circulating red-cell mass by 1 g per deciliter above control values resulted in significantly improved treadmill endurance, a lower heart rate during exercise, and less accumulation of blood lactate – all measures of improved performance. There was a mean overall increase in Vo_{2max} of only 5 per cent – less than predicted but consistent with the results of earlier studies (11, 12). These results suggest that either the athletes' maximal metabolic rate of muscle had been reached or other physiologic alterations took place that limited the effects of the increased haemoglobin concentration. Thus, the weight of the evidence suggests that red-cell infusions can improve the performance of world-class athletes, but the advantage appears to be a slight one.

Is it safe?

The *medical* benefits of blood transfusion are unquestioned. Blood transfusion has made possible such modern miracles as open-heart surgery, cancer chemotherapy, and bone marrow transplantation. In these situations, the benefits of transfusion clearly outweigh the risks. However, transfusion is far from risk-free. Immune side effects complicate approximately 3 per cent of all transfusions. Most of the complications are mild allergic reactions, such as fever and urticaria, but haemolytic transfusion reactions occur in about 1 in 6000 transfusions and may prove fatal (13). Anaphylactic reactions and bacterial contamination, which fortunately are uncommon, may also result in transfusion-related deaths unless they are promptly recognized and treated. Thirty-seven such deaths were reported in 1984. Up to 10 per cent of patients contract post-transfusion hepatitis. Although severe acute disease is no longer common, hepatitis progresses to chronic liver disease in an alarming number of patients (14). The true incidence of morbidity and mortality from transfusion-related chronic liver disease is unknown, but both are clearly underreported. The recent demonstration of an association between transfusion and the acquired immunodeficiency syndrome has raised further concern about unnecessary or questionably indicated transfusion (15). Finally, transfusion stimulates immune sensitization in normal young recipients and may make future medical management relating to blood transfusion, pregnancy, or bone marrow transplantation difficult or even impossible.

Ethical issues aside, from a strictly medical and scientific perspective, the reported method of transfusion used in the Olympic cyclists raises disturbing questions. Since the desired effect is to increase oxygen delivery, the appro-

priate transfusion product is packed red cells, not whole blood. To limit the hazards of disease transmission and sensitization, the athlete's own cells, previously frozen and washed free of plasma, would be the ideal component. These frozen red cells would have the further theoretical advantage of reducing allergic and febrile transfusion reactions and of supplying nearly normal levels of red-cell enzymes and 2,3-diphosphoglycerate, the organic phosphate compound that facilitates the transfer of oxygen from red cells to tissues. These substances tend to decline with time during the refrigerated storage of blood. Autologous frozen cells were used in the most persuasive physiologic studies (10). There is no reason to choose a less effective, less safe product. To ensure safety, blood should be collected by trained personnel, using approved techniques, and should be labelled and stored by a registered blood bank. Transfusion should be performed in a hospital setting, where the risks of misidentified blood products and unsterile practices are lessened and where emergency measures are available should an untoward reaction occur.

Is it medically and ethically justifiable?

There can be no medical justification for exposing a normal person to the serious and unnecessary risks of homologous blood transfusion. The fact that the people involved were Olympic athletes alters the circumstances, but does not improve the soundness of the medical judgment. But what if the protocol had stipulated autologous blood, appropriately collected, stored, and administered in a controlled medical setting? Certainly, this would have been preferable from a medical standpoint. Yet blood doping still represents an attempt to use a medical therapy to provide athletes with an *unfair competitive advantage*. In this sense, it differs little from the use of other stimulant drugs, which have been rightfully banned from Olympic competition. The physiologic effects may differ in magnitude, but the principle remains the same. Both practices epitomize the philosophy of «win at any cost», both are performed behind closed doors, and both trade health for medals.

One must ask how impartially and to what extent these normal persons were informed of potential risks and anticipated benefits. It is unlikely that the transfusion protocol used for the Olympic cyclists would have been scientifically acceptable for a clinical research project; it is equally unlikely that a committee for the protection of human subjects would have endorsed the protocol on ethical grounds.

There are other, perhaps equally compelling arguments against the practice of blood doping. Even autologous blood is unsafe if it is not collected, stored, and transfused under careful medical supervision. If its use were to be permitted in prestigious international competitions, such as the Olympics, it would be inconsistent and unrealistic to ban it from highly competitive intercollegiate sports programs; serious joggers would also be sorely tempted to use transfusion if it were medically acceptable and offered the prospect of a slightly improved personal best time in the Boston Marathon. Widespread recreational use of blood transfusion would inevitably result in serious injury to many normal, healthy

persons. Finally, in terms of national health priorities, removal of a large number of healthy prospective blood donors from the volunteer blood-donor pool would constitute a serious setback for supportive medical care in the United States.

Blood is a drug. Collection, storage, and compatibility testing of blood for transfusion are carefully prescribed by the Food and Drug Administration. Facilities for blood collection and transfusion are registered, licensed, and inspected for compliance. Like other drugs, blood should be given only for medical indications. In 1976 the Medical Commission of the International Olympic Committee formally condemned the practice of blood transfusion for athletes in good health. As of this writing, however, neither the International Olympic Committee nor the U.S. Olympic Committee has explicitly forbidden blood doping. They should.

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