SPECIAL COMMITTEE REPORT

Sickle Cell Anemia Trait in the Military Aircrew Population: A Report from the Military Aviation Safety Subcommittee of the Aviation Safety Committee, AsMA

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The question of whether sickle cell trait (SCT) is potentially dangerous to military aircrew personnel who have it and, consequently, whether such individuals should be allowed to fly in military aircraft is a very emotional issue. This article traces the evolution of how the U.S. military has dealt with the problem, and the present status of individuals with SCT in the U.S. military aviation community. Extensive studies and means for subjectively evaluating the problem were instituted by the Department of Defense in 1981, after making the decision not to restrict aircrew with the trait from aviation duties. All research projects and educational programs were abruptly stopped in 1985. Today, there are no actual restrictions on individuals with SCT for duty in the aviation and diving communities.

FOR SEVERAL YEARS, the Military Aviation Subcommittee of the Aviation Safety Committee of the AsMA has had on its agenda the question of what has happened to the sickle cell trait (SCT) investigatory programs promised by the Department of Defense (DOD) in 1981. These investigatory programs promised to investigate the possibility of medical problems in those with the SCT, especially as related to flight duties. The Subcommittee's members of the various services were convinced that programs were being carried out, not by their service, but by a sister service. Since our Subcommittee members had no clear data or knowledge of the present state of affairs, we decided that we needed to follow up on the previously promised efforts. What follows are the results of our investigation.

Sickle cell trait and sickle cell anemia are two related, yet very different, entities. We are very much aware of the problems experienced by individuals with sickle cell disease and, consequently, are able to delineate their degree of disability for various duties and occupations without undue difficulty (12). However, the disposition of individuals with sickle cell trait has long been a problem in the aviation community. Over the past several years, there have been many emotionally charged discussions regarding the disability, or lack thereof, for aviation duties for those carrying the sickle cell trait (8).

Probably the best review of the possible SCT problems to the military aviation community was made by Dr. L. W. Diggs, Goodman Professor of Medicine, Emeritus, of the University of Tennessee Center for the Health Sciences, in 1984. He carried out an exhaustive review of the world's literature on SCT in a series of four articles, with a cumulative bibliography of 200 articles (2–5). Diggs had worked with individuals with SCT for many years and had a personal knowledge of the possible problems in hypoxic conditions. He carefully dissected others' works, explaining the strong and weak points of their arguments. He also carefully explained why many feel there is no problem with SCT in hypoxic conditions, and why he feels there may be serious problems. He was particularly concerned with the following possibilities: 1) microinfarcts (ischemic necrosis) of the brain, spleen, cellular bone marrow and kidney at altitudes above 10,000 feet; and 2) sudden death syndromes after exposure to alcohol (inebriation), surgery and anesthesia, minor blood loss, minor trauma, overuse of sedatives, narcotics or other drugs and exhaustion due to overexertion; i.e., some form of physical stress (2–4).

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Diggs also examined the health, safety, ethical, legal, racial, and technical considerations of individuals with SCT in the military aviation community (5). He felt the civilian aviation and the military aviation communities are distinct and should not be confused with one another since civilian (commercial) aviation normally uses pressurized cockpits and military aviation can never promise a pressurized cockpit (many aircraft do not have pressurized cockpits; operational necessity or problems may cause loss of cockpit pressurization) (5). His findings will not be repeated here, but we highly recommend that this fascinating series of articles be consulted for further information. Diggs' recommendations are as follows: "For the sake of the health and safety of individuals, for the sake of completing the military missions successfully with minimum risk, as well as for the sake of society, it is recommended that those with SCT be excluded from training and assignment as pilots, co-pilots, and navigators of military aircraft, as paratroopers, as crews of transport planes, helicopters, balloons, or space ships, as deep sea divers, and as participants in activities that require sojourn in high mountains" (5). Several articles on SCT in aviation (hypoxic conditions) have been written since this series, but nothing new has been added to what Diggs reported.

In 1972, the U.S. Department of Defense requested guidance from the National Academy of Sciences-National Research Council regarding the establishment of "wise, rational and medically sound" policies for the assignment of recruits with various types of sickle cell conditions and diseases. An Ad Hoc Committee on S-Hemoglobinopathies was then appointed. The Committee consisted of physicians, military representatives, and the staff of the Division of Medical Sciences. The recommendations of the Committee were: 1) tests for anemia and automated dithionite tube solubility tests for sickle cell hemoglobin (Hb S) be included in the multiphasic screening laboratory procedures performed on all candidates; 2) blood specimens found to be Hb S positive be further processed by the cellulose acetate hemoglobin electrophoretic procedure and by a test to determine the quantity of Hb S and other types of hemoglobin; 3) those found to be positive for sickle cell anemia and other sickle cell diseases be excluded from military service; 4) those with sickle cell trait (SCT) be accepted for all military duties EXCEPT training and assignment as pilots and co-pilots of military aircraft; 5) persons with various types of S-hemoglobinopathy already engaged in hazardous activities be allowed to continue in these activities or be transferred to less hazardous duty, if they so wished; and 6) scientific investigations be continued, observations recorded in the literature be evaluated, and educational programs be established (1). These recommendations were adopted by all branches of the U.S. Military in 1973 (2).

As would be expected, the denial for participation in aviation duties for those with SCT was continually challenged. It was alleged there is no "well-documented medical proof" that those with SCT are at a greater risk, when exposed to hypoxic environments than those without the trait [(ATZQ-AAML-AA-ER ltr, 23 July 1981)] (2,8,10).

The exclusion from aviation duty for those with SCT brought national attention in 1979 when six SCT-affected individuals were disenrolled for medical reasons from the U.S. Air Force Academy. Congressional debates and the filing of protests followed, as did the initiation of a class action lawsuit against the U.S. Air Force (2).

The U.S. Air Force was understandably concerned about the safety of exposing SCT individuals to hypoxic conditions and the advisability of assigning SCT individuals to aviation duties. Consequently, in 1981, the U.S. Air Force asked hematologists to express their views on the subject. Of the 85 physicians who responded, 19 (22%) stated the risks were "unknown," 2 (3%) said there was "no risk," and 75% felt there were risks involved: 37 (44%) felt there were "potential" risks, 17 (20%) felt the risks were "minimal," 9 (11%) felt the risks were "moderate," and one individual felt the risks were "extreme." Consequently, the majority of physicians knowledgeable in SCT polled felt there was an element of risk in exposing SCT individuals to hypoxic conditions [Myers PW, personal communication cited in (2) as ref. 23].

In spite of the above, all three U.S. military services decided in 1981 to permit those with SCT to enter somewhat unrestricted aviation duty elements [(ATZQ-AAML-AA-ER ltr, 23 July 1981) (Secretary of Defense memo, 16 January 1981)]. It was arbitrarily decided that individuals with 41% or less Hb S (definition of SCT is 45% Hb S or less), as determined by quantitative hemoglobin electrophoresis, would be permitted to perform all aviation duties and (in the Navy) diving duties. Those with greater than 41% Hb S were to be allowed to enter unrestricted general duty, including duty as air traffic controllers, with the exception of diving and aviation duties. Sickle cell anemia and sickle cell disease were disqualifying only for special duty. Provisions were made for counseling and educating those with SCT. Essentially, the guidelines adopted in 1973, with the exception of the aviation exclusion, were to continue [(ATZQ-AAML-AA-ER ltr, 23 July 1981), (BUMEDINST 6260.26, 27 November 1981)] (2). The Army limited the flights an SCT individual could participate in to 10,000 ft pressure altitude, unless in a dual pilot status [(ATZQ-AAML-AA-ER, 23 July 1981), (Rossing RM, HSXY memo, 2 September 1983)].

The U.S. Department of Defense decided to again review all available evidence and to establish additional facts. A triservice sickle cell trait monitoring study protocol was adopted. The idea was that future policies would be based on results obtained by research planned and carried out by governmental agencies and institutions, with a critical appraisal of information contained in the literature. Also, retrospective studies were to be done, using the service and medical records of SCT and control individuals. The Uniformed Services University of Health Sciences was to develop and perform a monitoring study; the Navy was to prepare a tri-service technical medical study to assist all services in working from common information and data; the Army was to develop a clinical investigation protocol to evaluate individuals with SCT exposed to hypoxia/hypobaric con-

ditions; and the Army Research and Development Command was tasked with evaluating the significance of sickle cell trait in specialized military environments and provide appropriate recommendations for duty restrictions and further study [(ATZQ-AAML-AA-ER, 23 July 1981), (BUMEDINST 6260.26, 27 November 1981), (Sanford JP, ltr dated 27 May 1982, Subj: Triservice sickle cell trait monitoring study)] (2,7).

Probably the most comprehensive prospective (and probably definitive) study was to be done by Kark and associates at the Walter Reed Army Medical Center. The program gained final approval in 1983 (7). It was to be ". . . a prospective, controlled, non-blinded study of the response to altitude exposure in a barometric chamber for ten pairs of Hb AA and Hb AS aviator candidates, matched for age, sex, race, smoking habits, and alpha globin gene number. They [would] also be screened to exclude G6PD deficiency and beta thalassemia" (7). The Newsletter of the Center for Sickle Cell Disease at Howard University (February 1982) hailed the proposed study, stating ". . . at long last this problem is now under systematic study. . . . The present challenge is to carefully gather unbiased data which can hopefully settle the issue as to what conditions, if any, constitute an increased hazard to military personnel with SCT, when compared with service personnel who do not have the trait" (11). In January 1985, by a directive of the Secretary of Defense, ". . . all military occupational restrictions on sickle cell trait (SCT) bearers are to be removed effective immediately. . . . No sickle cell trait bearer will be subjected to any additional screening beyond that required of all candidates for that occupation" [Secretary of Defense memo, January 1985]. The triservice sickle cell trait study was canceled at this time before its completion, with the explanation that such a study was no longer necessary.

Kark did publish some findings in 1987 based on hypobaric chamber exposures in 13 SCT and 13 normal subjects. He found short serial exposures to hypoxia at high altitudes (1524 to 7620 m) did not seem to acutely or cumulatively alter DLco (diffusing capacity of carbon monoxide) or spirometric values in healthy nonexercising SCT individuals (6). His study evaluated only pulmonary function variables and did not evaluate symptoms. In addition, an Army publication [HSXY-AER (40-501), 1 February 1989] sent to all flight surgeons stated:

". . . recent series of prospective, controlled studies utilizing Army personnel has been conducted at 4,000 feet, 7,000 feet, and 13,000 feet to determine the effects of hypoxia on individuals with SCT. These studies have shown:

1) The percent of sickled cells increases with altitude.
2) The percent of sickled cells is much higher in the peripheral circulation than in the central circulation.
3) There is no difference between controls and individuals with SCT in exercise tolerance, cardiopulmonary and gas exchange functions, spirometric values, or diffusing capacity of carbon monoxide with increasing altitude.
4) At 13,000 feet, individuals with SCT had a statistically significant four-fold increase in headaches, dizziness, light-headedness, chest pain, left upper quadrant pain, and leg cramps (rates: 30/1000 SCT vs. 7/1000 controls). All left upper quadrant pain episodes occurred [in] individuals with SCT.
5) Retrospective studies have demonstrated that individuals with SCT are at increased risk for heat injury, and splenic and renal infarctions (manifested by painless hematuria) with hypoxia."

There appears to be no other published information from the promised studies.

The question seems to remain whether an individual with SCT is more likely to be incapacitated in the aviation environment than an individual without SCT. Anecdotal information (there is no official information) from anonymous medical observers in the three military services seems to indicate there is a problem. Incapacitation and, in some cases, deaths have been anonymously reported in SCT individuals at altitude, and while doing strenuous exercise in hot climates (we do not know if these were cases of pure SCT). These deaths and incapacitations in SCT individuals may be due to the known problems of hyposthenuria, hematuria, splenic infarctions with acute tubular necrosis, exertional rhabdomyolysis, and sudden death syndrome (most likely due to hypoxia, dehydration, acidosis, accumulation of endogenous reducing agents and activation of intravascular coagulation components) (3,4).

Studies need to be done to ". . . carefully gather unbiased data which can hopefully settle the issue as to what conditions, if any, constitute an increased hazard to military personnel with SCT, when compared with service personnel who do not have the trait" (11). Since the frequency of adverse events is very low while the frequency of SCT is relatively high, it may be difficult to accept a direct causal relationship without proposing other significant modifying, causative or contributing factors. We recommend a massive case-control, prospective study on the various military populations at risk be carried out from the initiation of basic military training through the termination of active duty service. Such a study could look, not only at the presence or absence of SCT, but also at other confounding variables: genetic, social, environmental, nutritional, developmental, infectious, etc. SCT may be sufficiently rare that the entire population of recruits at risk who test SCT positive could be monitored along with their controls. A careful prospective study, looking at possible confounding variables in sufficient depth and covering a large enough population to allow the statistical discovery of compounding rare events, would seem to be the best, and perhaps the only, way to arrive at a conclusion with sufficient certainty to allow its use as a basis for the establishment of administrative policy. Smaller scale studies might fortuitously chance upon the chain of causality, but fail to recognize it or indicate it with suffi-

cient certainty to allow its practical adoption, especially if there are subtle elements within.

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