Clinical Medicine

Relationship of Menstrual History to Altitude Chamber Decompression Sickness

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Records at the USAF School of Aerospace Medicine, Division of Hyperbaric Medicine, were reviewed to determine the relationship between the incidence of altitude chamber decompression sickness (DCS) in females and menstrual history. The study period spans 11 years, from January 1978 to December 1988. There were 81 records suitable for study. A significant inverse linear correlation was noted between the number of days since the start of last menstrual period and the incidence of DCS. This relationship was noted with both Type I and Type II DCS. Lack of information on the population at risk precluded an analysis of the effects of birth control pills on this phenomenon. The underlying mechanism for the correlation between menstrual cycle and susceptibility to development of DCS is unknown. We conclude that women are at higher risk of developing altitude related decompression sickness during menses, with the risk decreasing linearly as the time since last menstrual period increases.

THE UNITED STATES Air Force (USAF) has extensive experience in the treatment of altitude-related decompression sickness (DCS). Records of all DCS cases treated in USAF hyperbaric chambers are maintained at the USAF School of Aerospace Medicine (USAFSAM), Division of Hyperbaric Medicine, Brooks AFB, TX. In-depth reviews of the USAF experience have been published by Davis, *et al.* (2), and by Rayman and McNaughton (6). Bassett (1) has presented data demonstrating a four-fold higher incidence of altitude chamber DCS in women than men. This finding has been supported by a recent review over a 10-year period (Weien and Baumgartner, personal communication), who found the incidence of DCS among females to be 4.3 times higher than that of men. This apparent increase in DCS among females has been largely unexplained. The solubility of nitrogen in fat is five times that of lean tissue (7); consequently, some investigators have speculated that the higher percentage of body fat in females has caused this increased incidence in DCS.

This paper investigated the role of menstrual history in development of altitude chamber decompression sickness using our records on the treatment of DCS. To our knowledge, no prior studies have addressed the relationship of menstrual history to the development of altitude DCS.

METHODS AND MATERIALS

A review was conducted of potential records maintained at the USAFSAM, Division of Hyperbaric Medicine. This division maintains files on all patients treated in USAF hyperbaric chambers, including the treatment of DCS. All files contain AF Form 1352 or SAM Form 306, Hyperbaric Patient Information and Orientation, which supplies information on patient name, age, sex, date of treatment, type of exposure, and form of treatment. These forms also list information on the use of birth control pills (BCP) and number of days since start of last menstrual period (LMP). For this study, patient data were reviewed for the 11 years from January 1978 to December 1988. Due to lack of completeness and reliability, records on file before 1978 were not used. Patient records were reviewed for date of treatment, type of decompression sickness (Type I vs. Type II), age, number of days since start of LMP, and use of birth control pills. We assumed that all individuals exposed were in a good state of health, having been required to possess a current USAF Flying Class III physical in order to enter the altitude chamber. We also assumed that the time since LMP in females exposed to an altitude chamber environment is evenly distributed over a period of 0–29 d. After collection of data from the standardized form (AF 1352), the narrative summary and other documents in each patient record were reviewed to rule out possibility of error in data recording.

Data on days since start of LMP were available on 85

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of the 125 patient records available for review. Three of these records were excluded from study based on a prior history of hysterectomy. An additional patient was recorded as having her last menstrual period over 4 months prior to her treatment, without explanation; therefore, her records were also excluded. A total of 81 records remained for analysis. Collected data were entered on a microcomputer for compilation.

RESULTS

Data from the study are shown in Table I. The average age of females developing altitude chamber DCS was 26.5 years, with a range of 18 to 39 years. Of the 81 cases studied, 62 were Type I (joint pain only) DCS, and 19 were Type II DCS. All of the Type II DCS patients had neurologic symptoms, with or without joint pains. None of the patients experienced pulmonary DCS (chokes) or DCS shock, possibly because of rapid treatment in most cases.

The results of the study are shown in Fig. 1. In this graph, day 0 represents the first day of menses. The number of DCS cases declines linearly as the time since the start of LMP increases. The correlation coefficient for this graph is -0.988, thus indicating a very close linear relationship. Grouping the data into different numbers of columns fails to affect this correlation coefficient.

If we assume that the time since the start of last menstrual period is distributed evenly among all females with altitude chamber flights, the distribution of the subgroup developing DCS is significantly different from the uniform distribution that would be expected (Chi-square (5 df) = 16.41, $p < 0.01$).

TABLE I. DISTRIBUTION OF DCS DATA.

Days since start of LMP	Type I DCS		Type II DCS	
	BCP	No BCP	BCP	No BCP
0	1	3	0	1
1	1	3	0	1
2	2	0	1	0
3	0	4	1	0
4	0	2	0	2
5	2	1	1	2
6	0	4	0	0
7	3	1	0	1
8	0	1	0	0
9	0	1	0	0
10	3	2	1	0
11	1	2	0	0
12	0	2	0	0
13	0	0	0	2
14	0	3	0	1
15	2	4	0	1
16	0	1	0	0
17	0	0	1	0
18	0	1	0	0
19	0	1	0	0
20	0	3	0	0
21	1	2	0	0
22	0	0	0	0
23	0	0	0	1
24	0	2	0	0
25	0	0	0	1
26	0	0	0	0
27	0	1	0	0
28	1	1	0	0
29	0	0	0	0

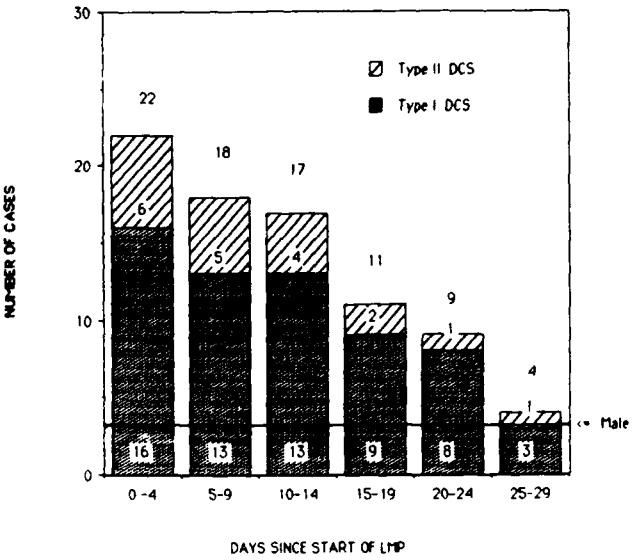

Fig. 1. Time since LMP in DCS cases.

In this series, Type I DCS predominated, representing 76.5% of total cases. This percentage remained fairly uniform throughout the menstrual cycle. The percentage of cases of Type II DCS in each group in Fig. 1 ranged from 18.2–27.8%.

Among women developing DCS, 27.2% were using BCPs (27.4% of Type I DCS cases and 26.3% of Type II DCS cases). The percentage of all women with altitude chamber exposure using BCPs is not known, nor is the type of pill nor the duration of use. As a result, no conclusions can be made regarding a correlation between BCP use and DCS susceptibility.

The solid line in Fig. 1 represents the incidence of both Type I and Type II DCS in males in relation to the groupings of females, obtained by using the incidence figures reported by Weien and Baumgartner. This demonstrates that the incidence of DCS in females approaches the incidence of DCS in males as the time since LMP increases. In the 25–29 day group, this difference becomes significant.

DISCUSSION

Previous studies have established differences in the incidence and presentation of DCS among males and females. Davis, *et al.* (2), noted in a 1977 review that females accounted for a greater number of difficult cases requiring more complicated management. No explanation was suggested to account for this difference. A 12-year study by Bassett (1) noted a four-fold greater attack rate of DCS among women than among men exposed to similar altitudes. Weien and Baumgartner (personal communication) recently reviewed the USAF experience with DCS over a 10-year period, and noted an incidence of DCS among females of 206.87 cases per 100,000 exposures. (In males, the incidence is 48.08 cases per 100,000 exposures). They noted an attack rate of DCS which is 4.3 times higher in women than men. Data on age, time since LMP, and use of birth control

pills in females having altitude chamber flights without developing DCS were not available.

Many factors have been implicated as having an effect on individual susceptibility to DCS. Lam and Yau (5) noted that obesity and past number of episodes of DCS were important individual risk factors for development of DCS in compressed air tunnel workers. Dembert, *et al.* (3), also noted an increased incidence of DCS in obese divers. In our series, obesity did not appear to play a role. No individuals exposed to reduced atmospheric pressure in USAF altitude chambers were obese, being required to meet physical standards for flying duties, including weight standards.

Dixon, *et al.* (4), studied the incidence of venous bubbling and DCS in 30 females exposed to a 7.8 psia suit environment. Five of the subjects (17%) developed symptoms of DCS, three of whom required recompression therapy. Dixon noted that 100% of females developing DCS were in the menses or early phase of their menstrual cycle, and only 32% of women who did not develop DCS symptoms were in the same phase of their cycle. This finding suggested a role of the menstrual cycle phase in development of DCS.

The current study provides further evidence of a significant role of menstrual cycle phase in the development of altitude chamber DCS in females. A clear correlation is noted between incidence of DCS and the time since start of LMP, with a higher number of subjects developing DCS earlier in their menstrual cycle. This trend is present whether considering Type I DCS or the more serious Type II DCS. The role of use of BCPs in DCS susceptibility could not be determined in this study.

Women play a significant and expanding role in activities which involve the risk of development of decompression sickness, including diving activities, aircrew duties, and in present and future space operations, especially those involving extravehicular activities (EVA). Our findings have important implications for these activities, and cannot be taken lightly. It must be strongly emphasized that our findings are preliminary. Further studies, including those of a prospective nature, are required to confirm the role of menstrual cycle changes in susceptibility to DCS. This study does not address the mechanism responsible for our findings. The changes that occur throughout the menstrual cycle include many complex hormonal and metabolic changes, a description of which are beyond the scope of this paper. The implication of any of these specific changes in the susceptibility to development of DCS would be mere speculation.

It is clear that additional studies to determine the physiologic basis for this relationship are not only warranted, but should be considered a high priority.

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