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Neil Armstrong syndrome

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Sir,

Since catecholamine levels in Space are twice supine levels on Earth [1], it should not be surprising that space flight is conducive to catecholamine cardiomyopathy, a form of acute temporary heart failure, first described by the Japanese in 1990. I was surprised to learn that during his last 20 lunar minutes, Neil Armstrong had severe dyspnea, notifying Johnson Space Center twice of this during a 4 minute interval; also he had severe tachycardia with a heart rate up to 160/min. See Fig. 1.

Tachycardia itself can trigger oxidative stress intensifying endothelial dysfunction with space flight; when reaching 85% of one's maximum age-related heart rate, it may be fatal [2].

In addition to high catecholamines, there are low magnesium (Mg) ions in Space and vicious cycles between the two; endothelial leaks through post-capillary venules with plasma loss, further intensifying dehydration from invariable decreased thirst. Despite the very poor sensitivity of Mg in the serum, with 99% intracellular, serum Mg levels have been shown to be reduced ($p < .0001$) in 196 space shuttle crew members. Mg is both a strong antioxidant and calcium (Ca) blocker.

In Space, there is not only an invariable reduction of Mg because of malabsorption, but also a loss of storage sites of Mg and water in skeletal muscles within a few weeks, and of Mg in bones, with 1–2% loss of bone/month. In addition, with high CO_2 levels in Space i.e. over 10 times higher than on Earth, there is the potential for Ca overload [3], conducive to both coronary vasospasm and injuries to the mitochondria and intensified by Mg deficits [2].

In microgravity, the aging process is accelerated by a factor of 10. This can be triggered by the reductions in Mg with, in turn, reductions in telomerase required for telomere function; telomerase is Mg-dependent. Also, the synthesis of telomeres requires Mg, particularly for its longer elongation products (TTAGGG). The heart is particularly vulnerable because of its dense mitochondrial network [4].

Recently, it has been shown that the function of mitochondria is partially dependent upon the action of telomeres with their dysfunction conducive to cardiomyopathies [5]; impaired mitochondrial function could have contributed to Armstrong's probable lunar heart failure.

Experimental animals, after space flight, show changes in the structure of mitochondria and reduced rate of ATP synthesis [2].

It has been known since the nineties, that there are elevations of core body temperatures with exercise in Space, probably because of impairment in convection, resulting in increased sweating, with further loss of Mg as well as renal Mg loss. With the space suit's water capacity limited to 32 oz, poor suit-air conditioning, lunar noon temperatures of 250 F, compounding dehydration, from impaired thirst in microgravity, severe dehydration can readily occur; this would increase angiotensin levels and in turn catecholamines [6]. The failure of Irwin's in-suit water device during all 3 lunar excursions and partial malfunction of Scott's, were probably contributing factors to the" Apollo 15 Space Syndrome" [7].

Armstrong's lunar heart rate of 160, was conducive to oxidative stress; yet, while still in microgravity, approximately 30 min before splashdown in the Pacific, his heart rate dropped all the way down to 61. This significant reduction can best be explained this way: during the 3 days back to Earth, despite the reduction in thirst in microgravity, he replenished his very depleted plasma volume, and in turn expanded his left ventricle, thereby reducing the gradient at the site of protrusion of the septum into the ventricle, as proposed by Merli et al. [8].

Now we have the components of a new syndrome, characterized by severe dyspnea, severe thirst, and severe tachycardia; the latter, corrected by fluid replenishment and instigated by an apparent reduction of postulated very high catecholamines as a response to severe dehydration, with a space suit water capacity of only 32 oz, inadequate suit-air conditioning, invariable Mg deficits and beginning soon after lift-off, progressive loss of skeletal muscle water storage sites.

It is noteworthy that 90% of those with catecholamine cardiomyopathy have been reported in post-menopausal women; in some cases possibly triggered by calcium supplements which may reduce Mg absorption [9]. Here, as well as in Space, there may be endothelial dysfunction and in turn impairment in convection with increased

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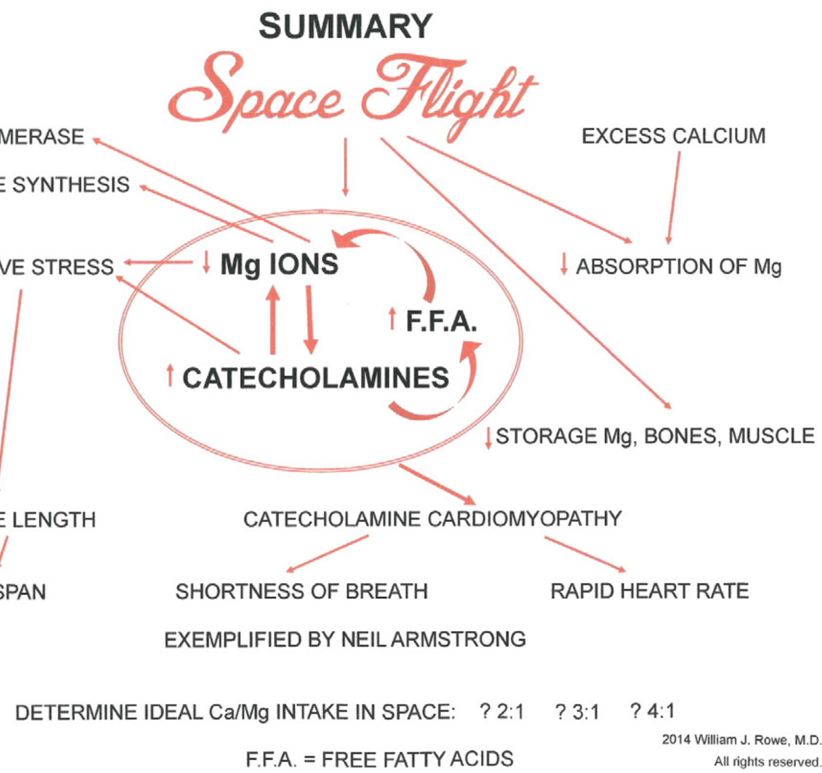

Fig. 1. Summary.

perspiration, increased core body temperature, and further Mg loss with sweating [2].

This syndrome may occur in marathoners as well; the risk is accentuated particularly near the finish line of a marathon, in hot weather and with dehydration, intensified by, in some cases, poor water absorption [10]. Mg is necessary for thermoregulation [2]. Correction by intravenous fluids or a Mg injection, thereby breaking vicious cycles with high adrenaline, might confirm this syndrome.

One of NASA's goals with Space research is to benefit life on Earth, exemplified by this syndrome, beginning in only 4 days in microgravity. A contributing factor was a probable Mg deficit prior to the mission, since the Apollo astronauts trained in “intense summer heat”; [7] Furthermore, there would have been oxidative stress, since in order to prevent decompression sickness, they were placed on 100% oxygen for 3 h prior to lift-off. (A. Hansson, personal communication). In addition to post-menopausal women and marathoners, this syndrome is more likely to occur in tropical climates with limited access to water. Mg deficits may occur in 60% of those In the U.S. and is a world-wide problem [4].

Although space flight is far more likely to trigger the Neil Armstrong syndrome because of the invariable combination of twice Earth catecholamine levels, severe Mg deficits with vicious cycles between the two, and invariable dehydration, this syndrome is also particularly likely to occur in post-menopausal women, marathoners, and those living in tropical climates, particularly with inadequate water supplies.

Conflict of interest

No conflict of interest nor funding.

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