The *Seated Arm-Lock Method* : a new concept of basic life support under simulated hypogravity of the Moon and Mars.

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ABSTRACT

Cardiopulmonary resuscitation (CPR) is an emergency procedure to return life to a person in cardiac arrest. This is indicated in those who are unresponsive with no breathing or only gasps. Studies have shown that the priority should be given to good external chest compressions, and to avoid the case where artificial ventilation may compromise survival [1] . Consistently, the *Evetts-Russomano Method* seems to be appropriate [2] to rescue a victim of cardiac arrest on aboard the International Space Station (ISS) in microgravity. We have found that, in simulated hypogravity, the classical basic life support (BLS) method does not provide good CPR results, especially during extended periods of resuscitation. We have developed The *Seated Arm-Lock Method*, which offers improved results in simulated hypogravity.

I. INTRODUCTION

Classical basic life support in simulated hypogravity is unstable and each compression pushes you away from the victim, resulting in a decreased rate and compression depth. The position requires more arm flexion and good arm strength, and quickly becomes tiring ; it may also be hard for female astronauts to perform. For this reason we have developed a new CPR method in order to improve BLS during future missions on the surface of the Moon or Mars.

Cardiac function and mass are diminished by spaceflight. The initial trigger of this effect is the fluid shift from the lower to the upper body that results in upper body blood volume expansion [9] . This stimulates central volume carotid, aortic and cardiac receptors inducing a transient increase in diuresis and natriuresis. Decreased heart size is observed, with cardiac filling, stroke volume and cardiac output [10] . Data obtained from magnetic resonance imaging measurements show a 14% reduction in left ventricular mass during spaceflight pointing out cardiac remodelling compromising myocardial function [10] . Arteries also change, responding to smaller volume by constricting to keep the blood flowing since they no longer see the shear forces that stimulate arterial walls [10] . Endothelial lining remodels walls in the heart with a lipid/protein. In conditions of inflammation it induces local or systemic damage [10] . This data shows that short-term spaceflight can be physiologically deleterious. Long-term travel out of Earth could then bring about chronic myocardial remodelling leading to heart failure and cardiac arrest. For this reason, we need a technique for performing CPR on the surface of the Moon or Mars. The proposed technique, should not require equipment and should consider the constraints expected during external exploration, taking into account that incidences may or may not occur within planetary habitats.

The ER Method provides good results

Currently *The Evetts-Russomano Method* seems to be the best technique to increase chances of resuscitation in microgravity [2]. CPR is an emergency procedure to return life to a person in cardiac arrest. It is indicated in those who are unresponsive with no breathing or only gasps : the rescuer gives chest compressions at a rate of 100 per minute in an effort to create artificial circulation by manually pumping blood through the heart [6]. He/she may provide breaths by exhaling or utilizing a device that pushes air into the lungs [11,12], but high quality chest compressions are more important than artificial ventilation [1]. Then, administration of an electric shock to the heart is needed to restore a viable heart rhythm. CPR is also required to induce a shockable rhythm [6]. Other resuscitation methods include : *The Bear Hug Method,* which provides [7] a good rate of compression (90 per minute), but the depth is below guidelines (36 mm) ; *The Hand Stand Method* which involves a vertical-inverted position, provides adequate external chest compressions depth (40 mm) and rate (98 per minute), but the position is unstable, and it could take time to the rescuer to find a good balance. Even if the position is good, it could be difficult to observe the face of the victim, to see signs of congestion and to communicate with the physician by radio. To determine whether *The ER Method* [2] could provide adequate ECC and be maintained over a period of 3 mins in a simulated microgravity, changes in arm flexion angle, perceived exertion, heart rate and anthropometric measurements have been studied. We can observe that *ER Method* [2] has an adequate ECC depth (42 mm), however the rate is low (80 per minute). Possible reasons have been given : trial limitations of 20-22 seconds due to parabolic flight simulation, positive and negative accelerations during each parabola (microgravity followed by hypergravity), no prior training of *ER Method* , the use of 1Gz + mannequin not designed for microgravity. Although ECC depth is good, chest/thorax decompression during μG (microgravity) is reduced. However, data has significantly shown that this method is more physically demanding, demonstrated by increases in heart and the Borg scale of exertion during simulated μ. It has also been found that individual morphology, such as arm and leg length are not critical factors in successful performance and that this method should be possible for any single person in microgravity. *ER* is able to fill the 2-4 min gap from time of arrest to develop and restrain the body and provide life-support in space [2].

Considering artificial ventilation

Future methods must consider providing ventilation in a simulated μG environment [2]. These considerations are important if we assume that a cardiac event may take place in habitat such as *The International Space Station (ISS)* or a planetary habitat on the surface of a planet or moon where we foresee a team of rescuers with medical devices to provide artificial ventilation and defibrillation [13]. But on the surface of Mars or the Moon, we can not envisage the removal of a helmet to provide artificial ventilation. Studies have shown that the most important aspect of life-support is circulation. Adequate oxygen exists within the blood during at least the first 10 minutes of cardiac arrest. If circulation is provided to distribute this, survival is not compromised with chest compression only, even if there is a totally occluded airway during the first 6 minutes of the arrest[1].

The *Seated Arm-Lock Method*

The SAL method was developed as a means to combat the main problem in performing cardiopulmonary resuscitation in hypogravity, namely, the increased difficulty in achieving adequate depth of compression without the rescuer becoming fatigued or being pushed away from the victim. The solution involves the rescuer straddling the victim with the victims arms being locked in behind the rescuers knees. The rescuers knees should be in the shoulder area of the victim and his toes by the victims hips, pointed backwards. The position prevents the rescuer being pushed away from the victim by using the their arms as strong and comfortable pivot points. No residual tone is required in the victims arms.

II. METHODS

Subjects were required to practice CPR using the *Seated Arm-Lock* technique prior to the beginning of the experiment under conditions of +1Gz and in simulated hypogravity on the Moon and Mars. The number of subjects was one person (n=1) due to time constraints. The *Seated Arm Lock Method* for basic life support was compared to the classical method of BLS in this trial. The frequency and depth of chest compression was recorded continuously through out the 3min protocol (30 compressions and 6 sec break as the 30:2 ratio from the American Heart Association guidelines). The rate of perceived exertion of the subject was taken using the Borg Scale. The heart rate was recorded after each trial.

III. RESULTS[1]

Considering the compression depth (mm) under hypogravity on Mars (+0.38Gz) and on the Moon (+0.16Gz) compared to the classical BLS, equivalent results were found between the two methods using the Earth gravity (42±2mm). We had an improved mean compression depth using SAL on Mars (45±6mm) and on the Moon (42±4mm). The frequency of compressions was approximately 100min-1 in all cases.

The heart rate increased similarly between the two method after BLS performance on Earth (81±2 bpm), on Mars (110±5 bpm) and on the Moon (150±2 bpm).

[1] We can send datas, pictures and graphs on demand. You can ask for it at yacine.benyoucef@gmail.com

We used the Borg Scale to evaluate the perceived exertion after each trial. We had the same results between the two method on Earth (10), on Mars (13) and on the Moon (17±1).

IV. DISCUSSION

We have found equivalence between classical BLS and the Seated Arm Lock Method in rate and depth of compressions, and our results meets 2005 AHA guidelines concerning CPR on Earth. The SAL position however shows more stability and comfort. Locking the arm of the victim with your legs prevents you from being pushed away from him/her during chest compressions. The rescuer is not quite seated on the abdomen, but he has his knees close to the axillae of the victims shoulders, with his own shoulders directly above the cardiac area, offering more precision for compression, and the ability to use arm flexion to enhance the strength of the compression if necessary. However it is hoped that the locking of the victims arms behind the rescuers knees will decrease the need for arm flexion by providing a stable point of attachment between victim and rescuer, allowing the rescuer to mainly use his shoulders and torso to provide the power of compression. Ventilation without moving from the SAL position is also possible with this method within a planetary habitat for an isolated rescuer.

This experiment was difficult because the design of the mannequin was not well adapted for this style of CPR. As a result, the arms were far too flexible and unrealistic. With better equipment, there is potential to show a strong decrease in effort, and a better compression depth, comfort and stability. Anthropometric variability of astronauts could diminish comfort and shorten the length of time over which BLS could be performed. If the victim has upper-limb trauma, this position may or may not be usable - it will depend on the extent of injury but in most cases, the priority would be to provide chest compressions before attending to problems in the limbs. Currently, the method does not address BLS outside of a planetary habitat because of the lack of information on future space-suit or skin-suit design, however a benefit of this method is that there is no loss of accuracy of chest compressions as there may be in suggested solutions that involve the use of other body parts such as knees and feet.

V. CONCLUSION

The *Seated Arm-Lock Method* can be used both on Mars and on the Moon, and seems to be an equivalent or better option than the classical basic life support. It addresses the issues associated with the classical BLS method such as exertion and stability, and allows for an easy transition for people who already know the classical method. Furthermore there is no loss of accuracy of hand positioning. Yet, more subjects are needed to increase statistical significance.

In summary, the Seated Arm Lock Method of cardiopulmonary resuscitation in hypogravity is a way of securing yourself to the victim that does not require the use of additional equipment. It is comfortable for both parties and less physically demanding than the classical method.

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