Title: Simulating Haemorrhage in Medical Students using a Lower Body Negative Pressure Chamber

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Abstract

Introduction This article is a descriptive report of a novel way of teaching the cardiovascular response to progressive haemorrhage in a first year medical undergraduate setting using simulation. Simulation may provide the means to allow students to see in practice the theoretical knowledge they have gained from lectures, thus giving clinical relevance to that knowledge.

Method The early phase (compensatory phase 1) of a 'simple' progressive haemorrhage is simulated in 6 volunteer medical students by applying sub-atmospheric pressure to the lower body using a lower body negative pressure (LBNP) chamber (see figure below). This is a technique that has been widely used in research to simulate

orthostatic stress and haemorrhage. The sub-atmospheric pressure causes 'pooling' of blood in the vessels (particularly veins) of the legs and pelvis. This 'pooling' reduces the amount of blood returning to the heart (venous return) and thus mimics the effects of loosing blood from the cardiovascular system. Parts of this method have been described elsewhere (1). To demonstrate the physiological responses to LBNP a range of cardiovascular parameters are monitored throughout the demonstration to allow students to observe the integrated (whole body) response to 'progressive haemorrhage'. Cardiac stroke volume is monitored using a portable ultrasound device (SonoSite MicroMaxx™), heart rate is measured accurately from an ECG trace and blood pressure using an automated sphygmomanometer. Tissue (skeletal muscle) oxygenation which, in this context reflects changes in blood flow in the deltoid, forearm and thenar eminence muscles is assessed using Near Infrared Spectroscopy (NIRS).

Results Progressive haemorrhage will reduce venous return and preload, thus reducing stroke volume by Starling's law of the heart (2) and ultimately reduce arterial pulse pressure. The body's initial response (mediated by the baroreceptor reflex) to the reduced arterial pulse pressure is an increase in heart rate to maintain mean arterial blood pressure (3) in the face of a falling cardiac output. The students are required to calculate the changes in overall total peripheral resistance and are able to see the consequences of the resulting reduction in muscle blood flow as a fall in muscle oxygenation.

Conclusion Durham University Medical Programme uses simulation in a novel way to reinforce didactic teaching of the cardiovascular response to haemorrhage utilising a

LBNP chamber. The simulated haemorrhage may provide the means to allow students to see in a 'clinical' context the theoretical knowledge they have gained from lectures, which may improve knowledge retention.

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