Biophysics of cardiopulmonary resuscitation with periodic z-axis acceleration or abdominal compression at aortic resonant frequencies.

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Periodic z-axis acceleration (pGz)-CPR involves an oscillating motion of a whole patient in the head-to-foot dimension on a mechanized table. The method is able to sustain blood flow and long-term survival during and after prolonged cardiac arrest in anesthetized pigs. However, the exact mechanism by which circulation of blood is created has remained unknown.

Objectives: To explain the hemodynamic mechanism of pGz-CPR and to suggest some theoretically useful improvements.

Method: Computer modeling using a hybrid analytical-numerical approach, based upon Newton's second law of motion for fluid columns in the aorta and vena cavae, Ohm's law for resistive flow through vascular beds, and a 10-compartment representation of the adult human circulation. This idealized 70-kg human model is exercised to explore the effects upon systemic perfusion pressure of whole body z-axis acceleration at frequencies ranging from 0.5 to 5 Hz. The results, in turn, suggested studies of abdominal compression at these frequencies.

Results and conclusions: Blood motion induced in great vessels by periodic z-axis acceleration causes systemic perfusion when cardiac valves are competent. Blood flow is a function of the frequency of oscillation. At 3.5 Hz, periodic acceleration using +/-0.6G and +/-1.2 cm oscillations induces forward blood flow of 2.1L/ min and systemic perfusion pressure of 47 mmHg. A form of resonance occurs at the frequency for peak-flow, in which the period of oscillation matches the round-trip transit time for reflected pulse waves in the aorta. For +/-1.0 G acceleration at 3.5 Hz, systemic perfusion pressure is 80 mmHg and forward flow is 3.8L/min in the adult human model with longitudinal z-axis motion of only +/-2 cm. Similar results can be obtained using abdominal compression to excite resonant pressure-volume waves in the aorta. For 20 mmHg abdominal pressure pulses at 3.8 Hz, systemicperfusion pressure is 7 mmHg and forward flow is 2.8L/min. PGz-CPR and high-frequency abdominal CPR are the physically realistic means of generating artificial circulation during cardiac arrest. These techniques have fundamental mechanisms and practical features quite different from those of conventional CPR and the potential to generate superior systemic perfusion.