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‘Heads Up’ on Advances in CPR

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It’s obvious that the Earth rotates around the sun, that stars are distant suns, that you push on the chest if you want to circulate blood during CPR, and that you should gradually raise the head and thorax if you want to better perfuse the brain during CPR.

Of course, our heliocentric orbit wasn’t obvious until Copernicus suggested it in 1543 (although Aristarchus proposed it 2,000 years earlier). It wasn’t obvious that stars were distant suns until Giordano Bruno suggested this in 1584 (Aristarchus also got there first). The ABC model of resuscitation (airway, breathing, compressions) wasn’t obvious until Peter Safar, MD, an anesthesiologist, published his treatise *ABC of Resuscitation* in 1957. The advantages of gradually raising the head and thorax during CPR won’t be obvious until the end of this review. However, once it’s obvious, it’s obvious.

Basic hydraulics

Pumping fluid into a closed space (such as the head) requires that the incoming fluid pressure exceeds the outgoing fluid pressure. Put another way, the arterial pressure must exceed venous pressure to move blood through the brain. During CPR, arterial pressure is very low, while venous pressure is high. The difference in pressures is barely adequate to keep the brain alive. If you gradually raise the head and thorax, then you will lower the arterial and venous pressures. By itself, this might have no effect because both would decrease by the height of an equivalent column of water. However, the head is a closed space. The only compliance spaces are the venous cavities continuous with the superior vena cava and the ventricles continuous with the spinal fluid. By

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Figure: The bundle of suction cup-based active compression-decompression, the ResQPOD impedance threshold device, and the EleGARD device to gradually raise the head and thorax during cardiopulmonary resuscitation (used with permission, AdvancedCPR Solutions).

Ultrasound-Guided Pediatric Regional Anesthesia for Orthopedic Surgery

Asha Clarke, MD

Gaston Labat stated in the forward to his seminal “Regional Anesthesia” textbook, “I do not look forward to the day when regional anesthesia will wholly displace general anesthesia; but undoubtedly it will reach and hold a very high position in surgical practice” (Regional Anesthesia: Its Technic and Clinical Applications. 1922). The development of point-of-care ultrasonography (POCUS) as a technique for

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Anesthesia Incident Reporting System Case 2024-02: Supply and Demand – Importance of the Supply Chain

Case presentation:

A 15-year-old adolescent female was scheduled for two surgical procedures on a Monday morning. The surgeon for the second procedure uses a harmonic scalpel. The OR nursing coordinator discovered on the previous Friday that the OR had no harmonic scalpels in stock and escalated this to hospital materials management. The nurse coordinator was assured that the harmonic scalpels would be delivered over the weekend. Pt taken to the OR and the first procedure completed. It was then noted that the harmonic scalpels were not available

This report highlights a series of gaps/errors resulting in an avoidable incident where a patient had to remain under anesthesia until the proper instrument was available. The COVID pandemic accentuated supply chain challenges in health

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In the Know: 'Heads Up' on Advances in CPR

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raising the head and thorax, you increase the capacitance of the cranial vault.

This might allow more blood flow to the brain. However, just raising the head and thorax could arguably decrease venous return to the heart, as venous blood may pool in the abdomen and legs. This could then decrease cardiac output, and decrease cerebral perfusion. So "simple hydraulics" might favor raising the head and thorax, but only if you compensate for the likely reduction in cardiac output.

Pig studies

In 2015, Debaty and colleagues at the University of Minnesota measured brain blood flow in pigs in ventricular fibrillation during CPR (*Resuscitation* 2015;87:38-43). CPR was performed on a tilt table, with the pigs either level or the head elevated or lowered by 30 degrees. As noted by the authors, "head down tilt decreased brain flow whereas head up tilt significantly lowered ICP and improved cerebral perfusion."

The authors maintained adequate arterial circulation using both an impedance threshold and a suction cup-based device (the LUCAS mechanical device) (asamonitor.pub/48h7MMF; asamonitor.pub/46SltjR). The impedance threshold device is a valve attached to the endotracheal tube. During the recoil following each chest compression, the valve closes. With the lumen of the endotracheal tube occluded, the elastic recoil of the ribs creates negative pressure in the thorax. This negative pressure draws blood from the vena cava, increasing venous return and decreasing intracranial pressure.

Suction cup-based active compression/decompression CPR was inspired decades ago by a kid who kept his dad alive by performing CPR with a toilet plunger (*JAMA* 1990;264:1661; asamonitor.pub/3RA3qKO). The suction cup actively retracts the sternum after each compression, turning the entire thorax into a more efficient pump.

Subsequent studies in pigs in ventricular fibrillation demonstrated that gradual controlled head and thorax elevation during CPR doubled cerebral blood flow when combined with active compression-decompression and the impedance threshold device (*Resuscitation* 2017;121:195-200; *Resuscitation* 2018;132:133-9).

A pig study in 2020 compared conventional supine resuscitation with heads-up resuscitation in 16 pigs in ventricular fibrillation (*Resuscitation* 2021;158:220-7). Resuscitation in the latter group comprised three interventions (as in the earlier pig studies): elevation of the head and thorax, active compression-decompression, and the impedance threshold device. All eight pigs receiving the bundle of three interventions had return of spontaneous circulation. Six of the eight pigs had full neurological recovery. Only three of the eight pigs receiving conventional CPR had return of spontaneous circulation. Only one pig had full neurological recovery after conventional CPR.

Pig studies have also demonstrated that raising the head alone without the use of the impedance threshold device and active compression-decompression decreases survival compared to CPR in the supine position (*Clin Exp Emerg Med* 2019;6:250-6; *Resuscitation* 2018;128:51-5). Heads-up CPR only works when combined with interventions to effectively pump blood uphill (*Resuscitation* 2018 Aug;129:e6-e7). Additionally, heads-up CPR should be instituted as rapidly as possible to improve the likelihood of successful resuscitation (*Resuscitation* 2023:110067).

Human studies

In 2019, Pepe and colleagues published the first human results looking at the efficacy of heads-up CPR (*Crit Care Med* 2019; 47: 449-55). The authors performed a "natural experiment" that looked at 2,322 consecutive out-of-hospital cardiac arrests managed by the Palm Beach County Fire Rescue from January 2014 through June 2017.

Through April 2015, out-of-hospital cardiac arrests were managed with active compression-decompression and the impedance threshold device, based on a randomized controlled trial demonstrating efficacy in nontraumatic cardiac arrest (*Resuscitation* 2013;84:1214-22). In the second quarter of 2015, rescue crews were taught to gradually elevate the head and thorax to 20 degrees after intubation, *after* placement of an impedance threshold device on the endotracheal tube, and placement of the active compression/decompression device (Figure). Alive-to-hospital admission rates increased from 18% to 34% before and after heads-up CPR was added to the resuscitation protocol. Roughly one-third of those successfully resuscitated had good neurological survival. Given the historically dismal results for out-of-hospital cardiac arrests, successfully resuscitating one-third of patients is an extraordinary advance.

A mechanical system to implement heads-up CPR, the EleGARD Patient Positioning System™, received FDA 510-clearance in 2019. Studies over the last four years by Moore et al. and others continued to demonstrate that the combination of gradual head and thorax elevation, suction cup-based CPR, and the impedance threshold device improved survival following cardiac arrest (see Figure) (*Resuscitation* 2022;170:63-63-9; *Circluation* 2022;146:A234; *Resuscitation* 2022;179:9-17). Improvement in brain oxygen delivery has been directly demonstrated using near-infrared spectrometry (*Resuscitation* 2022;175:159-66).

"Pig studies have also demonstrated that raising the head alone without the use of the impedance threshold device and active compression-decompression decreases survival compared to CPR in the supine position."

A recent analysis of out-of-hospital cardiac arrest outcomes from 11 EMS systems confirmed the earlier results (*Critical Care Medicine* 2024 in press). In out-of-hospital cardiac arrest patients who presented with a non-shockable rhythm (pulseless electrical activity and asystole), the bundle of heads-up CPR, active compression-decompression, and the impedance threshold device resulted in a nearly three-fold increase in patients discharged from the hospital (7.6% vs. 2.8%). This is a stunning improvement in survival, especially considering these patients have traditionally had the lowest likelihood of survival.

We hate to suggest YouTube as source of anything other than clips from Saturday Night Live. However, a Minneapolis television station, KARE, posted a video to YouTube that includes footage of a patient collapsing in the local airport terminal and being resuscitated with the bundle of heads-up CPR, active compression-decompression, and an impedance threshold device (asamonitor.pub/41mAlpt). The patient narrates the video of his near-death experience. A more complete video from the airport surveillance cameras has also been posted (asamonitor.pub/3Rd5rv8).

Application in the OR

For now, if a patient has a cardiac arrest in the OR, the patient should remain supine. The reason is that active compression-decompression CPR and impedance threshold devices are as rare as witch hazel (or hen's teeth) in most hospitals. Without these, elevating the head is likely to drop cardiac output and reduce cerebral blood flow.

In retrospect, it's obvious that elevating the head will improve survival, provided the blood can be pumped uphill. Perhaps it will soon become obvious that hospitals should incorporate these advances to improve survival following cardiac arrest. ■