Ground and Aeromedical Evacuation in the Era of Drone-Based Warfare: What Capabilities Must be on a Transport Litter?

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- The views presented here are the private views of the author(s) and are not to be construed as the official views or policies of the U.S. Department of Defense, or The Geneva Foundation

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- Work involving animals was conducted in compliance with the Animal Welfare Act, the implementing Animal Welfare Regulations, and the principles of the Guide for the Care and Use of Laboratory Animals

- In conducting research using animals, the investigator(s) adhere to the laws of the United States and regulations of the Department of Agriculture

- *Presenter is a co-inventor of the MELS system described in this presentation, but has no financial conflict to disclose*

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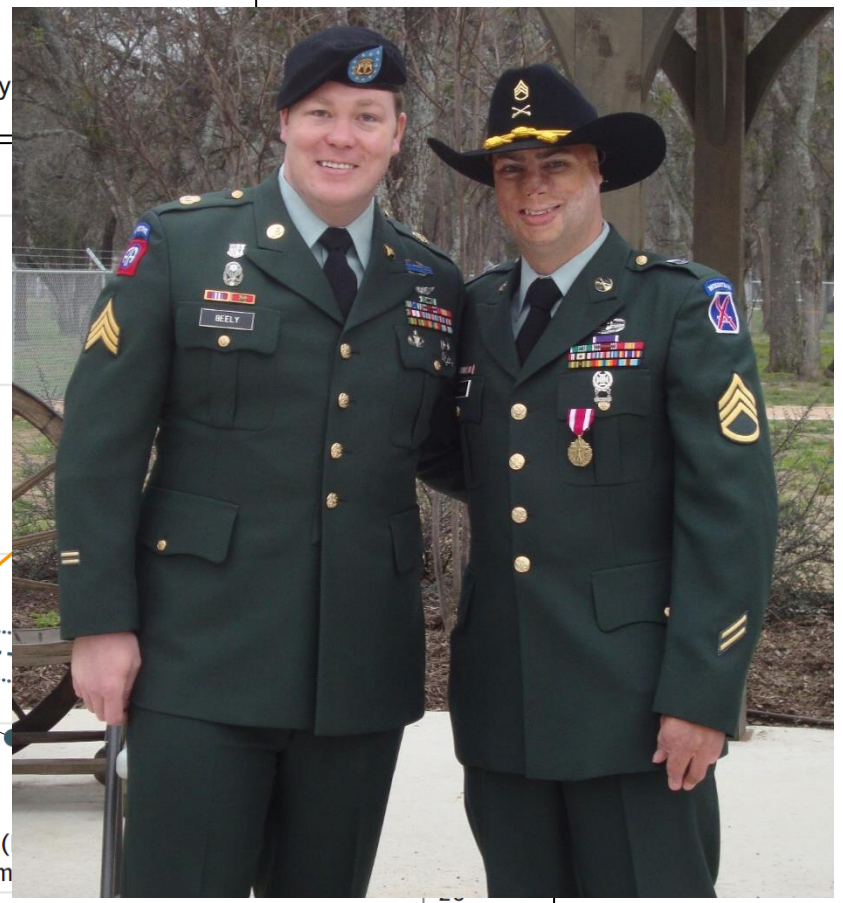
Original Investigation

The Effect of a Golden Hour Policy on the Morbidity and Mortality of Combat Casualties

Conclusions

A 2009 mandate by Secretary of Defense Gates reduced the time between critical injury and definitive care for combat casualties in Afghanistan. Despite evidence of increased severity and complexity of wounds from explosive devices, the combination of reduced prehospital transport time and increased treatment capability are likely contributors of casualty survival.



Kotwal R.S., Howard J.T., Orman J.A., Tarpey B.W., Bailey J.A., Champion H.R., Mabry R.L., Holcomb J.B., Gross K.R. The Effect of a Golden Hour Policy on the Morbidity and Mortality of Combat Casualties. JAMA Surg. 2016;151(1):15–24.

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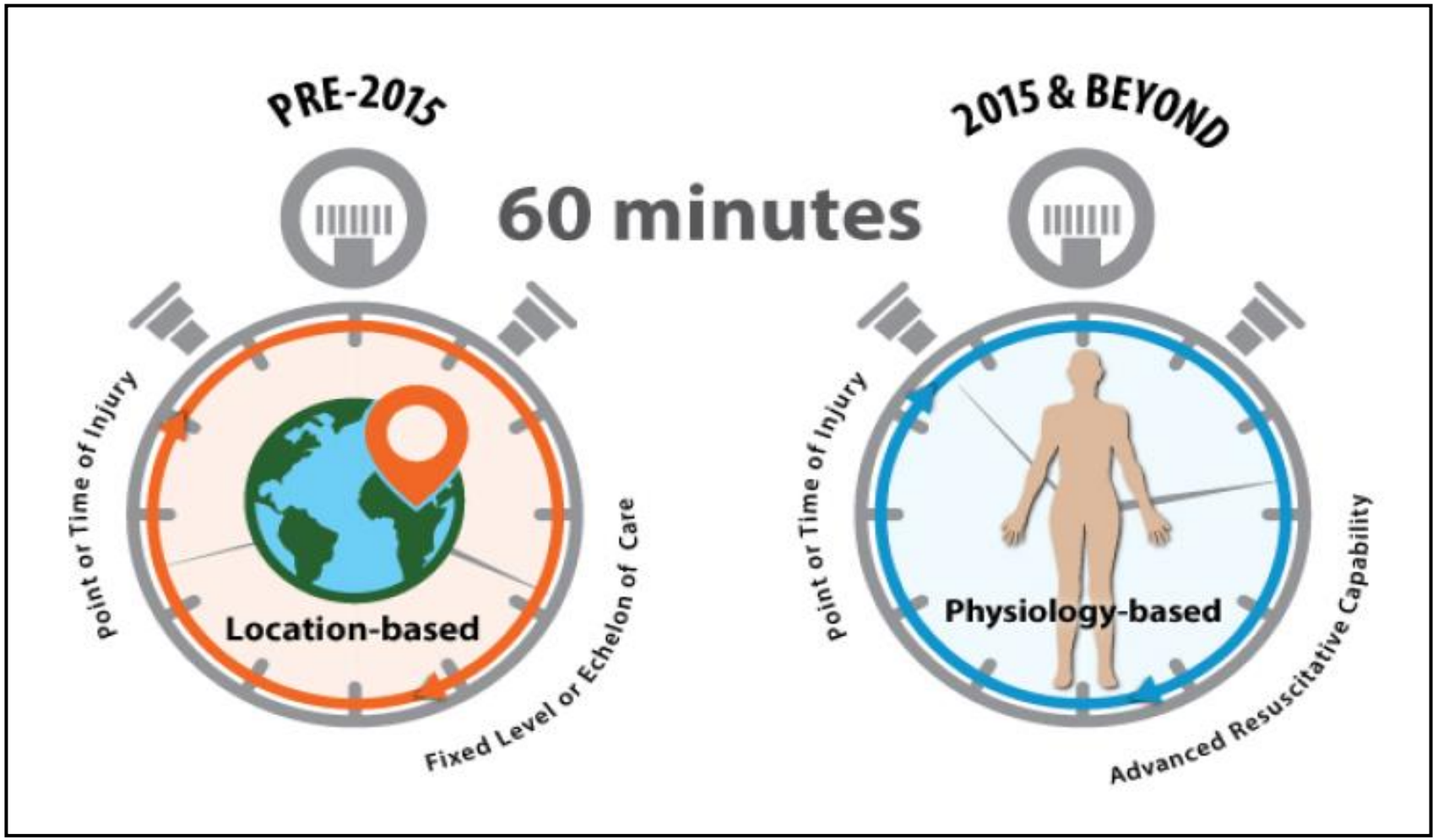
In the 'Golden Hour'

Combat Casualty Care Research drives innovation to improve survivability and reimagine future combat care



Rasmussen TE, Baer DG, Doll BA, JJr C. In the "Golden Hour", Combat Casualty Care Research drives innovation to improve survivability and reimagine future combat care. *Army AL&T Magazine* 2015; January-March: 81-85.

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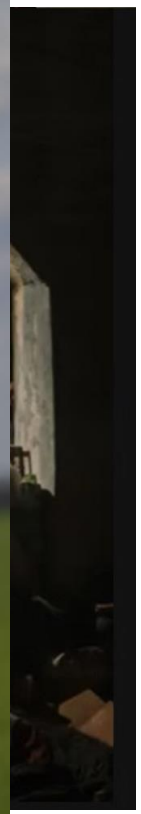
https://mwi.westpoint.edu/the-menace-of-misunderstanding-learning-the-wrong-lessons-from-ukraines-drone-saturated-battlefields/



OEF/OIF data http

TACTICAL COMBAT CASUALTY CARE: TRANSITIONING BATTLEFIELD LESSONS

Table. PFC core capabilities as identified by the Special Operations Medical Association Prolonged Filed Care Working Group

PFC tasks	*Minimum*	*Better*	*Best*
1. Monitor the patient to create a useful vital sign trend	Blood pressure cuff, stethoscope, pulse oximetry, Foley catheter (measure urine output), mental status, and understanding of vital signs interpretation	Add capnometry	Vital signs monitor to provide hands-free vital signs data at regular intervals
2. Resuscitate the patient beyond crystalloid or colloid infusion	Field fresh whole-blood (FWB) transfusion kits	Maintenance crystalloids also prepared for a major burn and/or closed-head injury resuscitation (2 to 3 cases of lactated Ringer's solution or Plasma-Lyte A; hypertonic saline); consider adding lyophilized plasma as available; fluid warmer	Maintain a stock of packed red blood cells and fresh frozen plasma and have type-specific donors identified for immediate FWB draw
3. Ventilate/Oxygenate the patient	Provide positive end-expiratory pressure (PEEP) via bag-valve mask (you cannot ventilate a patient in the PFC setting [prolonged ventilation] without PEEP or they will be at risk of developing acute respiratory distress syndrome)	Provide supplemental oxygen (O_2) via an oxygen concentrator	Portable ventilator (eg, Eagle Impact ventilator, Zoll Medical Corp, http://www.impactinstrumentation.com, or similar) with supplemental O_2
4. Gain definitive control of the patient's airway with an inflated cuff in the trachea (and keep the patient comfortable)	Medic is prepared for a ketamine cricothyrotomy	Add ability to provide long-duration sedation	Add a responsible rapid-sequence intubation capability with subsequent airway maintenance skills, in addition to providing long-term sedation (to include suction and paralysis with adequate sedation)
5. Use sedation/pain control to accomplish the above tasks	Provide opiate analgesics titrated intravenously	Trained to sedate with ketamine (and adjunctive midazolam as needed)	Experienced with and maintains currency in long-term sedation practice using intravenous morphine, ketamine, midazolam, fentanyl, and so forth
6. Use physical examination/diagnostic measures to gain awareness of potential problems	Uses physical examination without advanced diagnostics, maintain awareness of potential unseen injuries (eg, abdominal bleed, head injury)	Trained to use advanced diagnostics such as ultrasound, point-of-care laboratory testing, and so forth	Experienced in both
7. Provide nursing, hygiene, and comfort measures	Ensure the patient is clean, warm, dry, padded, and catheterized and provide basic wound care	Elevate head of bed, debride wounds, perform washouts, wet-to-dry dressings, decompress stomach	Experienced in both
8. Perform advanced surgical interventions	Chest tube, cricothyrotomy	Fasciotomy, wound debridement, amputation, and so forth	Experienced in both
9. Perform telemedicine consult	Make reliable communication, present patient, pass trends of key vital signs	Add laboratory findings and ultrasound images	Video teleconferencing
10. Prepare the patient for flight	Be familiar with physiologic stressors of flight	Trained in critical care transport	Experienced in critical care transport

Minimum–better–best is a planning tool. Differences between levels may reflect medical training or experience or available resources.

Keenan S, Riesberg JC.

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Objective: What should go into drones?

- Objective: Modular, mobile critical care represents a necessary step towards eventual integration of automated and autonomous medical systems for prolonged care in place and unmanned evacuation

- **These systems must be tested and validated in a robust and realistic manner. We describe here our current platform for testing of novel mobile critical care systems in combat relevant, severe translational trauma models and simulated aeromedical evacuation conditions**

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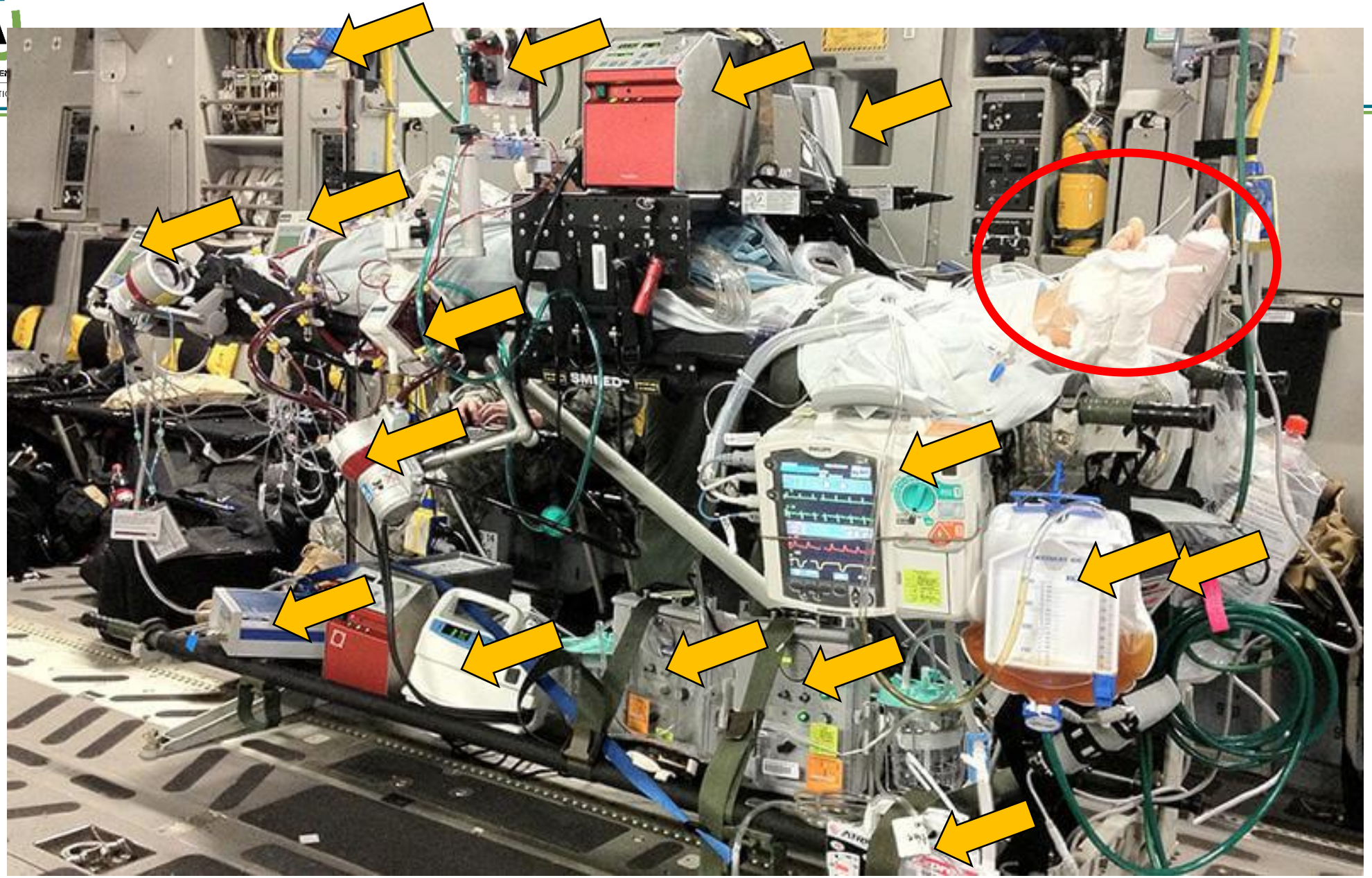
Current CCATT Allowance Standard

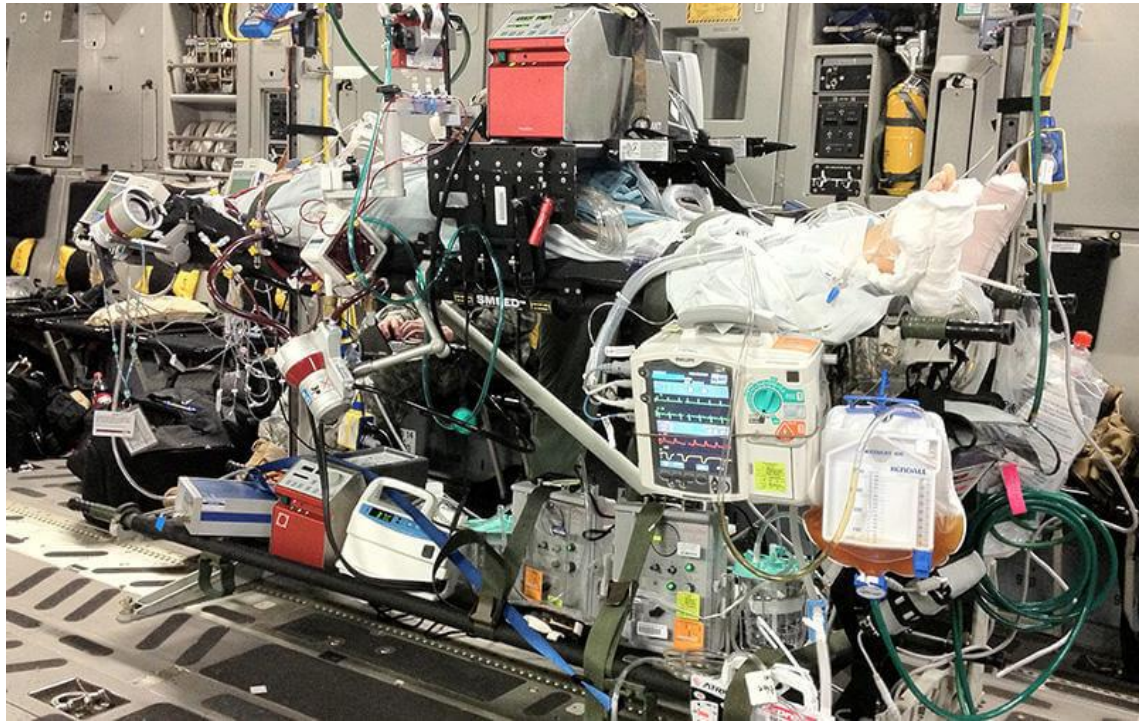
https://commons.wikimedia.org/wiki/File:CCATT_delivers_critical_care_in_the_air_150508-F-LH521-036.jpg

Total: 490#
1 L 3% Saline
1.5 L 0.9% NS
500 mL D5W
4x 100 mL 0.9% NS for drips
Only emergency meds counted

Crit Equip for 1 pt
1 SMEED: 23#
Gear case: 73#
- 1 monitor (± defib)
- 1x vent
- 1x suction
- 2x 3 channel pumps



Provider focus: patient or equipment?



Provider focus: patient or equipment?

ALWAYS FOCUS ON THE PATIENT

THE EQUIPMENT WILL LIE TO YOU

Our Test Setup

- Our team uses a modular, mobile ICU setup that remains with the patient at all times from point of injury until arrival at a definitive care facility

- ~40 kg total (w/o fluids/meds)

- Support for:
  - Ventilator
  - Monitor
  - IV Pumps
  - ICP monitoring
  - Battery powered ECLS
  - Simplified dialysis ability
  - Real-time data/waveform capture and telemetry

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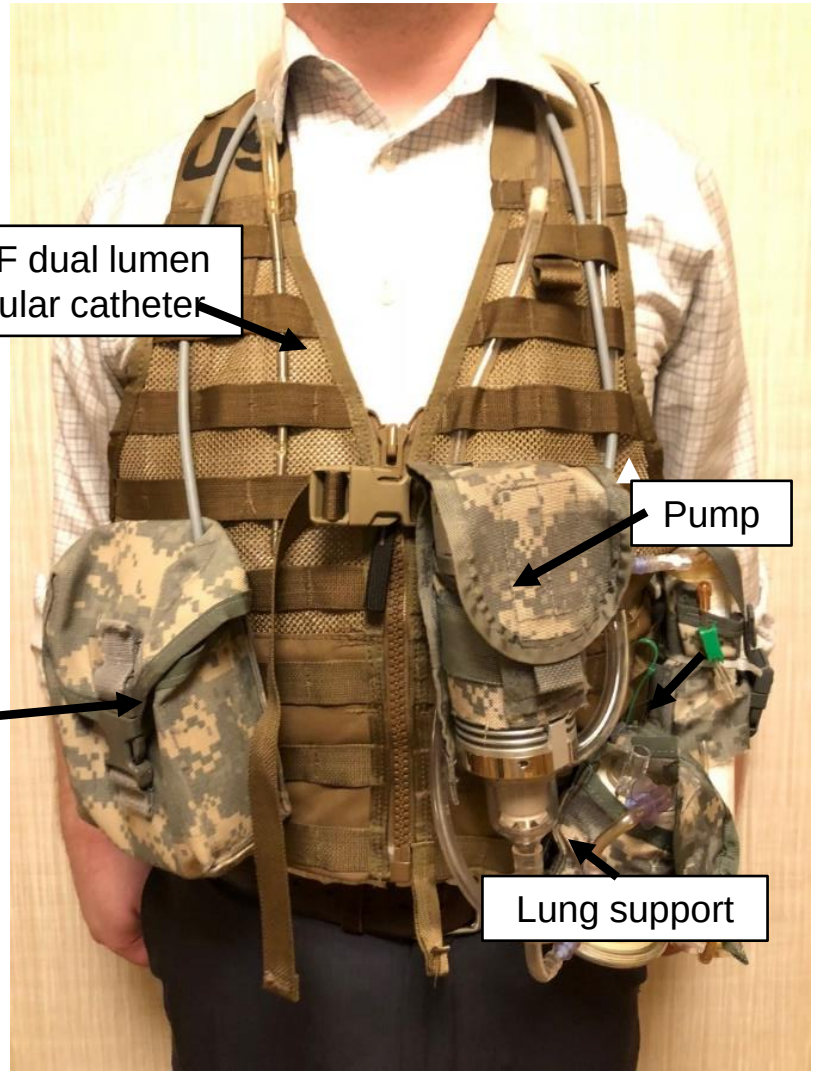
MELS: Multimodal Extracorporeal Life Support



Developed at AREVA

Inventors: Batchinsky, Harea, Wendorff, Beely, Roberts

Patented in US 2023 (US11654225)

To date, also patented in: Ukraine, Russia, India, EU, China, Honk Kong, Israel, Japan

Batchinsky A, Harea G, Wendorff D, Beely B, Roberts T. Wearable Modular Extracorporeal Life Support Device for Mobile Treatment of Single and Multiorgan Failure. US patent US11654225. 2023.

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Testing the MELS in actual flight

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Experimental ECLS circuit tubing during transport

Our Capabilities

- Enables real-world evaluation of novel life-saving interventions
  - Bio sensors (transcutaneous lactate, optical coherence tomography, body cavity samples for electrolytes and injury severity, etc.)
  - Open- and Closed-loop controlled devices
  - Autonomous care solutions
  - Tele-critical care
  - Real time data/waveform capture and decision support

- Suitable for all phases of combat casualty care

- Facilitates testing of aeromedical evacuation with chamber flights at any altitude profile and duration (including prolonged timelines)

- **Real time feedback from frontline medical providers in Ukraine**

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To date…

- > 250 multi-day large animal experiments of single and polytrauma – combinations of smoke inhalation, burn, TBI, pulmonary contusion, hemorrhage, shock, etc., etc.

- >50 chamber flights up to 6 hrs duration, up to 30k ft simulated altitude (including unmanned evac)

Realistic testing is the only way to move the needle

- The nature of war has **already changed**
- The reality of combat casualty care has **already changed**
- We **must** adapt our tools and change our testing to be relevant to what is happening
- The only way to prepare for the next war is to study and apply the lessons learned from the current war

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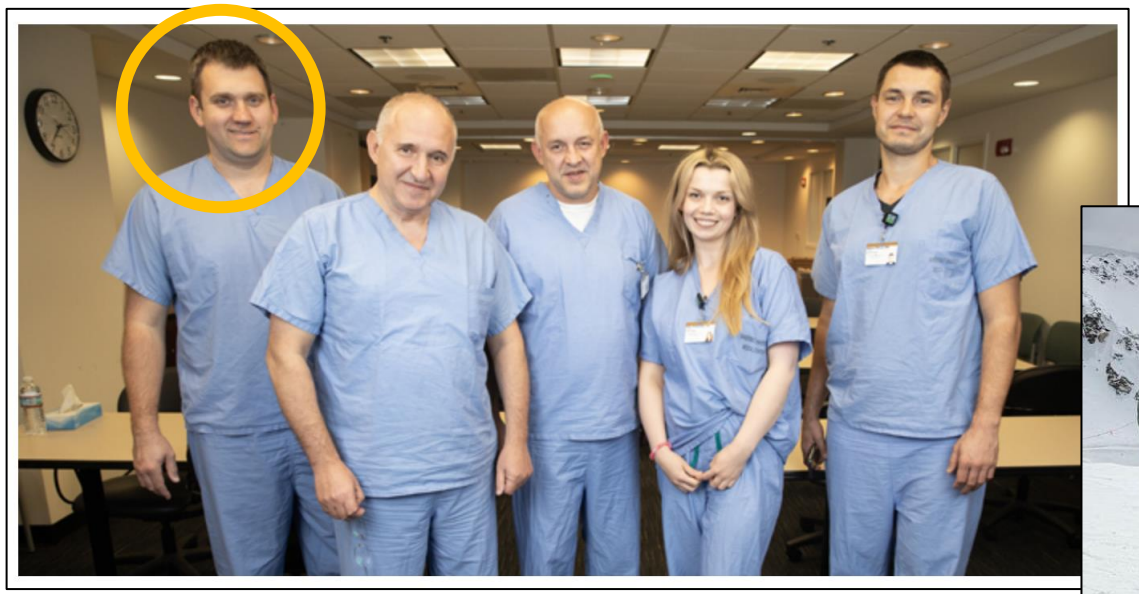

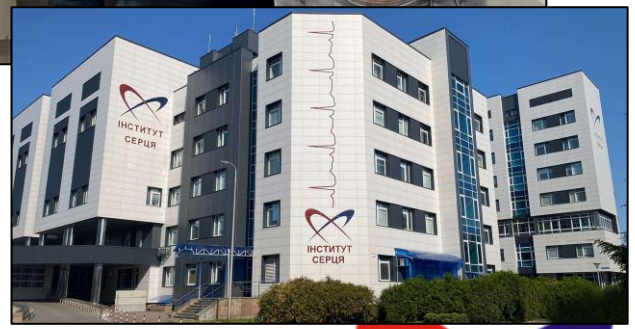

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Thank you for your attention!

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