AUTONOMOUS REANIMATION AND AREVA EVACUATION RESEARCH PROGRAM

THE GENEVA FOUNDATION

HEART INSTITUTE Ministry of Health of Ukraine

Developed in the USA, Implemented in Ukraine: First in Human Successful Use of Battery Operated Portable Extracorporeal Life Support in ARDS

Andriy I. Batchinsky, MD

Founding Director and Senior Scientist, Autonomous Reanimation and Evacuation Research Institute and Innovation Center, The Geneva Foundation, San Antonio, TX; Professor of Surgery and Medicine (Adj.) Uniformed Services University, Bethesda, MD, USA

THE GENEVA FOUNDATION

MHSRS 2026

Kissimmee, Florida

Acknowledgements

Authors: Andriy Batchinsky, MD[1*]; Serhii Sudakevych, MD, PhD[2*]; Igor Kuzmych, MD, PhD[2]; Stepan Maruniak, MD, PhD[2]; Sofiia Chaikovska MD, PhD[2]; Mykola Melnyk, MD, PhD; Daryna Maruniak, MD[2]; George Harea, PhD[1]; Brendan Beely, RRT[1]; Daniel Wendorff, B.S[1]; Lawrence Renna PhD[1]; Yurii Balandiiuk, MD[2];Valeriia Lenda, MD[2]; Kostjantyn Gumeniuk, MD, PhD[3]; Leopoldo Cancio, MD[4]; Borys Todurov, MD, PhD[2]; Teryn Roberts, PhD[1]

Author Affiliations:

[1*]Autonomous Reanimation and Evacuation (AREVA) Research Institute and Innovation Center, San Antonio, TX

[2*] Heart Institute the Ministry of Health of Ukraine, Kyiv, Ukraine

[3]Ukraine Military Medical Forces, Military Medical Academy of Ukraine, Kyiv, Ukraine

[4]US Army Institute of Surgical Research, JBSA Fort Sam Houston, TX

*Denotes co-first authors, Batchinsky for Translational Study and Sudakevych for clinical study.

Disclosures

- 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
- Animal studies presented here have been 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
- Member of scientific advisory board for SeaStar Medical, USA and Entegrion, USA, Fresenius, USA (past)
- Consultant Mission Mobile Medical, USA
- Past President of the International Society for Complex Acute Illness
- Inventor Multimodal Extracorporeal Life Support (MELS)

AUTONOMOUS REANIMATION AND

ARI

EVACUATION

THE GENEVA

Original Investigation

Kotwal R.S., nbat
Casualties. JAMA Surg. 2016;151(1):15–24.

AUTONOMOUS REANIMATION AND
AREVA
EVACUATION RESEARCH PROGRAM
THE GENEVA FOUNDATION

In the Military Setting:

World-wide conflicts with near peer adversaries; increasing weapon lethality and wars in high density urban setting ~~will~~ require significant intensive care capabilities

What kind of capabilities?

AUTONOMOUS REANIMATION AND AREVA EVACUATION RESEARCH PROGRAM

THE GENEVA FOUNDATION

Extracorporeal organ support following trauma: The dawn of a new era in combat casualty critical care

Lucas P. Neff, MD, Jeremy W. Cannon, MD, Ian J. Stewart, MD, Andriy I. Batchinsky, MD, David H. Zonies, MD, MPH, Jeremy C. Pamplin, MD, *and* **Kevin K. Chung, MD,** *San Antonio, Texas*

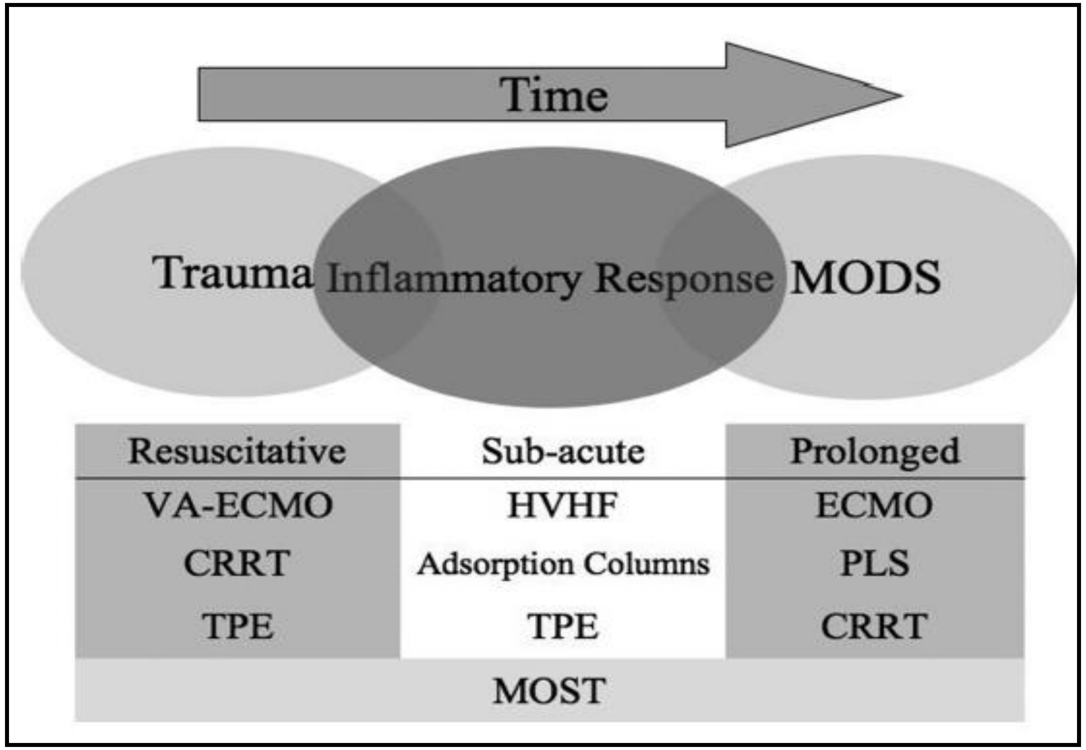
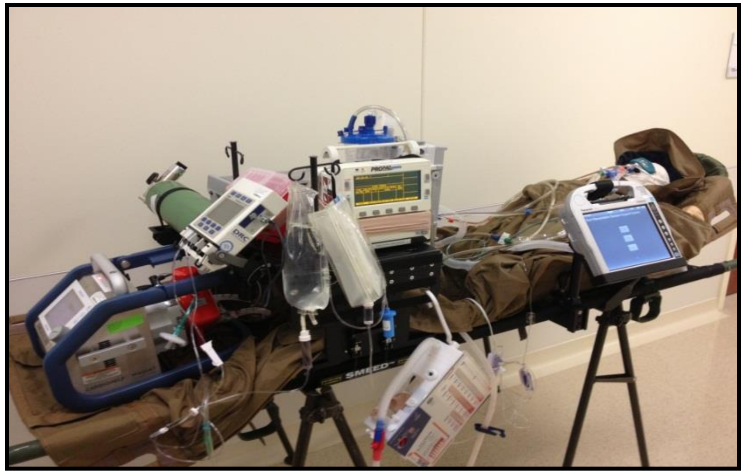
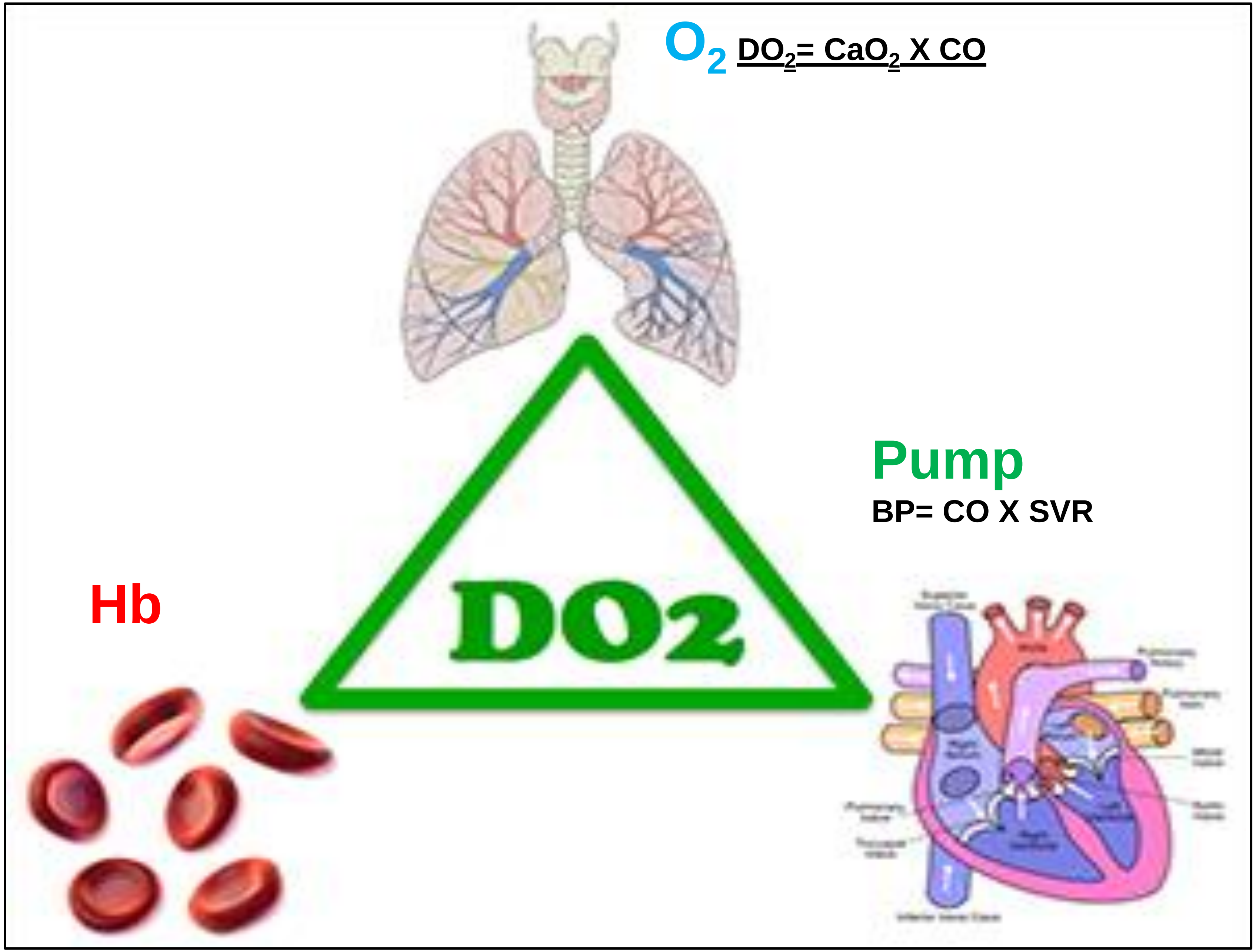


Figure 2. Foreground: ECMO unit in deployed environment (Bagram Air Base).



Neff, L.P., et al., *Extracorporeal organ support following trauma: the dawn of a new era in combat casualty critical care.* J Trauma Acute Care Surg, 2013. **75**(2 Suppl 2): p. S120-8; discussion S128-9.

Physiology of Survival: or what core capabilities should we target?



AUTONOMOUS REANIMATION AND
AREVA
EVACUATION RESEARCH PROGRAM
THE GENEVA FOUNDATION

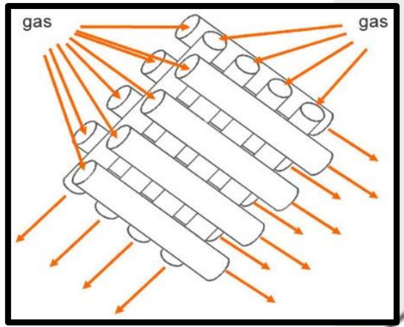
Table. PFC core capabilities as identified by the Special Operations Medical Association Prolonged Filed Care Working Group

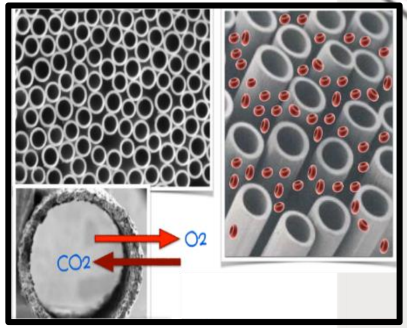
PFC tasks	*Minimum*	*Better*	*Best*
1. Monitor the patient to create a useful vital sign trend	Blood pressure cuff, stethoscope, pulse oximetry, Foley catheter (measure urine output), mental status, and understanding of vital signs interpretation	Add capnometry	Vital signs monitor to provide hands-free 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 PlasmaLyte 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 communications, present patient, pass trends of key vital signs	Add laboratory findings and ultrasound images	Video teleconference
10. Prepare the patient for flight	Be familiar with physiologic stressors of flight	Trained in critical care transport	Experienced in critical care transport

S138

Keenan and R

Keenan, S. and J.C. Riesbe





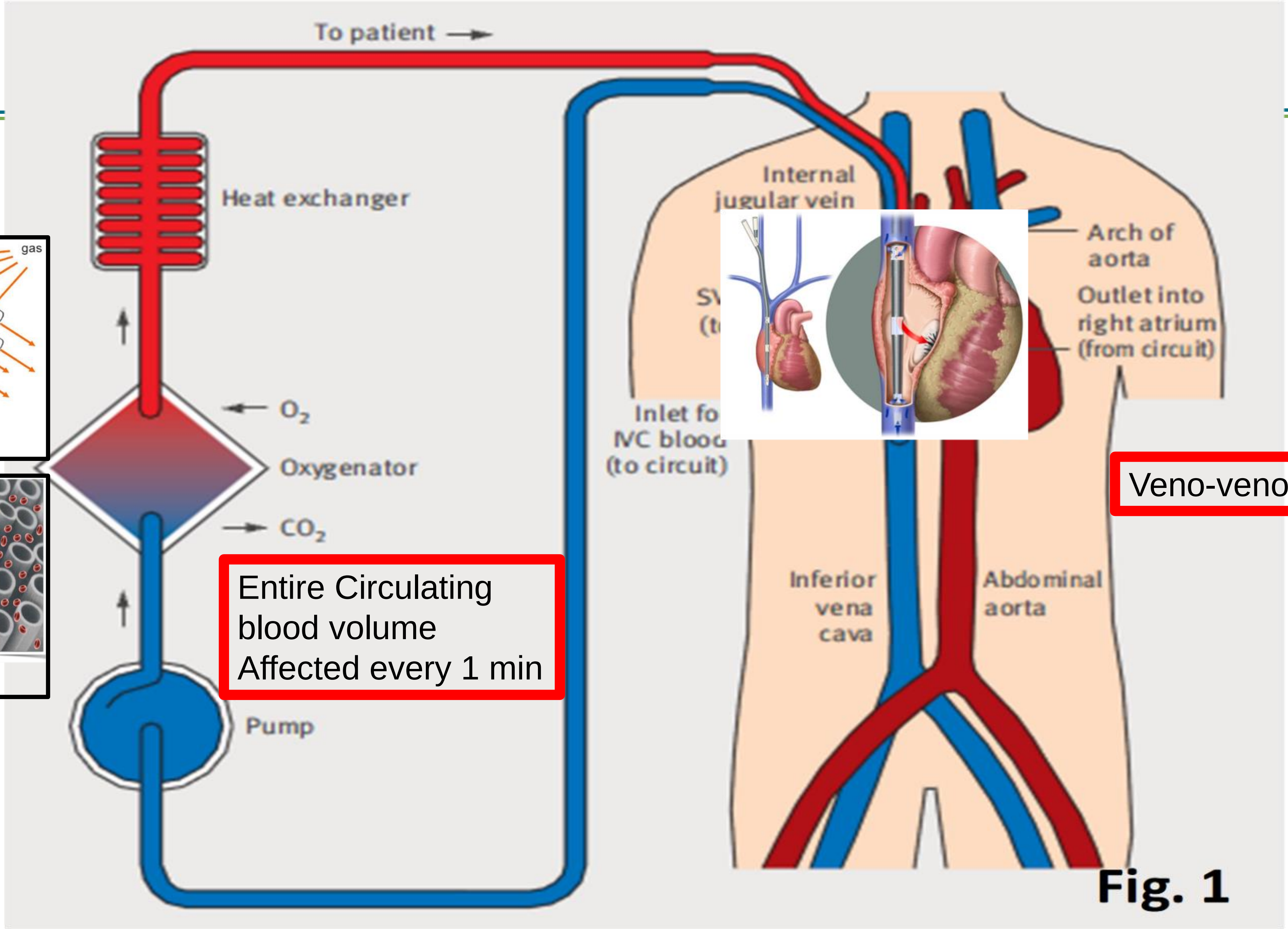


Fig. 1

Entire Circulating blood volume Affected every 1 min

Veno-venous configuration

Gaffney *et al.*. Extracorporeal life support. *BMJ.* 2010;341:c5317

AUTONOMOUS REANIMATION AND EVACUATION RESEARCH PROGRAM
THE GENEVA FOUNDATION

Venovenous extracorporeal life support improves survival in adult trauma patients with acute hypoxemic respiratory failure: A multicenter retrospective cohort study

Derek M. Guirand, MD, Obi T. Okoye, MD, Benjamin S. Schmidt, MD, Nicky J. Mansfield, BS, James K. Aden, PhD, R. Shayn Martin, MD, Ramon F. Cestero, MD, Michael H. Hines, MD, Thomas Pranikoff, MD, Kenji Inaba, MD, *and* Jeremy W. Cannon, MD, *San Antonio, Texas*

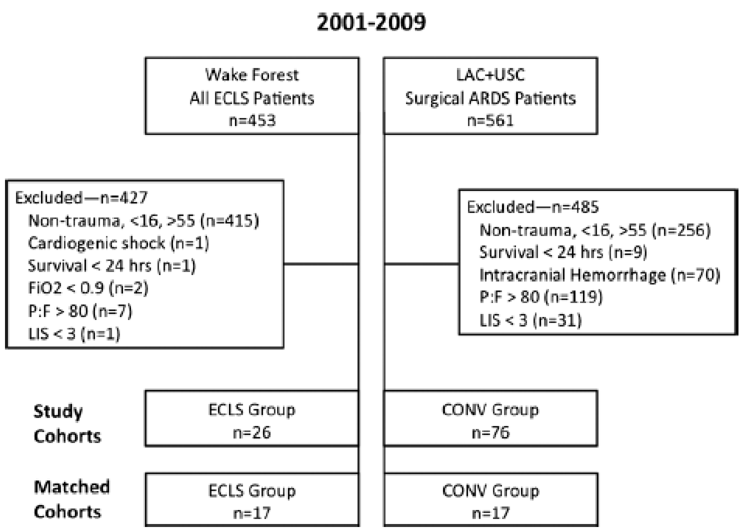


Figure 1. Study population demonstrating the application of exclusion criteria resulting in the final study cohorts and the matched cohorts.

TABLE 2. Mortality Analysis

	AOR (95% CI)	*p*
Full cohorts		
ECLS	0.193 (0.042–0.884)	0.034
Chest AIS	0.693 (0.496–0.967)	0.031
ISS	1.112 (1.056–1.171)	<0.001
Pre-ECLS fluid balance	1.156 (1.022–1.309)	0.022
LIS	10.939 (1.805–66.305)	0.009
Matched cohorts		
ECLS	0.038 (0.004–0.407)	0.007
ISS	1.123 (1.029–1.226)	0.009

Multivariate logistic regression with backwards elimination was used to determine factors independently associated with survival and mortality. A value less than 1 indicates an independent survival advantage, whereas a value more than 1 indicates an independent predictor of mortality. Variables included in the original model included ECLS, age, and any demographic, therapeutic, or complication variable with a $p \leq 0.02$ on univariate analysis comparing treatments (ECLS vs. CONV) or survival: ECLS, age, chest AIS score, ISS, base excess < −6, Pre-ECLS fluid balance, days from injury to ECLS criteria met, Pao_2/FIO_2, LIS, open abdomen, any RRT, any hemorrhagic complication, and any pulmonary complication.

AOR, adjusted odds ratio; CI, confidence interval.

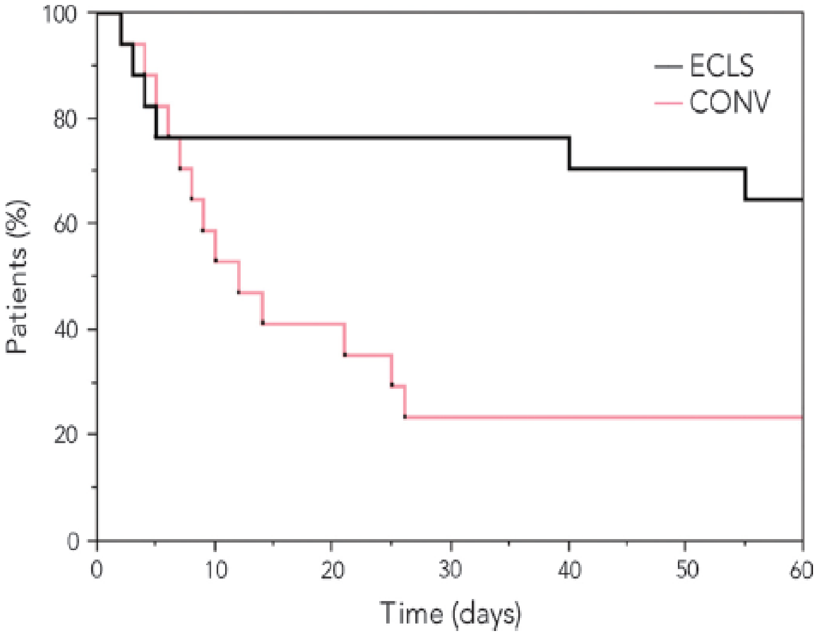


Figure 2. Kaplan-Meier survival curve for the cohorts of ECLS versus CONV patients matched for age and Pao_2/FIO_2 carried out to 60 days. Patients were censored at death or hospital discharge. Survival in the ECLS versus CONV matched cohorts was 64.7% versus 23.5% ($p = 0.01$).

Guirand et al., J Trauma Acute Care Surg, 2014

AUTONOMOUS REANIMATION AND

AREVA

EVACUATION RESEARCH PROGRAM

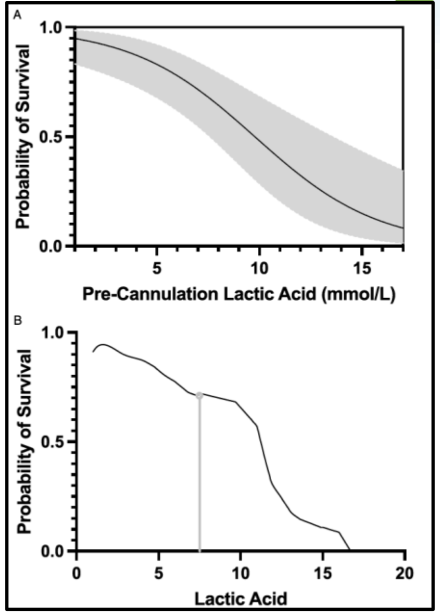
THE GENEVA FOUNDATION

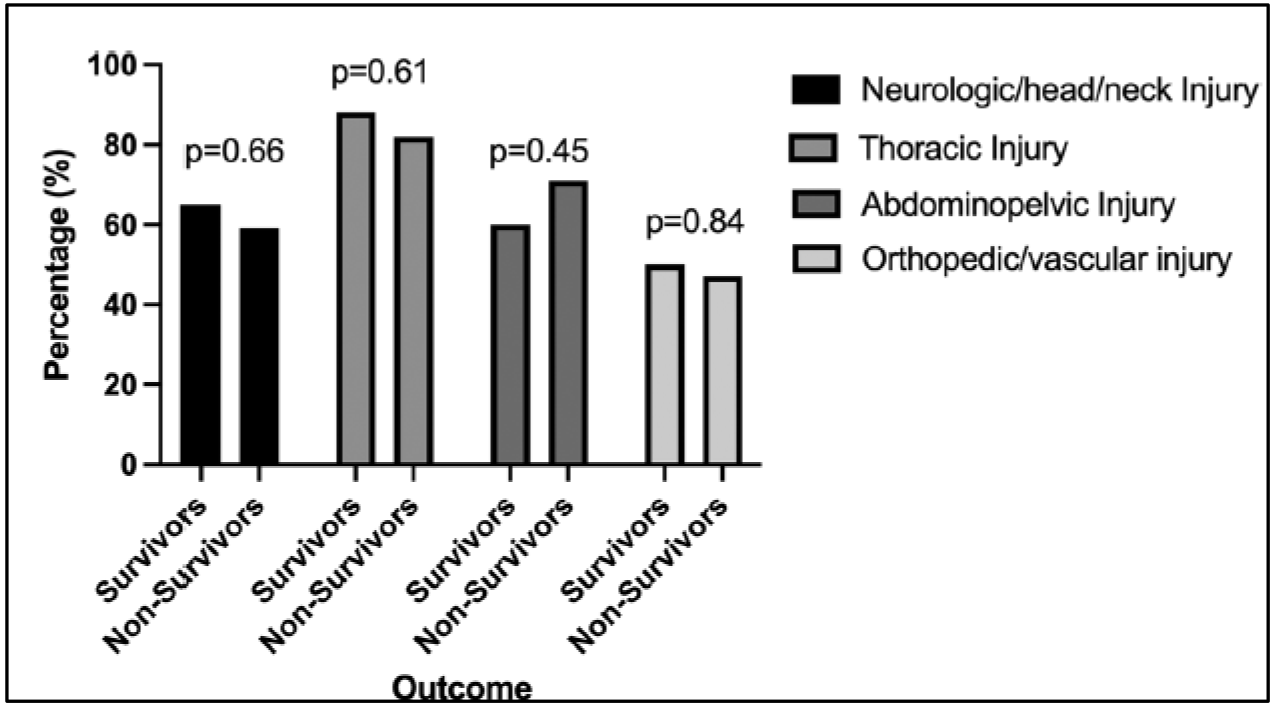
Early veno-venous extracorporeal membrane oxygenation is an effective strategy for traumatically injured patients presenting with refractory respiratory failure

Elizabeth K. Powell, MD, Tyler S. Reynolds, MD, James K. Webb, CRNA, Rishi Kundi, MD, Jody Cantu, PhD, Meaghan Keville, MD, James V. O'Connor, MD, Deborah M. Stein, MD, MPH, Matthew P. Hanson, MD, FAAP, CPE, Bradley S. Taylor, MD, Thomas M. Scalea, MD, *and* Samuel M. Galvagno, Jr, DO, PhD, MS, FCCM, *Baltimore, Maryland*

RESULTS: Seventy-five patients were identified and 57 (76%) underwent EVV. There was no difference in survival between the EVV and non-EVV groups (70% vs. 61%, $p = 0.47$). Age, race, and gender did not differ between EVV survivors and nonsurvivors. Time to cannulation (4.5 hours vs. 8 hours, $p = 0.39$) and injury severity scores (34 vs. 29, $p = 0.74$) were similar. Early VV survivors had lower lactic acid levels precannulation (3.9 mmol/L vs. 11.9 mmol/L, $p < 0.001$). A multivariable logistic regression analysis examining admission and precannulation laboratory and hemodynamic values demonstrated that lower precannulation lactic acid levels predicted survival (odds ratio, 1.2; 95% confidence interval, 1.02–1.5; $p = 0.03$), with a significant inflection point of 7.4 mmol/L corresponding to decreased survival at hospital discharge.

CONCLUSION: Patients undergoing EVV did not have increased mortality compared with the overall trauma VV ECMO population. Early VV resulted in ventilatory stabilization that allowed subsequent procedural treatment of injuries. (*J Trauma Acute Care Surg.*





Lactic Acidosis
And metabolic management is key

Mobile, Deployable, Critical Care Support Solutions: the wish list

1. Compact Consolidated Comprehensive Reanimation Platform

2. Can be initiated by medics at point of injury

3. Support respiration, cardiovascular function, administration of blood, fluids, medications, inline monitoring, rapid rewarming and metabolic support

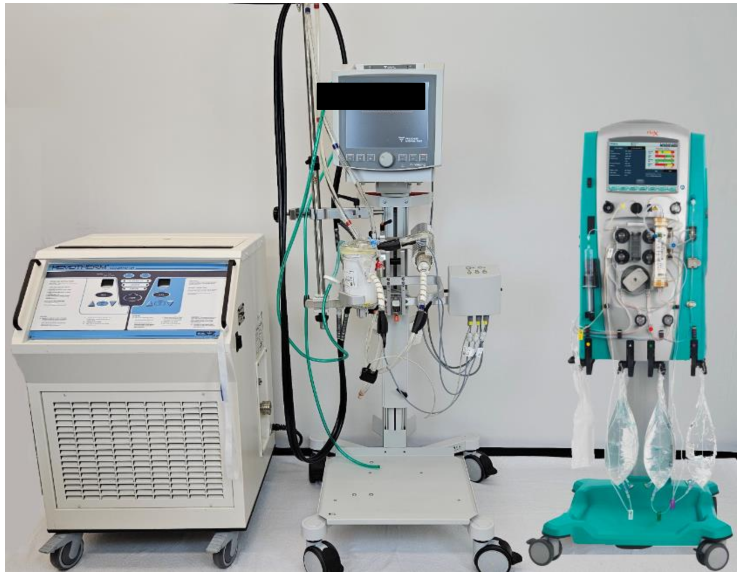
4. Low weight and cube, fitting into NATO litter or wearable

5. Able to stay in place, travel with patient and support during unmanned evacuation by drones

6. Symptomatic care in place for surviving casualties based on closed loop control and self adjusting features

7. Low power demands and using oxygen regeneration

Standard of care, multiple devices vs. MELS



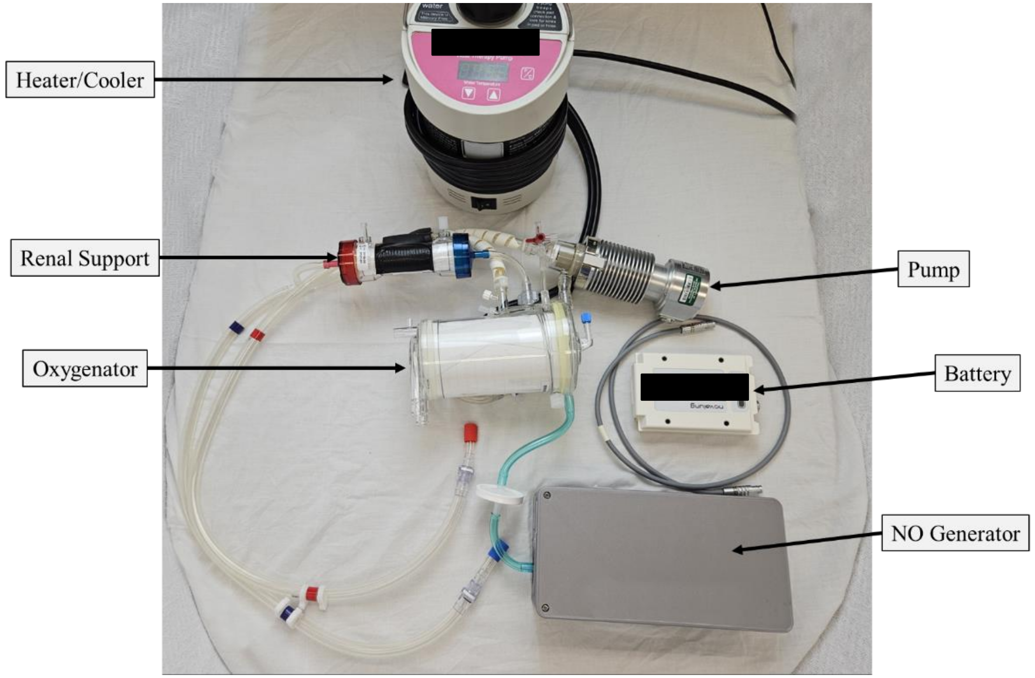


Diagram showing standard of care lung and renal support with heating and cooling capabilities vs. MELS.
Left upper of diagram shows heater cooler device (left), Stationary ECMO Console and ECMO set up (middle) and dialysis machine (right) which are commonly used in ICUs.
Left lower: currently in use ECMO system with heater and cooler connected but not visible. Source (Twitter, 18 April 2023.
Right: MELS components in expeditionary configuration. Can be packaged in a case, or placed on bed as is

Wearable Modular Multifunctional Extracorporeal Life Support : Heparin Free Lung, heart, renal support, infection eradication

AUTONOMOUS REANIMATION AND EVACUATION RESEARCH PROGRAM (AREVA)

THE GENEVA FOUNDATION

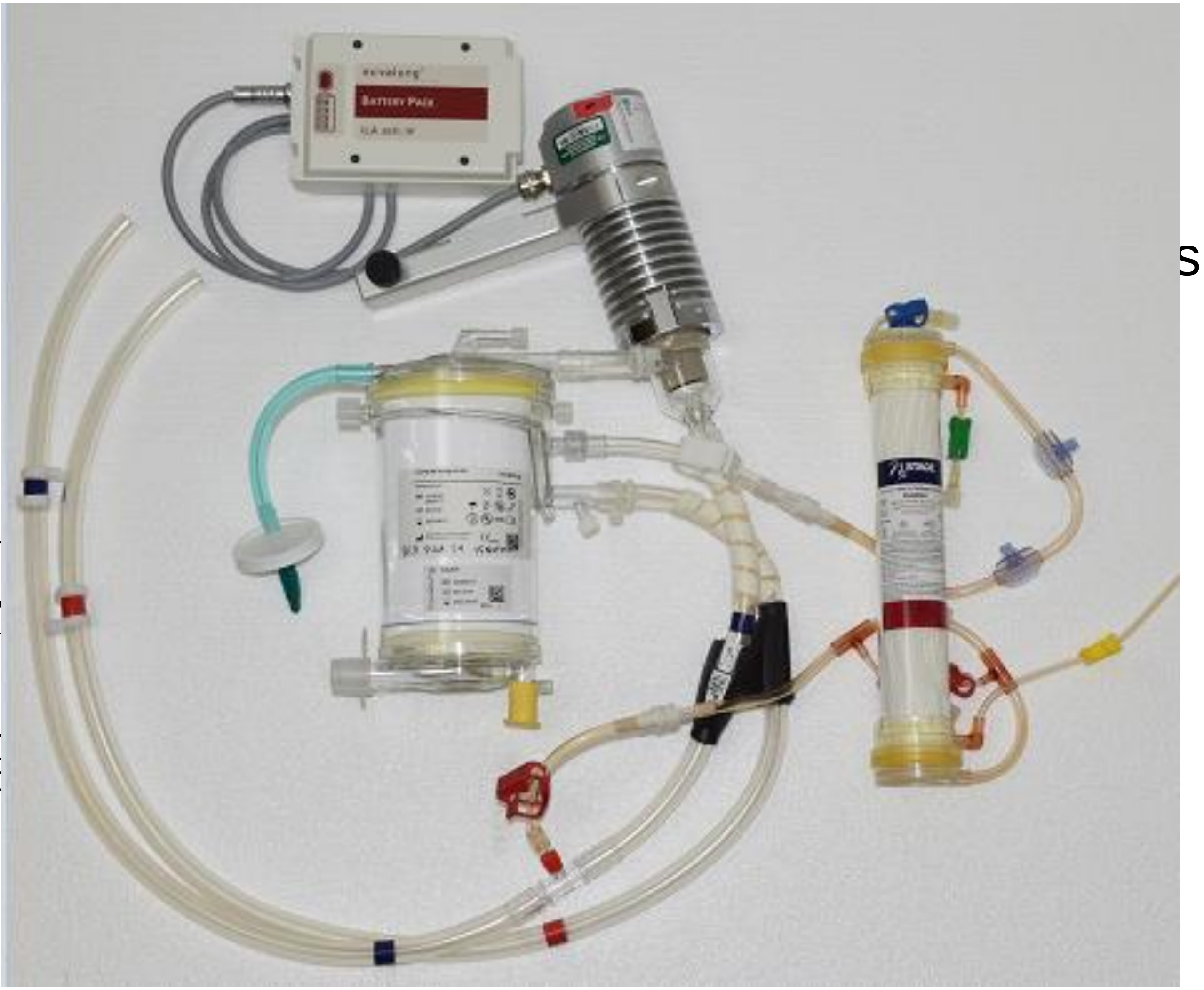
18 F dual lumen jugular catheter

Pump

Kidney supp
FDA approv

Battery, 8 hrs, swappable

Lung Suppo



s:

Batchinsky A, Harea G, Roberts T, Wendorff D, Beely B
US Patent No. 11654225
Patent pending in EU, Japan, Korea, Ukraine

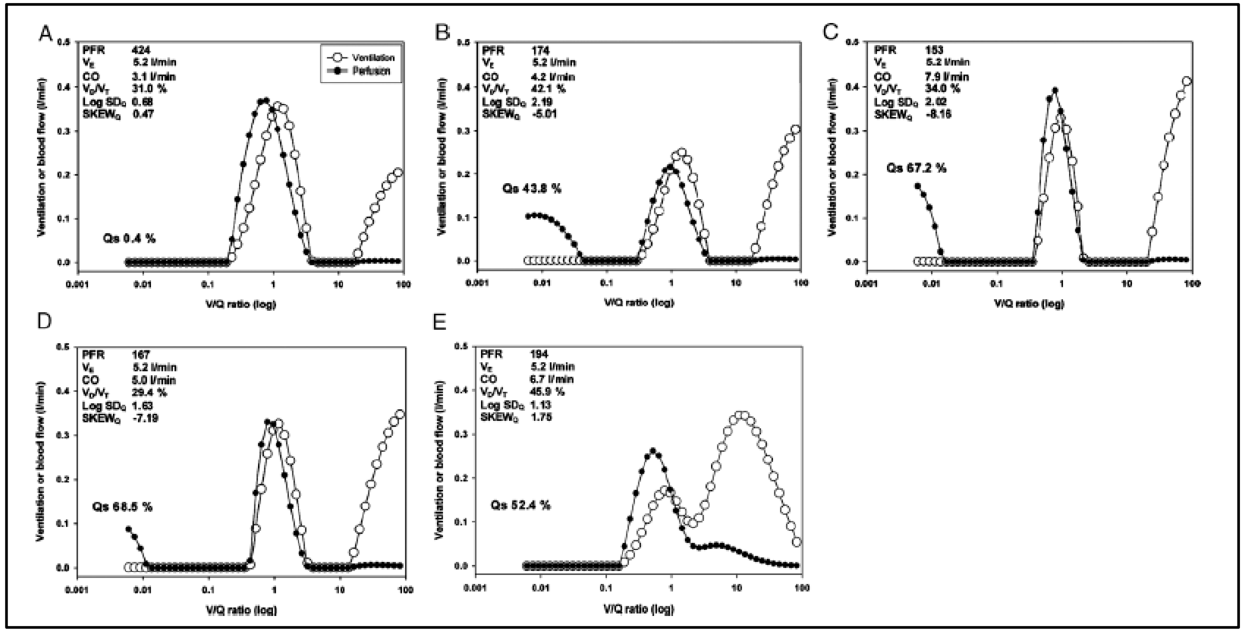
Email: abatchinsky@genevausa.org

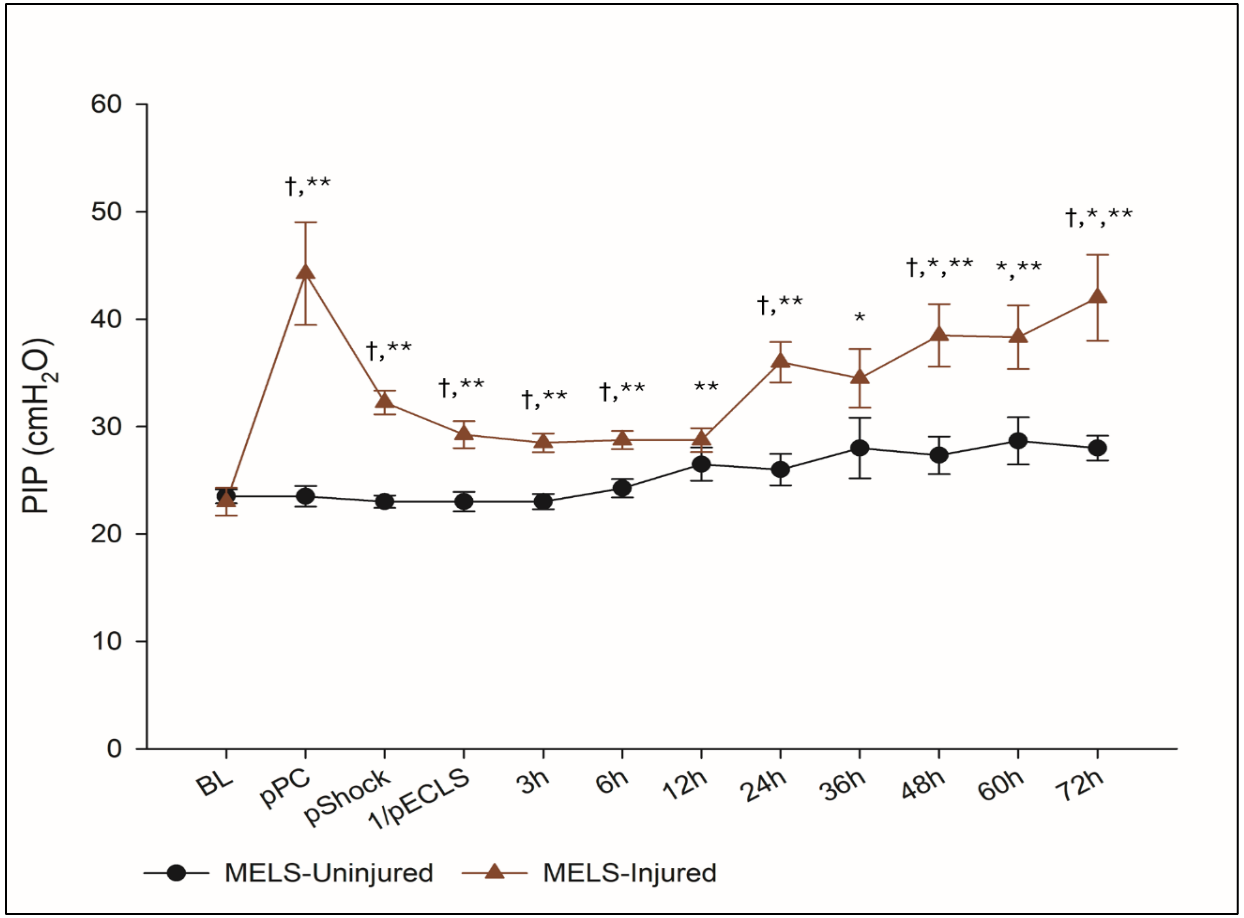
MELS Pilot Study: Severe Trauma Model

DYNAMIC CHANGES IN SHUNT AND VENTILATION-PERFUSION MISMATCH FOLLOWING EXPERIMENTAL PULMONARY CONTUSION

Andriy I. Batchinsky, Bryan S. Jordan, Corina Necsoiu, Michael A. Dubick, and Leopoldo C. Cancio

US Army Institute of Surgical Research, 3400 Rawley E. Chambers Avenue, Building 3611, Fort Sam Houston, Texas

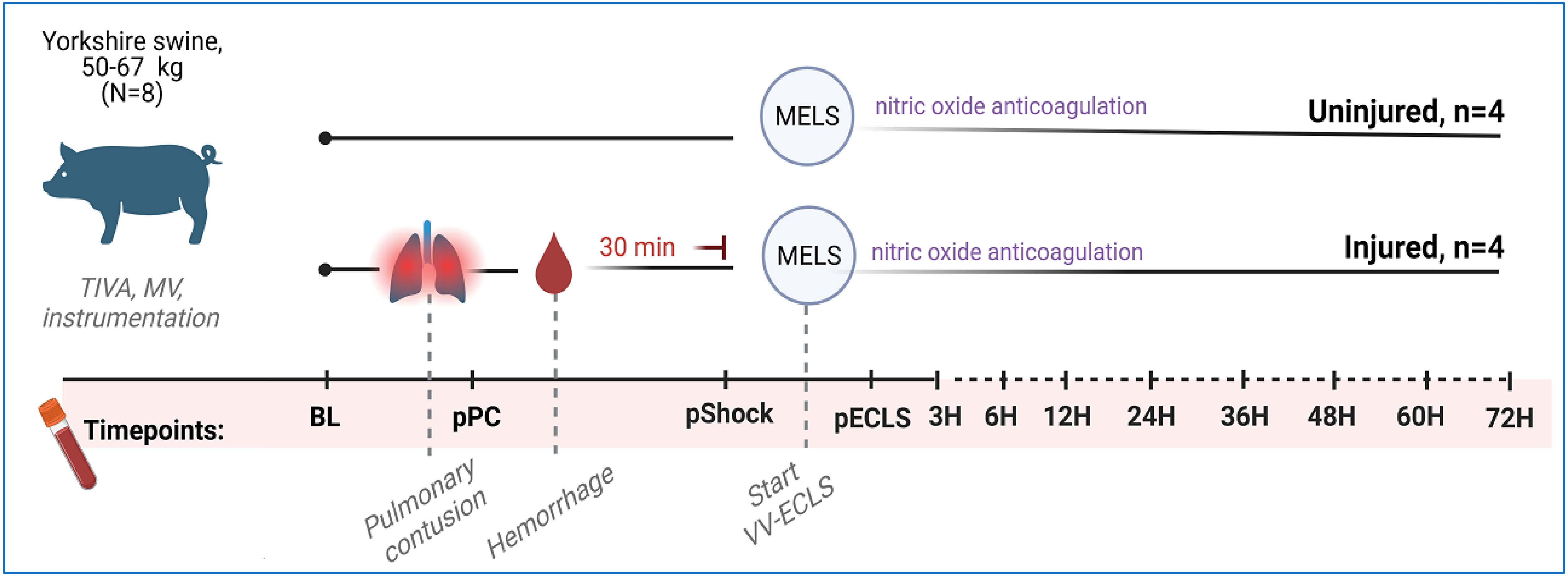




Peak inspiratory pressure levels measured over eight large animal experiments (MELS Uninjured n=4, MELS Injured n=4). Timepoints matched across groups; uninjured animals had sham injury timepoints as listed. BL: Baseline; pPC: post-pulmonary contusion; pShock: post-shock period; pECLS: post-ECLS application. Data shown as mean ± standard error; †significant difference between groups, *significant difference to BL timepoint for uninjured group, **significant difference to BL timepoint for injured group, $p<0.05$.

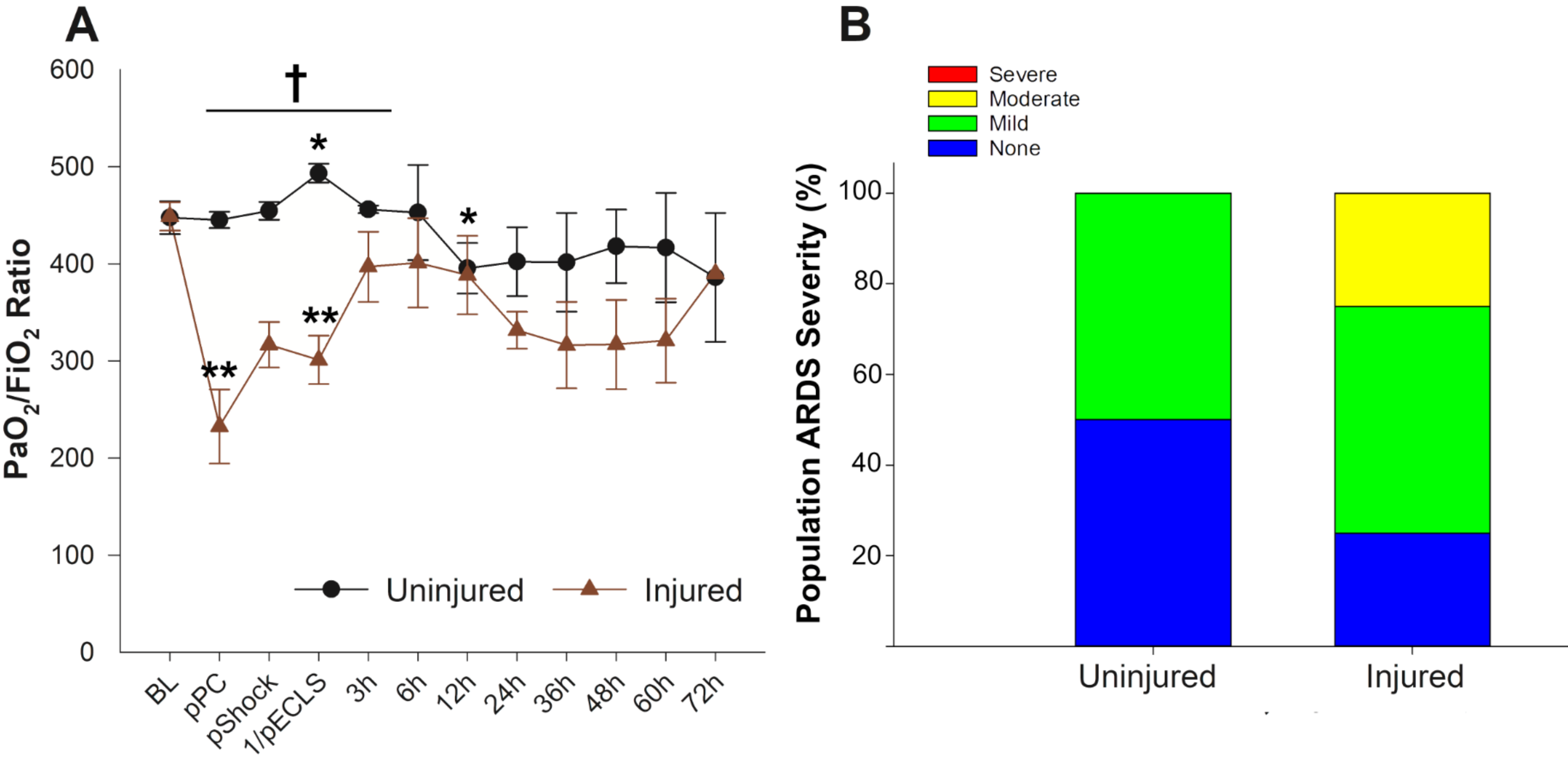
Batchinsky et al., Shock, 2010, Batchinsky et al., JAP, 2007

Heparin-free 72hr MELS Used In Severe Trauma



Batchinsky et al., 2025, Unpublished do not disseminate

MELS Reduces Injury Severity and Ventilator Settings

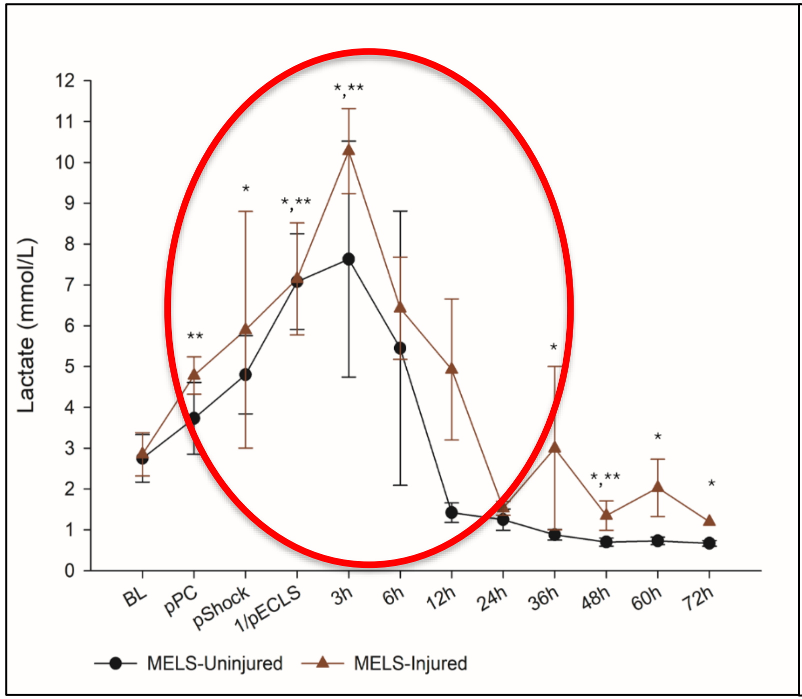


Batchinsky et al., 2025, Unpublished

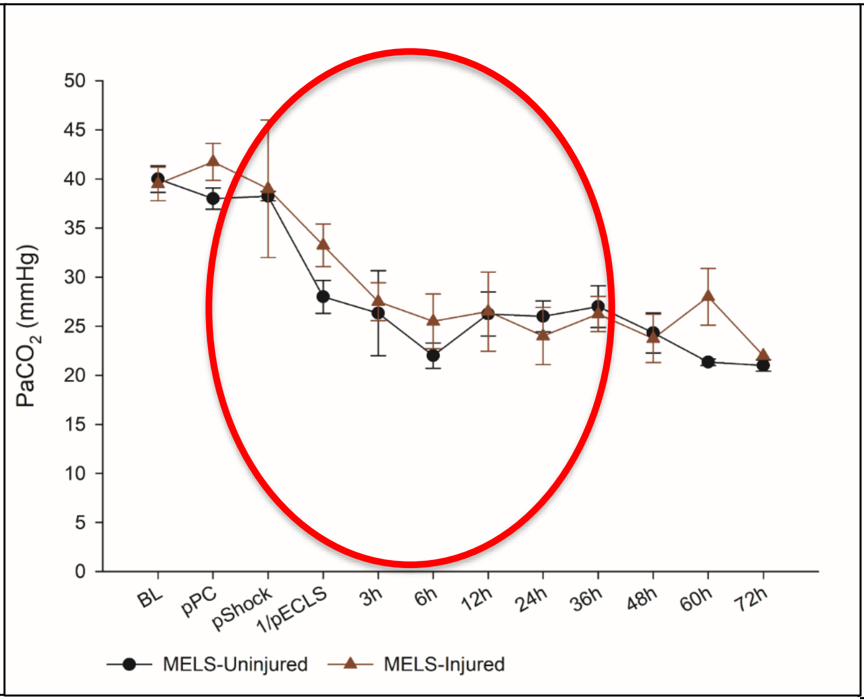
AUTONOMOUS REANIMATION AND EVACUATION RESEARCH PROGRAM (AREVA)

THE GENEVA FOUNDATION

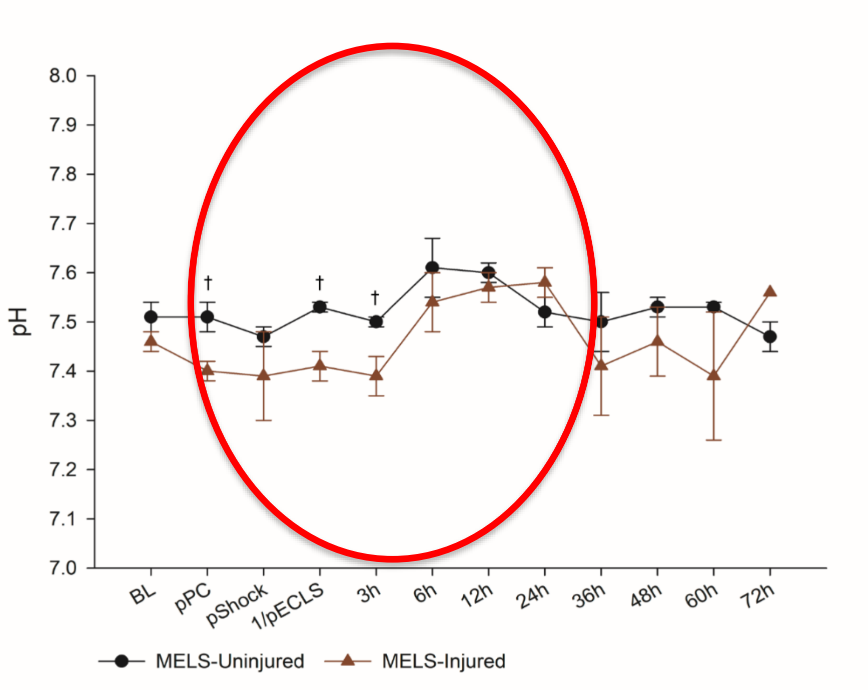
MELS in Trauma: Lactic acidosis, yet Hypocarbia and… *Metabolic Alkalosis…*



Arterial lactate levels measured over eight large animal experiments (MELS Uninjured n=4, MELS Injured n=4). Timepoints matched across groups; uninjured animals had sham injury timepoints as listed. BL: Baseline; pPC: post-pulmonary contusion; pShock: post-shock period; pECLS: post-ECLS application. Data shown as mean ± standard error; *significant difference to BL timepoint for uninjured group**significant difference to BL timepoint for injured group, $p<0.05$.



Systemic arterial carbon dioxide levels measured over eight large animal experiments (MELS Uninjured n=4, MELS Injured n=4). Timepoints matched across groups; uninjured animals had sham injury timepoints as listed. BL: Baseline; pPC: post-pulmonary contusion; pShock: post-shock period; pECLS: post-ECLS application. Data shown as mean ± standard error.



Arterial pH levels measured over eight large animal experiments (MELS Uninjured n=4, MELS Injured n=4). Timepoints matched across groups; uninjured animals had sham injury timepoints as listed. BL: Baseline; pPC: post-pulmonary contusion; pShock: post-shock period; pECLS: post-ECLS application. Data shown as mean ± standard error; †significant difference between groups, $p<0.05$.

MELS in Trauma: Heparin Free and yet clean Oxygenators after 72 hours

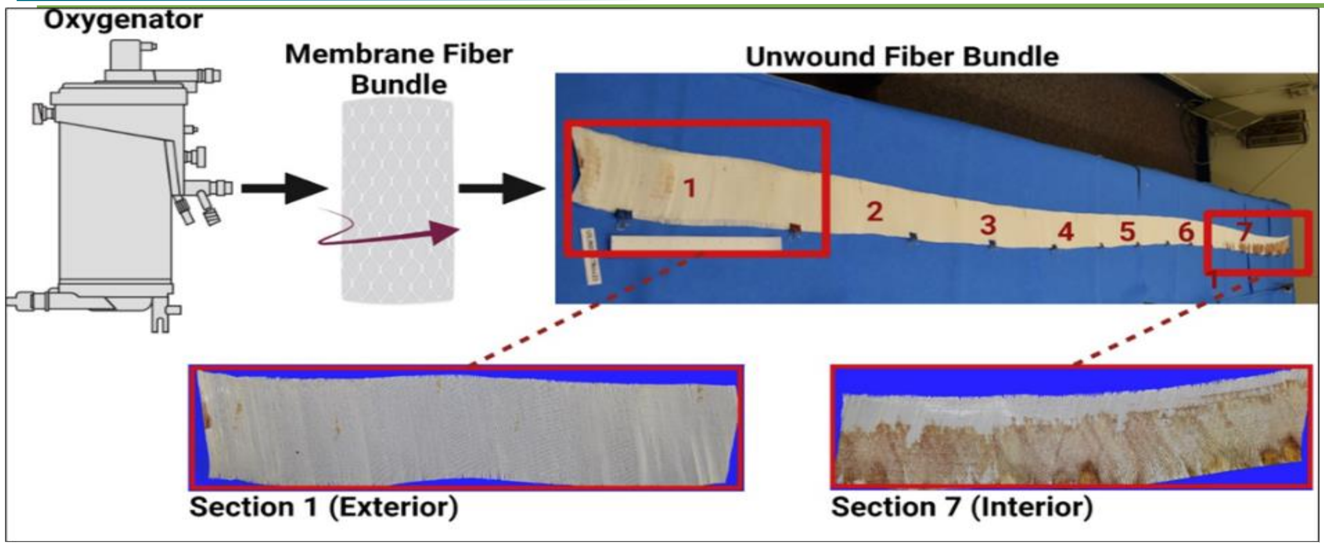
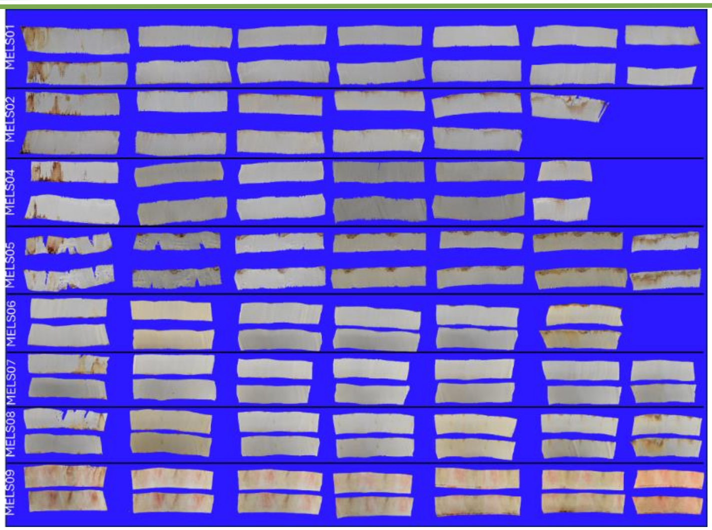
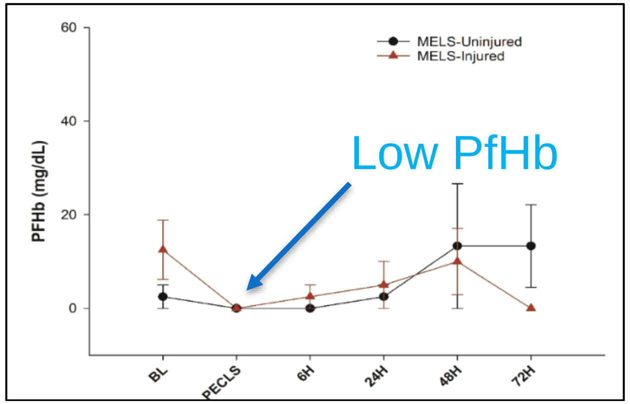


Figure showing disassembly steps. The oxygenator is dissected open, the membrane spool removed and unwound, then cut into 50 cm length sections. These sections are then separated into inner and outer layers and photographed. Those photographs are analyzed by blinded reviewers to assess thrombus deposition percent coverage.



Consolidated images of membrane fiber spools after disassembling and segmenting



Mean ± Std. Err plasma free hemoglobin (PFHb) for swine placed on extracorporeal support using MELS in either a non-injury model (n=4, MELS-Uninjured), or a pulmonary contusion polytrauma model (n=4, MELS-Injured). *Indicates significant change from baseline (BL) in MELS-Uninjured group. **Indicates significant change from BL in MELS-Injured group. †Indicates significant difference between groups.

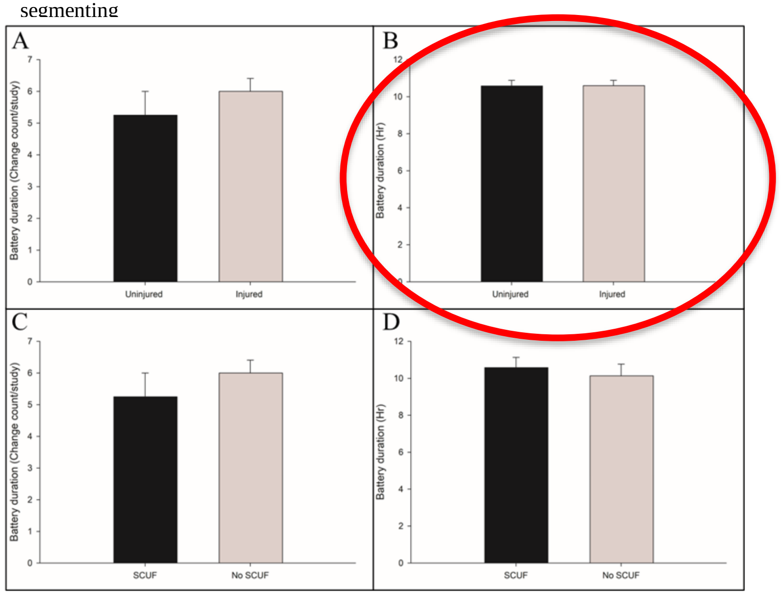


Figure 26. Battery usage data for the MELS system when used in either a non-injury model (n=4, Uninjured), or a pulmonary contusion polytrauma model (n=4, Injured). A) number of battery changes required comparing injured to uninjured swine ; B) duration of time between battery changes when comparing injured to uninjured swine; C) number of battery changes required when comparing swine requiring SCUF support to those that did not require SCUF support; D)duration of time between battery changes when comparing swine requiring SCUF support to those that did not require SCUF support.

Batchinsky et al., 2025, Unpublished

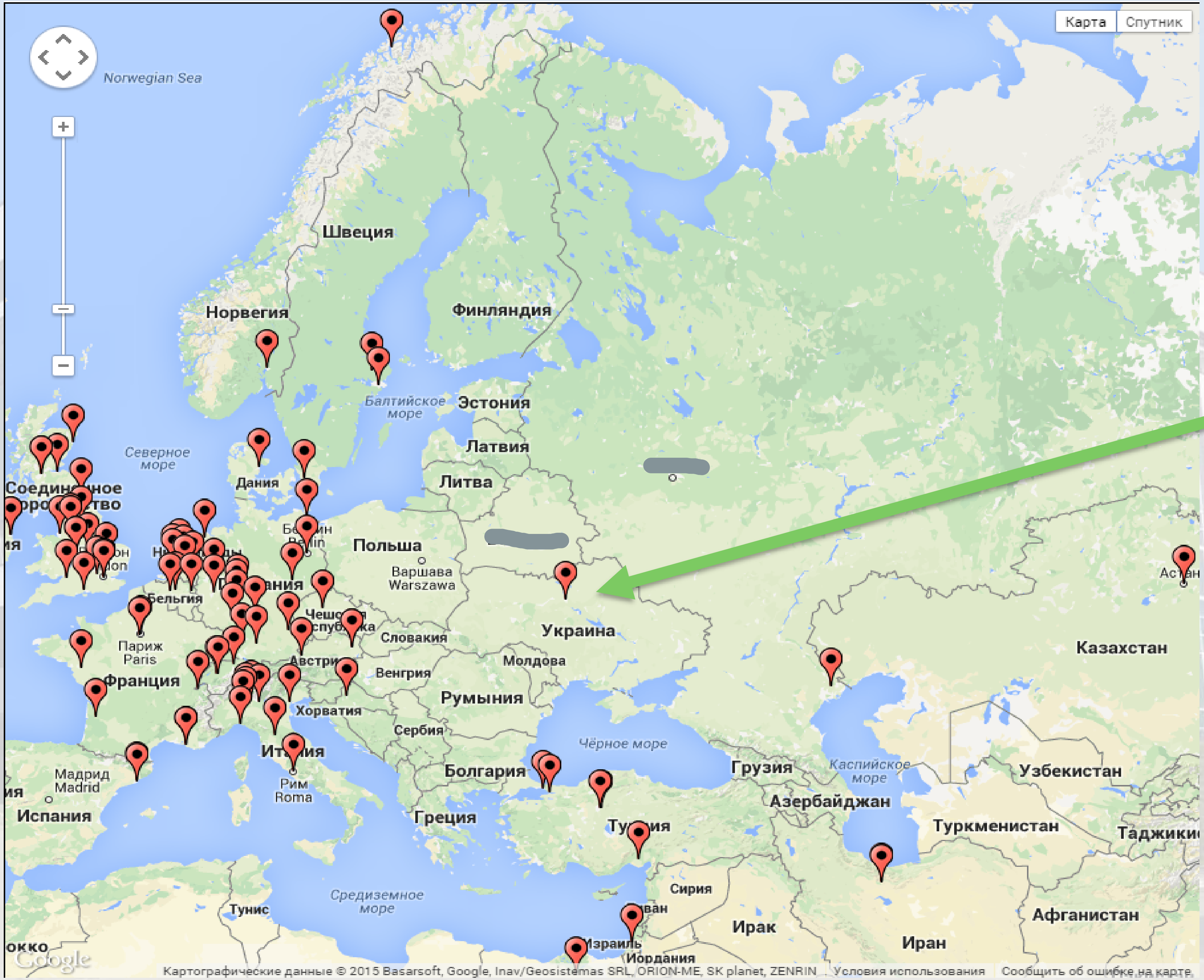
AUTONOMOUS REANIMATION AND AREVA EVACUATION RESEARCH PROGRAM

THE GENEVA FOUNDATION

AREVA Drone Experiments

Ground and aeromedical evacuation at 5k, 8k, 30k ft at AREVA this morning using portable battery operated heparin free ECLS with the MELS.

The MELS is the least complicated part of the setup now....



Ukraine, Kyiv

Heart Institute

since 2011

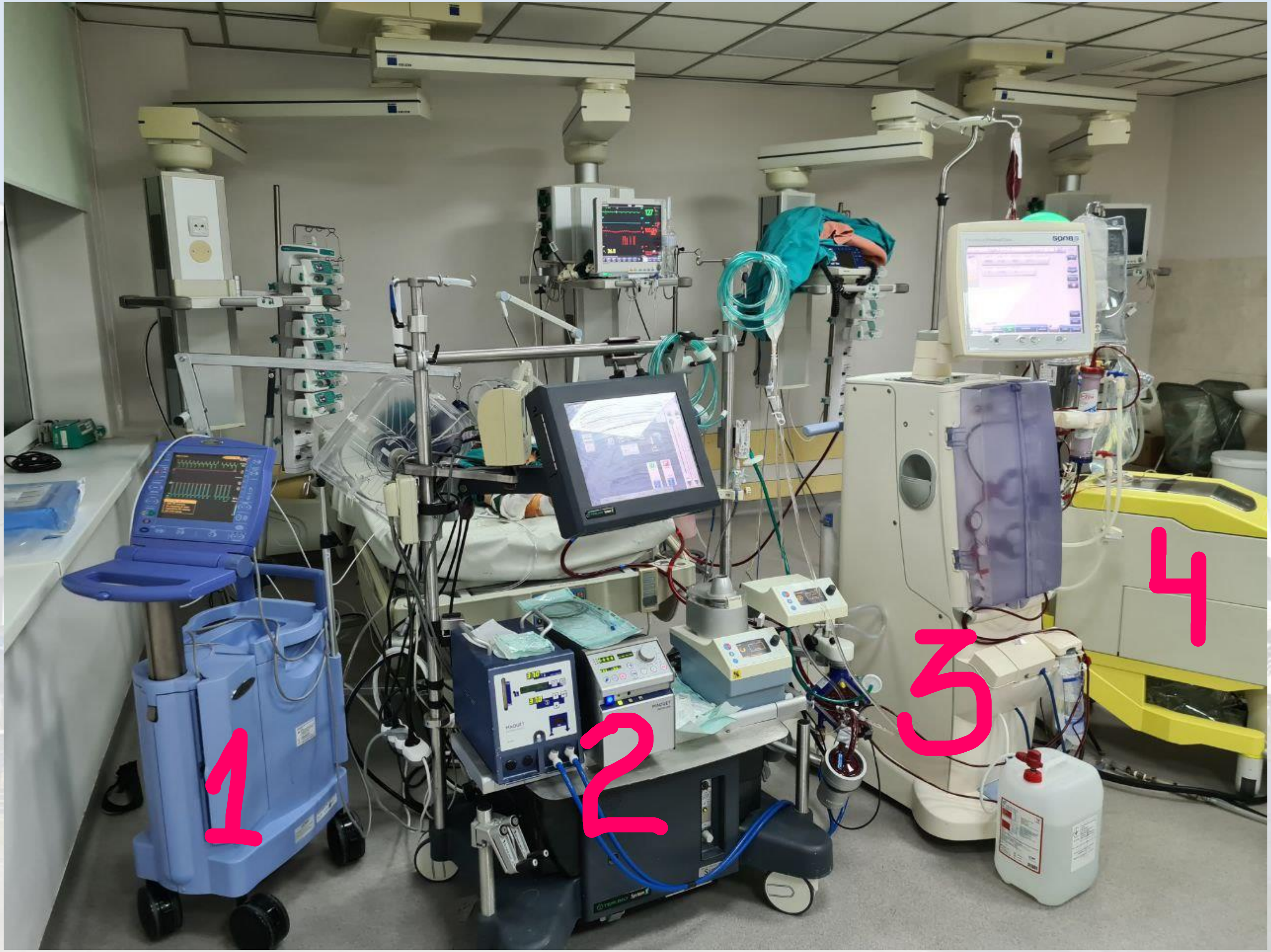
The first ECMO center in Eastern Europe

First successful case of ECMO, Heart Institute, 2010

**VV-ECMO,
H1N1
pneumonia
10 days on
ECMO**

ECMO ~~Routine~~

1. IABP
2. VA ECMO
3. Dialysis (CRRT)
4. Cell-saver

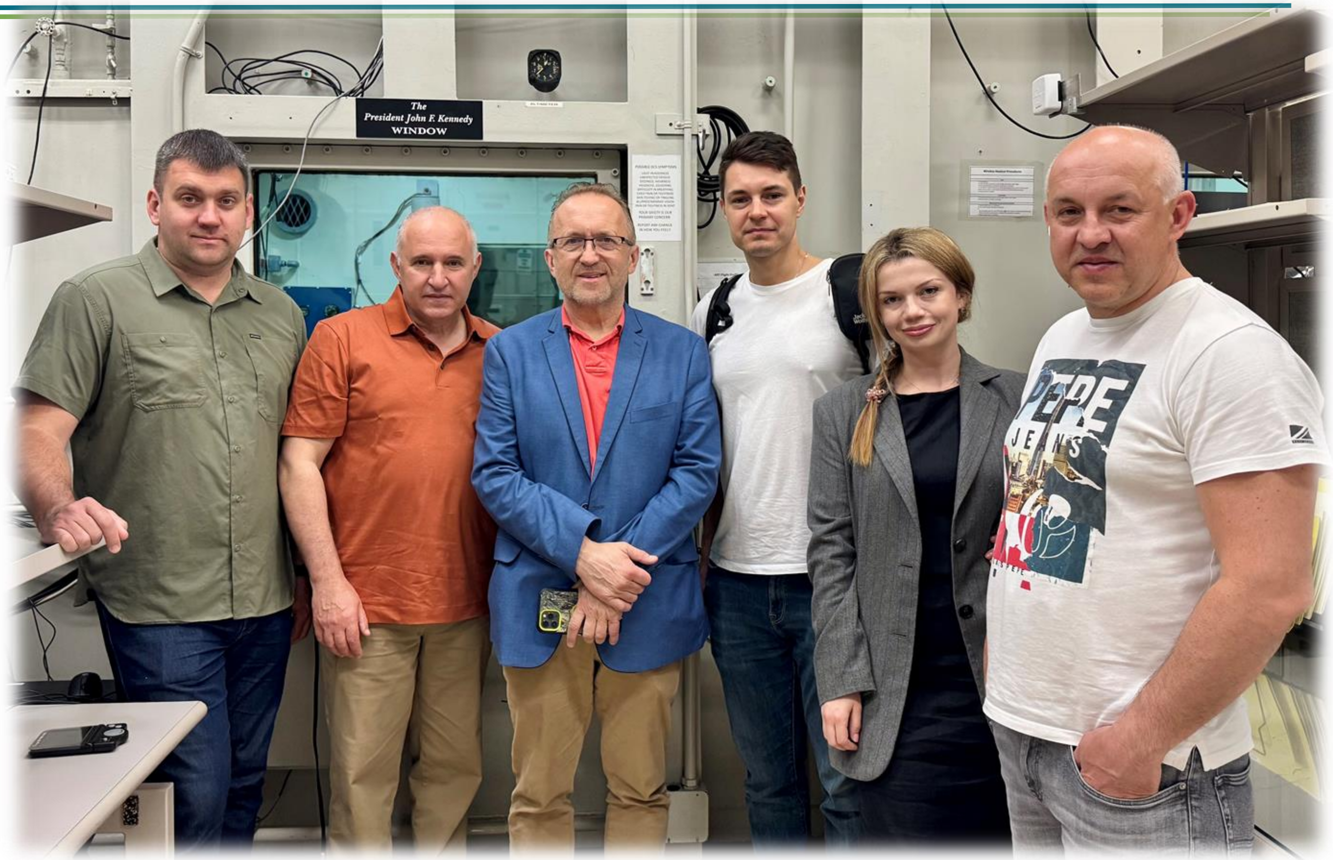


First ECMO transf

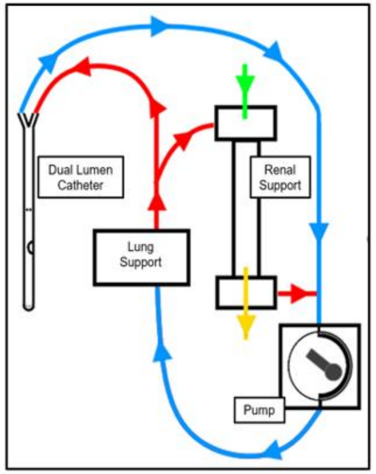
«Innovations" in transportation: More than flexibility

Research Collaboration

The Heart Institute of the Ministry of Health of Ukraine,
Kyiv, Ukraine
and
The Autonomous Reanimation and Evacuation Research Institute and Innovation Center,
San Antonio, Texas



Multimodal Extracorporeal Life Support: MELS

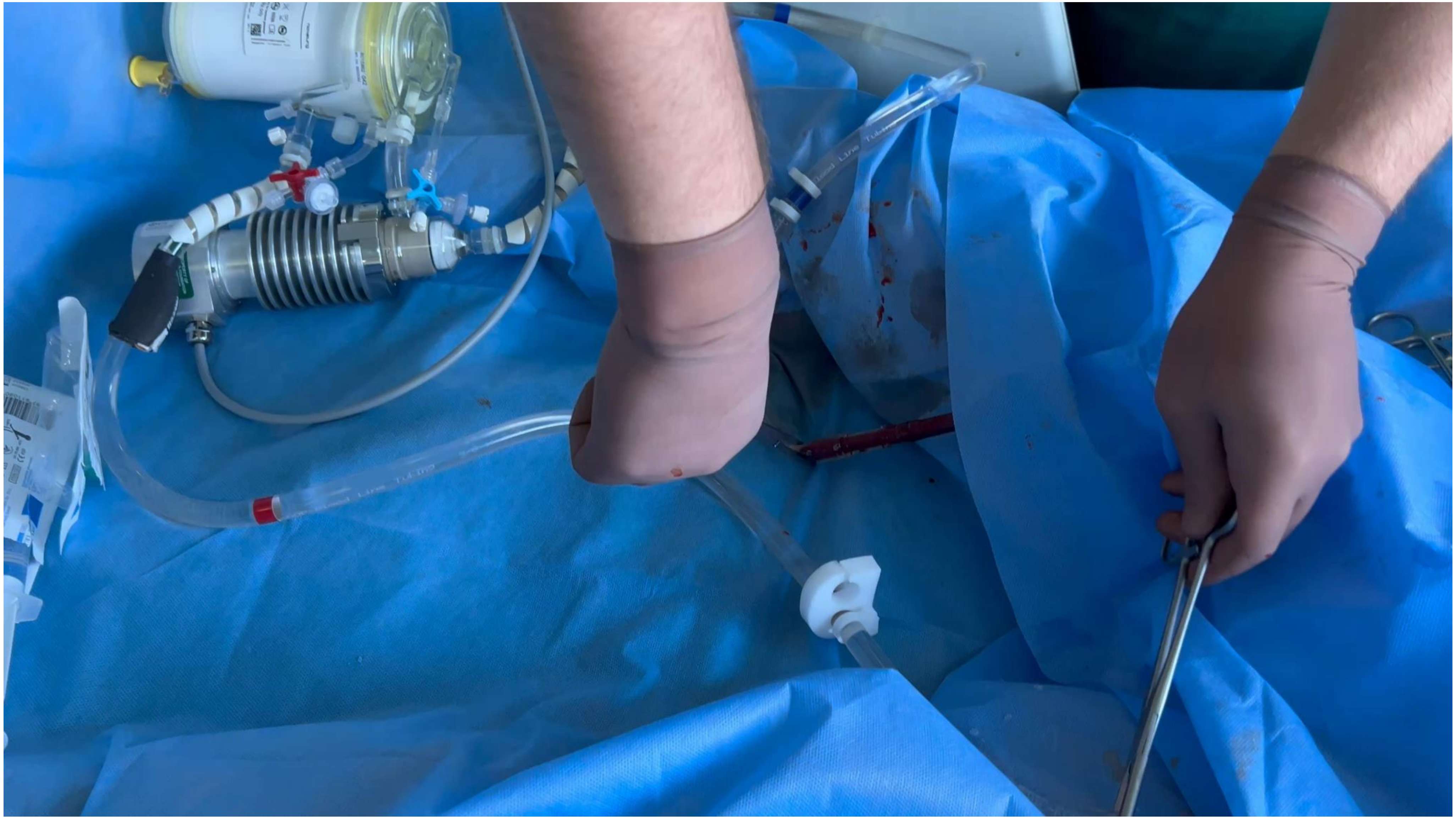


Courtesy Andriy Batchinsky MD, Patented in USA, EU, Israel, Ukraine, Japan Email: abatchinsky@genevausa.org

Collaboration on wearable/mobile ECMO and organ support and Drone-delivery of ECMO

MELS training in San Antonio

1st in the World case of Portable Battery-Operated ECLS



MELS: Recovery from fulminant ARDS in Ukraine

AUTONOMOUS REANIMATION AND

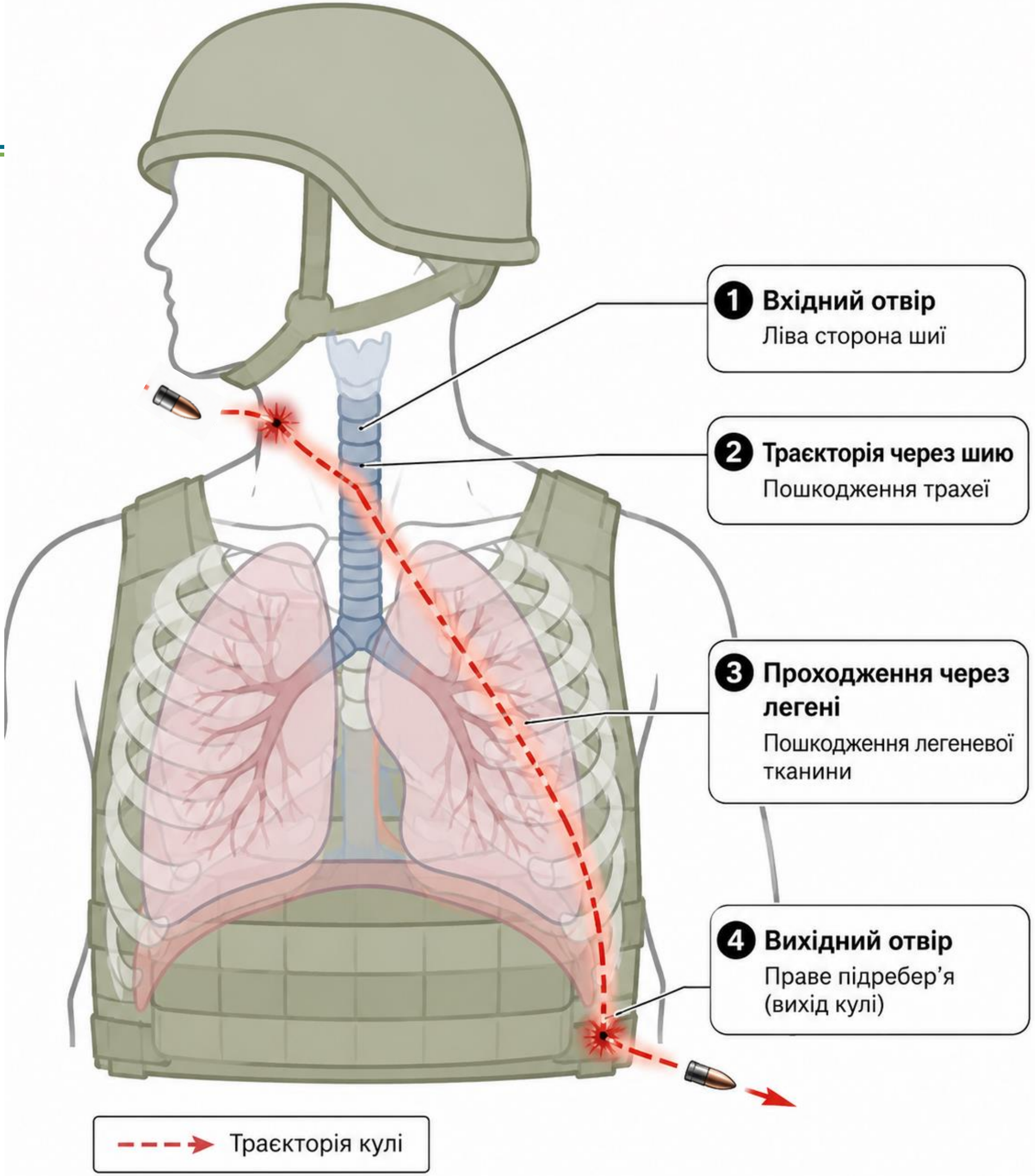
AREVA

EVACUATION RESEARCH PROGRAM

THE GENEVA FOUNDATION

Latest Case.

A soldier with a mine-blast injury and a bullet wound to the chest – Multimodal extracorporeal life support (MELS) as a technology of choice from the start



AUTONOMOUS REANIMATION AND
AREVA
EVACUATION RESEARCH PROGRAM
THE GENEVA FOUNDATION

Brief description of medical history

Diagnosis

MBI 06.05.26 / penetrating chest wound on the left

- through damage to the upper thoracic esophagus
- injury to the right lung, contusion of the left lung
- right-sided hemopneumothorax
- emphysema of the soft tissues of the neck on the left, mediastinitis
- fragmentary marginal fracture of the left clavicle
- a foreign metal body in the soft tissues on the right

Surgical treatment

07.05.2026

Thoracentesis on the right; PHO wounds; left-sided cervicotomy; sternotomy; suturing esophageal wounds; Drainage of the interstitial

08.05.2026

Gastrostomy according to Kader. Lower tracheostomy.

Бронхоскопія / ФГДС

Blood aspiration. Esophageal injury confirmed.

Dynamics

Visualization

- 07.05 CT: right hydropneumothorax, atelectasis, hydrothorax on the left, contusion of the left lung.
- 11.05 ultrasound: bilateral hydrothorax.
- 18.05 X-ray: bilateral inferior pneumonia.

Лабораторно

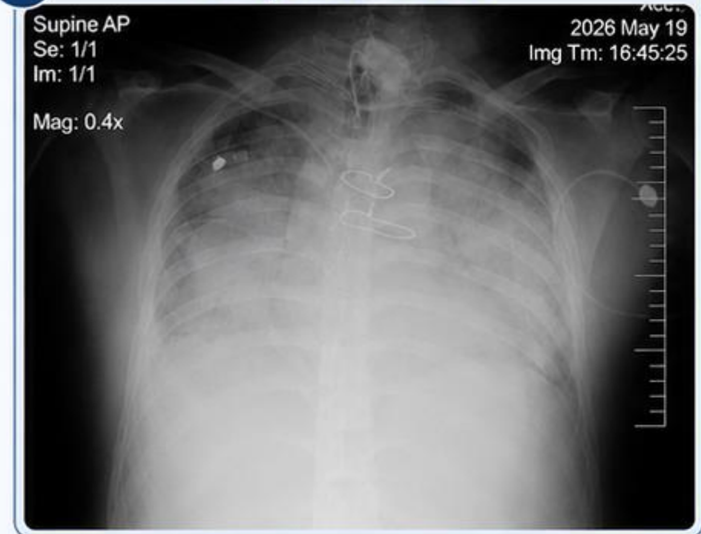
- Procalcitonin: 35.33 → 4.612 ng/ml.
- Hb: 147 → 84 g/l; leukocytes: 8.7 → 19.4×10⁹/l.
- Wound/sputum cultures: acinetobacter

19.05: transfer to the Heart Institute with pre-installation of VV-ECMO

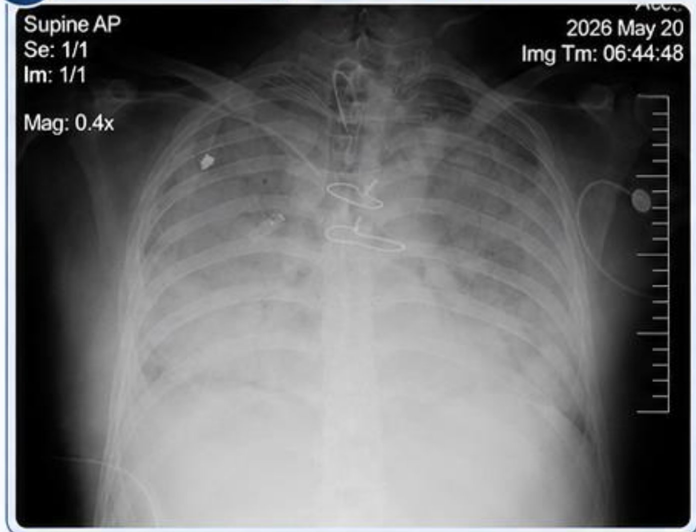
Рентгенологічна динаміка

Хронологічна послідовність рентгенограм органів грудної клітки

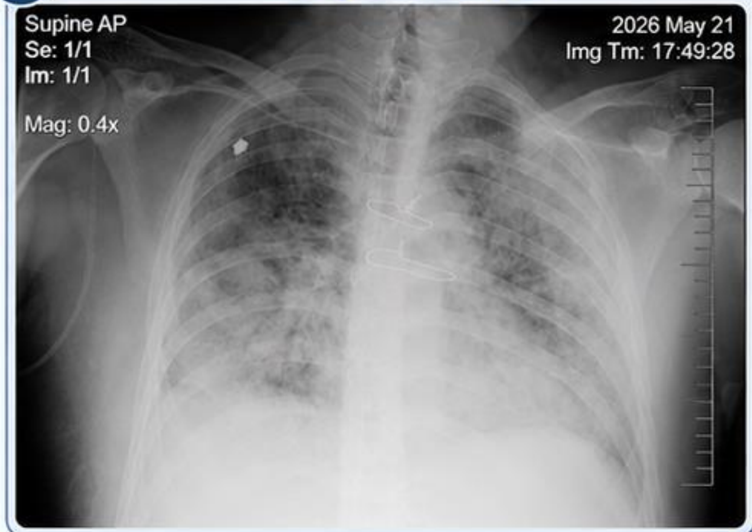
1 19 травня 2026



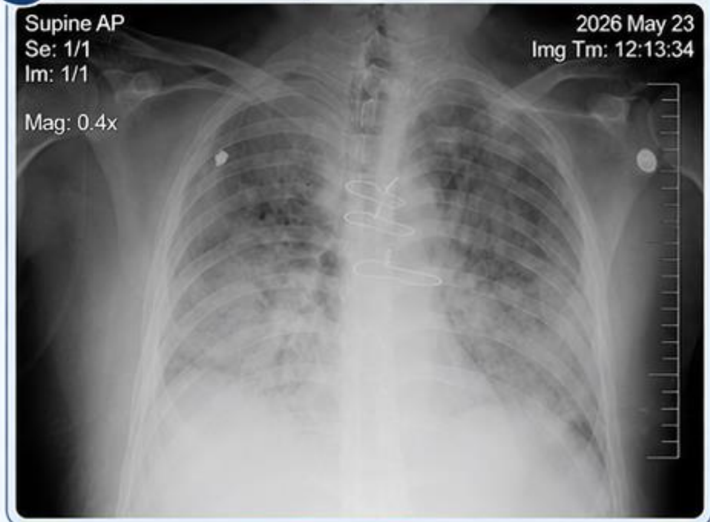
2 20 травня 2026



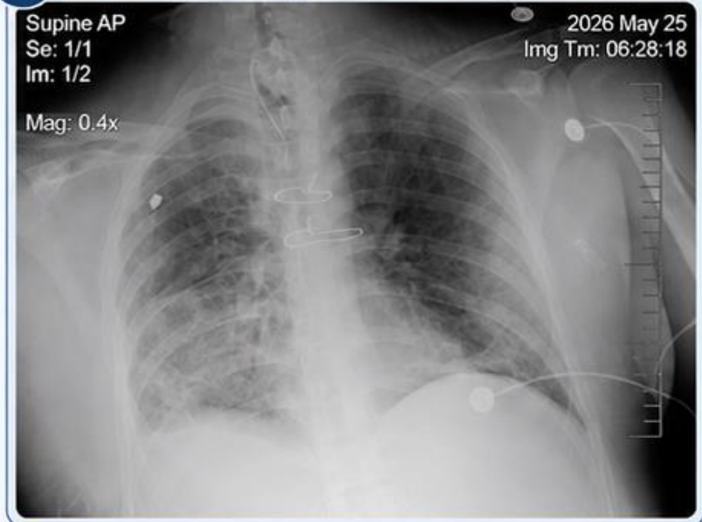
3 21 травня 2026



4 23 травня 2026



5 25 травня 2026



Condition on 16.06

HEART INSTITUTE
Ministry of Health of Ukraine

Ready to use MELS via Drone Delivery 4 hr experimental flight

Contact email:

abatchinsky@genevausa.org

AREVA Institute:

https://genevausa.org/programs/areva