Drone-based Warfare: Veno-Venous ECMO for Management of ARDS due to Polytrauma with Smoke Inhalation Injury after a Drone Attack

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DISCLOSURE

- The views and conclusions contained herein are those of the authors and should not be interpreted as necessarily representing the official policies or endorsements, either expressed or implied, of the government of Ukraine, the Heart Institute of the Ministry of Health of Ukraine, the U.S. Department of Defense, the U.S. Government, or The Geneva Foundation

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- **Photo and video of the patients used with the permission of the patients**

DYNAMICS OF THE TOTAL NUMBER OF OPERATION in HEART INSTITUTE

2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
5946	5934	5758	6137	4738	5791	5007	6001	5913	5808

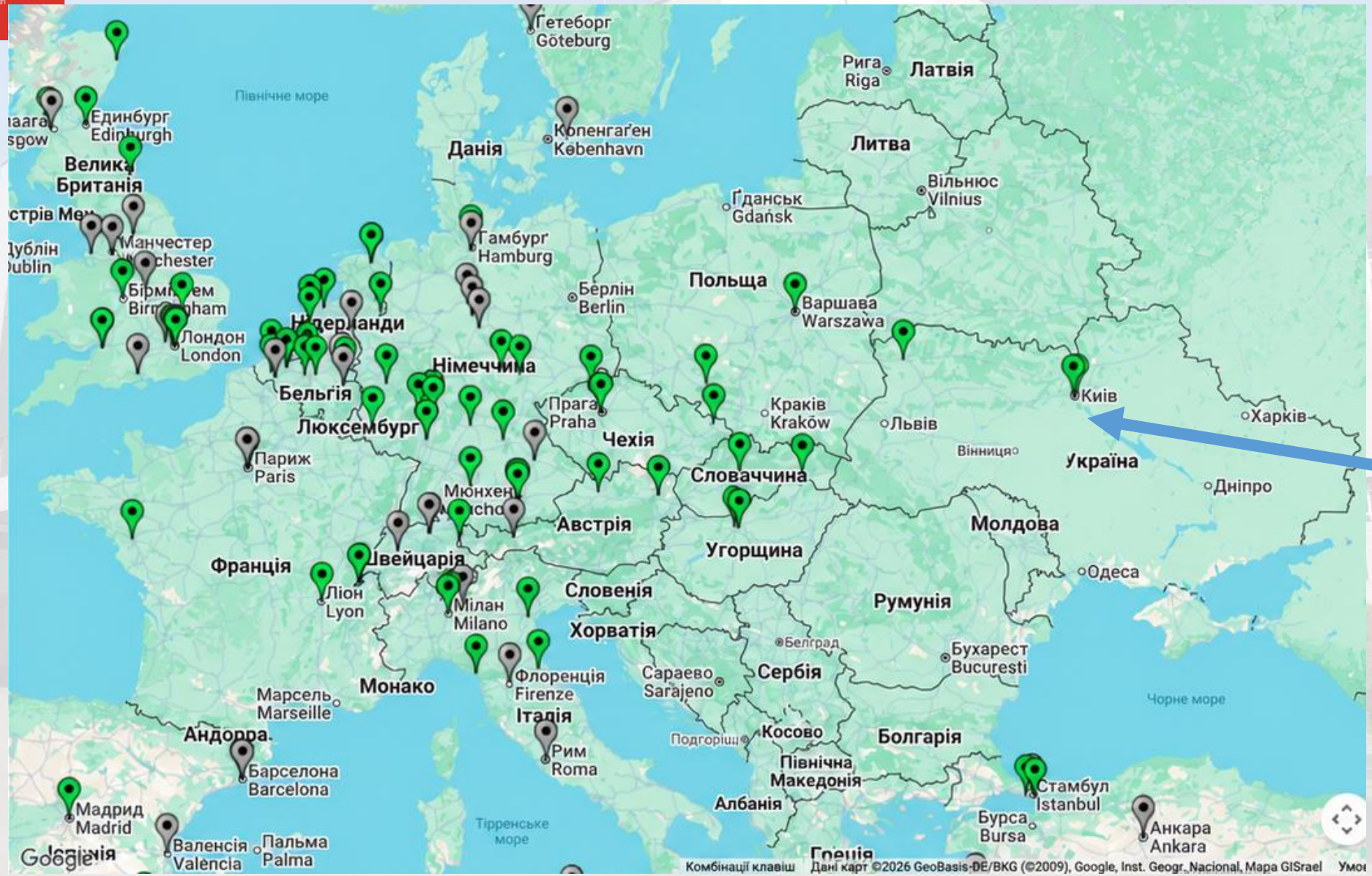
Challenges and problems faced by the heart institute in routine work (January 2026)

The first homemade ECMO machine and circuit (4 cases in 2009 out of hospital)

First successful case of ECMO, Heart Institute, 2010

VV-ECMO,
H1N1 pneumonia
10 days on ECMO

HEART INSTITUTE
Ministry of Health of Ukraine



Ukraine, Kyiv

Heart Institute

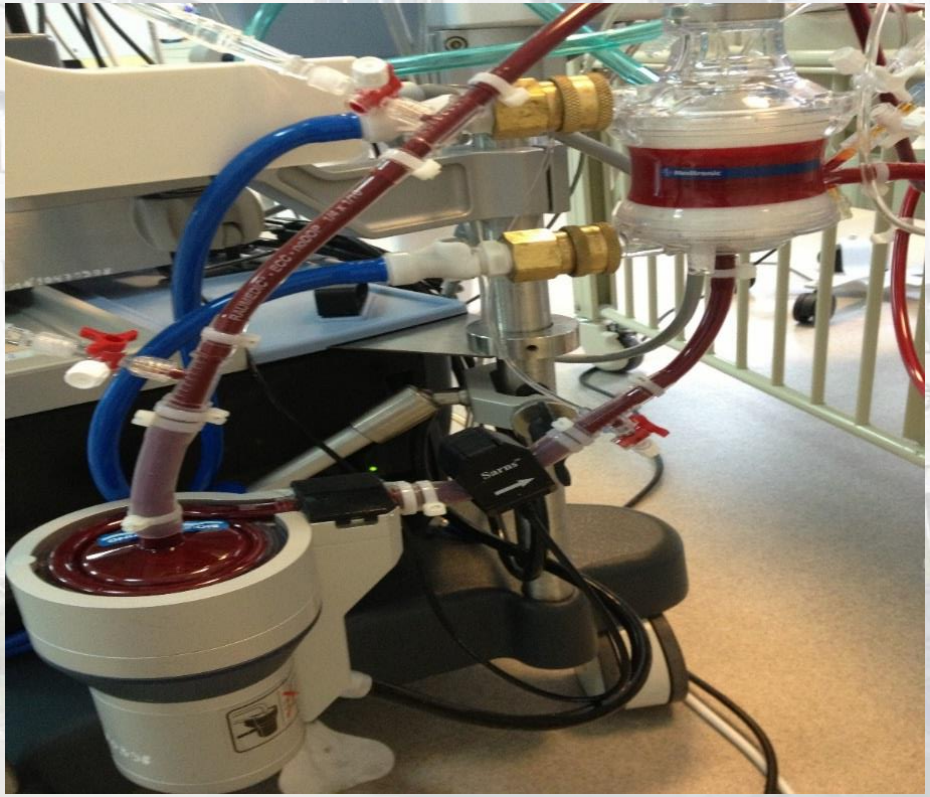
since 2011

The first ECMO center in Eastern Europe

#211

HEART INSTITUTE
Ministry of Health of Ukraine

First cases of children's VA-ECMO + hand made cell-saver



First ECMO transfer

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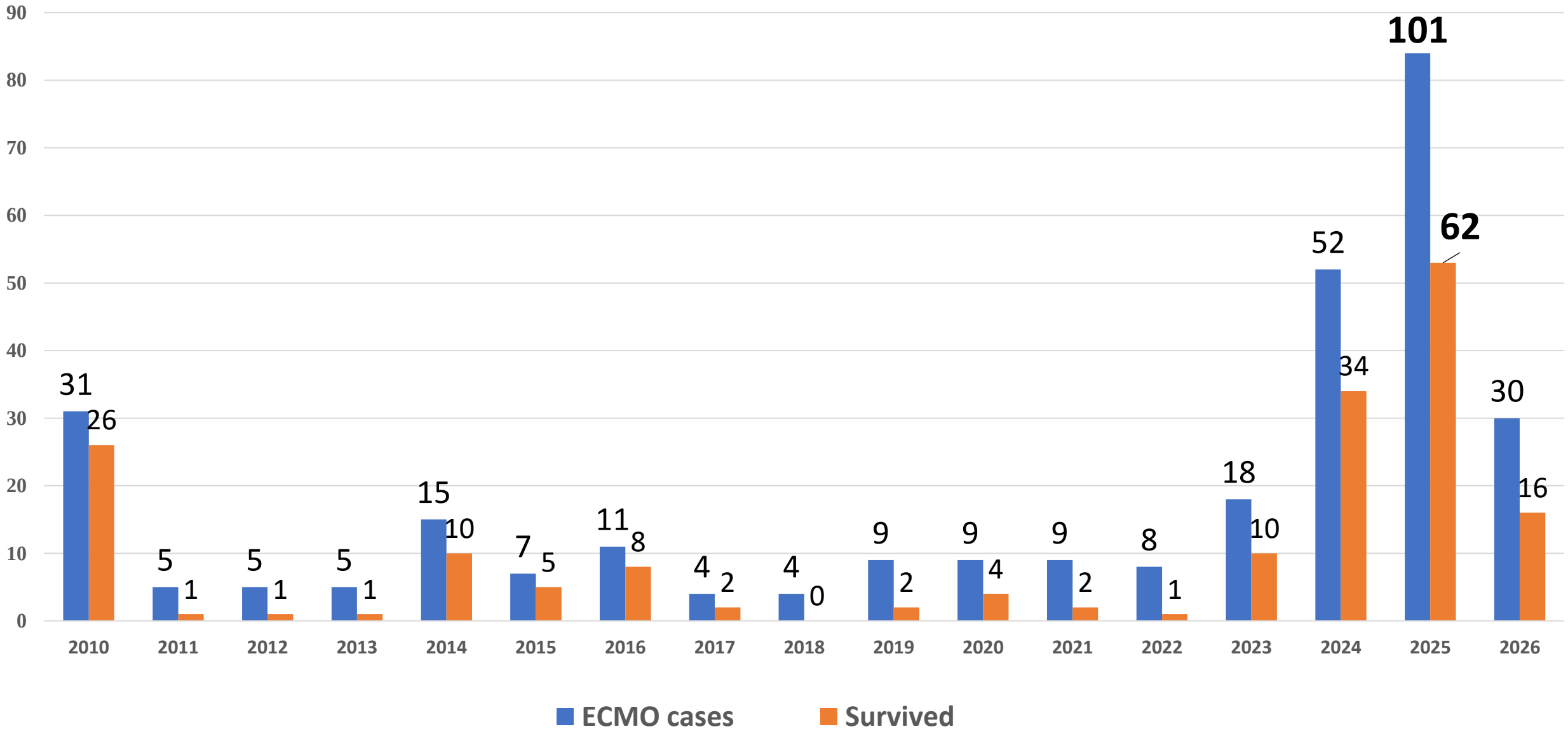
“Innovations” in transportation

More than flexibility

Veno-Venous ECMO patients transfer with polytrauma Complicated with ARDS due to Military trauma

Heart Institute, Total Cases/Survival (2010-2026) 323/185



ECMO ~~Routine~~

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

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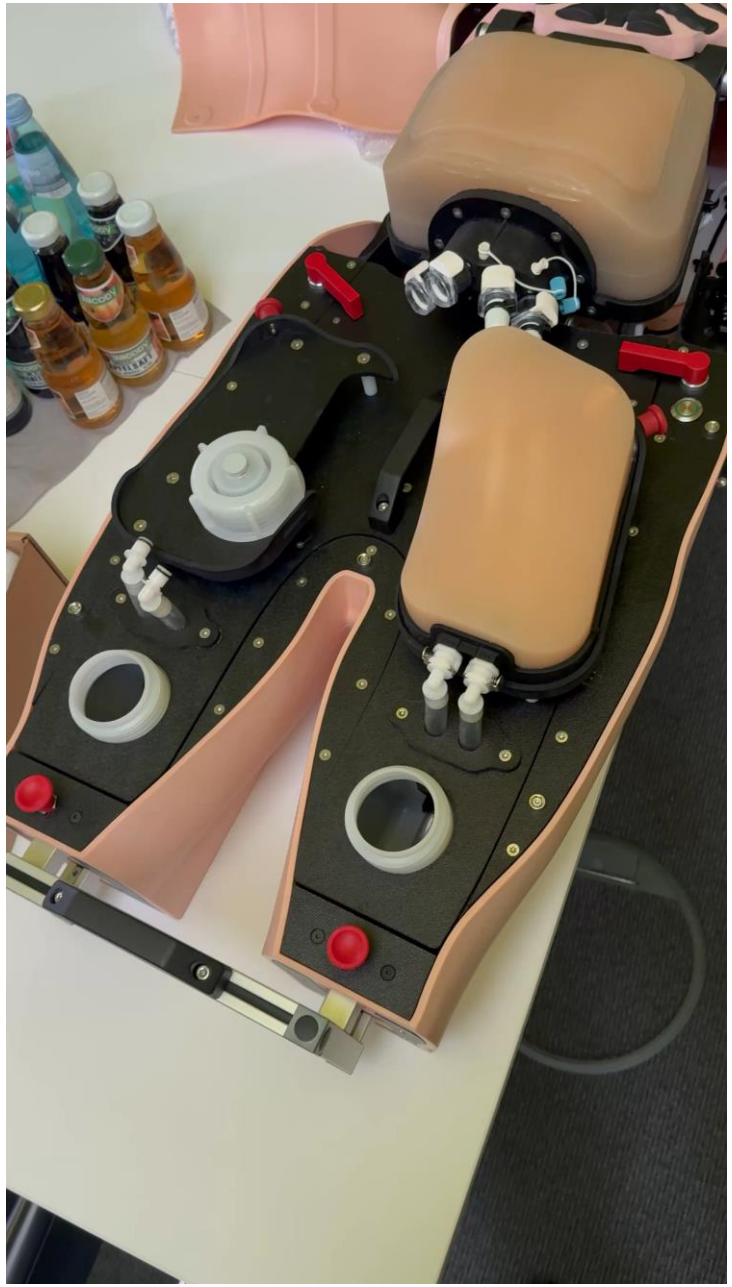
The first Ukrainian training simulation training program for doctors and nurses ICU ECLS in Ukraine + MILITARY

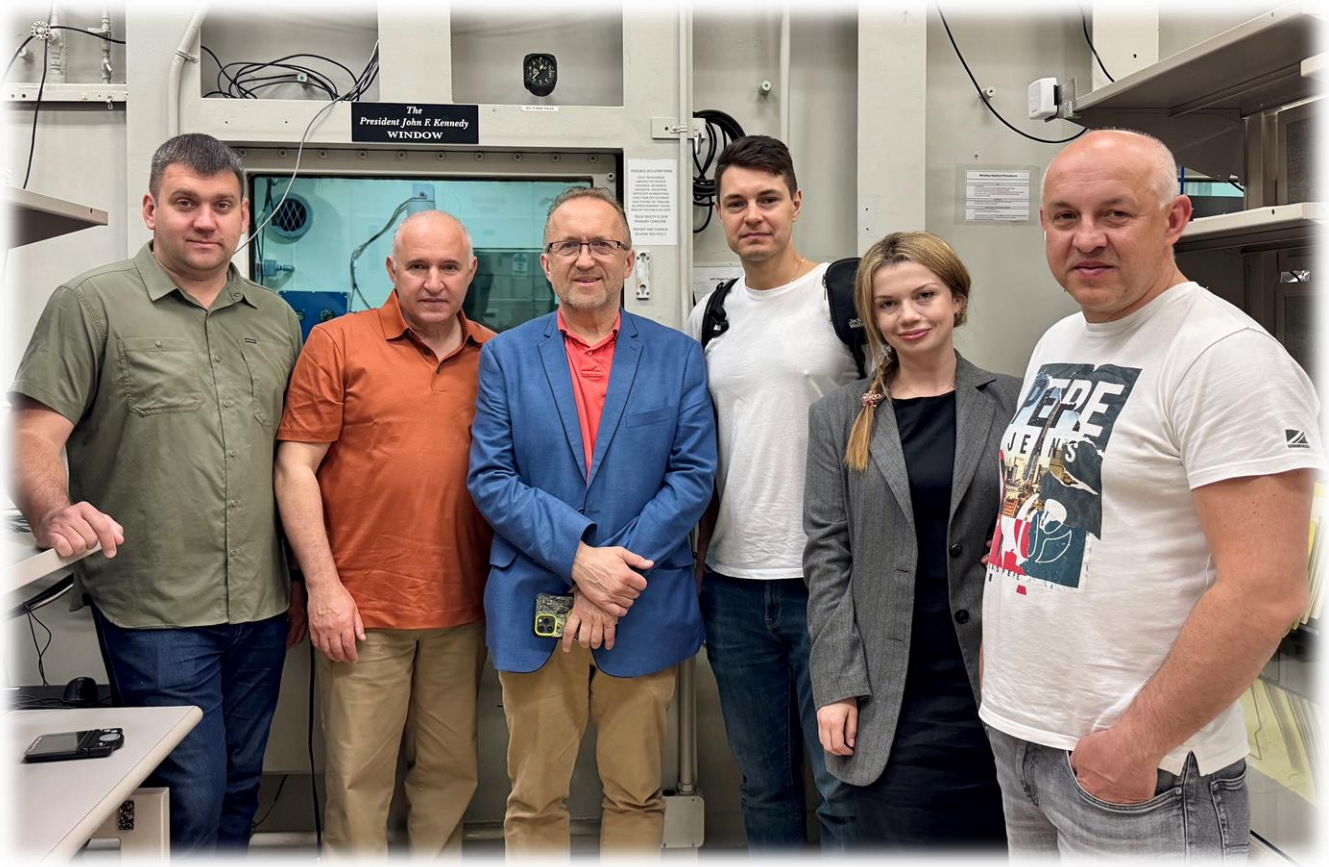


AUTONOMOUS REANIMATION AND EVACUATION RESEARCH PROGRAM

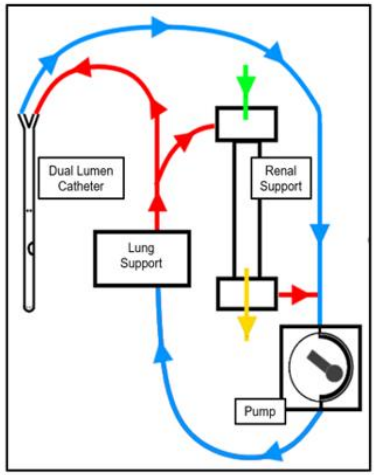
Research Collaborations between the:

THE GENEVA FOUNDATION
The future of military medicine. Today.

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



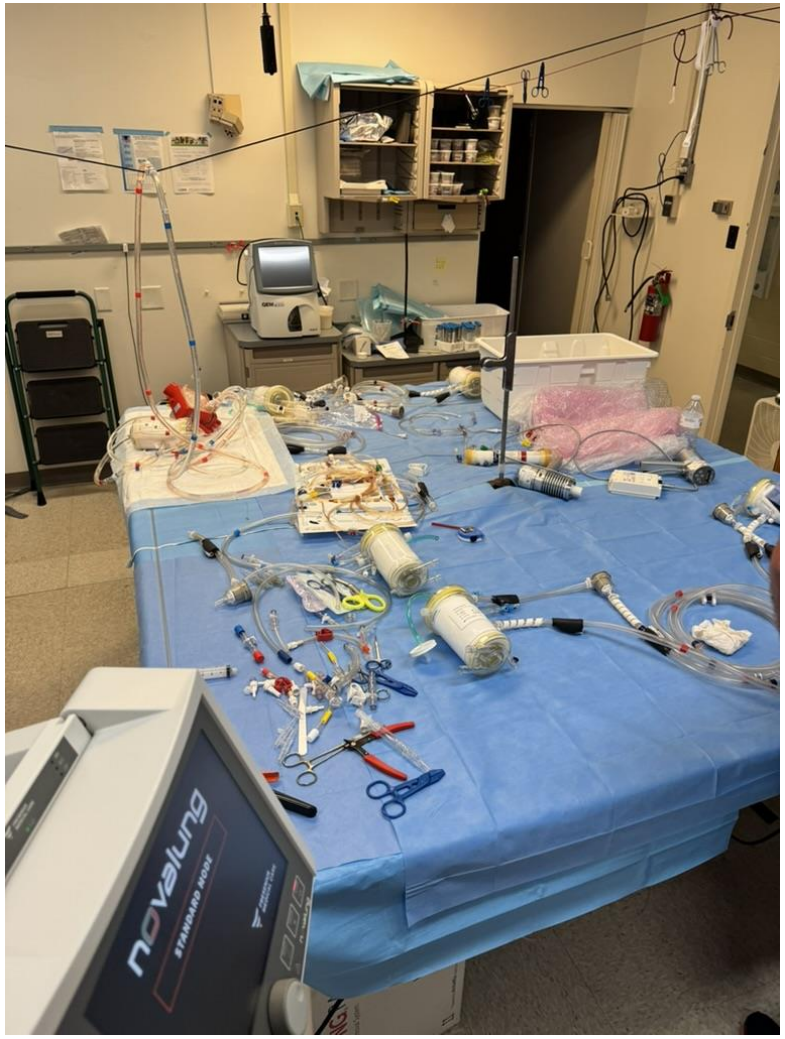
Multimodal Extracorporeal Life Support: MELS

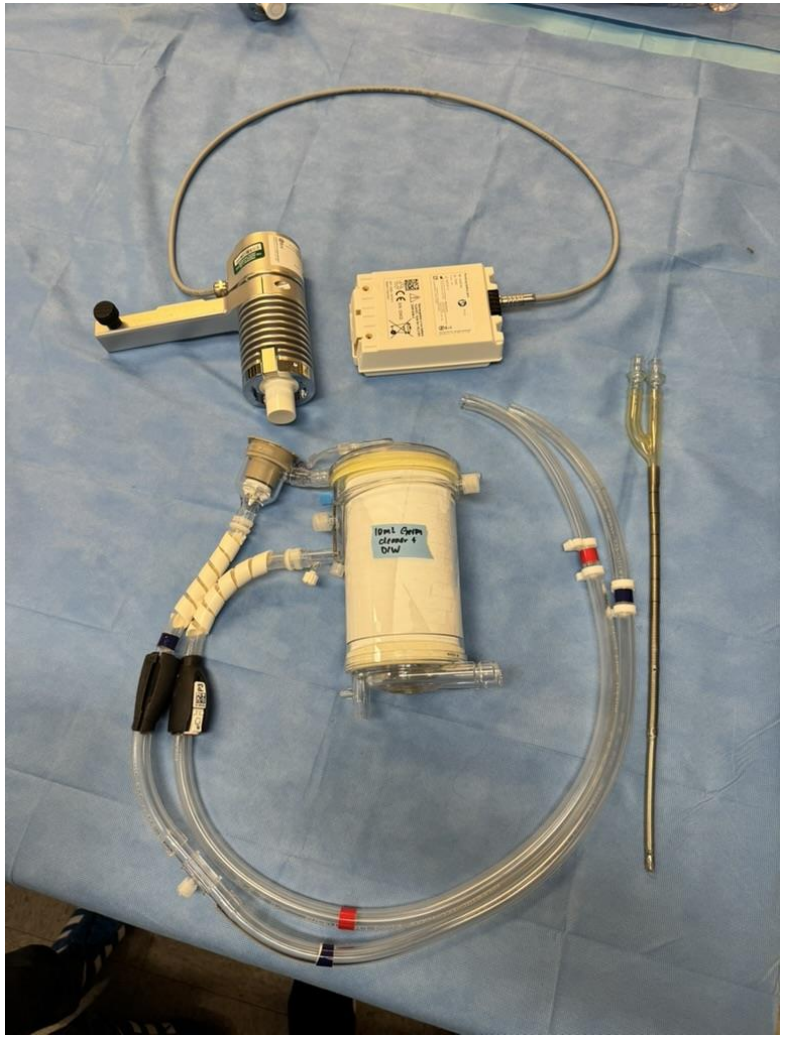


Courtesy Andriy Batchinsky MD, Patented in USA, EU, Israel, Ukraine, Japan Email: abatchinsky@genevausa.org

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

Promising and priority areas of work/plans for 2026 in cooperation with AREVA and Dr. Batchinsky – Multimodal Extracorporeal Life Support (MELS) and heparin free ECMO





A successful case that forced us to rethink opportunities and new directions

Why is this case important?!

This is not an "isolated" ARDS, but a multifactorial lung injury in a young patient where explosive trauma, smoke inhalation trauma and the effects of a fall from a height acted simultaneously.

- A combination of severe lung contusion, smoke inhalation injury, and systemic inflammation quickly led to severe ARDS.
- Pronation was not possible due to spinal injury and ventilation was beyond the protective regimen.
- ECMO had to be deployed in a hospital that does not have it and continued during transfer.
- Clinically significant bleeding appeared at the beginning, making anticoagulants a central management problem.

1 **Combined trauma**

Explosion + Smoke + Jump from the 4th floor

2 **Refractory pulmonary Insufficiency**

P/F 42, $PaCO_2$ 84, pH 7.13 with FiO_2 1.0

3 **Bleeding + the logistics of war**

4 days of heparin-free ECMO
Transfer to the ECMO center

Patient and injury mechanism

0 hr
Drone explosion → fire → jump from the 4th floor (10–12 m)

12 hr
Initiation of invasive mechanical ventilation due to hypoxemia

2nd day
CT: bilateral contusions, GGO, consolidation → ARDS

ON ADMISSION

- 23-year-old man, GCS 15
- Complaints: chest pain, weakness, pelvic pain, dyspnea
- BP 140/85 mmHg; HR 94/min; RR 19/min; SpO_2 94% on room air
- Bronchoscopy: upper airway burns, erythema, edema, soot, bleeding → SII confirmed
- Stable vertebral and pelvic fractures; upper limb fracture (external fixation), ISS 23
- No indication for emergent surgery

Clinical challenge: combined blast + thermal + fall injuries with early progression to ARDS

Venovenous ECMO without a systemic anticoagulant after polytrauma complicated by trauma from smoke inhalation as a result of a drone strike

Cannulation

Right femoral drainage 25 Fr
Left femoral return 23 Fr

Initial settings

Blood flow 4.0 L/min
Sweep 5 L/min
O_2 100%

After cannulation

PEEP 8 cm H_2O
TV 210 mL (3 mL/kg)
RR 16/min • Ppeak 25
FiO_2 0.7

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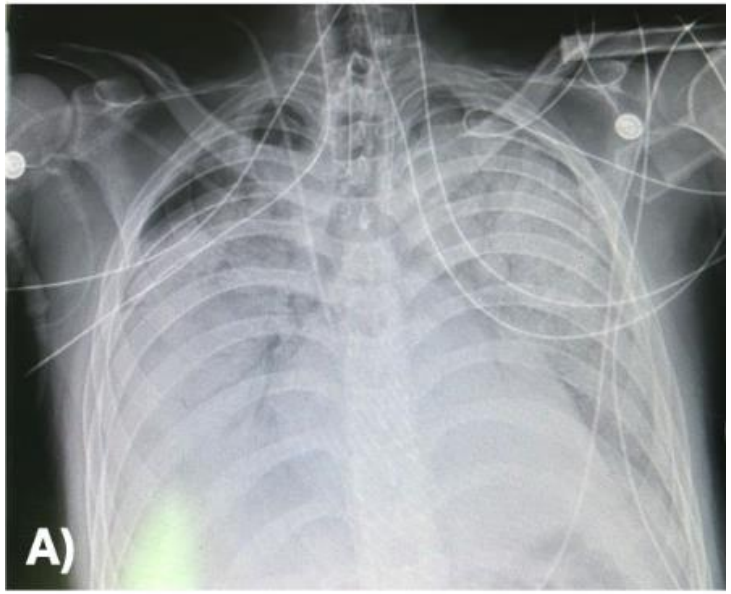
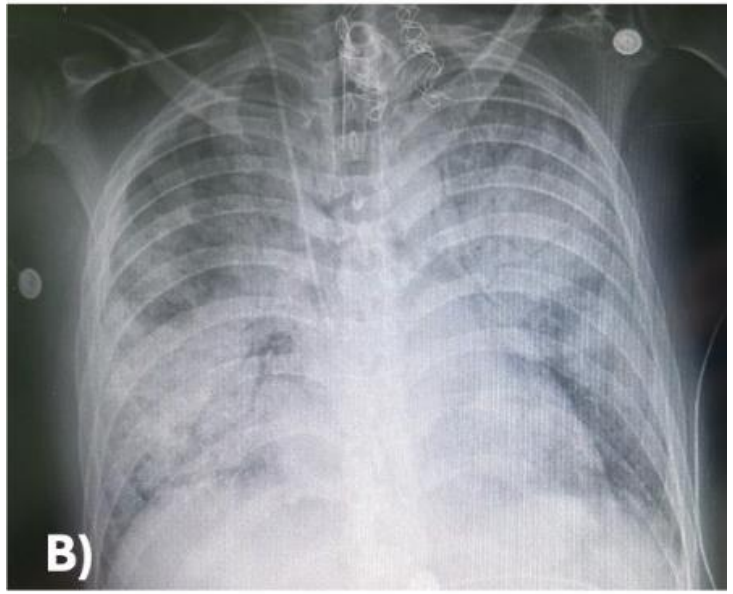
Arterial Blood Gas Data

Parameter	Before cannulation	2 h after ECMO	Day 1	Day 2	Day 5	Day 8 before decan.	2 h after decan.	Before IMV term.	2 h after IMV term.	Last ICU day
pH	7.13	7.28	7.34	7.37	7.40	7.42	7.39	7.41	7.38	7.43
pO_2, mmHg	68	86	85	88	93	112	92	94	78	86
pCO_2, mmHg	82	56	44	39	37	36	41	39	43	38
Hb, g/L	92	88	91	94	98	103	105	108	109	112
sO_2, %	72	94	94	95	98	99	96	97	95	97
Lac, mmol/L	5.8	3.9	2.4	1.8	1.3	1.1	1.4	1.2	1.5	0.9
cBase, mmol/L	–10.8	–6.4	–3.1	–1.5	0.2	1.1	–0.8	0.6	–1.2	1.4
cHCO_3^-, mmol/L	17.1	20.3	22.4	23.5	24.6	25.2	23.8	24.8	23.4	25.5

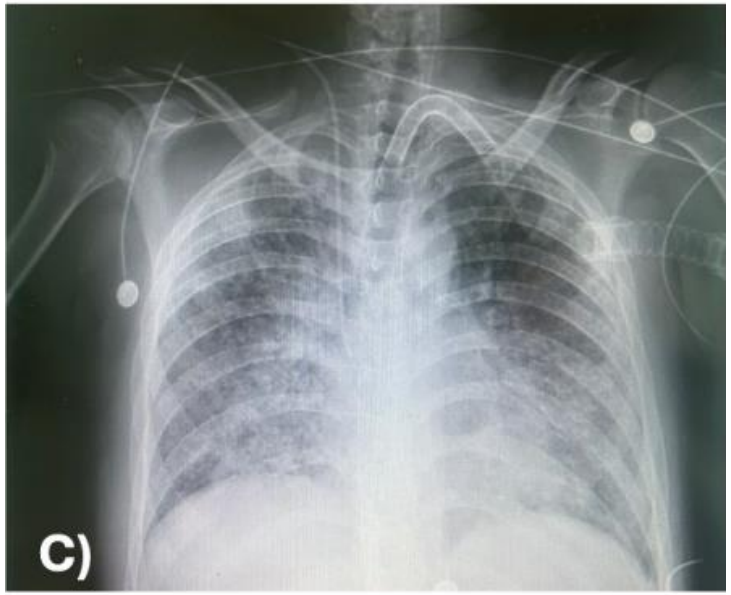
Early response to ECMO



A. Pre-ECMO



B. 3rd day ECMO



C. Last day of ECMO

2 hours after starting VV ECMO

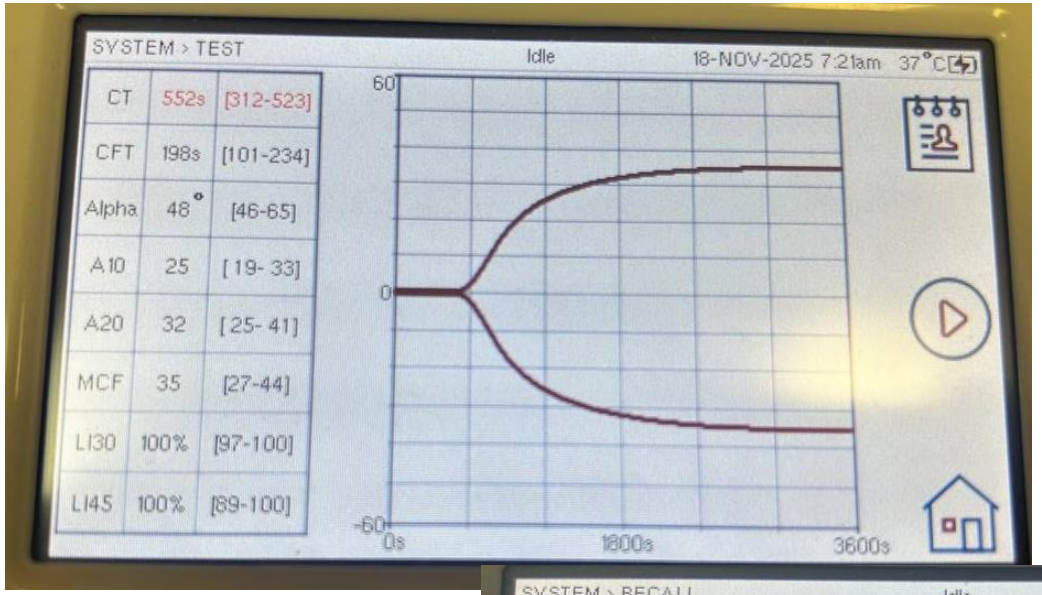
PaO_2 42 → 73 mmHg
SaO_2 73% → 94%
pH 7.13 → 7.42

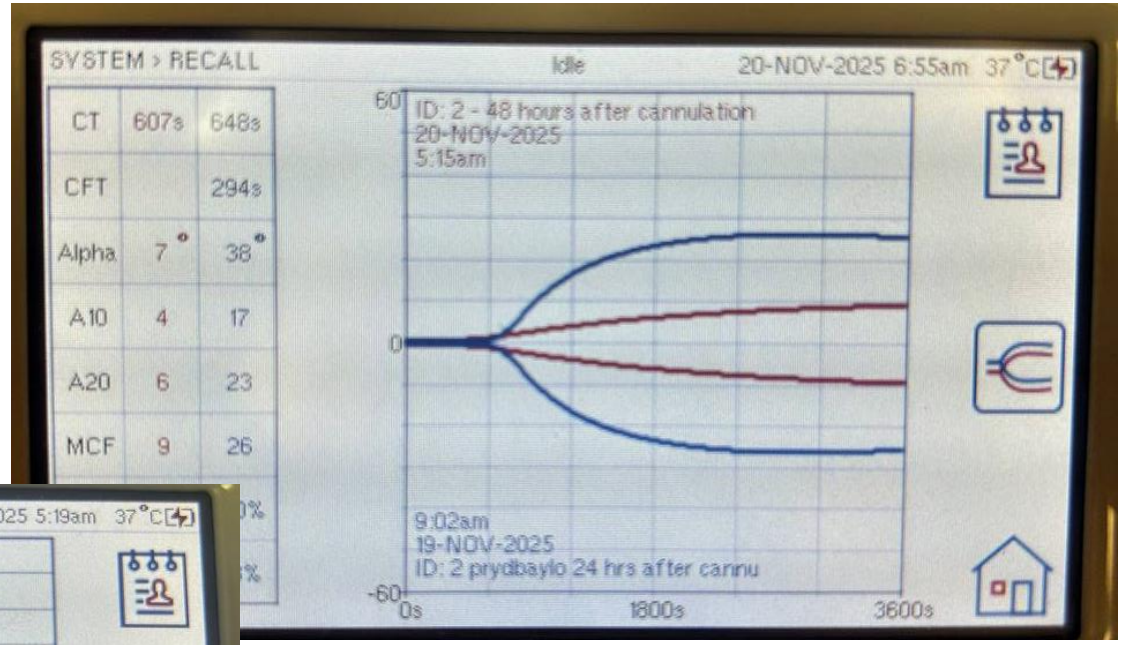
After the cannulation, it became possible to return to protective ventilation

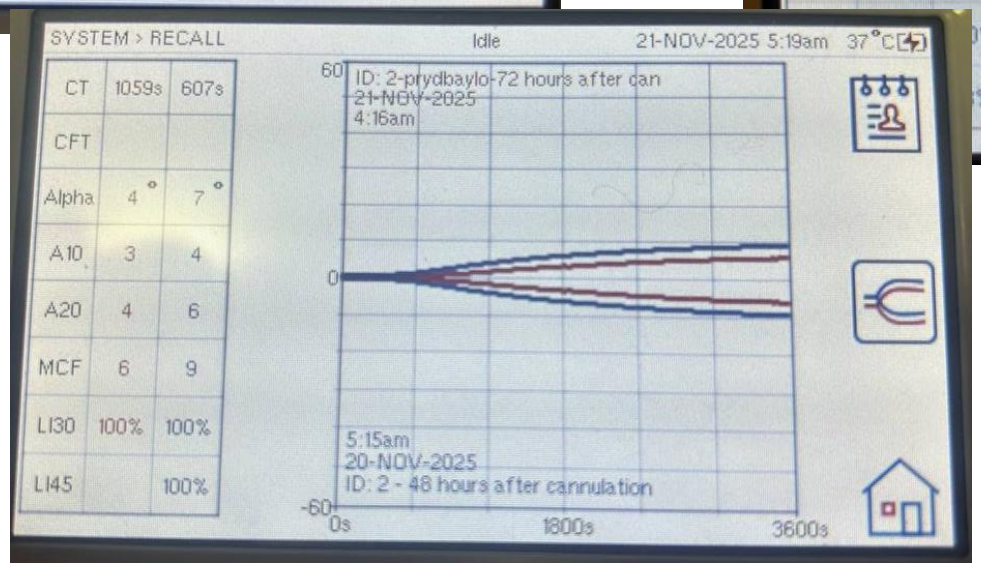
TV 320 → 210 ml
Ppeak 46 → 25 cm H_2O
FiO_2 1.0 → 0.7
Negative fluid balance: −0.8 to −2.1 L/day

VCM data

- Photo 1. VV ecmo initiation
- Photo 2. 24 hours of ECMO
- Photo 3. 48 hours on ECMO







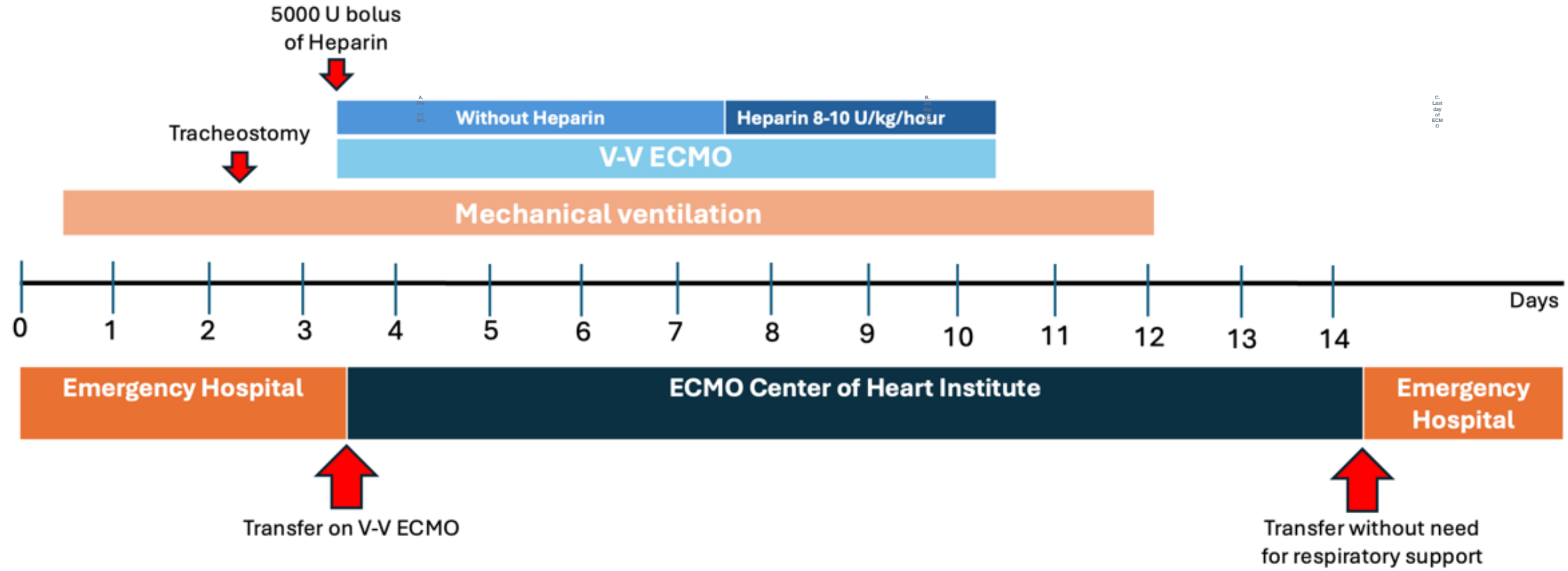
ECMO weaning and results

Key stages:

D7 — decanulation

D12 — Extubation

D14 — return to primary hospital



Ready to use MELS via Drone Delivery 4 hr experimental flight

Conclusions

- **In the era of drone based warfare, we document the successful use of extracorporeal respiratory support in ARDS due to SII and severe chest trauma in a resource constrained environment during war in Ukraine.**
- **Proactive use of ECMO should be considered for management of ARDS due to polytrauma in experienced ECMO centers that have trained teams and point of care monitoring technology permitting comprehensive monitoring and logistically simplified transport**
- **Heparin-free ECMO is a promising and increasingly relevant strategy for supporting patients with polytrauma and severe Acute Respiratory Distress Syndrome, especially in cases of high risk of bleeding.**

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