

# **“Operation Rescue” Ukrainian Wartime Neurosurgery— Past Results and Future Prospects**

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An air-raid siren was the first sound that one of us heard when we stepped off the train on our first visit to Dnipro. But no one at the train station was worried. Frequent air-raid alarms have become part of daily life in Dnipro and many other regions in Ukraine.

The Russian invasion has brought terrible death, pain, suffering, and destruction to Ukraine. War spares no one. Many children, elderly people, and noncombatants have died.

Very few neurosurgeons in the world have been forced to learn how to work during ongoing warfare. Surgery and other patient care must be done under the constant sound of air alarms and threat of missile and drone strikes. Ukraine air defenses are very good but not perfect. The worst stress for Ukrainian health care workers is not the large volume of cases or severity of patients’ injuries: it is knowing that their families are also in danger.

## **Achievements**

Mechnikov Hospital in Dnipro, only 100 km from the front line, provides the highest level of complex care. In the United States it would be called a quaternary care facility; in the American military system it would be a Role 4 facility. The hospital has continued to provide its usual medical services to the citizens in eastern Ukraine at the same time it cares for civilian and military casualties from a wide region. Refugees and displaced persons are also treated; no one is refused care. Since February 2022, Mechnikov Hospital has treated approximately 1050 casualties from the war every month. The neurosurgical service performs an average of 3.2 craniotomies per day for penetrating TBI.

Neurosurgeons of Mechnikov Hospital are now rewriting methods of wartime neurosurgical care and pushing back the limits of performing neurosurgical interventions in a war zone. Three neurosurgical centers with 120 beds (cerebral, spinal, and vascular neurosurgery) and an endovascular center with two angiography suites have gathered the greatest experience in the treatment of gunshot wounds in military and civilians since the Second World War. Over the two past years alone, 1,076 angiograms and 227 neurointerventional procedures were performed. These numbers include 919 angiograms and 162 endovascular operations for penetrating shrapnel injuries in both civilian and military casualties. In addition to this war-related work, over 200 mechanical thrombectomies were performed for stroke.

The spectrum of neurovascular pathologies of the head and neck from gunshot and penetrating blast trauma is extensive:

- Internal carotid artery/common carotid artery injury: 132 (70 were operated on)
- Vertebral artery injuries: 70 (42 were operated on)
- Other intracranial injuries (pseudoaneurysms, carotid-cavernous junctions, AV fistulas, dural sinuses): 35 patients
- Traumatic lesions of other neck arteries: 16 (10 were operated on)

During the first two years of the war, neurosurgeons at Mechnikov Hospital operated on more than 1500 patients with severe penetrating TBI, including 280 with involvement of the paranasal sinuses and 75 with injuries to the posterior cranial fossa. Mechnikov Hospital has also accumulated unique experience in the surgical treatment of spine and spinal cord injuries, as well as peripheral nerve injuries. The neurosurgeons treat all patients and operate on all civilian and

military casualties in hopes of saving everyone, even those who in peacetime would be thought hopeless. There is no therapeutic nihilism, defeatism, or avoidance of difficult cases.

Despite manpower and equipment shortages, neurosurgical and neuroendovascular procedures continue to be performed at the highest level on a daily basis. This includes ultra-early angiography and endovascular intervention for vascular injuries caused by penetrating shrapnel as well as early and aggressive treatment of penetrating brain injuries. Basic principles of treatment include open microsurgical decompression and debridement of cranial wounds, watertight dural and skull base reconstruction, and supplementation of titanium implants with local vascularized pedicled pericranial flaps.

As soon as wounded warfighters at Mechnikov Hospital become stable, they must be transferred to create space for 30-50 new casualties every day. To keep up with the new admissions, the hospital developed and refined a strategy of early and extensive neurosurgical intervention. Typically, in the absence of systemic contraindications, casualties are brought to the operating room in the first 2-3 hours after admission. Complete, definitive neurosurgical interventions are performed as required for each patient. Those patients not requiring surgery are transferred to other cities for continued care away from the front lines as soon as they are stable.

Mechnikov Hospital neurosurgeons constantly study, evaluate and record the results of their treatment of these complex patients. They share their experience with colleagues around the world through numerous reports at congresses, conferences, symposia, and publications in world-renowned journals (see partial list at end of this article). These efforts are carried out despite rolling blackouts, air raid alarms, and limited electrical power outside the hospital.

These lessons have already impacted the new guidelines for the treatment of penetrating TBI, especially the management of penetrating carotid and vertebral artery injuries, which until now have been treated based on the experience of the military campaigns in Iraq and Afghanistan. But the volume of casualties, proximity of Mechnikov Hospital to the battlefield, and application of new techniques and technology in the first modern “Near-Peer Adversary” wartime conflict make the Ukrainian experience far different from that of prior conflicts.

A practical neurosurgical guide called "Lessons of War" has already been published in Ukrainian. At the initiative of Professor Rocco Armonda, it will be supplemented and translated into English and distributed as widely as possible.

### **Problems**

From the beginning of the full-scale invasion of Russia into Ukraine until June 5, 2024, more than 29,000 wounded--both civilians and military--have been treated at Mechnikov Hospital. Lack of supplies and technical means to treat such large numbers of wounded is a constant worry. However, the main problem is maintaining the quality and quantity of the medical staff.

The health care providers have not had rotations or vacations for more than two years. Just imagine: in addition to the large number of neurosurgical patients who were receiving treatment at Mechnikov Hospital before the war, there are now thousands more casualties, as well as hundreds of refugees and displaced persons. The civilian patients often require the most complex neuro-oncological and neurovascular operations, but these can only be offered when the operating rooms and endovascular suites are not being used for wartime casualties.

Neurosurgeons in eastern Ukraine do not have the opportunity to travel to conferences abroad or even within Ukraine. Many health care providers in Dnipro and nearby areas resigned, went abroad, found easier jobs in western Ukraine, or were mobilized to the ranks of the armed forces. Life under constant alarms and explosions throughout the city, often without electricity and internet, is hard to imagine in an advanced country in the 21st century. The task is not only to survive but also to save people's lives while constantly worrying about the safety of relatives.

In difficult times, people pray to God and look for a leader. The head of the neurosurgical service of Mechnikov Hospital, Professor Andrii Sirko, helps to maintain the defense. As President, Ukrainian Neurosurgical Association, he has the responsibility to lead by example and show where and what a real neurosurgeon and a real patriot of Ukraine should do. High-level professionals, including Sergii Grygoruk, Dmytro Ovcharenko, and Yurii Cherednychenko, actively help and support this difficult work. Even during the war, Professor Sirko continues to train and graduate scientific personnel, including having one of his students present his doctoral dissertation while air raid sirens blared in the background. A military-civilian interaction has been established with all military neurosurgeons, providing round-the-clock advisory assistance, helping to resolve issues of triage, and consulting on neurosurgical interventions.

### **Inspirational help and support**

Several visitors have provided strong support in difficult times and did not allow Mechnikov Hospital's neurosurgeons to give up. They were not afraid; they traveled to the front-line hospital in Dnipro; they worked every day in the operating and resuscitation rooms, rescuing wounded soldiers and civilians. They brought new techniques, technologies, and equipment. Most importantly, they brought support to our disadvantaged people and confidence in our victory and in the victory of democracy. Not only doctors, but also nurses, and many others in the hospital received renewed hope for salvation and a huge charge of positive energy to continue the struggle.

Professor Rocco Armonda from America became the first permanent and reliable assistant not only for neurosurgery but also for all services of the hospital. Having served 31 years in the US Army Medical Corps, with deployed experience in the austere environment of Iraq early in the war in 2003, he identified with the struggles of Mechnikov physicians. They were part of the same brotherhood of surgeons, facing unique challenges and far greater volumes than American physicians saw in the recent wars in Iraq and Afghanistan. Professor Armonda and his colleagues and friends provide great support to the neurosurgical and surgical centers of Mechnikov Hospital in the form of consumables, instruments, devices, and medicines. This included colleagues trained in TCD neuromonitoring (Alex Razomovsky and Ken Greene), neuroendovascular surgery, and neurotrauma and critical care. All the material regularly sent by Professor Rocco Armonda--with the support of RAZOM for Ukraine--is used the very next day after arrival to save wounded civilians and defenders (Heroes of Ukraine).

Other American neurosurgeons who have visited Mechnikov Hospital are Alex Valadka, Luke Tomycz, Maxim Shapiro, Kim Nelson, Kim Wright, and Connor Berlin. Rocco Armonda operated and treated patients at the Mechnikov Hospital twice (in 2023 and 2024). Alex Valadka also worked at Mechnikov Hospital for a week in 2024 and will return later this year. University of Virginia fifth-year resident Connor Berlin lived, worked, and assisted in operations at Mechnikov Hospital for a whole month. Sharing difficult and stressful experiences forges friendships that cross national borders and allow visitors to return to their homes and spread the word about what is happening in Ukraine.

Other important visitors included Professor Dr. med. Constantin Roder, who is senior consultant for neurosurgery at University Hospital Tübingen, Germany, and Professor Pedro-Lilyk from Buenos Aires, Argentina. Canadians James Rutka and Greg Hawryluk, American Russell Andrews, Briton David Baxter, German Uwe Max Meier, and Swede Mattias Skold are neurosurgeons who have joined many others in extending their support and help.

This extraordinary global cooperation and support has been invaluable for helping patients receive the best and most up-to-date care. Benefits of this international collaboration include obtaining modern equipment and instruments, implementing contemporary techniques and technologies, expanding the range of available open and endovascular operations, consulting on

complex surgical and intensive care unit patients, conducting research, publishing articles and monographs, presenting papers at congresses, meetings and symposia worldwide, maintaining constant online and telemedicine consultations, educating a resident from America, and much more, including Dr. Armonda even donating his blood for the wounded in Mechnikov Hospital.

Sadly, this unnecessary war continues. Mechnikov Hospital and all of Ukraine need constant support and help from the international neurosurgical community. Good must overcome evil. The world must know the truth about what is happening in Ukraine. This is not only a fight for Ukrainian freedom and independence but also a fight for peoples' rights and for democratic freedoms everywhere so that those who would threaten that freedom anywhere in the world will see how fiercely it is defended. Tragically, this fight to protect all of Europe and to resist tyranny is being paid for every day by the best representatives of Ukraine's people and youth.

We know you can support Ukraine, Ukrainian neurosurgery, and the neurosurgical service of the Mechnikov Hospital. We will be grateful for any and all help. Together to victory!

### **Additional readings:**

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- Tomycz LD, Markosian C, Strelko O, Sirko A, Lovha M, Armonda RA; contributors to Razom Health. Urgent need for neurological care in Ukraine. *Lancet Neurol.* 2023 Mar;22(3):202-203. doi: 10.1016/S1474-4422(23)00026-1. PMID: 36804088. <https://pubmed.ncbi.nlm.nih.gov/36804088/>

**Fig. 1. UANF 2023. Ukrainian-American Neuro Friendship in Dnipro, Ukraine.**

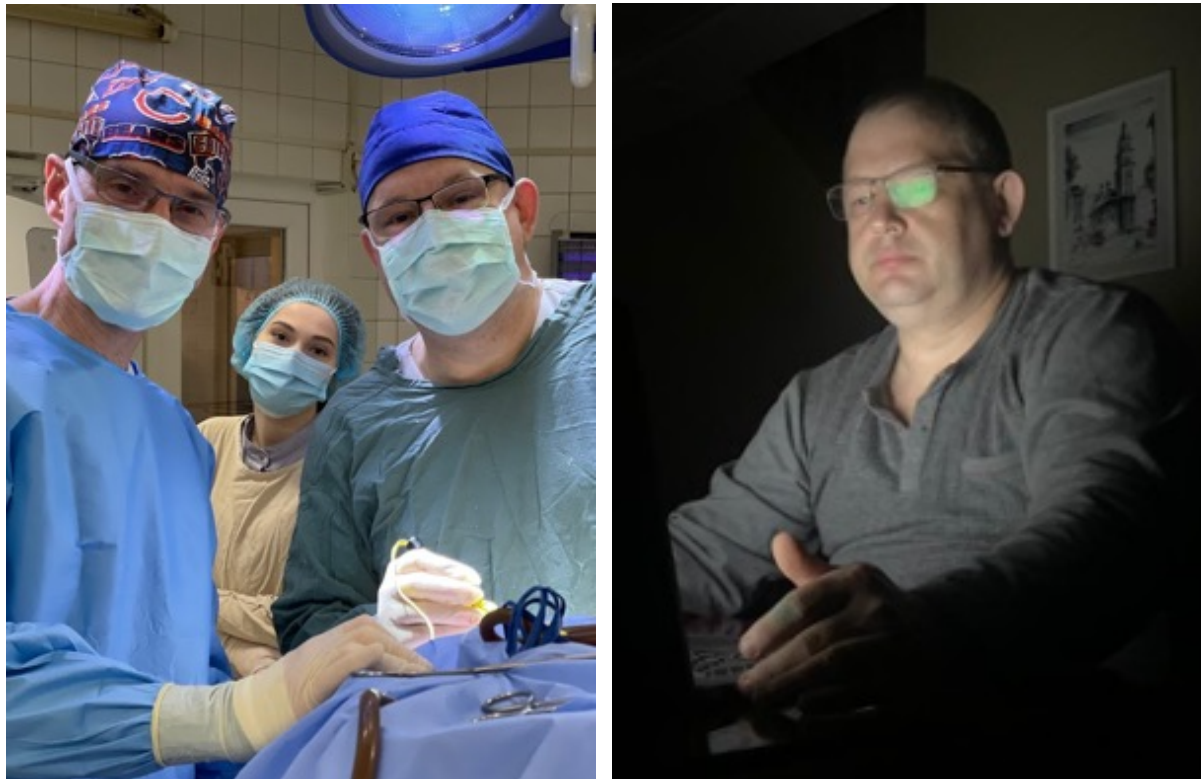


**Fig. 2. Doctor Yuriy Cherednychenko and Professor Rocco Armonda perform endovascular surgery on a wounded civilian.**





**Fig. 3.** Left: Professors Alex Valadka and Andrii Sirko operate on a seriously injured defender of Ukraine in an open neurosurgical operating room. Right: Professor Andrii Sirko is working on a scientific project on the residual charge of a laptop in the absence of power supply due to damage to the region's electrical system by enemy missile strikes.



**Fig. 4.** Neurosurgeons of the Mechnikov Hospital operate on a patient with a mine-explosive shrapnel penetrating craniofacial wound through a transnasal approach.

