



Peripheral nerve surgery in Serbia: “Think global, act local” and the privilege of service



Lukas Rasulić^{a,b,*}, Mariano Socolovsky^c, Christian Heinen^d, Andreas Demetriades^e, Milan Lepić^f, Nathan A. Shlobin^g, Andrija Savić^{a,b}, Jovan Grujić^{a,b}, Stefan Mandić-Rajčević^h, Sanja Lepićⁱ, Miroslav Samardžić^{a,b}, WFNS Peripheral Nerve Surgery Committee Task Force (Contributors)

^a Faculty of Medicine, University of Belgrade, Belgrade, Serbia

^b Department of Peripheral Nerve Surgery, Functional Neurosurgery and Pain Management Surgery, Clinic for Neurosurgery, Clinical Center of Serbia, Belgrade, Serbia

^c Peripheral Nerve and Plexus Program, Department of Neurosurgery, University of Buenos Aires School of Medicine, Buenos Aires, Argentina

^d Peripheral Nerve Unit Nord, Christliches Krankenhaus Quakenbrück GmbH, Quakenbrück, Germany

^e Department of Neurosurgery, Royal Infirmary of Edinburgh, Little France, Edinburgh, UK

^f Department of Neurosurgery, Military Medical Academy, Belgrade, Serbia

^g Department of Neurological Surgery, Northwestern University Feinberg School of Medicine, Chicago, IL, USA

^h School of Public Health and Health Management and Institute of Social Medicine, Faculty of Medicine, University of Belgrade, Belgrade, Serbia

ⁱ Institute of Hygiene, Military Medical Academy, Belgrade, Serbia

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ABSTRACT

Introduction: The phrase “think globally, act locally”, which has often been used to refer to conservation of the environment, highlights the importance of maintaining a holistic perspective and stipulates that each individual has a role to play in their community and larger world. Although peripheral nerve surgery has been largely unemphasized in global neurosurgical efforts, a wide disparity in peripheral nerve surgery is presumed to exist between high-income and low- and middle-income countries. Serbia is an upper middle-income country with a long history of peripheral nerve surgery.

Research question: How can understanding the development of peripheral nerve surgery in Serbia advance global education and improve peripheral nerve surgery worldwide?

Material and methods: An anecdotal and narrative review of recent advances in peripheral nerve surgery in Serbia was conducted. The World Federation of Neurological Society (WFNS) Peripheral Nerve Surgery Committee discussions on improving peripheral nerve surgery education were summarized.

Results: In this manuscript, we describe the application of “think globally, act locally” to peripheral nerve surgery by providing an account of the development of peripheral nerve surgery in Serbia. Then, we report measures taken by the WFNS Peripheral Nerve Surgery Committee to improve education on peripheral nerve surgery in LMICs.

Discussion and conclusion: Viewing the development of peripheral nerve surgery in Serbia through the lens of “think globally, act locally” may guide the development of peripheral nerve surgery in LMICs.

1. Introduction

The phrase “Think Globally, Act Locally”, which has often been used to refer to conservation of the environment, emphasizes the importance of maintaining a holistic perspective and stipulates that each individual has a role to play in their community and larger world. This concept was

introduced to international education in the 1950s and publicized in 1989 through the article “Think Globally, Act Locally: A Delphi Study of Educational Leadership Through the Development of International Resources in the Local Community.” (Grauer, 1989) Despite the development of the Internet and other tools to facilitate collaboration on small and large scales, this concept has experienced less uptake than might be expected.

* Corresponding author. Department of Peripheral Nerve Surgery, Functional Neurosurgery and Pain Management Surgery, Clinic for Neurosurgery, Clinical Center of Serbia, Višegradska 26, Belgrade, Serbia.

E-mail address: lukas.rasulic@gmail.com (L. Rasulić).

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Recently, “Think Globally, Act Locally” has been popularized in medicine. Dr. Tedros Adhanom Ghebreyesus, Director-General of the World Health Organization (WHO), is perhaps the most prominent figure who has emphasized its importance. While publicizing the Global Action Plan on Physical Activity in 2018 during a visit to Lisbon, Portugal, in 2018, he noted,

“as the world’s leading authority on health, we spend a lot of time analyzing global trends, agreeing on global action plans and setting global standards. But those plans and standards don’t mean anything unless they result in local action; unless they have an impact on the lives of people and communities.” (Ghebreyesus, 2018)

This concept, applied to the design of health systems and international medical collaborations (Smoyer et al., 2016; Macfarlane et al., 2008), led to the establishment of global neurosurgery, which brings together neurosurgical care and public health to address the global burden of neurosurgical disease, with a specific focus on the disproportionate burden on low- and middle-income countries (LMICs) (Park et al., 2016; Dewan et al., 2018; Niqen-Jimenez et al., 2020). In neurosurgery, “Think Globally, Act Locally” has been implemented most prominently through the World Federation of Neurosurgical Societies (WFNS) and its committees and representatives. Notably, the WFNS Training Centers, WFNS Fellowship, and WFNS Foundation Neurosurgical Equipment Support initiative serve as exemplars of this concept (Robertson et al., 2020; Arraez, 2021; Karekezi and El Khamlichi, 2019). Most global neurosurgical efforts have focused on traumatic brain injury, stroke, hydrocephalus, epilepsy, and tumors as these comprise the majority of essential neurosurgical cases worldwide (Dewan et al., 2018).

Although peripheral nerve surgery (PNS) has been largely unexplored in global neurosurgical efforts, a wide disparity in peripheral nerve surgery is presumed to exist between high-income countries and LMICs. The concept of “Think Globally, Act Locally” may be mobilized to address the health systems and training-related factors that lead to inadequate provision of PNS. At present, most neurosurgeons report insufficient exposure to peripheral nerve surgery during training, discomfort with complicated procedures, and limited case volumes (Maniker and Passannante, 2004; Maniker, 2011). Serbia is an upper middle-income country with a long history of peripheral nerve surgery (The World Bank, 2022; Rasulić et al., 2022). In this manuscript, we describe the application of “Think Globally, Act Locally” to peripheral nerve surgery using the example of Serbia and discuss measures taken by the WFNS Peripheral Nerve Surgery Committee to improve education on peripheral nerve surgery in LMICs.

2. Think globally

Peripheral nerve surgeons in Serbia have manifested the concept of “thinking globally” through their involvement in neurosurgery on an international scale, making important contributions while overcoming economic and political challenges.

Professor Miroslav Samardžić, the founding father of modern PNS at the Clinic of Neurosurgery at the Clinical Center of Serbia, was the first individual to publish a paper on peripheral nerve surgery in a major neurosurgical journal. In 1986, he published a manuscript that analyzed histologically prepared nerves and the surgical results of donor pure motor nerves in the reinnervation of the brachial plexus (Samardžić et al., 1986). Professor Zoran Roganović, the most prominent neurosurgeon in Serbian military surgery, published articles on peripheral nerve injuries based on the experiences from the Yugoslav Wars in the Military Medical Academy in Belgrade, Serbia. Manuscripts focused on repair of missile-induced injuries of the ulnar, median, peroneal, tibial, and sciatic nerves and the difference in recovery potential of peripheral nerves after graft repair (Roganović et al., 2005; Roganovic, 2004, 2005a, 2005b; Roganovic and Pavlicevic, 2006). Moreover, PNS was the first subspecialty of Serbian neurosurgery to become recognized internationally and

have representatives in WFNS Committees. Since then, Serbian PNS has become well-recognized worldwide.

The last ten years have been marked by Professor Rasulić’s participation in major neurosurgical events, in which he has served as a promoter of Serbian neurosurgery, Serbian PNS, and PNS in general, and increased interest in the subdiscipline among neurosurgeons worldwide. A pre-meeting event at the World Congress of Neurological Surgery focused on peripheral nerve surgery, while the XV WFNS Interim meeting in Rome in 2015 included a committee workshop on “Controversies in Peripheral Nerve Surgery” (Rasulić, 2015). Additionally, Professor Rasulić has been invited, either as a co-president or organizing/scientific committee member of the faculty, to notable peripheral nerve surgery conferences. These include the first *World Congress of Brachial Plexus and Peripheral Nerve Surgery* held in New Delhi, India in 2016 organized by Indian Society for Peripheral Nerve Surgery; and *WFNS Theoretical & Practical International Courses in Peripheral Nerve & Brachial Plexus Surgery* held in Leon (2016), Frankfurt (2018), and Buenos Aires (2019) respectively; the *Copenhagen Peripheral Nerve Surgery Courses*; Narakas International Symposia on brachial plexus and peripheral nerve surgery; and Sunderland Society Meetings (Mehta and Sinha, 2019).

After being involved with the WFNS Committee for Peripheral Nerve Surgery for many years, Professor Rasulić was appointed as Vice-Chair in 2015, before being elected as Chairman in 2019. He served as the founder and founding president of the European Association of Neurosurgical Societies (EANS) Section for Peripheral Nerve Surgery (2017–2021). Being the most proactive EANS Section, it has organized the most webinars of all Sections, published a systematic review and consensus papers on thoracic outlet syndrome (Dengler et al., 2022), and derived a preliminary European nerve surgery curriculum.

Furthermore, Professor Rasulić has helped spearhead close collaborations with the American Association of Neurological Surgeons, Congress of Neurological Surgeons, Latin American Federation of Neurosurgical Societies, Asian Australasian Society of Neurological Surgeons, and Continental Association of African Neurosurgical Societies, as well as individual national societies. These symbiotic partnerships have elevated the Department of Peripheral Nerve Surgery at the Clinic of Neurosurgery of the Clinical Center of Serbia as a center of excellence and endowed peripheral nerve surgery as the crown jewel of all Serbian neurosurgical subspecialties.

3. Act locally

Historically, the Serbian Neurosurgical Society (SNSS) was relatively isolated, apart from a few international anniversary events organized by the leadership of the SNSS with the support of Professor Madjid Samii. The election of Professor Rasulić as President of the SNSS in 2015, along with his efforts as one of the founders of the South East Europe Neurosurgical Society (SeENS) in 2012, ushered in a new era of the SNSS. Neurosurgeons in Serbia gained unrestricted access to important international neurosurgical faculty, beginning with the invitation of international faculty to the SeENS Congress in Belgrade in 2013 and the introduction of the SNSS Annual Meeting in 2015. Since then, events have been well attended by international faculty. Belgrade hosted the 2nd Theoretical Practical and Hands-on course in 2017 in conjunction with the SNSS Annual Meeting (Fig. 1), as well as the 1st WFNS International Meeting in 2019 (Fig. 2). (Rasulić, 2021) The EANS 2022 Congress will be held in Belgrade. The fact that Serbia has been entrusted with hosting two major international neurosurgical congresses in a row – WFNS 2019 and EANS 2022 – is an unprecedented development for the country and illustrates the growth of Serbian neurosurgery.

As a result of these endeavors, interest in PNS in Serbia has dramatically increased among neurosurgeons in the recent years, with a sequential increase in the number and range of surgical procedures performed in the neurosurgical and peripheral nerve centers country-wide. Noteworthy, a significant portion of recent international publications by the authors from Serbia have been within the field of PNS



Fig. 1. Participants of the 2nd Theoretical, Practical & Hands-on International Course in Peripheral Nerve and Brachial Plexus Surgery held in 2017, in Belgrade, Serbia, with a high number of participants from all over the world.



Fig. 2. Representatives of the WFNS, Organizing and Scientific Committees during the 1st WFNS International Meeting in 2019, Belgrade, Serbia. In picture are (from left to right): Franco Servadei, Ihsan Solaroğlu, Ioan Stefan Florian, Marco Cenzato, Francesco Tomasello, and Lukas Rasulić.

(Rasulić et al., 2017; Rasulić et al., 2017a, 2017b, 2018, 2020), and PhD candidates are increasingly choosing topics related to PNS for their doctoral dissertations.

The local and regional medical communities have also increased their interest in PNS. Moreover, Professor Rasulić's efforts towards the global

recognition of Serbian PNS and neurosurgery were summarized by Professor Karl Schaller, president of the EANS at the time, during the EANS Training Course in Head Injury/Functional Neurosurgery in 2018 in Belgrade:

"I must admit, speaking from my heart. Nobody knew Serbian neurosurgery until you appeared on the floor! This was 4–5 years ago, and we had no idea about Serbia, and you made everything happen here, in Serbia, not only the training course but also the European Congress ...".

3.1. Serbian Center for Peripheral Nerve Injuries and Diseases

To further enhance the development of PNS in Serbia, Professor Rasulić established the Serbian Center for Peripheral Nerve Injuries and Diseases. The Center embraces the transdisciplinary nature of PNS and utilizes the multidisciplinary approach, embracing:

- Muscle/bone/vascular repair as a single-stage primary surgery (with nerve repair, for simple sections). The approach is exceptionally important in mutilate injuries (extremity avulsions).
- Delayed nerve repair as a secondary procedure when the primary procedure is not possible, performed in the PNS center of excellence – the Department of Peripheral Nerve Surgery in the Clinic for Neurosurgery of the Clinical Center of Serbia. The complete nerve and adjacent tissue surgical reconstruction and restoration is performed as a single-stage procedure through a multidisciplinary approach in collaboration with vascular, orthopedic, and plastic surgeons (Rasulić et al., 2017).
- The third stage and palliative procedures in cases when nerve repair previously failed are performed by neurosurgeons and orthopedic microsurgions (muscle & tendon transfers).
- Evaluation in both preoperative and postoperative settings is achieved through the collaboration with the same group of neurologists and neurophysiologists.
- Imaging is performed by experienced radiologists via magnetic resonance imaging and ultrasound.
- Stimulation and rehabilitation follow the surgery during the hospital stay, while further postoperative treatment is carried by rehabilitation centers.

Unfortunately, the Center is not yet housed under one roof, but rather formed through patient flow, communication, and coordination between healthcare personnel. Furthermore, future areas for exploration include the use of robotics, artificial intelligence, non-neural repair, augmentation of regeneration with cell therapy, and physical methods. The field of peripheral nerve surgery, and by proxy, the Center, are interested in the development of new methods and techniques for improved functional recovery following brachial plexus surgery with proximal and distal neurotization and improvement of quality of life through surgical and nonsurgical approaches (Rasulić et al., 2017a).

A strong pillar of the Serbian Center for Peripheral Nerve Injuries and Diseases is education, in part through national and locally held international meetings that attract a variety of specialists. Two national courses deserve special mention: the Serbian Medical Society Neurosurgical Section Meeting in Zlatibor, Serbia, in 2016, and an event dedicated to peripheral nerve diseases and injuries in Slatina, Bosnia and Herzegovina, in 2018. The faculty from these two national meetings were invited to participate with chapter contributions in the volume [in Serbian] "*SSurgery of Peripheral Nervous System: Multidisciplinary Approach*, which was edited by Professor Rasulić and published in 2021 (Fig. 3), targeting Serbian medical practitioners who manage these patients.

4. Privilege of service

In the case of PNS in Serbia, thinking globally and acting locally has resulted in the disproportionate impact of Serbian PNS on global PNS. Despite its relatively small size and modest economic position, Serbia has led the development of peripheral nerve and brachial plexus surgery and cemented the importance of this subfield within neurosurgery more

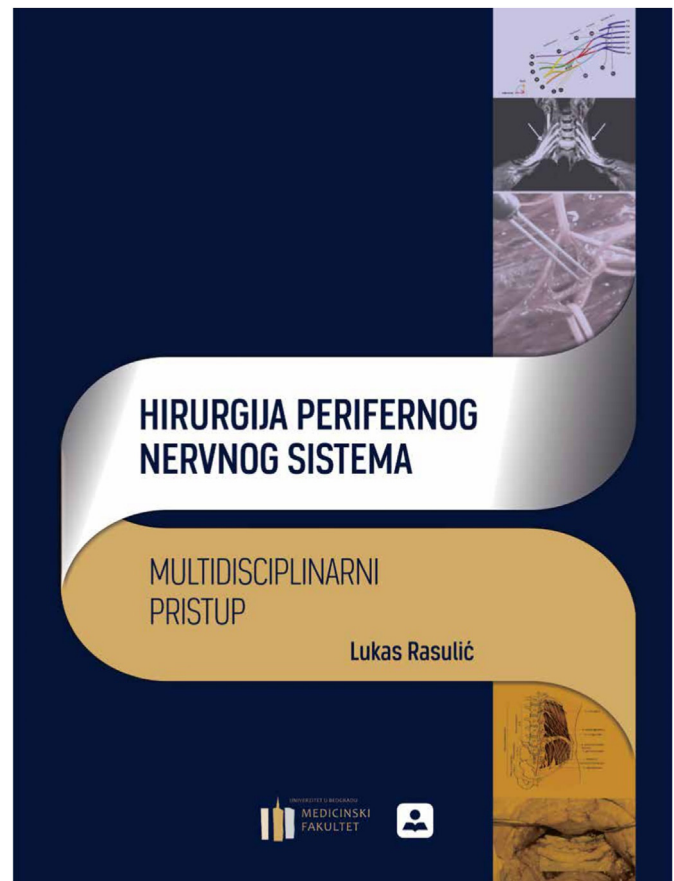


Fig. 3. Cover for the "Surgery of Peripheral Nervous System: Multidisciplinary Approach" book in Serbian.

broadly.

The international neurosurgical community has recognized Serbian PNS through two means: locally as an example of development in the provision of neurosurgical care and globally as a center for international education. Over the past few years, many international observers and fellows have visited the Department of Peripheral Nerve Surgery in the Clinic for Neurosurgery of the Clinical Center of Serbia to improve their clinical reasoning and engage in hands-on cadaver training, microsurgical skills labs, and in-surgery training (Table 1).

Through the efforts of the WFNS Peripheral Nerve Surgery Committee, EANS Section of Peripheral Nerve Surgery, SeENS, and SNSS, PNS has gained broader visibility and recognition. Moreover, the field has helped shed traditional criticisms, such as the long and questionable recovery, difficult and prolonged operations, and lack of surgeon satisfaction (Laws, 2003). The end of the second decade of the 21st century bears witness to this paradigm shift. The subspecialty has gained attention with the dedicated sessions in the recent WFNS International Meeting in Belgrade, Serbia (2019); Special World Congress in Beijing, China (2019); EANS Congress in Brussels (2018), Dublin (2019); SeENS Congresses in Belgrade (2013), Sarajevo (2015), Cluj-Napoca (2017) and Thessaloniki (2019); the XVII World Congress of Neurosurgery in Bogotá (2022), and the EANS Congress in Belgrade (2022).

4.1. Improving peripheral nerve surgery education in LMICs

The WFNS Global Neurosurgery Committee and Peripheral Nerve Surgery Committee organized a joint webinar titled "The Centrality of Peripheral Nerve Surgery" in May 2021 to raise awareness regarding the importance of peripheral nerve surgery, particularly in LMICs. In these countries, capacity for this particularly specialized form of surgery is

Table 1

International observership and fellowship attendees (2018–2022) and applicants in the field of peripheral nerve surgery at the Department of Peripheral Nerve Surgery, Functional Neurosurgery and Pain Management Surgery in Clinic for Neurosurgery of the University Clinical Center of Serbia in Belgrade.

	Country of origin	Timeframe
Observer/Fellow		
Wu Yafang	China	20.04–20.10.2018.
Marcelo José Da Silva De Magalhães	Brazil	16–27.07.2018.
Ivan Domazet	Croatia	July 2021 and 28.10–01.11.2019.
Natalia Denisova	Russia	03–14.09.2018.
Roman Kovalenko	Russia	03–14.09.2018.
Ibrahim Alhalal	Saudi Arabia	01.10–31.12.2018.
Berényi György	Hungary	18–25.03.2019.
Suyash Singh	India	18.03–04.04.2019.
María Elena Córdoba Mosqueda	Mexico	18.03–26.04.2019.
Dmitry Rogov	Russia	30.09–11.10.2019.
Jacopo Visani	Italy	maj-novembar 2021.
Izchel Orozco Aponte	Mexico	18.09–21.10.2022.
Phridoni Devdariani	Georgia	15.10–21.11.2022.
Lasha Dzotsenidze	Georgia	15.10–21.11.2022.
Applicant		
Ujwal Yeole	Inida	TBD
Khaled AlAli	United Arab Emirates	TBD
Francesco Maria Crisa	Italy	TBD
Mian Awais	Pakistan	TBD
Ahmed Hussein	Egypt	TBD
Brighton Nyamapfene	Zimbabwe	TBD
Tamara Ius	Italy	TBD
Ante Rotim	Croatia	TBD
Domagoj Gajski	Croatia	TBD
Dragan Janković	Germany	TBD
Vedran Dovečer	Croatia	TBD
Vojislav Đurković	Bosnia and Herzegovina	TBD
Chandan Mohanty	India	TBD
Arunkumar Sekar	India	TBD
Rajesh Kumar	Pakistan/Dubai	TBD

often inadequate due to limited trained surgeons, resources, and funding and inadequate healthcare infrastructure. Members of the Peripheral Nerve Surgery Committee then created a Taskforce dedicated to improving peripheral nerve surgery education in LMICs (Table 2). During the group's first meeting on June 25, 2021, the group resolved to:

1. Create a surgical curriculum outlining surgical procedures, from basic to innovative. The approach that will be used - "KISS" (Keep it simple surgeon!), will enhance educational and treatment activities while minimizing resource constraints to the extent possible.
2. Create instructional videos that will follow the surgical curriculum
3. Organize a collection of video presentations and lectures and distribute them through the WFNS network
4. Travel to different countries for pre-established periods of time and operate on patients with the local neurosurgeons to enhance their training. This will be conducted in cooperation with national, regional, and continental neurosurgical societies and be based on the training needs of the local surgeons
5. Travel and organize specialized theoretical and hands-on courses for groups of neurosurgeons and develop specialized training courses (where applicable)
6. Accept individuals from LMICs for residency training at hospitals in EANS member countries and provide them with the best possible and affordable conditions
7. Organize live webinars and educational courses

While these are preliminary steps, increasing momentum to improve the provision of PNS and care globally through clinical training and

Table 2

WFNS PNS Taskforce Group members.

Member	Country
Mariano Socolovsky	Argentina
Robert Jay Spinner	USA
Thomas Kretschmer	Austria
Stefano Ferraresi	Italy
Christian Heinen	Germany
Hesham El-Sobky	Egypt
Debora Garozzo	Dubai
B. Indira Devi	India
Mohammadreza Emmamhadi	Iran
Bassam Addas	Saudi Arabia
Allan Belzberg	USA
Eric Zager	USA
Fernando Guedes	Brazil
Carlos Alberto Rodríguez Aceves	Mexico
Zarina Ali	USA
Fernando Martinez Benia	Uruguay
Line Jacques	USA
Christopher Winfree	USA
Vincenzo Paternó	Germany
Willem Pondaag	Netherlands
Wilson Zachary Ray	USA
Fernando Romero Prieto	Guatemala
Mark A. Mahan	USA
Prabin Shrestha	Nepal
Lukas Rasulić	Serbia

education, with particular focus in LMICs, is encouraging, it suffered a significant delay in actions due to the coronavirus disease 2019 (CoViD-19) pandemic. Now that the pandemic end is finally in sight, the efforts are expected to intensify. The Taskforce and other groups are eager to engage in tangible action to improve education in PNS in LMICs (most likely in Africa for the very first time), centering efforts around local priorities and navigating resource constraints will be essential to address the global burden of peripheral nerve disease (Ng-Kamstra et al., 2016).

PNS has remained true to its roots. It does not need expensive equipment or supplies and is not dependent from the advanced post-operative care. Surgical skills are indispensable and could not be compensated with the use advanced technological devices. Based on the experience of PNS in Serbia, the WFNS Peripheral Nerve Surgery Committee, EANS Peripheral Nerve Section and WFNS Taskforce expect their efforts to enhance the capabilities of LMIC in PNS in the future. These educational initiatives will train the next generation of global peripheral nerve surgeons, including the future leaders in this specialty both globally and locally.

5. Conclusion

The maxim of "Think Globally, Act Locally" serves as a powerful lens through which we conceptualize the development of PNS. Applying this lens to the specific case of the development of peripheral nerve surgery in Serbia through may guide the development of PNS in LMICs.

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None.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

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