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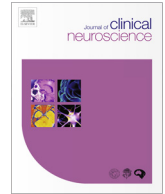
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Review article

European women in neurosurgery: I – A chronology of trailblazers



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ABSTRACT

Neurosurgery as a distinct speciality has been around for 100 years. Some of the earliest women neurosurgeons were European, emerging from the 1920's onwards. Here we detail the rise of women in neurosurgery across Europe with a decade by decade account of big events and firsts across the continent. The emerging themes are seen in stories of pioneers with enormous resilience, camaraderie, trailblazing and triumphing in a system with great obstacles and challenges. Our journey through this chronology brings us to the modern day, where most European countries have or have had a woman neurosurgeon and the future for women in neurosurgery in the continent is very bright.

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1. Introduction

Europe is a melting pot of peoples; a crossroads of ethnicities, cultures, languages, and religions. While this diversity can be enriching and foster tolerance and intercultural exchange, it also accounts for great heterogeneity between nations. In terms of gen-

der parity, this variability is evident. While Western Europe is the highest performing region in the world according to the World Economic Forum, Eastern Europe occupies the fourth place in this ranking.[1] Looking at individual countries, Iceland, Norway, and Finland are the frontrunners in gender equality worldwide, while Armenia, Hungary, and Tajikistan occupy the 98th, 105th, and 137th global positions respectively, at the bottom of the European ranking.[1]

European medicine reflects this disparity. The proportion of female physicians has continuously increased between 2007 and 2017; however, in countries such as Luxembourg and Cyprus, only 36% and 38% of practicing doctors are women, while almost three quarters of the medical workforce are women in Baltic nations.[2] Conversely, neurosurgery continues to be a male-dominated field in Europe, with an average of 12% of the neurosurgical workforce being women,[3] and only 6% of the leadership positions in European national neurosurgical societies held by women.[4]

Some European countries still await their first neurosurgeon: Andorra and San Marino. No board-certified women neurosurgeons have practiced in Azerbaijan, Cyprus, Moldova, Monaco, Montenegro, Tajikistan, Turkmenistan, and Uzbekistan. Interestingly, despite not having graduated a woman neurosurgeon until the 1970 s, the percentage of women neurosurgeons at 36% is highest in Italy (Fig. 1). Nevertheless, a positive trend is obvious in women recruitment into the specialty: in 2016, the average percentage of woman neurosurgery residents was 29%, compared to 9% of board-certified women neurosurgeons.[3]

Here we celebrate the journeys, contributions, and achievements of the women trailblazers in European neurosurgery who have made change possible and continue to advance our field through their ingenuity and dedication. Their stories are testimonies to European diversity and to the glass ceiling in European neurosurgery, yet they all share an underlying leitmotif: resilience, commitment to patients and excellence, and passion for our challenging, yet most rewarding profession.

2. Methods

The research method for this study was chain-referral sampling. Information presented in this paper represents the labors of a collaborative global working group of women involved in neurosurgery in different countries at various stages of neurosurgical careers. Information was gathered through personal communications, identification of pertinent publications, and communication with neurosurgical societies and neurosurgeons across Europe. Europe was defined as the 53 countries listed by the World Health Organization as belonging to the European Regional Office.[5] Much of the data we present is continuously changing. The information we have catalogued is the most accurate as of 9/26/2020.

In April 2020, a continental working group was initiated by a handful of women neurosurgeons, practicing mainly in Europe. These individuals identified other European women neurosurgeons to join the collaborative. New members were encouraged to do the same. The goal was to establish contact with at least one woman neurosurgeon in every European country. For countries with no contacts identified through referral sampling, the World Federation of Neurosurgical Societies and its membership database were consulted. Multiple embassies in Washington, D.C. were also contacted for information.

We asked the women neurosurgeons from each country to provide the following information: (1) the current number and proportion of women neurosurgeons in the country; (2) history of the first women neurosurgeons in the country; and (3) histories of female neurosurgeons who have made significant contributions in the field as leaders, scientists, and/or educators.

This research has uncovered a multitude of talented women with numerous and varied achievements. It is impossible to fully do justice to all their ground-breaking work. With this account, we aim to give a representative flavor of events and achievements relating to women European neurosurgeons over the past century.

3. Chronology of trailblazers

With the exception of the Salerno medical school in medieval Italy, women were not allowed to study medicine in Europe until the late 1800's. The first women in neurosurgery emerged at the beginning of the 20th century.

3.1. 1920's

The first neurosurgical procedures performed by a European woman were probably done by Anna Bormane in the 1920's. She was the first woman in Latvia to obtain an academic doctorate. She worked until 1981 (aged 85) as a surgeon and carried out numerous procedures on peripheral nerves.[6]

The first women to perform cranial surgeries as “neurosurgeons” were in neighbouring Russia and Germany: Serafima Semyonovna Bryusova and Alice Rosenstein, both starting their neurosurgical practices in 1920's. Bryusova wrote the first Russian monograph “Brain Angiography” in 1951. She was multilingual and translated many seminal neurosurgical works of the time into Russian (Fig. 2).[7] Rosenstein contributed to the refinement of pneumoencephalography in Germany and completed comprehensive training in neuroradiology, psychiatry, neurology, and ophthalmology, in addition to neurosurgery. To escape the Nazi persecution of Jewish people, Rosenstein emigrated to the United States in 1934. She had significant operative experience in performing cordotomies and tumour resections while in Europe, but gave up neurosurgery in the United States, becoming a neurologist and psychiatrist in the U.S. Army.[8]

3.2. 1930's

World War II also temporarily derailed the neurosurgical career of Diana Beck in England. After graduating from medical school in 1939, she trained in neurosurgery at University of Oxford. She was unable to assume a consultancy position at the Royal Free Hospital in 1943 because she was called to the Emergency Medical Service to treat WWII casualties. Once the war ended, she became a consultant at the Middlesex Hospital in 1947, where she was the first woman and first neurosurgeon to join the staff. She successfully created and ran the neurosurgical service there.[9]

3.3. 1940's

The 1940's saw the continuous rise of women in neurosurgery in Eastern Europe. In Romania in 1943, Sofia Ionescu, at the time still a medical intern, evacuated an epidural hematoma from a comatose 8-year-old boy. This experience became a pivotal point in her life and unleashed a prolific academic and neurosurgical career. She was honored as the world's first woman neurosurgeon at the 2005 WFNS congress.[10]

Poland's first woman in neurosurgery, Halina Koźniewska, started practice in 1945 and founded the neurosurgical department in Lublin. She was also a non-partisan member of the Polish parliament. (Anna Antonowicz, personal communication, 2020). [11]

Ksenia Ivanovna Kharitonova founded the Siberian department of neurosurgery in 1946 at the Novosibirsk Institute of Traumatology and Orthopedics. From there, she launched neurosurgical

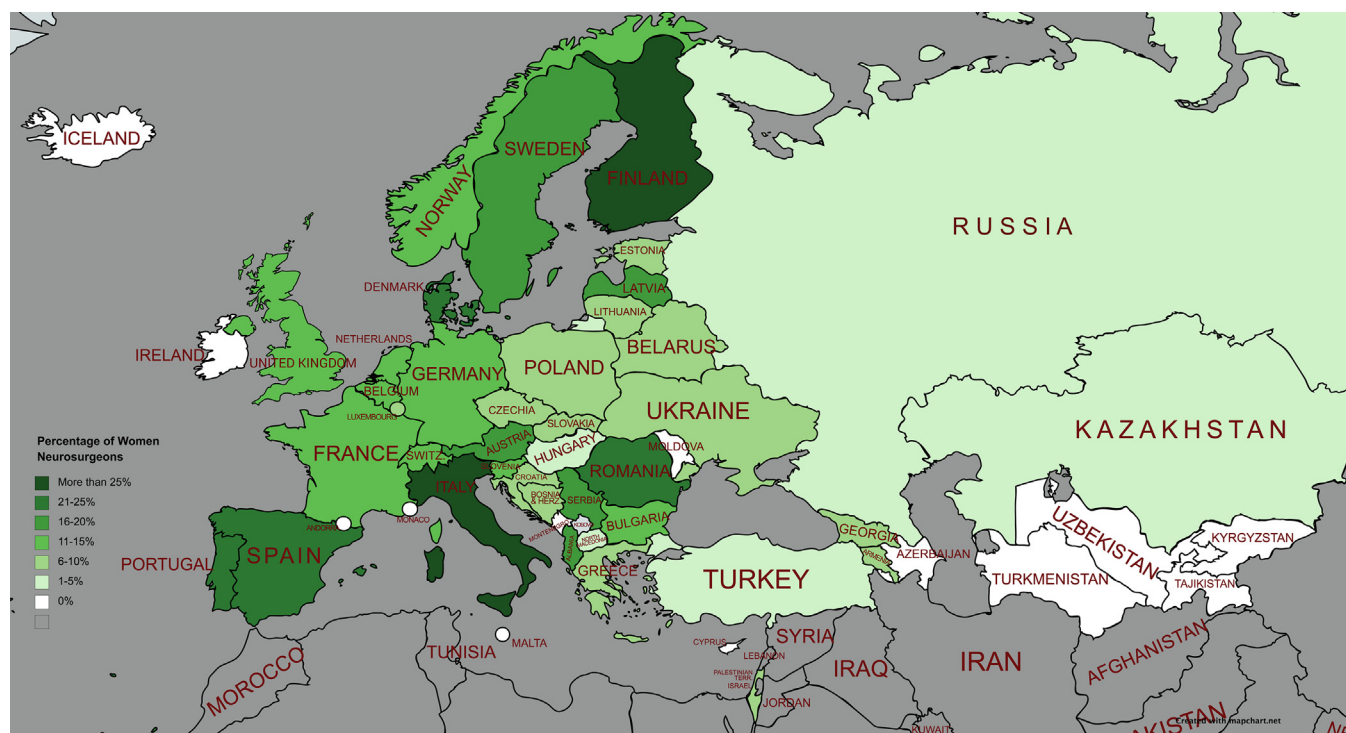


Fig. 1. Proportion of women neurosurgeons currently practicing in each European country, as of 26/09/20.



Fig. 2. Serafima Semyonovna Bryusova in Nikolay Burdenko's team. Upper row, left to right: E. M. Rossels, S. M. Berg, A. S. Chernyshov, A. A. Arendt, K. G. Terian, M. U. Rapoport and lower row, left to right: G. S. Cimmerman, V. V. Kramer, S. S. Bryusova, B. G. Egorov ca. 1930, reproduced with permission from B. Liktherman and G. Danilov.

departments in Krasnoyarsk, Kemerovo, Prokopyevsk, Tomsk, Barnaul and other Russian cities.^[7]

In neighbouring Belarus, Marfa Vasilievna Pavlovets started her 40-year neurosurgical career at the Belarussian Scientific and Research Institute for Neurology, Neurosurgery and Physiotherapy and, in 1948, became the country's first woman neurosurgeon. She was a driving force in the development of vascular neurosurgery in the former U.S.S.R. and also fought in the Belarussian Great Patriotic War (Anna Boriseyko, personal communication, 2020).

A year later, Azerbaijan's Anna Artaryan left her home in Baku to start a 49-year career in pediatric neurosurgery in Moscow. In 1982, she became the chair of Russia's first center for pediatric neurosurgery, a position she held for over 30 years.^[12] Like her,

women today leave Azerbaijan to train in neurosurgery, and the country still awaits its first in-country trained woman neurosurgeon (Insa Janssen, personal communication, 2020).

3.4. 1950's

In Estonia, Ruth Paimre was not only becoming the country's first woman neurosurgeon, but also, in 1950, was appointed the first director of the newly founded Department of Neurosurgery at the Tartu University Hospital. Paimre introduced the treatment of radiculopathy to Estonia and became known as the "Queen of Discs". A dedicated surgeon, she served as director of the neurosurgical department until 1983.^[13]

The 1950 s saw the creation of neurosurgical departments in other parts of Europe as well. Evgenija Azarova, a military surgeon in Kazakhstan, recognized a major gap in care for patients with traumatic brain injury in her country, noting they suffered from high mortality and morbidity rates. She founded the Department for Neurosurgery at the Alma Ata Military Hospital. Through her efforts, the mortality rate of traumatic brain injury was decreased to 4–5%, and the full recovery rate increased to 70%. Azarova was also a passionate scientist and teacher, organizing in 1964 the first university courses in neurosurgery and the first training program for neurosurgeons in Kazakhstan.^[14] Other remarkable women neurosurgeons followed her legacy and chaired the department of neurosurgery at Alma Ata in the 1970s: Alexandra Chirkova Illarionovna and Rufina Zhukova Nikolaevna.^[15] Meanwhile, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan still await their first woman neurosurgeon, some 70 years after Azarova introduced the specialty to the region.

Nadezda Smilkova was also making history by becoming the first woman to be trained in neurosurgery at the recently founded university neurosurgical department in Sofia, Bulgaria. After completing her training in the late 1950's, she founded the first neurosurgical department at the Multidisciplinary University Hospital in Ruse in 1963, the largest and oldest regional hospital in north-

eastern Bulgaria. She headed the department until her retirement in 1981.[16]

Meanwhile in Turkey, Aysima Altınok became the first woman neurosurgeon upon completing her training in 1959 at Haydarpaşa Numune Hospital. From 1968 to 1992, she was chief of neurosurgery at Bakırköy Mental and Psychological Health Hospital. In 1968, Altınok co-founded the Turkish Neurosurgical Society. Her notable contributions to Turkish medicine earned her the “Medical Doctor of the Year in Turkey” Award in 1990.[17]

3.5. 1960's

France's first women neurosurgeons were both refugees. Judith Lepeintre fled Romania after World War II. Though she was formally trained as a general surgeon in her home country, in the 1960's she quickly began surgical treatment of children with traumatic brain injury at the Necker Hospital in Paris. Similarly, Aimée Redondo escaped the Spanish Civil War and arrived in France as an 8-year-old girl with tuberculosis. In 1969, she became the first woman neurosurgical resident at La Salpêtrière hospital. After completing training, she went on to become the first and youngest woman professor of neurosurgery in France in 1978 (Evelyn Emery, personal communication, 2020).

Israel's first woman neurosurgeon was Yafa Doron, a refugee and holocaust survivor who migrated from Poland in 1934. She trained in Switzerland, the United States, and Jerusalem, becoming a board-certified neurosurgeon in Israel in 1960. However, in the 1970's she abandoned neurosurgery to become a neuropathologist. In 1965, Veronika Krafkova became Slovakia's first woman neurosurgeon (Anna Steklacova, personal communication, 2020).

In the 1960's, Jadvyga Irena Subačiūtė published the first neurosurgical literature in Lithuania, in collaboration with the father of Lithuanian neurosurgery, Leonas Klumbys. In 1999, she obtained an academic degree for her thesis on extramedullary spinal cord tumors.[18,19] Hungary's Róza Gombi also started making significant academic contributions in her country in the 1960's, in the fields of epilepsy surgery and neurooncology (Mario Ganau, personal communication, 2020).

3.6. 1970's

Larisa Petrovna Tskrialashvili became the first woman neurosurgeon in Georgia in the 1970's, after training in Russia. She herself had a brain tumor, which inspired her to become a neurosurgeon (Lika Khorbaladze, personal communication, 2020).

In 1974, on a whim, Mirjana Nagulic applied for a position at the Clinic for Neurosurgery in the Clinical Center of Serbia. Originally, she wanted to become a neurologist, so she applied for residency with the intention of moving into the department of neurology. She was the best candidate and was appointed to the position. She immensely enjoyed her work and, in 1980, became the first woman in neurosurgery in Serbia, almost by accident (Tijana Ilic, personal communication, 2020). In Slovenia, Milena Jezernik also began her career at the end of the 1970's and became the country's first woman neurosurgeon. She went on to become a renowned endoscopic skull base surgeon, operating on over 400 patients in the region.[20]

Although Milena Aretta Rosso became the first Italian woman neurosurgeon in 1973, Lucia Benvenuti, who started her training in 1974, is generally regarded in her country as the pioneer of women in Italian neurosurgery (Italian Medical Register & Donatella Sgubin, personal communications, 2020).

Around 1975, two Spanish women were entering the neurosurgical world and paving the path for those to come: Josefa Ramiro Hernández and Balbina Ferreras Ferreras. After overcoming many gender-related obstacles, they completed their training and

became consultants in Madrid. When all of their male superiors were unavailable, they were left in charge of the neurosurgical department. Although the chairmen from neighboring departments advised to refer patients elsewhere during the men's absence, Ramiro and Ferreras not only kept the department afloat, but also performed complex aneurysm and skull base surgeries, winning over their skeptics and earning the respect of their contemporaries (Balbina Ferreras Ferreras & Josefa Ramiro Hernandez, personal communications, 2020).

In Turkey, Yıldız Yalçınlar was appointed chief of neurosurgery at Ankara University Faculty of Medicine in 1976. She also contributed to the education of local children by establishing an elementary and a middle school in Ankara.

In 1979, Ukraine's Lyudmyla Nikolaevna Verbova started a 40-year career in pediatric neurosurgery, specializing in neonatal trauma. She has led the pediatric neurosurgical department in Kiev since 2016.[21]

3.7. 1980's

Denmark's first women neurosurgeons began training almost simultaneously in the decade to follow, supporting and encouraging each other and developing a close friendship. They were Birgit Mosdal, Benedicte Dahlerup and Elizabeth Hoppe-Hirsch. While Hoppe-Hirsch was pregnant, Dahlerup would take on-call shifts with her, helping her with administrative tasks and surgeries, so that her training would not be negatively impacted by her pregnancy (Benedicte Dahlerup & Helga Angela Gulisano, personal communications, 2020) (Fig. 3).

In the Benelux countries, Saskia Bakker-Niezen and Vera van Velthoven were embarking upon their neurosurgical journeys and becoming Holland's and Belgium's first women neurosurgeons, respectively. Bakker-Niezen began her training in 1980 and defended her Ph.D. dissertation on tethered spinal cord six years later.[22] Shortly after, she left neurosurgery and went on to pursue a career as an artist. She is now an acclaimed sculptor with frequent exhibitions in the Netherlands (Fig. 4).[23] Van Velthoven became the first woman neurosurgeon in Belgium in 1987. She was academically and scientifically active throughout her career, and in 2015 became the chair and professor of neurosurgery at Vrije Universiteit Brussel.[24]

3.8. 1990's

Although Scandinavia is a world-leader in gender equality, many of its countries did not see their first women neurosurgeons until the 1990's. Sweden's Åsa Solvig Carola Ivarsson, who finished training in 1969, is an exception. She left neurosurgery after finishing training, however, and instead practiced many years as a general surgeon (National Board of Health and Welfare of Sweden & Elisabeth Ronne-Engstrom, personal communication 2020). In neighbouring Norway, Sissel Reinlie was the first woman to complete neurosurgical training in 1994. In 2000, she became the first woman to chair a neurosurgical unit in Norway (Norwegian Directorate of Health, personal communication, 2020). In 1996, Leena Kivipelto became Finland's first in-country trained woman in neurosurgery, although the first Finnish woman to become a neurosurgeon was Terttu Pietilä, who trained in Germany in the 1980's. Pietilä practiced in Germany, while Kivipelto remained in Finland, where she is an associate professor at Helsinki University Hospital and a respected vascular neurosurgeon (Finnish Institute for Health and Welfare & Helsinki University Hospital, personal communications, 2020).

Simultaneously, Denmark's Marianne Juhler was the first woman to be appointed head of clinical neurosurgery at Rigshospitalet, Copenhagen. Juhler then became president of the Danish



Fig. 3. Benedicte Dahlerup (left) and Elizabeth Hoppe-Hirsch (right), two of the three first female neurosurgeons in Denmark, ca. 1980's, reproduced with permission from B. Dahlerup and E. Hoppe-Hirsch.



Fig. 4. Saskia Bakker-Niezen's sculpture. Title: Bescherming (protection). Reproduced with permission from S. Bakker-Niezen.

Neurosurgical Society from 2003 to 2007 and is currently Chair of the Pediatric Neurosurgery Section of the European Association of Neurosurgical Societies.[25]

At the end of the decade, Iceland's Hulda Magnadóttir started her residency at Dartmouth College in the United States. Like her, all Icelandic women in neurosurgery are working in foreign lands. There are only four neurosurgery consultant positions in Iceland, and they are all currently held by men (Hulda Magnadóttir, personal communication, 2020).

3.9. 2000's

With the advent of the new millenium, women neurosurgeons surfaced in smaller countries, where they made great contributions to the advancement of medicine and the neurosurgical profession.

In Bosnia and Herzegovina, Selma Jakupović was appointed to her consultant position in 2001. Like many other women European neurosurgeons, she trained abroad. While doing her residency in France, she visited her hometown of Tuzla as part of a humanitarian mission and went on to establish a cooperation between the two countries (Selma Jakupovic, personal communication, 2020). Similarly, Anna Galstyan became Armenia's first woman in neurosurgery in 2001 after training in Russia and the United States. In the latter, she researched neuro-oncological immunomodulation. In 2017, she co-founded Armenia's first pediatric neurosurgery department (Anna Galstyan, personal communication, 2020) (Fig. 5).

Also in 2001, Austrian Monika Killer-Oberpfalzer was trailblazing uncharted territories for most neurosurgeons in Central Europe: as one of very few dually-trained neurosurgeons/neurointerventionalists, she co-founded the Paracelsus Medizinischen Privatuniversität in Salzburg. In 2007, she became the chair of the neurointerventional department at the Salzburg University Hospital.[26]

Ireland's Mary Murphy was appointed a consultant in London in 2006. She developed a novel pediatric cranial simulator, "babyMarty," allowing residents to gain experience in performing craniotomies for children (Fig. 6).[27]

Turkey's Nurperi Gazioğlu began amassing milestones in 2008, when she became the first woman neurosurgeon to achieve full professorship in her country. She was also the first woman president of the Central Nervous System Surgery Society and co-founded the Istanbul University Pituitary Center in 2015. Since 2017, she has chaired the neurosurgical department at the Demiroğlu Bilim University in Istanbul (Nurperi Gazioğlu, personal communication, 2020).

3.10. 2010's

At the turn of the decade, another woman was trailblazing academic neurosurgery in her country: Eva Brichtová. She is the only woman to be associate professor of neurosurgery in Czechia, a position she attained in 2010. Aside from being an expert in hydrocephalus and pediatric epileptology, Brichtová is an avid painter, equestrian, pianist, archer and keeper of three pet kangaroos.[28]

The decade of the 2010's also saw the rise of women in neurosurgery in the Balkans. In 2011, Aleksandra Dimovska-Gavrilovska became the first and only certified woman neurosurgeon in North Macedonia.[29,30] In Albania, Ejona Lilamani and Jetmira Kërshaliu completed their residencies and were licensed as neurosurgeons in 2015 (Medical Order of Albania & Mentor Petrela, personal communications, 2020). A year later, Nikolina Sesar, a polyglot speaking Croatian, French, Spanish, English and Portuguese, became Croatia's first woman neurosurgeon.[31]

In Greece, Kalliopi Tsoleka became the first woman to lead a neurosurgery department in 2012, when she assumed leadership at the Papageorgiou General Hospital in Thessaloniki, one of the biggest hospitals in Northern Greece. It is notable that the number of women neurosurgeons is almost double than that of men in her department (5/3) (Hellenic Neurosurgical Society and Kalliopi Tsoleka, personal communications, 2020)! [32] In Luxembourg, the majority of residents are also women (4/2), even though Dagmar Broeker is Luxemburg's only certified woman neurosurgeon (Lynn Schroeder, personal communication, 2020).

In 2017, Bernadette Stilhart was awarded the French Legion of Honor. She trained in Paris at Beaujon Hospital with Aimée Redondo (Fig. 7), and in 1987 became chief of neurosurgery at the Centre Hospitalier of Colmar in Alsace.

This decade also witnessed great contributions in basic science and operative techniques by women. Portugal's Claudia Faria co-invented Alsterpaullone, a novel small molecule to target group 3



Fig. 5. Anna Galstyan, Armenia's first woman neurosurgeon. Members of Association of Neurosurgeons of Armenia with Prof Konovalov A.N. (behind and third on left) and Prof Likhtherman L.B. (front and center) from Burdenko Neurosurgery Institute at the conference on neurosurgery in 2001, Yerevan, Armenia. Prof Kalayjyan A.I. (front and first on left), Prof Zohrabyan S.G. (front and second from right), Dr. Galstyan (behind and second on right), members of Association of Neurosurgeons of Armenia and the secretary of Prof Zohrabyan (behind and center). Reproduced with permission from Anna Galstyan.



Fig. 6. Mary Murphy teaching students how to implant a ventriculoperitoneal shunt in the pediatric model babyMartyn, November 2019. Reproduced with permission from Mary Murphy.

medulloblastoma and founded Lisbon's brain tumor biobank.^[33] Meanwhile, Switzerland's Kathleen Seidel co-developed a dynamic aspirator for intracavitary stimulation and intraoperative neuromonitoring during tumor surgery. This device was commercialized in 2015 and is now used in over 40 countries. Seidel has also launched projects to bring neuromonitoring to low-income countries, such as India and Myanmar.^[34]



Fig. 7. Bernardette Stilhart (right) and Aimée Redondo (left), ca. 1980's. Reproduced with permission from Bernardette Stilhart.

3.11. Future legends

Maria Karampouga is the first woman associated with neurosurgery in Cyprus. She is currently in the final stages of her residency, aiming to subspecialize in pediatric neurosurgery. She also performs as an amateur singer of rembetiko music (Maria Karampouga, personal communication, 2020) (Fig. 8).

There have been two women neurosurgeons who trained elsewhere but worked in Malta. The first Maltese-born woman neurosurgeon is likely to be Anouk Borg, who is currently completing training (L Zrinzo, personal communication, 2020).



Fig. 8. Maria Karampouga singing rembetiko music, 2019. Reproduced with permission from Maria Karampouga.

Ivana Jovanovic will likely become the first woman neurosurgeon in Montenegro. She started her residency training at the Clinical Centre of Montenegro, Podgorica in 2016. She is an avid reader, and in addition to being fluent in English and Spanish, she is currently learning German and Turkish (Ivana Jovanovic, personal communication, 2020).

4. Conclusions

We have discovered many inspirational stories of incredibly talented and resilient women across Europe. It is impossible to chronicle every individual journey pertinent to this topic. In an effort to do the subject justice, we have compiled stories about historical and living legends of neurosurgery in an ancillary paper (Murphy et al, unpublished manuscript). There are several themes which have emerged in our extensive research of this subject. We have encountered numerous examples of women neurosurgeons moving abroad for training and/or consultant positions, including a number of refugees. Many of the women we discovered were multitalented: linguists, artists, and musicians. We have disappointingly few examples of European women in leadership and/or academic positions. We have heard incredible stories of overcoming tremendous odds, resilience, camaraderie, dedication, and achievement. European neurosurgery is at a promising juncture, with increasing proportions of women residents and consultants. The future of European neurosurgery is bright...and, increasingly, female.

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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.

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