HOW WILL ACADEMIC NEUROLOGY EVOLVE IN THE NEAR FUTURE?

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The term "*Neurology*" was first introduced by Thomas Willis in his landmark book *Cerebri Anatome* in 1664. In this book, written in Latin, "Neurologie" is referred to as "the Doctrine of Nerves" (cranial, spinal, peripheral). It did not originally include the brain and spinal cord, but later towards the end of the 18th century it acquired a broader meaning as this in the Oxford English Dictionary ("neurology: the scientific study or knowledge of the anatomy, functions and diseases of the nerves and the nervous system") [1].

Neurology as a medical specialty has passed through 3 major phases: the initial phase, where the phenomenology of the living patient was linked to the anatomical substrate, usually postmortem. This phase was started with Jean-Martin Charcot in mid-end of the 19th century, overlapped significantly with Psychiatry and continued until the second phase in 1971, when for the first time the anatomical details of the brain were visualized in vivo on computed tomography (and few years later, in 1977 on the magnetic resonance imaging). The third phase is in the current times, where through the advent of computerized data collection and analysis, we are able to decipher genetic diseases, view connectomes and develop brain-computer interphases (BCI).

The economic burden of neurological diseases is tremendous and has been estimated in 2017 to exceed $800 billion/year in the United States of America, with headache having the highest incidence and prevalence in that population [2]. This high demand for neurological services is balanced by shortage of neurologists across the Globe. Neurology faces the same challenges that other medical specialties face, which results from uncertainties in Health Care: limited access, safety, quality, and affordability. Fragmented care, lack of communication, difficult access to Neurologists, over-specialization and lack of generalists, inundation by non-Neurological patients, inability to satisfy the demand for neurological expertise (and thus "giving away" sections of Neurology), lack of patient education and participation in care, a need for a different, remote tele-neurological examination during the pandemic are few of the additional challenges that we face. Like in other specialties, neurologists and, especially, academic neurologists, must face these challenges and develop solutions to deliver services with value to their patients. I would argue that in the near future Academic Neurological Departments have to move simultaneously along 5 axes:

1. Patient Care: bring value to patients without burnout to neurologists.
2. Financial Stability: maximize the net revenue.
3. Retention, Growth and Diversity: aim at the best and for all subspecialties.
4. Education of the Next Generation: transmit the knowledge and bridge the gap.
5. Research: shape the future on a macroscale.

Patient Care: It is debatable how an academic Department can bring value to patients without burnout to neurologists, since in the USA alone in 2012 there was a 11% shortfall between supply and demand for neurologists (and this was expected to increase to 19% in 2025) [3] and at the same time Neurologists, along with emergency medicine and internal medicine physicians, had a 3-fold increased odds of burnout compared to other specialties. Moreover, 60% of neurologists report symptoms of burnout [4,5]. One solution would be to separate the 3 types of academic neurologists, clinician-educator, physician-scientist and the "triple threat" (clinician, researcher and educator) [6] into different locations, with different budgets and separate staff or develop *service lines* that reach beyond the traditional departments and encompass Neurologic, Neurosurgical, Imaging *as a continuum*, under a single umbrella [7].

Financial stability: academic Departments are not isolated from the financial pressures that modern Medicine is experiencing. Two surveys, in 2002 and 2019, by the Association of University Professors of Neurology and the American Neurologic Association showed that academic Neurology Departments spend more effort on clinical revenue-generating activities in 2019 compared with 2002 [8]. Increasing access to outpatient services via telemedicine and decreasing unnecessary demand by identifying and educat-

ing referring physicians may be tangible solutions to generate more revenue for the Departments.

Retention, Growth and Diversity: attrition is a serious problem that academic institutions face. Up to 21% of academic faculty were considering leaving Medicine because of dissatisfaction in a large survey of USA medical schools [9]. Retention and growth are therefore imperatives, and a stable financial state of any Department is a healthy springboard to achieve that. Diversity and equal payment are other problems: only 39% of all 2018 American Academy of Neurology members are women [10], only 12% of Neurology Department Chairs are held by women and there is a $37,000 gap in academic Neurology yearly compensation between men and women, the highest relative gap amongst all specialties [11].

Education of the Next Generation: there is a trend towards training residents into two separate paths, one hospital-based and another outpatient-based [7]. This may be due to different characteristics on sub-specialization the trainees seek, with neurointensivists and movement disorders specialists at the two extremes of the spectrum. By the same token, residents are paying less time educating themselves in the traditional (and to the very neurological core!) localization paradigms and more on reading images and mastering the electronic medical records, with fewer overall hours *residing* in the hospital. How this will differentiate them in the future from other health care providers (nurse practitioners and physician assistants, for example), who are cheaper compared to an academic neurologist and could equally provide tele-health services, has to be seen.

Research: although the highest percentage of research funding is still via federal entities in the USA (National Institute of Health) or pharmaceutical companies, the highest increase in compound annual research growth rate is not for those (in fact they show negative growth rates), but for medical devices and biotechnology firms [12]. How academic Neurology Departments will adjust to this type of non-bench basic research and funding is unclear, especially since there has been a plateau or decline in neuroscience research translation from bench to the patient [13]. Genetics of neurological diseases, advance neuroimaging with connectomics and networks and BCI [14, 15] seem to be the most promising fields for future academic research.

In conclusion, academic Neurology will be the core of Neurology in the near future but needs to adjust to the demands of our times. Its pillars, which will allow it to survive and thrive, will be the same: it needs to continue providing patient care with value, balance the budget, become more inclusive and diverse, train the new generation of Asclepiadae and shape the near and remote future by conducting research. It is likely that the gap between clinicians and researchers in academic Neurology will widen. The same will be true between trainees or practitioners in the inpatient and outpatient-care settings. Additional sub-sub-specializations will emerge from the Neurological Academia and spread to the rest of Neurology. Therefore, drastic changes in the organization and function of academic Departments will be required to address the internal challenges and external pressures.

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