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Editorial

What's holding us back? Understanding barriers to innovation in academic neurosurgery

On a yearly basis, I review residency applications to my department of neurologic surgery. Time and time again, as we from our department review curricula vitae and letters of recommendation, we are humbled by the high caliber of applicants who seek to join our ranks. I think of how many times that I and others have asked ourselves whether we would be accepted into the profession if we were applying now. In parallel, the last decade of science and technology has manifested a historically unrivalled potential to substantively alter the manner in which we practice neurosurgery. The rapid advances in the fields of novel biomaterials/ bioengineering, nanotechnology, bioimaging, bioinformatics, inexpensive computing, and molecular biology have created almost boundless opportunities for innovation in every aspect of neurosurgery. With this high level of intellect and ability as well as the immense and accelerating means of today's science and technology, it is surprising that our field is not following the same levels of achievement as those witnessed in the computing, automotive, entertainment, and communications industries. This begs the question—what is holding us back? Why are we as neurosurgeons not able to invent and innovate with this largesse of potential within and around us?

In the highly technically oriented field of neurosurgery, technical innovation and leadership in the academic mission are virtually synonymous. The tenets of leadership in academic neurosurgery revolve around providing cutting-edge clinical care and training leaders who are capable of producing advances in the field. In the clinical realm, however, this academic mission is threatened secondarily to reduced time and finances available to support it. In an environment of declining medical reimbursement and higher costs of medical liability, the classical financial and temporal largesse available for scientific, educational, and innovative pursuits is diminishing. Maintaining departmental solvency requires that clinical members participate in higher levels of revenue-generating clinical output. As a result, there is less free time available for endeavors intrinsic to the academic mission, such as scientific inquiry and teaching junior medical staff.

Beyond the paucity of time available for creative pursuits, there are also fundamental barriers of translating those ideas to clinical application. The first and most fundamental barrier to creating something new is ignorance to the innovative process. Physicians, although they may have an interesting insight, innovation, or inventive breakthrough, are rarely well versed in the necessary steps needed to take an idea to practical market application. These steps begin with drafting and prototyping of the idea; progress through patenting and further device testing; and end with FDA (Food and Drug Administration) approval, garnering investment, and engaging the industry [2]. These many steps create a huge inertial barrier to a given physician. One simply does not know where to begin, how best to proceed, or where to even find help. In general, a physician has limited access to the appropriate extra-medical domains of expertise (ie, legal, business, and engineering). This lack of insight on the process of idea development and potential device application concomitantly leads to difficulties in ascribing market value to a given idea. There is often a misperception of the valuation of a given idea leading either to undervaluation (and early abandonment) or to overvaluation (and inability to collaborate or share ideas with others). In addition, for the physician, there is no easily accessible method available to even see if an idea is new or not.

There are also significant time and financial constraints that impair an individual academic surgeon's ability to participate in innovative enterprises. In a standard situation, dedicating time to innovative efforts detracts surgeons from more pragmatic activities. For surgeons, it would mean a reduction in the time that they could use for other career-advancing activities (eg, writing and publishing articles) or immediately financially rewarding endeavors (eg, more surgical cases, consulting). In addition, there is also a substantial initial financial investment required on the part of an inventor to begin the process of idea development. The average cost to prototype and patent a new device is US$50,000. This is not an insignificant sum for a single physician. These elements lead to the perception that pursuing innovation is more of a hassle than it is immediately worthy.

The broader academic culture itself often has certain perceptions inherent to the profession that create a hostile

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environment toward invention and translation of ideas. Overwhelmingly, in the modern medical environment, there is very little error tolerance. Within a highly litigious environment, mistakes in medical care are considered a dangerous and unacceptable proposition; in medical research, an error or mistaken endeavor is also considered inefficient. This intolerance does not allow for the natural process of trial and error necessary for true creativity. Having an environment with a high error tolerance is essential for the iterative and nondirected process of invention to occur. This is born out in many historical examples in the industry, ranging from Bell's Lab to Xerox Park [1]. Furthermore, older and more conservative centers may often perceive bringing an innovation to the market as somewhat contrary to the academic mission. Entrepreneurial activity is negatively perceived as opportunist and self-serving. These perceptions lead academic physicians to live separate lives, between one of academic medicine and another of technology development. The medical culture also has a tendency to be somewhat insular in its interaction with other professions. Interacting with people from the legal profession is in general perceived as unpleasant. There tends to be a lack of appreciation for the extrascientific domains of expertise (eg, business experience, legal expertise, FDA legislation). As is often necessary for appropriate patient care, the medical culture (neurosurgery in particular) tends to operate in a very hierarchical and regimented fashion. This pyramidal structure engenders a perception in which the younger and more junior individuals in the group (medical students and residents) are not afforded the same level of respect with regard to the relevance of their ideas and insights. Because trainees tend to be more youthful, numerous, and not as fixed in their thought patterns for clinical care, they are a fruitful ground often overlooked.

The solution to this multifaceted conundrum of actualizing the academic mission, while at the same time maintaining a neurosurgical/interventional department's financial stability, is engaging in the world beyond the field of clinical neurosurgery. Neurosurgery in isolation is an anachronism. The technical innovations and clinical advancements to be developed cannot be accomplished by neurosurgery alone. They require the input from a broad range of medical, scientific, technical, and industry expertise. This open interaction of neurosurgical, neuroscience, and engineering insights is vital for the development of truly novel technologies and research to be performed—advances that would not emerged singularly. Furthermore, a new model that departs from the classically insular medical model provides an improved paradigm for the emerging physicians in how leadership is accomplished in a world where dynamic change can be expected to be the rule rather than the anomaly. For academic neurosurgery to survive, it needs to engage and adapt to a rapidly changing technical future. To do so, neurosurgeons must promote collaboration with multiple fields of expertise that can help them understand those changes. Moreover, for industry and academia to benefit from the emerging neurosciences market, they too must better understand the culture and nuance of the neuroscience field for which the neurosurgeons are the clinical linchpins. It is this new orientation to participation in a dynamic and technically dominated future that will allow the field of neurosurgery to maintain its academic mission and its viability while also contributing to the larger academic and industry community.

By collaboration with experts in such fields as engineering, molecular biology, and computer science, one can create the novel solutions that the field of neurosurgery needs and bring value to the department and individual by creating novel intellectual property. This allows the clinical physician to capitalize on the emerging neurotechnology markets through innovative technical solutions as they apply to patient management. Moreover, neurosurgery acts to a large extent as the output arm for a significant portion of neuroscience and engineering applications to patient care. Current examples of this can be seen with Cyberkinetics in its emerging brain computer interface technology and Neuropace in its development of neuromodulating devices for the treatment of epilepsy. Historically, other examples include the deep brain stimulator for Parkinson's disease and tremor, spinal stabilization constructs, and radiosurgery. The ability to maintain awareness and to engage these emerging trends in technology and neuroscience as well as adapt them to neurosurgical needs allows one to participate in the leadership of novel medical therapies. Beyond contributing to the field through novel therapeutics, developing these new technologies, which the industry is eager to capitalize on, allows for a potentially new source of revenue. This new insight allows a given department to leverage in a novel way on the expertise it already has. To develop technologies (which neurosurgeons have a unique insight on) that have a market value allows a given department to generate revenue from licensing fees and spin-off companies that ensue. Moreover, developing these technologies actualizes the insight and expertise of given neurosurgeons for their entire field. Because the neurosurgical and neurointerventional markets are poised for significant growth (which is currently in the billions), this becomes increasingly relevant to the future of these fields. These rapidly expanding markets are numbers that academic medicine must not ignore. They are trends that need to be recognized and embraced for future academic development and growth.

It is from this understanding of physician barriers to creativity and a new understanding of neurosurgery's role in a more rapidly evolving and growing future that even the fundamental notions of a solution can be born—an idea that removes neurosurgery from its seclusion and seeks to find connection between larger academia, the external community, and industry as well as an environment that will both enrich the educational experience of its members to a new and changing world and facilitate the development of ideas that ensue from that endeavor. The question is—do the independent universities, departments, and practices have the will and courage to achieve such ends? Neurosurgery's future rests on the answer.

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Commentary

Dr Leuthardt describes an important issue for academic neurosurgery. As he describes, the confluence of 2 evolutions—(1) the growing complexity of the innovation process itself driven by regulatory and financial developments and (2) the growing diversity of technology underlying neuroscience innovation (biologic sciences, computing and information management, imaging, materials science)—is challenging the traditional structure of academic neurosurgery in its historical mission to provide leadership in science and technology innovation. These evolutionary trends make it virtually impossible for the traditional clinician-scientist to succeed as a solo innovator. Academic neurosurgery must rethink its paradigm for leadership, not just in the clinical arena (where the evolution to multidisciplinary care has begun) but also in the arena of technical innovation.

To address the author's issue successfully seems to require 3 developments. First, the academic center's neuroscience establishment needs to organize in a fashion that creates sufficient critical mass to permit support of research; that is, it needs to support a research-and-development function for clinical enterprise that allows groups of clinician-researchers to engage in the innovation/development process on an ongoing basis. There is a price to pay for this: in the research role, clinician-researchers do not get compensated at clinician market rates! Innovation requires passion—and success can bring rewards, both psychic and monetary. Second, the neuroscience enterprise needs to broadly include all relevant disciplines as the author indicates, not just neurosurgeons, to gain the required scale but, more importantly, to stimulate the interdisciplinary innovation process that drives new technology today. Finally, the neuroscience enterprise needs to be supported by a university-level technology transfer function that can provide the business, financial, legal, and regulatory competencies to exploit research-and-development output.

These developments pose significant political and financial hurdles for any academic neuroscience enterprise. Is there a viable alternative?

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