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Original Article

Do neurosurgeons need Neuroanesthesiologists? Should every neurosurgical case be done by a Neuroanesthesiologist?

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Abstract

Neuroscience is exponentially growing and accompanied with everyday innovations and intriguing developments. There are new branches of science that are being developed within neuroscience. For instance, the fields of computer interface nanotechnology, molecular biology, ultra cellular, and gene therapy. The neuroscience programs have been established nationwide and worldwide. There is strong belief that better patient care is obtained through high volume and specialty physicians and hospitals. In fact, there are new subspecialties that already developed from within the specialty itself. Neuroanesthesia is one of the specialties that has contributed tremendously over the years to neuroscience yet it remained non-accredited and supported. In fact, there is a discouraging trend to pursue advocating the necessity of neurosurgery cases to be done by neuroanesthesiologists. It is one of the specialties that is lagging behind compared with other specialties and subspecialties in neuroscience. There is an ongoing debate within the neuroanesthesia society about the role of neuroanesthesiologists in neurosurgery. The author, being a neurosurgeon, neuroanesthesiologist, and neurointensivist, is presenting the topic, the views and expressing his opinion.

Key Words: Neuroanesthesia, neuroanesthesia fellowship, neuroscience, society for neuroscience anesthesia and critical care

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BACKGROUND ABOUT THE AUTHOR ADDRESSING NEUROANESTHESIOLOGIST FOR NEUROSURGEONS

Like many of you, I have seen the exponential growth in neuroscience field recently. It is fascinating to explore the nervous system in the cellular and molecular levels. The contribution of the basic neuroscience research over the years has been spectacular. It allowed for application of nanotechnology and neural computer interface.

Based on the conjoined training and expertise, I am in a unique position to be able to address the neurosurgery and neuroanesthesia and neurocritical care part. I graduated from Ain Shams University, Cairo, Egypt and completed my training in anesthesiology and neuroanesthesiology at Cook County hospital, and neurological surgery at University of Illinois at Chicago, Illinois. I have spent my entire career thus far to my passion, neuroscience. I was fortunate to have great mentors such as Dr James Ausman, Antonio Aldrete and Verna Baughman. My expertise was

not limited to neurosurgery only but to neuroanesthesia, neurocritical care, pain and neuromonitoring, and neuroresearch. I have completed in full the American training in neurosurgery and anesthesiology and fellowship in neurophysiology, neurotrauma and neurocritical care. I have done extensive research and pioneer work in neuroscience including neuromonitoring, motor-evoked potentials, and neurotrauma.[15-27] I continue to practice and learn about the five specialties in neuroscience till today. I was granted professorship in 2011 in both neurological surgery and anesthesiology. The qualifications placed me in a good position to address the topic of neuroanesthesia for neurosurgeons and vice versa.

NEUROSCIENCE SPECIALTIES AND SUBSPECIALTIES WORLDWIDE

Early on in medical school, I made a commitment to neuroscience and it was also my Christian devotion to the field of neuroscience and the service of neurological patients. I have always believed that neuroscience is not for everyone. It is a complex and demanding and low volume, high skilled medical and surgical discipline. It is the most difficult system to study in medical school and to learn during clinical residency program. The ordinary graduating student and resident possess limited knowledge about neuroscience. It is not a subject to study without being interested and devoted to.

Over the past three decades, the medical field expanded so much and each discipline became a specialty in its own. This was not enough to match with the rapid growth and therefore, many subspecialties within a specialty arose. It was the logic step to take and master the high skill required within the complexity of a low volume neurological illnesses. The model was established and encouraged based in good medicine and publications were overwhelming of "high volume hospitals and specialty doctors".[4,6-8,12,13,32,33,36,40,42-44] The progress did not stop at subspecialty level, in the past few years subspecialties arose within the subspecialty. The pendulum is not stopping and new discoveries and innovations are not far from becoming reality.

The field of neuroscience has many specialties such as neurology, neurological surgery, neuroradiology, neurocritical care, neuropsychiaty, neuroanesthesiology, neurological monitoring and neurophysiology, pain medicine, rehabilitation medicine, neuroancillary services, experimental neuroscience, and neuroreserach. Under each specialty, several subspecialties arose. For example, from the specialty of neurological surgery developed neurovascular, neurointerventional, neurooncology, neurotrauma, spine, radiosurgery, epilepsy, functional, and pediatric. Recently subspecialties are being developed within the subspecialty. For example, from the subspecialty of "spine" developed minimally invasive spine surgery, complex and deformity spine and spinal radiosurgery.

Modern medicine has departed from "general" practice to "specialty" practice and most recently "subspecialty". In the very near future, it will be "nano-subspeciality" which a term I refer to second and third generations of "subspecialty". It also created more competitions among specialties and subspecialties with overlapping among services. Despite the revolution of specialty and subspecialty in neuroscience, anesthesiologists are not "catching up" at the same speed. The principal of specialty, subspecialty and nano-subspeciality is well-established not only in USA but also in Europe and other countries worldwide.

THE SUBSPECIALTY OF NEUROANESTHESIOLOGY WORLDWIDE

Worldwide including USA, there is no formal and accredited fellowship training program in neuroanesthesia despite the early establishment of the speciality and the society of neuroscience anesthesia and critical care (SNACC) in 1972.[1,30] Furthermore, there is a broad opposition to the principal that neuroanesthesiologists are needed for all neurosurgery cases; similar to neurosurgeons being needed for neurosurgery cases and not general surgeons as used to be more than a century ago. Over the years, the field of anesthesiology/neuroanesthesia missed opportunities such as taking the lead in the development of the perioperative neurocritical care and neuromonitoring. In USA, there are few programs that offer postgraduate neuroanesthesia training and rather heavy resistance to move forward toward acknowledgment of the need for and accreditation for neuroanesthesiology. Sadly, the dreams of the fathers of neuroanesthesia in the USA such as Jack Michenfelder and Maurice Albin as of yet have not come to fruition. The author explores some of the facts and his personal views in this matter.[1-3]

HOW WAS THE INFORMATION BELOW OBTAINED?

Amazingly, there is not much literature published in the subject. I had to depend on personal efforts since I was asked to present my insight at the SNACC, 10/12/2013, San Francisco, CA. I contacted various neuroscience societies including the American Association of Neurological Surgeons (AANS), the Congress of Neurological Surgeons (CNS), American academy of Orthopedic Surgeons (AAOS), the North America Spine Society (NASS), Neurocritical Care Society (NCS), Society of Neuroscience Anesthesia and Critical Care (SNACC), and American Society of Anesthesiology (ASA). In addition to medical literature, I included some of personal communications.

VIEWS AMONG NEUROANESTHESIOLOGISTS WORLDWIDE

The majority of neuroanesthesiologists do believe that general anesthesiologists are as good as neuroanesthesiologists for neurosurgery cases (9, some of SNACC members including 9 out 12 personal communication and from Dr Michael Todd presented in 2011 "A neuroanesthesiologist is essential for all intracranial procedures" debate).

I submitted a questionnaire to ten prominent neuroanesthesiologists worldwide as follows:

> Questionnaire submitted by Dr. Ghaly to 12 renown Neuroanesthesiologists worldwide.
>
> "I am currently preparing a discussion for coming SNACC annual meeting on October 2013. I am seeking your input and reply to the two questions and any additional information:
>
> - Does every neurosurgery case need a neuroanesthesiologist?
> - In your institution and your country, what is the common practice? Does every neurosurgery case is performed by the neuroanesthesiologist?
> - Your additional insight in this matter. Your comments and feedback will be incorporated with the debate.
>
> Thank you. Respectfully, Ramsis F Ghaly".

The responses were discouraging toward "neuroanesthersiologists for neurosurgery": out of 12 renowned neuroanesthesiologists, only 3 agreed, 7 disagreed, and 12 partly agreed. The Current views of the neuroanesthesiologists including the following: there is no need for fellowship training to practice neurosurgical anesthesia, Neuroanesthesiologists are restricted to major academic institutions, general anesthesiologists do the same "job" if performed frequent, neuroanesthesiologists can work as consultant to general anesthesiologists in certain cases and neuroanesthesiologists for selected complex neurosurgical cases such as vascular and skull-base procedures. Those who are against specialty neuroanesthesiology (also from the survey) have many reasons to support their stand.[10,38] They believe that specialization in neuroanesthesia is costly and economically unsound, impractical, inefficient and a noble idea but premature in growth. Other reasons include, lack of interest, lack of specialty definition, more training, certificates and obstacles to practice medicine, legal implications, limited numbers, and humanly impossible to care for all neuroscience patients. Some other reasons include most of the knowledge in neuroscience is academic exercise only and do not affect patient care. There is a lack of evidence in outcome and majority of cases are straight forward where and residency training provides sufficient basic neuroscience education. The general anesthesiologists, if they adhere to common anesthesia principals and essentials could do as well and follow practice guidelines and standards. What made advocates for no specialization stand so powerful is the fact that there is no single study to demonstrate that having neuroanesthesiologists makes a difference in neuroscience patient's outcome. It is believed that the national educational institutions for anesthesiology residency programs ensured that those who completed the residency programs are reasonably competent with delivery of anesthetic care to neurosurgery patients. There is a common feeling that neuroanesthesiologists are requested for the comfort of neurosurgeons and their familiarity with the procedures and the field. In Europe, it is thought that the structure of anesthesia residency in such a way that there is no need for fellowship. There is a dissimilarity in the residency program between USA and abroad. In United States, the anesthesia training program is 4 years with recommendation of 1-2 years fellowship for subspecialties such as critical care, pain medicine and neurosurgical anesthesia. Abroad (Canada and Europe), the anesthesiologists are trained over 5 years for general and all surgical subspecialties with no subspecilaity fellowship training. Another interesting finding is that the technology and advance in neuroscience understanding made neuroanesthesia simple and could be conducted by general anesthesiologists. Neurosurgeons are not performing as much of complex brain and spinal cord cases within the operating room as used to. For instance, many of difficult vascular cases and skull base cases are directed to radiosurgery and interventional neuroradiology.

NEUROANESTHESIA AS A FULLY COMMITTED SUBSPECIALITY TO NEUROSCIENCE

As it is always a part always part of neurosurgery in particular and neuroscience in general, neuroanesthesia specialty cannot turn its back and abort its service and commitment. Quality neurosurgery depends on quality neuroanesthesia care. Despite the fact that there is no quality study done to prove that superior outcome is associated with neuroanesthesiologists compared with general anesthesiologists, there are at least 15 reasons that ask for immediate neuroanesthesia commitment and growth in neuroscience. I always believed that with commitment comes quality and with dedication comes excellence.[14,31]

1. Neuroanesthesiologist are the best for perioperative neuroscience care

The central nervous system is a complex and fascinating system. The science is still in the infantile stage in understanding the complexity of the brain. The brain is the smallest (1.5 kg) yet the most energy dependent and consumes 25% of

the total cardiac output. It is the most fragile and susceptible to perioperative events with devastating sequlea. Time is brain and every second counts under anesthesia. Neuroanesthesiologists are the best to understand and respect the central nervous system. The nervous system has no external warning mechanisms like the cardiac and respiratory system. It does not show changes under anesthesia and does not reveal the damages to its function. The available neuromonitoring modalities are not understood by the general anesthesiologists and staff. They are also not accurate reflection of the CNS. The perioperative damages of the CNS are irreversible and majority is preventable. There is no accurate monitoring under anesthesia that predicts with certainty the well-being of the brain. During delivery of anesthesia for already compromised CNS, everything counts. An early intervention may save millions of susceptible neurons. It may not show in the overall outcome of the patient but it certainly will show in the individual brain function of the patient. We are obligated to protect the neurons during the perioperative period to the best of our knowledge and what we know scientifically. The billions and billions of neural circuits are disrupted under anesthesia and could be easily affected during the surgical and anesthetic deliveries. This is the time to apply the best of what the scientific neuroscience could offer to protect and maintain the well being of the CNS. Specialty neuroanesthesiology and quality neurosurgery goes hand in hand. My most respected mentor in neurosurgery Dr James Ausman used to tell say "neuroanesthesia is my right hand and neuroradiology is my left and I cannot do good work without either." They are also in position to protect the brain, spinal cord, and peripheral nerves. Every day I learn something new and my professorship in anesthesia and neurosurgery is just a reminder that I need to learn more about the most mysterious system of mankind. Anesthetics are producing their effects by their sole actions on the nervous system. The CNS is the target organ and the anesthetic agents and vasoactive drugs in conjunction with the respiratory ventilator are supporting the human body during the perioperative period. The neuroanesthesiologist is in the best position to support the nervous system during anesthesia for neurosurgery. Neuroanesthesia is a subspecialty with special knowledge, expertise, and demand. It fulfills the definition of "quality" as defined by the institute of medicine "the degree to which health services for individuals and populations increase the likelihood of desired health outcome and are consistent with current professional knowledge."[11] It is in the same category and in agreement with "evidence-base" practice of better outcomes in hospitals with high surgical volumes, surgeon volume, and board certification.[4,6-9,32,33] There are many reasons to support the dire need for neuroanesthesiologists for all neurosurgery cases. There is no simple case in neurosurgery when dealing with the central nervous system. The highest disability comes from neuroscience complications. Devoted neuroanesthesiologists have the knowledge, the skill and the fundamentals of brain and spinal cord pathophysiology and dynamics. Their perioperative knowledge in neurocritical care, neuromonitoring, and neuroprotection made them distinguished and irreplaceable service in the operating room. They are well prepared to various neurosurgical circumstances and events. Furthermore, they are familiar of the procedures, the needs of the neurosurgeons and can be influential in streamline the perioperative neuroscience delivery of care. The academic and visionary neuroanesthesiologists, by joining the neuroscience family, could expand our horizon in the future.

2. The neuroanesthesia mission

Neuroanesthesia was one of the very early specialty to partner with neurosurgeons (Dr. Maurice Albin, neuroanesthesiologist and Thomas Langfitt, a neurosurgeon) and lead the way in various basic and clinical neuro-research. In the turn of century, the neuroanesthesia founders established the subspecialty and mission of service. Nonetheless, it is not yet accomplished.[1-3] In fact in a write up, "Mission (not yet) accomplished" by Dr. Maurice Albin, a founder and visionary leader in neuroanesthesia mentioned in SNACC Newsletter fall 2008, "we made no progress, no subspecialty recognition, not moving forward, no increase in fellowship programs, fewer residents interested in fellowship, no subspecialty board certification, etc., all due to economic downturn. No long range plans to serve the future framework or future expansion. Increase complexities of today's neurosurgical procedures necessitate an equivalent neuroanesthesia expertise. …to insure the propagation of the high standards of care that we have fought for over the years than to have the expertise that subspecialty certification will bring in its wake… teaching fellowship programs, certification, …then we might be able to state, mission accomplished."

3. A comprehensive neuroanesthesia fellowship program in place and deem successful

The structure of fellowship has been in place for more than a decade and the ongoing debate to consider 1- or 2-year fellowship programs.[14,34,35] The graduating fellows will not only be qualified to practice neuroanesthesia but also related perioperative disciplines such as critical care and neuromonitoring. It is comprehensive, well-rounded training. A 1-2 years fellowship is already in place, some graduated fellows over the years. The author proposed in the SNACC Newsletter 2009, a proposal for a 2-year

comprehensive fellowship in neuroanesthesia to offer more than anesthesia training with much brighter future and potentials in related fields.[12] The title is "The future of neuroanesthesia: calling for a 2-year comprehensive structure." Neuroanesthesia SNACC news letter, 2009.[14]

The proposed program is extensive and worthwhile for each candidate; it covers eight disciplines including the following:

- Clinical neuroanesthesia
- Diagnostic neuroradiology
- Interventional neuroradiology
- Peropierayive neuromonitoring
- Neurocritical care
- Clinical neurology and neurosurgery
- Neuroprotection
- Experimental neuroscience research.

The visionary fellowship rotations are as follows: the neuroanesthesia fellowship will include comprehensive training and certification not only in clinical neuroanesthesia (preoperative assessment, anesthetic induction, positioning, anesthetic maintenance, emergence, postoperative, and complication avoidance delivery of care) for general and various neurosurgical subspecialties (such as brain and spine procedures, neurovascular, neuroncology, pediatric, radiosurgery, seizure, functional) but also in diagnostic neuroradiology (such as interpretation of imaging findings in various neurological and neurosurgical disorders in computerized tomography [CT] scan, X-ray, magnetic resonance imaging [MRI], Doppler, and cerebral and spinal angiography), and neuroradiology intereventional (such as cerebral aneurysm coiling, arteriovenous malformation [AVM] embolization, stroke interventional, intraarterial thromblysis, and stenting), perioperative neuromonitoring (such as wake-up test, awake neurological monitoring during awake craniotomy, cranial nerve monitoring, somatosensory-evoked potentials [SSEP], auditory-evoked potential [ABR], visual-evoked potential [EVP], motor-evoked potential [MEP], electromyography [EMG], transcranial Dopplar [TCD], electroencephalography [EEG]), neurocritical care (for neurological and neurosurgical patients such as subarachnoid hemorrhage [SAH], traumatic brain injury [TBI], strokes, multiple sclerosis, Guillain-Barre syndrome, and amyotrophic lateral sclerosis [ALS] including various aspects, e.g. ventilatory management, hemodynamic monitoring and management, electrolyte and endocrine, epilepsy, 24-h EEG and neurophysiology recording, hypothermia, sedation, pain management, brain death, and bioethics), clinical neurology and neurosurgery, invasive and innovative neurological monitoring (such as invasive and noninvasive cerebral blood flow, autoregulation, lumbar drains, intracranial pressure [ICP], external ventricular drain [EVD], computer brain interface monitoring, nano-neurological recordings), neuroprotection, experimental neuroscience, and neuroscience research. The founders of neuroanesthesia knew the importance of neural protection and measures to decrease ICP under anesthesia. Therefore, our neuroanesthesia programs could lead the scientific community in further innovations and our knowledge as they did in the past.

4. The current system is not inspiring fellows across the Globe for neuroanesthesia subspecialty: The future is limited; It needs to change:

The "status quo" needs to change. The society has been in place since 1972 and the membership has never grown since 1979 (membership ranked from 400 and 500 members).[30] I am afraid to say that there is still ongoing dispute about the essential role and importance of neuroanesthesiologists for neurosurgery cases. In fact the spirit continues to downgrade the specialty compared with other specialties in the neuroscience field. We need to secure the future for our future generations in neuroscience. The current number of neuroanesthesiologists nationwide and international is limited and the interest to join the specialty society is declining. It is more alarming when it is compared with other specialty societies (see below). The SNACC members total worldwide is only 649 (USA is 444). The interest level varies according the region; in USA, higher in New York (46), California (38), Ohio (32) and Texas (29), Pennsylvania (17), Illinois, Massachusetts, North Carolina, Michigan (17), district of Columbia (15) and in Abroad including Canada (35), Germany (31), United Kingdom (20), Belgium (9), Japan (18), and India (12).

Furthermore, Neuroanesthesia is not recognized or accredited. In USA, there are average of 40,000 anesthesiologoists and 39,000 nurse anesthetists (CRNAs). In comparison, the American society of anesthesiologist (ASA) from ASA census registry is 7477 practicing anesthesiologists (MD/DO), of those 4599 are board certified, 252 are critical care certified, 232 are pain certified, and 80 are pediatric certified. There are 132 total anesthesiology residency programs in USA (2012/2013), 5904 total trainees; 1108 residents in CA3 (senior last year of residency). The entire anesthesia residents are exposed to total 847,931 neurosurgery nonspine cases per year, 1:143.6 for total residents or if only performed by senior residents 1:765.

Neuroanesthesia fellowship is not approved or accredited worldwide. In USA, only five fellowships

are approved and accredited in anesthesiology and graduate 877 Fellowship yearly. They are cardiothoracic-172, critical care medicine-148, obstetrics and gynecology-19 (programs just accredited in 2012), pain medicine-324 and pediatrician-214.

The SNACC society started on 1972 and designated Journal of Neurosurgical anesthesia (JNA) first edition 1988. The two founders of the Specialty and the SNACC were a neuroanesthersiologist Dr Maurice Albin and a Neurosurgeon Dr. Thomas W. Langfitt. Dr. Maurice Albin was the first president of the SNACC.[1] In the late 1960s, three other neuroanesthesiologists were known Drs Andrew Hunter, RGB Gilbert and A Galindo. By 1973, total SNACC members were 40.[1] By 1979, membership increased to 400 and never grew beyond 500 till today (30). There is no other specialty society in neuroscience that I am aware of, which does not grow.

Let us take the congress of Neurological surgeons Society, their members included total of 8625; active (USA) 3510, active international 349, international vista 839 (licensed practicing neurosurgeons from outside of the US, Canada, and Mexico), Senior 1096, Resident 1592, International vista resident 185, transitional 206, associate 69, affiliate 114, medical students 160, honorary 9, and inactive 493.

Let us take an example of the recently developed society for neurocritical care (NCS) 2002; the total number of members is 1374, international 219 and total physicians 691. Total neurocritical care fellows are 143. The United Council for Neurological Subspecialities (UCNS) is the body responsible for certification and accreditation of neurocritical care specialty, which began in 2007. There currently are 49 UCNS-accredited fellowship programs. There are 554 trained and certified physicians in Neurocritical care and the number is rising. The primary specialty for those applied and certified in neurocritical care is as follows: 262 are boarded in Neurology, 13 are boarded in Neurosurgery, 40 are boarded in Anesthesiology, and 239 have other boards (Internal Medicine, Surgery, Emergency Medicine, Pediatrics, or equivalents). The top three States with the most NCC diplomates: New York has 70 diplomates, California has 44 diplomates, and Illinois has 41.

5. The number of neurosurgery cases worldwide is limited and considered high skilled low volume specialty

To understand how rare neurosurgery cases among hospital admissions, in an epidemiology of aneurysmal admission,[34] out of one billion USA hospital admissions over 30 years (1979-2008), only 612,500 cases of aneurysmal SAH was found (0.07%).[34] Out of 70,000 clinicians delivering anesthesia in the USA (from ASA Census Registry), there are only 3700 active neurosurgeons. In USA, there is one neurosurgeon in every 100,000 and recently 1:65,000, total US neurosurgeons are 4546 and active 3800. Their distribution is average 80% Caucasian, 69% private practice, 84% group practice and 95% hospital-base surgery (from AANS Neurosurgical Procedures Statistics Report: Survey based report).

Table 1: National neurosurgical brain procedures statistics survey report 2011

Brain tumors	148,902
Skull base	24,378
Neuroendoscope	17,886
Vascular	30,346
Seizure	15,470
Others	42,690
Stereotactic	139,644
Craniofacial	12,923
Trauma	102,971
Intracranial pressure monitor	44,159
Cerebrospinal fluid shunt	103,895
Pain/functional	55,992 (brain 12.1%, spine stimulator/ pump intracthecal delivery 56.5%)
Peripheral nerve	55,992
Extracranial	6870

The overall number of neurosurgery cases nationwide is small. The national neurosurgical procedures statistics report in a survey based report 2011 from the American Association of Neurological Surgeons indicates:

Total of USA neurosurgery cases is 2,296,331 and out of those, spine cases 1,448,400 [Table 1] including spinal fusion spine fusion 801,330 and brain craniotomy surgeries are 579,376. Not only brain surgery cases are limited but also the number of neurosurgery subspecialties is restricted. The brain surgery cases are further divided according to diagnosis and procedures including:

There is no way with such limited numbers in brain surgery that adequate training could be provided to the general anesthesia residents. Even for the fellows, the numbers are not enough to graduate well trained fellows in all neurosurgery subspecialties. Perhaps, with time over the years, the neuroanesthesiologists will depend on building the expertise and the numbers to back them up.

What about spine surgeries? More than 60% of the neurosurgery cases are spinal surgery and more than 50% of spinal surgery is spinal fusion. Does spine procedure be considered part of

neuroanesthesiologists? The subspecialty deals with the spinal cords and peripheral nerves and has similar neurosurgical implications of the CNS. Spine surgery has risen exponentially. The market share of spine surgery is estimated to be 9.3 billion dollars. The surgeries are performed by both neurosurgeons and orthopedic spine surgeons (3694 spine surgeons in USA). The total members of the American academy of orthopedic surgeons members is 36,000. The total orthopedic surgeons in USA 25,653.0, 3345 (13%) spine orthopedic surgeon with fellowship as of 2005. In contrast, the total numbers of North American Spine society (NASS) is 3694, approximately 2285 orthopedic surgeons and about 1409 neurosurgeons as members.

6. The number of neurosurgery cases in anesthesia residency programs is even smaller and hence restricted exposure of general trainee is not sufficient.

Surgery of the CNS is not high volume. Since not all the cases are done at teaching institutions, the overall number of cases is even smaller. In comparison to other surgeries, the number of neurosurgery cases is small and many of the neurosurgery subspecialties are even smaller. Subsequently, the exposure to neurosurgery cases and various types of cases are by no means adequate during anesthesia residency training program. The neuroanesthesia rotation for residents is only 4 months. By any measurement, the 4 months period do not provide the education and skill required to conduct anesthesia for neurosurgery cases. In the US, anesthesia residents are exposed to only 4 months of neuroanesthesia rotation as part of the 4 years core training. The total residents per year are 1587 nationwide residents for 2011/2012. There are no accredited neuroanesthesia fellowship programs and no documented data of how many are currently active? There is no data available of how many neuroanesthesiologists in USA but at least 444 SNACC members are assumed fellowship trained. The total neurosurgery cases in US are 2,296,331. There is a great need to increase the neuroanesthesiologists since the current ration for each neuroanesthesiologist: 5172 cases

The anesthesia training programs exposed to some and not to all the neurosurgery cases since many cases are performed in community hospitals. The total general anesthetic cases delivered in hospitals with accredited residency programs are 4 millions and regional 100,000. Out of those, the total craniotomies are 18,589 cases (0.302% of total cases 6,151,958), trauma brain cases 7083 (38%), total craniotomies for aneurysm 13,965.6. This means that each anesthesia resident will be exposed to 8.8 cases, spread over 1587 residents in 128 anesthesia residency programs in USA. The number of endovascular aneurysm cases in the total programs is 9522 (6.0 per resident). In contrast, the total spinal fusion cases are 106,402 (1.735% of total cases). The average experience of each resident for craniotomy for vascular/endovascular/craniotomy for nonvascular is 8.6/4.8/28.4 cases, respectively.

7. Quality is determined by specialization and specialist and subspecialist for high complexity low volume discipline (high volume hospital and specialists)

Look around you, the 21st century medicine is structured based on specialization and subspecialists. Nothing is more complex than brain surgery. In fact the media refer to brain surgery as a "supernatural task" and needs the highest skill around. It has been proven that patient outcome and cost effectiveness are determined by "high volume" hospital and high volume specialist. It takes not just a surgeon but also the entire institution to have the skill and the system in place to master such cases.[6,8] Not only neurosurgery cases should have staffed with neuroanesthesiologists but also it should be subspecialization of neuroanesthesiologists into perioperative neuroscience aspects such as neuromonitoring, neuroprotection, vascular neurosurgery, and awake craniotomies.

In neurocritical care, in addition to cost effectiveness, neuroscience patients had better outcome and patient satisfaction when neurointensivist care for these neurological patients in a dedicated neurocritical care unit with multidisciplinary CNS staff.[28,29,37,43,44] The multidisciplinary staff and the entire system speak the same language and experts in the CNS. The efficiency and quality of care are superior and smooth implantation of the CNS protocols and policies.

Likewise, in neurosurgery, there are not only neurosurgeons for neurological surgical procedures but also subspecialist neurosurgeons for specific procedures such as vascular, skull base, functional seizure, pediatric, peripheral nerve, deformity spine and minimally invasive spine surgeon. There is dedicated team in every aspect of neurosurgery. It is proved essential, right thing to do and in many circumstances better outcome. There is no single study that states otherwise. It is clear that recent trends even more dedicated subspecialist within the specialty.[4,6,7,9,12,13,33,34,39] For instance, a neurosurgeon specialized in neurovascular surgery, then subspecialized in aneuryusm surgery. A neuroncologist neurosurgeon specialized in brain tumors surgery and subspecialized in acoustic neuroma surgery. Everyone of the team is familiar with the essential neurosurgery equipment and surgical steps such as pneumatic Midas drill, microscope, ultrasound, ultrasonic aspiratory, image navigation system, neurophysiology

monitoring, surgical various micro instruments specific for each surgical procedure. The members are expert in timely critical thinking and troubleshooting during the complex and delicate surgery. Again, it is associated with better outcome, cost effective and patient satisfaction when specialized neurosurgeon and neurointerventionalist care for neurosurgical patients.

Other medical and surgical subspecialties did the same. In general surgery, there is oncology, minimally invasive, vascular, colorectal, and plastic surgery. Within plastic surgery there are breast surgeon specialist and another microanastomsis and flap specialist. Internal medicine possesses specialties such as pulmonary, gastroenterology, nephrology, geriatrics, oncology and hematology and cardiology. Recently, specialists have developed for in-house hospital care such as medical and surgical hospitalists.

Likewise, in anesthesia, there are recognized and accredited subspecialties such as critical care, cardiac, pediatric, and pain management.[1-3,14,29,41] Each subspecialist works together with their multidisciplinary staff and also having the on-call team. Similar to neurosurgery, the entire team familiar with the set up and surgical steps and the specific essential equipment, for example, bypass pump, heparin, transoesphgeal echocardiogram and various vasopressors and iontropes with specific dosages, critical thinking, and trouble shooting. Why neuroanesthesia should be any different? *Perhaps, the problem is over the years we trying to associate ourselves with the administrative section and business minds more than advancing our field and we did not track the quality results*. In fact we are behind all other neuro-related subspecialties and societies when once our founders were on the top of neuroscience movement.

8. Specialty team: With dedication there is quality, with commitment, there is excellence and with number, there is experience

It is not only about the volume hospitals and number of cases the specialists do, but also the dedication and commitment to the specialty, but the sincere interest in neuroscience and desire to care for such patients and master the challenges. Therefore, for neurosurgery and neuroscience care it requires dedication, commitment, and specialization. For each division, there is a team and on-call 24/7. For example, there is "open heart" team for heart surgery and "Neuro-team" for neurosurgery cases. Within the "team" there are leader, instructor, scrub, circulator, and medical engineer. Likewise, in the intensive care unit, there is a neuro-manger, instructor, case manger, nursing, ancillary services (physical, occupational, speech, social, and psychology). In the Neuro-interventional team, there are a leader, technician, nursing, and various support staff.

9. Delivery of anesthetic management is different than other nonneurosurgical cases

The brain has its own pathophysiology and does not share many of the other organs perfusion. It has its own autoregulation and from patient to patient, the cerebral circulation varies. Neuroanesthesiologists are instrumental in basic, experimental, and clinical neuroscience. They know best about cerebral dynamics, microvasculature, brain effect and distribution of anesthetics, neuroprotection, resuscitation and invasive monitoring compared with nonneuroanesthesiologists. In the past, CNS lead the neuroscience basic research especially in brain protection, stroke model, neural inflammation, and many others. In the first years of SNACC, the neurosurgeons were integral part of the society and working hand in hand to tackle the perioperative challenges in various neurosurgical disorders. What about anesthesia for understanding the brain, neural netwiring and circuitry, affecting molecular modulation, refractory seizure and neurocritical care, neurplasticity, neuropsychology, and neuropsychiatry. It is still intriguing to explore and know more about the science of anesthetic mechanisms, awakening and effects on CNS continue. The past three decades have been designated for "decade of the Brain". Much of work needs to be done and the neuroscience family is taking baby steps". The SNACC and specialty neuroanesthesia could partner with the neuroscience family to lead us into the future of nanomedicine, neural inflammation, and optical pharmacokinetics and CNS drug delivery.

10. Neurosurgery cases set up is unusual, complex and not in the main stream

Positioning under anesthesia for neurosurgery cases is not like other surgical procedures. The set-up by no means could be considered "routine" or the same from day to day. There is a great emphasis and time consuming and efforts placed in the patient's positioning. Positioning is the most important step to take once induction is completed. There are so many different positions and they vary according to the surgical approach but also to the surgeon preference. These positions could affect the patient adversely, such as prone position and sitting position. The neurosurgical equipment used are numerous, large, and delicate. Most of the time, the patient and surgery field are distant from the reach of the anesthesiologist. The neuromonitoring leads in addition to standard ASA monitors are usually mingled together. Who knows better neuromonitoring other than neuroanesthesiologists?

Some of the positioning and set up is demanding and complex even for the skilled neuroanesthesiologists. It is rather difficult to induce and position an unstable complex craniocervical spine fracture. Patient safety could dramatically be affected. The troubleshooting and critical thinking are assets for the neuro-team. Many things could go wrong if the team is not cohesive and well familiar with the entire set up and the basics of various neurosurgical procedures.

11. Misleading information about our role as neuroanesthesiologists and values of neuroanesthesia principals

Recently, many of us followed the obligatory assignment that we had to proof that what we do, and do not do, backed up by patient outcomes has received another title "evidence-base practice". Gradually swept up many minds and became an obligation to prove that neuroanesthesiologists are needed for better patient's outcomes. We took it to heart that our job to prove and in some cases made us depart from our commitment and innovation and research. The write up started to question everything we do and even the fundamentals of our specialty such as hypothermia as neuroprotective or the value of monitoring ICP.[10,38,40] We are no longer adding more to the scientific community of new ideas and discoveries like our fathers but rather got busy proving what our mentors taught us was wrong or of no value. It is false rationale and has nothing to do with our obligation to deliver quality and secure the future. It was a rational argument and we were forced to downsize instead of what we believe in.

We should value our role and what we do not on patient's outcome but rather on the effects of the target organ (s); in our case it is the brain and the spinal cord. Many variables can affect patient's outcome. But let us be specific in regarding to the specialty and the organ (s) we protecting and monitoring. Over the past 5 years, we all carried in away on the "cost", outcome and evidence-based practice instead of being superb caregivers, leader scientists, innovative physicians. Over the past 5 years, we no longer monitor patients extensively, not because we found better and accurate modalities but rather we could not demonstrate effect on patient's outcome nonspecific studies. Such monitors included central venous pressure, Swan Ganz catheter, ICP and neurophysiology monitoring for spine surgery

12. Neurocritical care and perioperative neuromonitoring are natural expansion to the field of neuroanesthesia

Critical care was always an integral part of anesthesiology. In the early days of anesthesiology back when I was a resident, in 1988, the anesthesia department was named the department of "Anesthersiology and Critical care." Anesthesiologists are well-trained in percutaneous and bedside procedures from first year of training. They perform unlimited numbers of intraspinal injections and catheter placements, lumbar drains, arterial lines, central venous catheterization, invasive hemodynamic monitoring, continuous EEG recording, and many more. The specialty of neuroanesthesia was in a position to merge neurocritical care and lead the nation, but it did not. Yet, the society remained to name it the society of neuroscience anesthesia and critical care. Furthermore, when I began my training in neuroanesthesia in 1989, neuromonitoring was managed and funded by the neuroanesthesiologists. Again, the specialty of neuroanesthesiua did not merge and captured the subspecialty of neuromonitoring and lead the nation. Neurocritical care and neuromonitoring have always been recognized as subspecialties during the perioperative care of neurosurgery patients. It was a natural extension to see the specialty of neuroanesthesia taking the lead nationwide for training the neuroanesthesia fellows. The specialty would have recruited many fellows nationwide with unlimited potential to grow with a lucrative future. Instead, the specialty was busy debating its role and need by evidence-base practice and effect on patient outcome. The choices that were made in the past have failed the specialty. The specialty could have offered much to its fellows such as accredited training and certification in not only neuroanesthesia but also neurocritical care and neuromonitoring. Yet, it is not too late to broaden the training to our neuroanesthesia fellows and expand their role to the "perioperative care" of neurosurgery patients.

13. Having no neuroanesthesiologist in neurosurgery invites errors and exert hardship

The success of operative neurosurgery depends on not only the neurosurgeon's quality but also on the anesthesiologist and neuro-team nursing. The neurosurgeon would definitely wish to have neuroanesthesiologist in every neurosurgery case. If the anesthesiologist has no good understanding of neurosurgery and is not dedicated to the care of such patients, it will create an environment to invite errors and mishaps. I also found it produces aggravation, hardship, and obstacles to the smooth functioning of an operation that I have experienced them too many times, personally. Here is a sample of some examples I have experienced; nitroglycerin is known, to neurosurgeons and neuroanesthesiologists, as weak antihypertensive medication and cause profound

cerebral vasodilation and should not be used when hypertension is not permissible. It was very hard to convince a general anesthesiologist that nitroglycerine is not the drug of choice for hypertension during meningioma tumor resection and blood pressure continued to be elevated. Another example, a simple procedure such as kyphoplasty for thoracic level T7, a general anesthesiologist utilized Ketamine (a sedative but a long-acting hallucinogenic drug), as the main anesthetic and sedative agent and it took 5 h for the patient to regain his sound conscious to be able to move the lower extremities for neuro-assessment. A third example, a general anesthesiologist who refused to perform awake fibroptic intubation because "he did not believe in it and he is not skilled in it" and the neurosurgeon could not evaluate the patient after intubation in a severe cervical stenosis and spinal cord compression. A fourth example, a general anesthesiologist administered 3 l of lactated Ringers solution in a bloodless brain surgery despite the neurosurgeon warning of brain swelling during the case. A fifth example, a patient with expanding subdural hematoma and dilated fixed pupil, the general anesthesiologist demanded to place a central line in the internal jugular vein and prevented the neurosurgeon from evacuating the intracranial hematoma in a timely fashion. There are many more examples of similar practices that most definitely nonspecialty anesthesiologists were not the "common practice" or the "common sense" actions by the general anesthesiologists. The neuroanesthesiologist has invested his time understanding the principals of brain and spinal cord pathophysiology with respect to neurosurgery practice without much aggravation and deviation. The lack of understanding in part of the anesthesiologist will certainly lead to the stress within the operating room theater, add to dispute and invite argumentative behavior and distraction from the patient's care. It exerts hardship and mistrust when the neuroanesthesiologist is not caring for neurosurgery patients regardless of what type of surgery. I always teach the residents that to be a good neuroanesthesiologist you must be a good neurosurgeon meaning the knowledge of surgical steps and principals of management at different stages of surgery is crucial. In fact, Dr James Ausman used to prepare a typed surgery plan sheet with the essential key steps, surgical plan, and preparation for each surgery. He would hand it personally to the neuroanesthesiologist and neuro lead nurse in the beginning of the case. We, his residents learned from him. It was our "time out" back in the 1980s and 1990s. The operating room was one team and we all knew the key parts of surgery and ready to team up. It enhances the working relationship and trust of the neurosurgeon and neuro-nurses when a knowledgeable and skilled neuroanesthesiologist caring for the patient. Some of the reasons include excellent delivery of perioperative anesthetic management, delivery of quality and efficiency, best operating room environment, best neurocritical care continuity of care, smooth team work, less disruption, less mishaps, and complications and ultimately better outcome. It may be hard to prove its effect on patient's outcome but it definitely makes all the sense in the world.

14. The Field of neuroscience is growing fast and getting more complex

Modern neuroscience is merging very well with the technology. The field is changing rapidly and steeply. The general anesthesiologist will not be able to master it or be part of it. The potentials are unlimited and the opportunity is "golden" for neuroanesthesia to be part of the frontier in the field. I enumerated on some of the "so many aspects of neuroanesthesia including: Cerebral and spinal cord physiological dynamics, pathological dynamics, neurosurgical principals and operative steps, neurosurgical positioning, neurosurgical navigation systems, CNS pharmacodynamics, neuroprotection, intraoperative neuroscience monitoring modalities, and neurocritical care management." We have not made significant advance in neuroprotection. The common fields known to the neuroanesthesiolgists are the following: neurosurgery for pediatrics, adults and geriatrics, brain–spine–peripheral nerve, vascular–tumorand functional neurosurgery, interventional neuroradiology, and neurocritical care. The neurocritical care includes invasive procedures (lumbar drains, jugular catheterization, ICP monitoring, Cerebral blood flow (CBF) recording neuroimaging (including intraoperative MRI, CT scan, ultrasound, and Doppler), neuromonitoring and neurophysiology, and bedside neuro-procedures. Innovative neuroscience fields are being evaluated in clinical practice and are approaching our armamentarium such as robotic neuroscience, computer-brain and extremity interface, y, nano-neurotechnology, y, gene therapy and delivery and other neuroscience research topics. The neuroanesthesiologist is in a better position to advance the skills required for neuroscience anesthesia. In simple words, neuroscience and neurosurgery are so complex, delicate, demanding and innovative that it requires dedicated, committed and skilled knowledgeable individuals. The neuroscience in general and neurosurgery in particular are branching and growing without limits. Therefore, it is fundamentally important for neuroanesthesiologists to partner with their neurosurgeons, round with them and be part of the

multidisciplinary team case discussion and grand rounds. Back during my neurosurgery residency, Dr James Ausman implemented at University of Illinois at Chicago (UIC) the first multidisciplinary clinical rounds and case conference where the integrated team of neuroscience family work together and involved in each patient care management. The team consisted of neuroanesthresiologists, neurosurgeons, neuroradiologists, neuropsychologist, clinical pharmacologist, neuro nursing, and ancillary rehabilitation services such as physical therapy, occupational therapy, speech therapy, nutritionist, social worker and case manager, and patient advocate.

15. Neurosurgery needs a healthy neuroanesthesia society and recognized subspecialty

The next generation of neuroanesthesiologists is demanding of us to lead the way for a healthy specialty and be exemplary in the defending of the foundation of our cause. The next generation will be best fit for adopting the changing concepts of modern and future neurosurgery and the challenges facing neuroanesthesiologists. Examples in neurosurgery include minimally invasive surgery, radiosurgery, robotic surgery, neuro-interventional radiology and stroke therapy, functional neurosurgery and deep brain stimulation, CNS catheter delivery, navigation technology, 3-dimenstional neuroimaging, nano-surgery, molecular and genetic therapy, intrapartum CNS surgery, transplantation, neuro-pharmacodynamics, neuropathology in anesthesia, the science of "awakening and altered mental status," neurodegenerative therapy, neuro-inflammation and many more in experimental neuroscience research.

A Transient system while restablsihing the neuroanesthesia exclusive care for neurosurgery patients

While the specialty of neuroanesthesia fellowship is being restructured and established, there are essential steps to implement to ensure quality neuroanesthesia care to neurosurgery patients. One of the main steps is to develop competency assessment for neuroscience for general anesthesiologists. The purpose of the competency assessment is to ensure the anesthesiologist has adequate interest, understanding, knowledge, skill, expertise, critical thinking and troubleshooting during perioperative care of neurosurgery patients. The structured neuroscience training for common anesthesiologists could be in a form of postgraduate fellowship training, postgraduate nonfellowship training, hands on workshops, courses and virtual reality simulation laboratory with mentorship and endorsement. In the meantime, the neuroanesthesiologist is used for complex adult cranial and intracranial neurosurgical cases such as cranial surgery (vascular, skull-base and deep lesions and patient position other than supine); spinal surgery for cervical, thoracic, and deformity spinal surgery including spinal instrumentation; other neurosurgical cases with comorbidities and nonneurosurgical cases with complex neuroscience disorders (e.g. spine fracture, CVA)

CONCULSION

Recently, neuroscience as a field has shown exponential growth. Neuroanesthesia has an essential role in caring for neuroscience patients and the specialty should partner with other specialties, neuroscience in general, and neurosurgery, neurocritical care, and neuromonitoring in particular. Neuroscience patients require specialized neuroanesthesiologists, the neurosurgical procedures are performed by dedicated neuroscience team including neuroanesthesiologists. Nonetheless, the field of anesthesiology is lagging behind in creating an accredited neuroanesthesiology fellowship compared with other neuroscience disciplines. It is of a paramount importance to elevate the awareness among neuroanesthesiologists regarding their unique contribution especially during the perioperative periods of neuroscience patients. The subspecialty for neuroscience anesthesiology and critical care provides a broad spectrum of services including; neuroanesthetic delivery, neuroprotection, neuromonitoring, neurocritical care, and neuroresearch in advancing the neuroscience field. The effect on outcome should not be the only parameter to justify the role of the neuroanesthesiologist, rather the effect on the target organ (s), that is, the nervous system in its entirety and well-being. The neuroscience field should not allow anything but the full commitment and growth of neuroanesthesiology as an accredited and fully acknowledged subspecialty.

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