Defining Excellence in Vascular Neurosurgery

Nader Sanai, MD, and Robert F. Spetzler, MD

Success as a vascular neurosurgeon almost always begins with passion, an inherent love for the work that drives an insatiable desire for personal improvement. A personal definition of excellence in vascular neurosurgery includes several fundamental qualities: mastery of the basics, refinement of technique, advancement of technology, investigative study, advanced decision making, microsurgical innovation, a well-rounded surgical armamentarium, and a lifelong commitment to teaching. Ultimately, the reward for these efforts is the ability to influence generations to come, particularly as one follows the rising careers of former trainees, each redefining the term ''excellence'' in vascular neurosurgery.

In the field of neurosurgery, the term ''excellence'' assumes a new meaning. Achieving excellence begins with a thorough knowledge of one's specialty and a demonstrable, if not contagious, enthusiasm for it. The first signs of such command can be evident at an early age, although any precociousness is usually matched by an inherent desire to expand one's knowledge base beyond standard textbook materials. As one gains experience, however, there must be a concomitant awareness of one's peers, regularly following the intellectual developments of the discipline and of related fields. This multifaceted process of maturation can eventually create a leader, an individual with vision, who takes a strong interest in the broader issues yet remains intellectually admirable to coworkers and colleagues.

PERSONAL DEFINITION FOR VASCULAR NEUROSURGERY

Within the relatively small subspecialty of vascular neurosurgery, certain traits accentuate and tailor this broader definition of excellence. Success as a vascular neurosurgeon almost always begins with passion, an inherent love for the work that drives an insatiable desire for personal improvement. This commitment to continually build on prior progress is realized through self-assessment, learning from your mistakes (and those of others), and incorporating excellence from those around you. In a practical sense, these habits are realized by considering every alternative when faced with a clinical or surgical decision and by staying abreast of the medicine, science, and academics of vascular neurosurgery. This process is both internal, encompassing one's whole being from dawn to dusk, and external, encouraging excellence in those around you, including residents, fellows, students, nurses, and colleagues. Thus, in the pursuit of excellence in vascular neurosurgery, the objective is to strive for improvement in all phases of life while setting an example on which others can build.

0148-396X

BASICS OF EXCELLENCE IN VASCULAR NEUROSURGERY

In the contemporary era, the fundamental elements of vascular neurosurgery have remained largely unchanged since the introduction of the operating microscope. The concept of maximizing microsurgical abilities by improved stability and expanded functionality is not new. Nonetheless, the methods through which these objectives are accomplished are continually evolving (Figure 1). In the operating room, working in a seated position, with anatomical support for the arms and wrists, intuitively fosters greater surgical dexterity and microsurgical stability. Technological integration of the microscope chair with the operating microscope allows the microscope to serve as an extension of the surgeon by adjusting focus and angle of approach with the foot pedals and relocating the microscope position with the mouthpiece while preserving freedom of both hands. Advances in operating room technology, which also are constantly evolving, are an additional asset to vascular neurosurgeons. In recent years, image guidance, 3-dimensional endoscopy, and indocyanine green (ICG) angiography have all moved the field forward tremendously. Each innovation adds a new dimension of functionality for vascular neurosurgeons.

Refinement of Technique

The process of technical development begins with the simple habit of learning to learn from each procedure. Within vascular neurosurgery, this mindset applies not only to issues of judgment, such as patient selection and operative approach, but also to refinement of technique. The evolution of a modified orbitozygomatic approach for routine vascular and

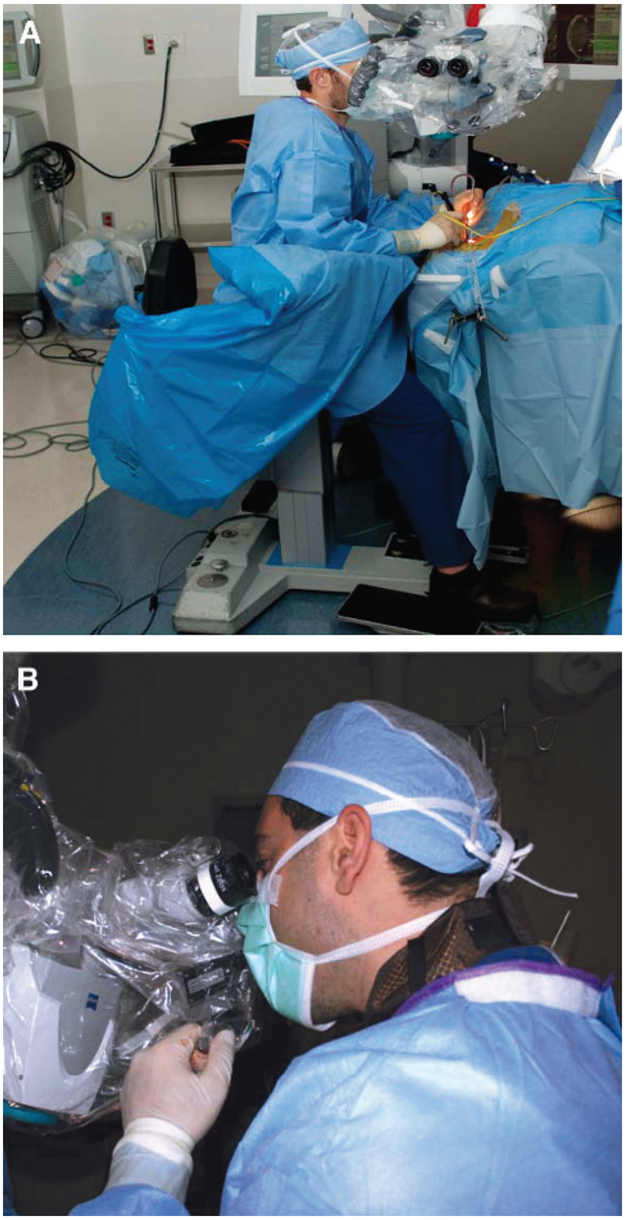

FIGURE 1. Enhanced surgeon stability and expanded functionality of surgical capabilities are 2 basic tenets of advances in vascular neurosurgery. An operating environment in which the microscope serves as an extension of neurosurgeon is an effective strategy to achieve these objectives. Used with permission from Barrow Neurological Institute.

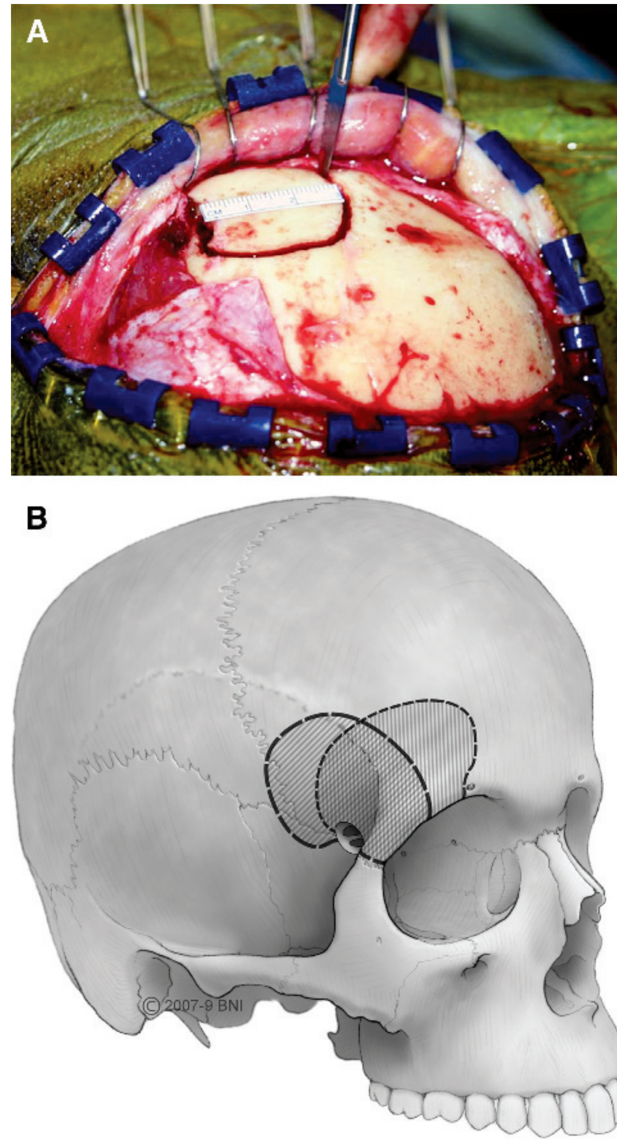

FIGURE 2. The evolution of the modified orbitozygomatic (OZ) approach exemplifies the continual refinement of neurosurgical technique through vascular neurosurgery. Skull-base laboratory anatomical studies have progressively minimized the orbitozygomatic craniotomy to focus its exposure while maximizing benefit. The current modified orbitozygomatic approach emphasizes the cranio-orbital component while de-emphasizing the orbitozygomatic component. Used with permission from Barrow Neurological Institute.

skull-base lesions exemplifies this effort (Figure 2).[1–3] The added refinement of adapting this skull-base procedure to general neurosurgical practice improved operative exposure and reduced the need for brain retraction. Studying the genesis of the modified orbitozygomatic craniotomy, we see that its roots can be traced to a method for a supraorbital craniotomy[4] and to the 1-piece combination of a pterional craniotomy and superolateral orbitotomy.[5] Ultimately, through many iterative cycles, the best aspects of these modifications (and others) were integrated into a modified orbitozygomatic craniotomy that can be tailored to fit specific needs. The result has emerged as a workhorse and efficient skull-base approach for vascular neurosurgery that provides an excellent cosmetic result and facilitates the emergence of retractorless neurosurgery.

Operative experience serves as one forum for refinement, but the commitment to technical self-improvement should extend beyond the operating room. In this arena, cadaver courses, prosections, microvascular anastomosis training with animals, and constant review of basic anatomy are all cornerstones for achieving mastery. Not only are these habits essential to maintaining and improving surgical standards, but they lead to refinement and development of surgical corridors. For cortical and subcortical lesions in the posterior portion of the medial temporal region, for example, both the supracerebellar transtentorial (SCTT) and occipital transtentorial (OCTT) routes are available. Corridor selection, however, is largely subjective and depends on the individual surgeon. In an effort to define the advantages and indications of each route anatomically, injected cadaver heads were dissected via both approaches. Identical deep target points were used for both routes, although variations in initial exposures were acceptable. Data gathered with the P2-P3 junction as an apex created 2 adjoining triangles (anterior and posterior) in the middle and posterior medial temporal region (MTR). Actual and projected degrees of freedom were calculated for each angle of approach. This analysis demonstrated no difference between the SCTT and OCTT approaches in terms of surgical views to the MTR. However, the OCTT approach provided a wider corridor for surgical manipulation compared with the SCTT approach in most parts of the MTR.[6] Together, such anatomical study data enable neurosurgeons to select the most favorable approach to specific lesions of the MTR. Thus, despite advances in neuroimaging and other perioperative technologies, the ability to conduct direct anatomical studies remains a valuable tool for vascular neurosurgeons.

Technological Evolution

The constant pursuit of modernization and technological development in vascular neurosurgery fosters the expansion of the surgeon's capabilities. Embracing innovation early rather than being skeptical about it shapes and directs such progress. In terms of microsurgical equipment, the development of lighted microbipolar and microsuction improved visualization and increased flexibility. The evaluation and adoption of intraoperative ICG videoangiography in the treatment of aneurysms and arteriovenous malformations is another example of technology directly influencing vascular neurosurgery. Microscope-based ICG videoangiography represents a new technique for intraoperative imaging of vascular flow. In a multicenter cooperative study, the value of this surgical adjunct was clearly demonstrated and its widespread use encouraged.[7] Distinct advantages of this technique included its integration into the surgical microscope and its ability to image perforating arteries with submillimeter diameters. Its simplicity, speed, and high level of accuracy for detecting incompletely clipped aneurysms and inadvertently occluded vessels support its use during aneurysm and arteriovenous malformation surgery. Although it cannot replace intraoperative digital subtraction angiography, another significant technological innovation, ICG videoangiography has now become more widely available than conventional intraoperative angiography. Therefore, it still has the potential to greatly impact vascular neurosurgery practice.

Technological evolution has also enabled endovascular therapy to progress. During the past 2 decades, the endovascular treatment of cerebral aneurysms has quickly evolved from a nascent technology to a front-line therapy. Now, a new generation of self-expanding, microcatheter-delivered, intracranial microstents has been specifically engineered primarily to achieve definitive parent-vessel reconstruction of the cerebral arteries giving rise to aneurysms[8] (Figure 3). Preliminary experience suggests that endovascular reconstruction with this device represents a safe, durable, and curative treatment of selected wide-necked large and giant cerebral aneurysms.[9] Although the need for additional refinement is inevitable,[10] early adoption of this technology has added yet another dimension to the armamentarium of vascular neurosurgery.

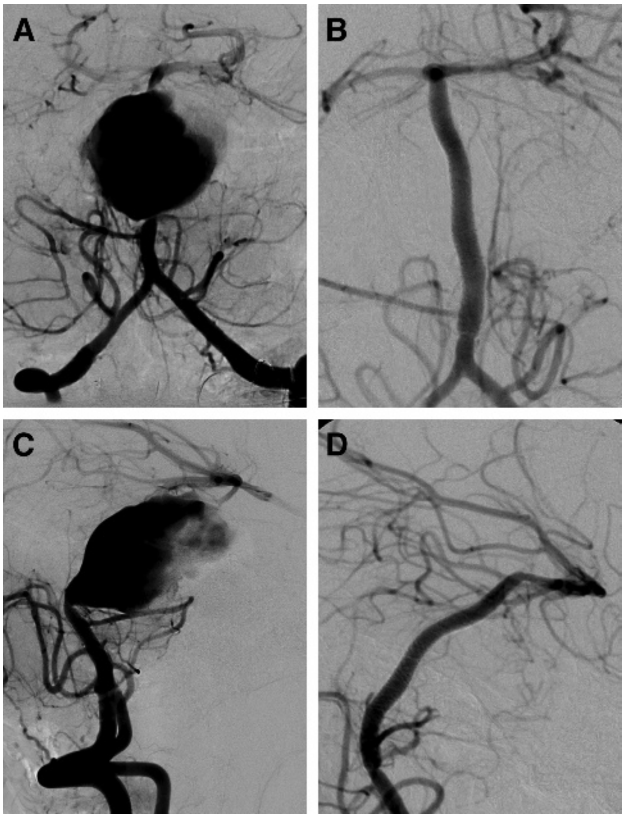

FIGURE 3. The use of intracranial microstents to reconstruct and remodel complex aneurysms represents another cutting-edge technology poised to revolutionize vascular neurosurgery. Used with permission from Barrow Neurological Institute.

Microsurgical Innovation

Although technique and technology should steadily improve over a lifetime, fundamental innovations to microsurgery are rare. Such groundbreaking changes define another element of excellence in vascular neurosurgery. The introduction of the operating microscope, for example, was an essential, yet natural, evolutionary step in vascular neurosurgery.[11] Similarly, the introduction of self-retaining retractors in neurosurgery[12] has long enabled neurosurgeons to work within confined spaces unhindered by an assistant's hand but with a constant force repositioning structures that would otherwise impinge on the operative line of sight. In the contemporary neurosurgical era, effective use of retractors has served as a cornerstone for microsurgical training, particularly for the treatment of vascular and skull-base lesions. Consequently, at many neurosurgical centers, retractors are ubiquitous when the surgeon is faced with a complex intracranial lesion under the operating microscope. However, the utility of fixed retraction comes with a price. Parenchymal pressure from retraction can lead to secondary brain tissue damage, not only through direct cortical or subcortical injury but also as a consequence of the local ischemia generated by reduced regional perfusion. These effects are amplified in the setting of cerebral hypotension, and in its most severe form, retractor injury can lead to infarction with subsequent hemorrhage after a retractor is removed. Beyond the sequelae of prolonged parenchymal pressure, self-retaining retractors also introduce the added risk of entanglement with instrumentation cables or accidental displacement through careless or inadvertent motions of the neurosurgeon or assistant, either of which can translate into injury of critical intracranial structures.

Although retractor-induced tissue edema and injury remain significant sources of neurosurgical morbidity, the use of retractors in vascular neurosurgery has persisted for decades. Nevertheless, a natural alternative to brain retraction is no brain retraction (ie, retractorless neurosurgery). Retractorless surgery, while routine for peripherally located intracranial lesions, remains uncommon in operations on lesions of the vasculature or skull base. Techniques incorporated to eliminate the need for retraction include careful positioning of handheld suction, meticulous microdissection of arachnoidal planes, patient positioning to maximize gravity retraction, and thoughtful selection of the operative corridor. In an effort to evaluate the utility of this microsurgical strategy, a prospective study of consecutive vascular and skull-base lesions in 223 patients was performed (Figure 4). On the basis of a 97% rate of completely retractorless neurosurgery, this microsurgical innovation now appears to be an achievable goal, regardless of surgical complexity. Selective use of brain retraction, however, is appropriate under certain conditions: (1) to protect adjacent brain tissue, (2) to free both hands for bypass anastomosis, and (3) when lobar mobilization is required for a prolonged period of time, particularly in the setting of nearby draining veins.

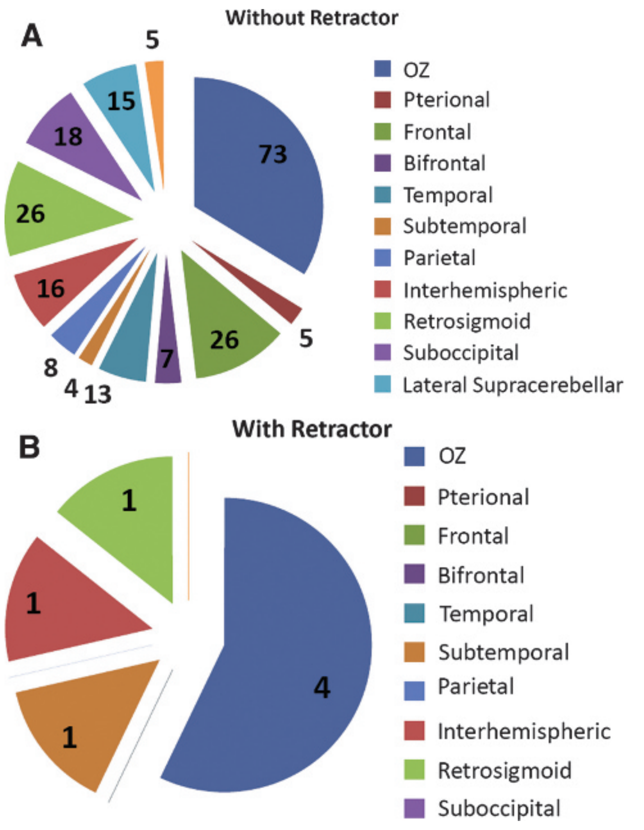

FIGURE 4. A prospective study of retractorless and fixed-retractor neurosurgery demonstrates the feasibility of operating on complex vascular and skull-base lesions without a self-retaining retractor. Used with permission from Barrow Neurological Institute.

In this study, the 7 cases that needed brain retraction exemplified these criteria but also served as a reminder that no specific procedure always requires retraction.

THE VALUE OF TEACHING

Excellence in vascular neurosurgery is fully and finally realized in the setting of neurosurgical education. As a conduit for clinical knowledge and microsurgical teaching, the vascular neurosurgeon must incorporate years of experience into accessible paradigms for trainees. The discipline, commitment, and technique accumulated over a career serve as an example for future generations, each of which builds on the progress of the previous practitioners. However, the mentor-trainee relationship is a 2-way street. This special bond not only enables the senior neurosurgeon to experience familiar scenarios with fresh eyes but also challenges the teacher to distill surgical complexities and skill sets into basic lessons in vascular neurosurgery. Ultimately, the rewards for these efforts are as great as any in neurosurgery, particularly as one follows the rising careers of former trainees, each of whom redefines the term ''excellence'' in vascular neurosurgery.

CONCLUSIONS

Excellence in vascular neurosurgery involves common elements but remains highly personalized. While underlying motives are similar, as are its effects, the means through which excellence is achieved are constantly evolving. In the end, however, the lifelong commitment is justified, and the intangible rewards of achievement are worth the investment.

REFERENCES

1. Gonzalez LF, Crawford NR, Horgan MA, Deshmukh P, Zabramski JM, Spetzler RF. Working area and angle of attack in three cranial base approaches: pterional, orbitozygomatic, and maxillary extension of the orbitozygomatic approach. *Neurosurgery*. 2002;50(3):550-555.
2. Lemole GM Jr, Henn JS, Zabramski JM, Spetzler RF. Modifications to the orbitozygomatic approach: technical note. *J Neurosurg*. 2003;99(5):924-930.
3. Zabramski JM, Kiris T, Sankhla SK, Cabiol J, Spetzler RF. Orbitozygomatic craniotomy: technical note. *J Neurosurg*. 1998;89(2):336-341.
4. Jane JA, Park TS, Pobereskin LH, Winn HR, Butler AB. The supraorbital approach: technical note. *Neurosurgery*. 1982;11(4):537-542.
5. Al-Mefty O. Supraorbital-pterional approach to skull base lesions. *Neurosurgery*. 1987;21(4):474-477.
6. Jittapiromsak P, Deshmukh P, Nakaji P, Spetzler RF, Preul MC. Comparative analysis of posterior approaches to the medial temporal region: supracerebellar transtentorial versus occipital transtentorial. *Neurosurgery*. 2009;64(Suppl 3):35-42.
7. Raabe A, Nakaji P, Beck J, et al. Prospective evaluation of surgical microscope-integrated intraoperative near-infrared indocyanine green videoangiography during aneurysm surgery. *J Neurosurg*. 2005;103(6): 982-989.
8. Fiorella D, Woo HH, Albuquerque FC, Nelson PK. Definitive reconstruction of circumferential, fusiform intracranial aneurysms with the pipeline embolization device. *Neurosurgery*. 2008;62(5): 1115-1120.
9. Lylyk P, Miranda C, Ceratto R, et al. Curative endovascular reconstruction of cerebral aneurysms with the pipeline embolization device: the Buenos Aires experience. *Neurosurgery*. 2009;64(4):632-642.
10. Kallmes DF, Ding YH, Dai D, Kadirvel R, Lewis DA, Cloft HJ. A second-generation, endoluminal, flow-disrupting device for treatment of saccular aneurysms. *AJNR Am J Neuroradiol*. 2009;30(6):1153-1158.
11. Yasargil MG, Krayenbuhl H. The use of the binocular microscope in neurosurgery. *Bibl Ophthalmol*. 1970;81:62-65.
12. Greenberg IM. Self-retaining retractor and handrest system for neurosurgery. *Neurosurgery*. 1981;8(2):205-208.