Preparedness of neurosurgery graduates for neuroendovascular fellowship: a national survey of fellowship programs

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OBJECT Endovascular interventions have become an essential part of a neurosurgeon's practice. Whether endovascular procedures have been effectively integrated into residency curricula, however, remains uncertain. The purpose of this study was to assess the preparedness of US neurosurgery graduate trainees for neuroendovascular fellowship.

METHODS A multidomain, global assessment survey was sent to all directors/faculty of neuroendovascular fellowship programs involved in training of US neurosurgery graduates. Surveyees were asked to assess trainees as they entered fellowship.

RESULTS The response rate was 78% (25/32). Of respondent program directors, 38% reported that new fellows did not know the history and imaging of the patient and 50% were unable to formulate an appropriate treatment plan. As many as 79% of fellows were unfamiliar with endovascular devices and 75% were unfamiliar with angiographic equipment. Furthermore, 58% of fellows were unable to perform femoral access, 54% were unable to perform femoral closure, 79% were unable to catheterize a major vessel, 86% were unable to perform a 4-vessel angiogram, and 100% were unable to catheterize an aneurysm. Additionally, program directors reported that over 50% of fellows could not recognize neurovascular anatomy and 54% could not recognize/classify vascular abnormalities. There was an overall agreement that fellows demonstrated professionalism and interest in research and had good communication/clinical skills.

CONCLUSIONS The results of this study suggest potential gaps in the training of neurosurgery residents with regard to endovascular neurosurgery. In an era of minimally invasive therapies, changes in residency curricula may be needed to keep pace with the ever-changing field of neurosurgery.

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KEY WORDS endovascular; fellowship; neurosurgery; residency; training; interventional neurosurgery

VASCULAR neurosurgery is a rapidly evolving field in which endovascular interventions have become an essential part of daily practice. For vascular neurosurgeons, dual training in microsurgical and endovascular techniques has become the norm, especially in North America. Today, in addition to microsurgery, neurosurgeons perform endovascular procedures to treat a wide range of intracranial vascular abnormalities, including aneurysms, arteriovenous malformations (AVMs), ischemic stroke, carotid stenosis, and tumors such as retinoblas-

toma.^{1–8,13–15} For some vascular disorders, endovascular interventions have shown even higher or at least similar safety/efficacy compared to microsurgery, not to mention that minimally invasive approaches are becoming heavily favored over traditional approaches by patients.¹²

The non-transferability of skills between open and endovascular approaches requires a compensatory increase in exposure to endovascular procedures during training. The already complex open microsurgical procedures coupled with the duty hours restrictions have made it diffi-

ABBREVIATION AVM = arteriovenous malformation.

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cult for neurosurgery residents to be adequately exposed to endovascular procedures. It is also uncertain whether endovascular procedures have been effectively integrated into residency curricula.

This study assesses the level of preparedness of incoming fellows from US neurosurgery programs to endovascular fellowships and determines potential gaps in training that could be acted upon during residency.

Methods

A multidomain, global assessment survey was sent electronically to all directors/faculty of neuroendovascular fellowship programs involved in training of US neurosurgery graduates. One survey was sent per program. The list of programs offering endovascular fellowships for neurosurgery residents was taken from the fellowship section of the website of the American Association of Neurological Surgeons.

The survey focused on professionalism, psychomotor ability and independent practice, clinical evaluation and management, and academia and scholarship (Table 1). The survey was kindly provided by the General Surgery Fellowship Council Research Committee and was subsequently adapted to neurosurgery.¹⁰ The final version included 39 quantitative items and 1 open comment section. Quantitative items used a standard 5-point Likert-style scale. Surveyees were asked to assess trainees as they entered fellowship. The survey was sent electronically to 32 active fellowship program directors of accredited endovascular fellowships in September 2013 (Table 2). The electronic link was accompanied by an introductory statement outlining the goal of the survey, explaining that the survey was completely anonymous, and emphasizing the need to provide an assessment of fellows as they entered fellowship. Three reminders were sent at 1-week intervals to increase the response rate.

Data are presented as mean and range for continuous variables and as frequency for categorical variables.

Results

The response rate was 78% (25/32).

Professionalism

Of respondent program directors, 38% reported that new fellows did not know the history and imaging of the patient they were treating, 46% arrived unprepared for the procedure, and 50% were unable to formulate an appropriate treatment plan (Tables 3 and 4). On the other hand, 83% of trainees were thought to communicate effectively with patients, 76% to demonstrate ownership toward patients, 88% to treat ancillary staff with respect, 96% to treat residents and house staff with respect, and 96% to demonstrate professional behavior.

Independent/Graduated Practice Domain

As many as 79% of respondents felt that fellows were unfamiliar with endovascular devices and 75% felt that fellows were unfamiliar with the angiographic equipment. Furthermore, 58% of fellows were unable to perform fem-

oral access, 54% were unable to perform femoral closure, 79% were unable to catheterize a major vessel, 86% were unable to perform a 4-vessel angiogram, and 100% were unable to independently catheterize an aneurysm or an AVM feeder.

Additionally, program directors reported that over 50% of fellows could not recognize neurovascular anatomy and anatomical variants, and 54% could not recognize/classify vascular abnormalities, while 52% were unable to identify early complications. Only 32% were able to take calls with only occasional consultation with the attending, and 48% were able to take care of all perioperative issues.

Disease State Expertise Domain

Program directors noted that 67% of fellows understood the pathophysiology of the disease, 56% understood options for treatments and the role and indications for surgery, while 84% were able to design the correct work-up. Also, 75% were able to counsel patients regarding the differential diagnosis and the recommendations of care, and 80% demonstrated clinical maturity to identify features of the potentially critically ill patient, to triage to the appropriate level of care, and to seek senior help in a timely and communicative way. As many as 36% of fellows did not understand the indications for the procedure, 48% did not have a good grasp of alternatives for treatment and the areas of controversy, and 44% did not understand disease-specific post-surgical or post-radiographic follow-up.

Research/Academic Ability Domain

There was an overall agreement that fellows demonstrated professionalism and interest in research and had good communication and clinical skills. Specifically, 80% of fellows showed healthy curiosity in understanding underlying mechanisms, 64% showed genuine interest in academic projects, 52% were familiar with recent publications, and 60% displayed self-initiative in conducting clinical research.

Questionnaire Assessment

Only 12% of respondents did not agree that the survey adequately assessed the research question.

Discussion

Endovascular neurosurgery is probably the most rapidly evolving subspecialty in the field of neurosurgery. It is an attractive subspecialty to neurosurgery residents, driven not only by the emergence of innovative, safe, and effective devices but also by the popularity of minimally invasive approaches among patients. Today, endovascular procedures constitute about 75% of a vascular neurosurgeon's practice. Neurosurgeons have also taken a prominent role in the field both at the national and the international level. Whether endovascular procedures have been effectively integrated into residency curricula, however, remains uncertain.

The present study evaluated the readiness of graduating neurosurgery residents for neuroendovascular fellowship. The results of the survey suggest potential gaps in the

TABLE 1. Questionnaire*

Professionalism
A Communicates effectively with his/her patients
B Promptly comes in after hours to evaluate a patient that may need higher level care/ICU transfer
C Demonstrates ownership towards his/her patients
D Treats the ancillary staff with respect
E Treats the residents and house staff with respect
F Demonstrates professional behavior
G Knows the history and imaging of the patients they are operating upon
H Arrives to the endovascular suite prepared for the procedure
I Formulates a plan of action for patients (inpatient/outpatient) prior to you seeing the patient
Independent/Graduated Practice Domain
J Is familiar and comfortable with the devices (access devices, closure devices, wires, catheters, etc.)
K Is familiar and comfortable with the angiography equipment
L Can obtain femoral access
M Can perform vascular closure
N Catheterization of a major vessel safely without me being scrubbed
O Performs a 4-vessel angiogram safely without me being scrubbed
P Aneurysm or AVM feeder catheterization safely with me in the room next door
Q Take calls with only occasional consultation with me and only occasional assistance in the suite for difficult cases
R Cares for all postoperative issues on our patients
S Is proficient in recognition of the neurovascular anatomy
T Can recognize anatomic variants
U Is proficient in recognition and classification of neurovascular abnormalities
V Can identify early complications
W Understands pathophysiology of the disease
X Understands options for treatments and the role and indications for surgery
Y Is able to perform an initial outpatient interview and the design of the correct workup
Z Is able to counsel patients regarding the differential diagnosis and the recommendations for care
AA Understands indications for procedure and appropriate work-up
AB Has a good grasp of alternatives for treatment and the areas of controversy or lack of consensus
AC Understands disease-specific post-surgical or post-radiographic follow-up
AD Demonstrates clinical maturity to identify features of the potentially critically ill patient, to triage to the appropriate level of care, and to seek senior help in a timely and communicative way
Research/Academic Ability Domain
AE Shows healthy curiosity in understanding underlying mechanisms
AF Shows a genuine interest in academic projects
AG Is familiar with recent publications in his/her field of advanced training
AH Displays self-initiative in conducting clinical research
AI Is able to compile and analyze data
AJ Shows understanding of research protocol design
AK Shows understanding of basic statistics
AL Is capable of writing a coherent manuscript
Do you think that the survey adequately assesses the research question?
Free comments regarding any aspect of the readiness of trainees for neuroendovascular fellowship

* Respondents were asked to indicate the degree to which they agreed with the above items using a Likert-style scale (choice of one of the following responses: strongly agree, agree, neutral, disagree, strongly disagree).

training of neurosurgery residents with regard to endovascular neurosurgery. Areas where neurosurgery graduates underperformed include trainability, independent ability, decision making, and knowledge of neurovascular anat-

omy and abnormalities. For example, over 50% of graduating neurosurgeons could not achieve femoral access or closure, a task that should typically be mastered during the internship year. Also, over 75% of trainees were not

TABLE 2. List of surveyed programs

University of Iowa
Tulane University
Yale and New Haven Hospital
Barrow Neurological Institute
University of Virginia
Virginia Commonwealth University
University of Florida
Mayo Clinic
Vanderbilt University
University of California, San Diego
Duke University
Capital Health
University of Illinois
University of Miami
University of Cincinnati
University at Buffalo
University of Medicine and Dentistry of New Jersey
University of Tennessee
Stanford University
Northwestern University
Johns Hopkins
Emory University
Thomas Jefferson University
Ohio State University
University of Michigan
Albany Medical Center
Cedars Sinai
Cleveland Clinic
University of Pittsburgh Medical Center
Massachusetts General Hospital
New York University Medical Center
Rush University Medical Center

familiar with the devices/equipment and were unable to catheterize a single major vessel. This suggests that incoming fellows likely may not have had enough time to practice these skills during training. This is somewhat surprising given the current requirements for certification for neurosurgery residents in the United States. In fact, it is mandated by the Residency Review Committee and the American Board of Neurological Surgery that neurosurgery programs have an endovascular rotation. This represents a potentially important opportunity for future enhancement in neurosurgery residency. There is little doubt that the potential lack of readiness of incoming fellows may limit their ability to fully benefit from advanced training during endovascular fellowship.

There are several possible explanations for the findings of this study, the most important of which is the somewhat rigid nature of the current neurosurgery residency training paradigm, which has been unable to fully keep pace with technological advancements not only in the endovascular field, but in other fields as well. Other reasons for the lack

of preparedness of neurosurgery graduates include limited exposure to endovascular procedures, lack of mentor availability, duty hours restriction, and increased supervision requirements. Also, in some programs, endovascular procedures are performed by a neuroradiologist, which creates an additional barrier for exposure to endovascular procedures for neurosurgery residents. Some residents also feel that they will not need the endovascular skill set if they elect for a nonvascular fellowship or for private practice. Moreover, neurosurgery residents often assume that endovascular procedures are rather simple compared with open neurosurgical procedures and can be quickly mastered during fellowship. However, because the duration of most endovascular fellowships is 1 year, the learning curve is obviously steep. It is also well established that the more prepared the fellow is, the faster he or she can ascend the learning curve, allowing more time for refining necessary skills.^{9,11} Conversely, incoming fellows who did not acquire basic endovascular skills during residency will have to overcome a steeper learning curve and may not be able to achieve the expert phase or independently perform complex endovascular procedures by the completion of their fellowship. The relatively low degree of inclusion of endovascular techniques into neurosurgery curricula reminds us of the time—approximately 20 years ago—when spine instrumentation “belonged” to orthopedic surgeons and neurosurgery residents had little to no exposure to this vital technique. Today, it has become the norm for graduating neurosurgery residents to be proficient at spine instrumentation.

On the other hand, there was a high level of interest in academic and scholarly activities among graduating neurosurgeons. Additionally, there were high levels of communication skills among graduates, demonstration of respect for colleagues and ancillary staff, and ownership toward patients. This is a reminder of the quality of residents recruited by neurosurgery programs and their commitment to academics and advancement of surgical science in the United States.

Limitations

The present survey is limited by a less than perfect—although high (78%)—response rate. Because the survey was anonymous, there is no way to determine whether nonrespondents differed from respondents. While the survey shows that graduates entering fellowship for the most part are in need of fellowship training, it did not address the skill sets of those graduates not entering fellowship.

Because the survey was anonymous, we could not study the correlation between the answers of fellowship program directors and residency program directors for the same trainee. In fact, the present study relies on the subjective opinions of the trainees’ new mentors and provides no objective evidence that the trainees are actually deficient in any of these areas. This could introduce a potential bias, particularly in the case of trainees coming from other institutions (who likely account for the majority of the trainees). There is a possible natural bias against new trainees coming from other institutions, which may affect the opinions of fellowship program directors. A similar positive bias exists for one’s own trainees. Having fellow-

TABLE 3. Survey results

Survey Item	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
Communicates effectively with patients	30.43	52.17	8.7	8.7	0
Promptly comes in after hours to evaluate a sick patient	36	36	20	8	0
Ownership towards his/her patients	24	52	4	20	0
Treats the ancillary staff with respect	32	56	12	0	0
Treats the residents and house staff with respect	36	60	4	0	0
Professional behavior	33.33	62.5	4.17	0	0
Knows the history and imaging	22	44	16	20	0
Arrives to the endovascular suite prepared for the procedure	20	36	24	20	0
Formulates a plan of action for patients	24	36	20	20	0
Is familiar and comfortable with the devices	8	12	24	40	16
Is familiar and comfortable with the angiography equipment	8	16	20	40	16
Femoral access	12	28	28	24	8
Vascular closure	12	32	12	36	8
Catheterization of a major vessel	8	12	24	32	24
4-vessel angiogram safely	8.7	4.35	13.04	43.48	30.43
Aneurysm or AVM feeder catheterization	4	0	8	32	56
Take calls with only occasional consultation	4	28	20	44	4
Cares for all postoperative issues on our patients	8	40	16	36	0
Recognition of the neurovascular anatomy	8	40	28	24	0
Can recognize anatomic variants	8	32	24	32	4
Recognition and classification of neurovascular abnormalities	8	36	28	24	4
Can identify early complications	8.33	37.5	25	25	4.17
Understands pathophysiology of the disease	20.83	45.83	29.17	4.17	0
Understands options for treatments and the role and indications for surgery	16	40	28	16	0
Is able to perform an initial outpatient interview and the design of the correct workup	20	64	16	0	0
Is able to counsel patients regarding the differential diagnosis and the recommendations for care	12.5	62.5	16.67	8.33	0
Understands indications for procedure and work-up	16	48	28	8	0
Grasp of alternatives for treatment and the areas of controversy	16	36	28	16	4
Understands disease-specific post-surgical or post-radiographic follow-up	20	36	28	16	0
Demonstrates clinical maturity	20	60	12	8	0
Healthy curiosity in understanding underlying mechanisms	28	52	12	8	0
Genuine interest in academic projects	32	32	24	12	0
Is familiar with recent publications	16	36	32	12	4
Self-initiative in conducting clinical research	20	40	20	20	0
Compiles and analyzes data	20	52	20	8	0
Understanding of research protocol design	16	48	16	16	4
Understanding of basic statistics	16	40	24	20	0
Writing a coherent manuscript	16	52	20	12	0
Do you think that the survey adequately assesses the research question?	16	56	16	8	4

ship program directors provide separate answers regarding internal and external fellows may have partly accounted for this problem. The ideal way to study the preparedness of neurosurgery graduates would be to objectively assess their clinical and surgical performance with standardized tests.

Although the survey did not specifically assess the

reasons for the potential gaps seen in training, it is likely that the lack of preparedness is mostly due to poor use of existing case material rather than a lack of case material. It would have been interesting to ask program directors the same set of questions regarding their graduating fellows to assess whether the deficiency resides in the residency training environment versus the trainee.

TABLE 4. Results of the survey for each program (n = 25)*

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
2	3	2	2	2	2	2	2	2	4	4	3	4	4	5	5	3	3	3	3	4	4	3	3	2	2	2	2	3	2	2	3	4	4	4	4	2	
2	2	2	2	2	2	2	3	4	4	4	3	3	5	5	5	4	2	2	2	2	4	2	3	2	3	3	3	3	3	2	1	2	2	2	2	2	
2	3	2	2	2	3	3	3	4	4	4	4	4	4	4	4	4	2	4	4	4	2	4	2	4	4	4	4	4	2	4	4	4	4	4	4	4	
2	1	1	1	1	2	2	2	3	3	2	2	3	4	5	4	3	2	2	2	2	2	2	2	1	2	2	1	1	1	2	2	2	2	2	2	2	
2	3	2	3	2	2	3	3	2	3	2	2	3	2	3	5	4	4	2	4	4	4	2	4	3	2	2	4	2	2	3	4	4	3	3	5	4	3
2	2	2	2	2	2	3	3	3	2	2	2	2	2	4	2	2	2	2	2	2	2	3	3	2	3	2	2	2	2	2	3	3	2	2	2	2	2
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2	2	2	2	2	3	3	3	3	3	3	2	2	3	4	4	3	4	3	4	3	3	3	4	3	3	3	4	3	3	3	3	4	4	3	4	4	
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1	1	1	1	1	1	1	1	1	5	5	5	5	5	5	5	4	3	4	4	5	4	3	3	4	4	5	4	4	4	1	1	3	3	4	3	3	3
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2	2	2	2	2	2	2	2	2	4	4	4	4	5	5	5	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

* Letters (A to AL) represent survey questions (please refer to Table 1). Each row represents a program; 1 refers to "strongly agree," 2 to "agree," 3 to "neutral," 4 to "disagree," and 5 to "strongly disagree."

Conclusions

This study suggests potential gaps in the training of neurosurgery residents with regard to endovascular neurosurgery. These gaps may hinder the ability of neurosurgery graduates to benefit fully from postgraduate endovascular training. In an era of minimally invasive therapies, changes in residency curricula may be needed to keep pace with the ever changing and evolving field of neurosurgery.

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