Neurosurgery Research

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Introduction

This guide to conducting and presenting neurosurgical research is geared toward international medical graduate (IMGs), but the recommendations generally apply to US students, too. Please also consult the guide to Conducting and Presenting Research in the original Medical Student Guide for Matching in Neurosurgery. Much of what follows overlaps with the original guide, although we have tried to focus on the aspects that are unique to the IMGs. We hope that this guide will help you in your journey toward becoming a capable medical researcher and neurosurgeon.

Getting Started in Neurosurgery Research

If getting a residency position in the United States is like a golden gate, then research is the key to it. Honing your research skills as a student or even as a medical graduate is extremely important for becoming a great clinician, surgeon, and scientist. Great academic neurosurgeons all around the world are recognized by not only their great clinical and surgical achievements but also their innovations and publications. Even if you do not intend to publish, having access to the medical literature and regularly updating your knowledge of new trends and guidelines are still required.

Conducting research is a skill that entails a lot of components. In this chapter, we review these components.

Tips for Beginners

No great neurosurgeon or scientist came to life as an expert in research; they all started with limited knowledge about medical research. Now it is your turn to become like them. In fact, your reading of this article is the first step in this direction. Next, we discuss some tips to help you begin.

Familiarize Yourself with the Medical Research Databases

Your first step toward familiarizing yourself with the published medical literature is to access it through the indexed research databases that contain all published medical papers from around the world. The following is a list of the most commonly used databases available online:

- PubMed/Medline—part of the National Library of Medicine, this database provides access to papers going back to the mid-1960s, and it is the most commonly used database worldwide.
- Cochrane Library—contains data on the majority of prospective clinical trials worldwide.
- Embase—produced by Elsevier, aims to collect all major biomedical and pharmacological journal articles.
- Scopus—contains all published research from journals published by Elsevier, the largest medical publisher.

How to Search for a Topic of Interest

Searching a huge medical database that has hundreds of thousands of published research items can be challenging. The key to avoiding confusion or distraction while searching is to be smart about search keywords. Always use short, concise, and single keywords that are the most relevant to the topic of interest. For example, if you are interested in the role of adjuvant radiotherapy in patients with Ewing sarcoma and you want to learn more, the best keywords to use are “Ewing’s,” “sarcoma,” and “radiation.”

How to Read a Paper

If you want to write a paper or just achieve the maximum data extraction when reading papers, you must learn how they are constructed and how to read them. Start with simple papers, such as case reports. These papers are short and provide an easy start into the realm of medical research. You can grow from here. Randomized controlled trials are also recommended, because they have a uniform structure and often a clearly structured analysis.

After you become proficient at searching the medical research databases and are comfortable with reading the literature, you might then decide that you are interested in doing research and publishing the results yourself. As an IMG, you have 2 options: (1) you can do research with a mentor at your home university. The importance of obtaining a research mentor cannot be overstated; he or she can provide invaluable guidance and help you take your first steps in

neurosurgical research. (2) You can go international and apply for a research position in, for example, the United States or Canada.

Applying to a Research Position Abroad

If you are applying for a research position abroad, it is highly recommended that you master the basic research skills before applying. Such mastery will allow you to progress with research projects much more efficiently. It is also imperative to complete some projects at your home institution so that your potential is clearly demonstrated. The following is a small overview of the basic research skills that every researcher should aim to master:

Essential Skills

- Familiarity with research methodology/epidemiology and the different types of research studies
- Basic knowledge of biostatistics
- Basic knowledge on how to navigate common statistical software packages, such as R, SPSS, SAS, Stata, and JMP Pro
- Familiarity with the structure of a scientific manuscript and basic medical writing skills
- Basic to advanced clinical knowledge of the area of interest

Bonus Skills

- Basic knowledge of photo-editing software, such as Adobe Photoshop, for creating figures and video-editing software for creating surgical videos
- Basic knowledge of text editor and advanced data-management/electronic data-capturing (EDC) software packages

Once you have learned the foundations of these basic skills, you are ready to apply for a research position. Whether you are interested in basic science or clinical research, it is best to contact the faculty directly. It is recommended that you assemble a list of potential faculty and universities with which you would want to work and then write a detailed but brief professional e-mail asking about the possibility of joining the program as a research fellow.

This list can be created by performing your own online search for research opportunities or by asking other research fellows or IMG neurosurgery residents about potential mentors and research opportunities. The lists can vary between applicants on the basis of their research interests (clinical versus basic science, brain versus spine, cerebrovascular versus tumor research, etc.), institutional preferences, and other expectations.

Remember to always be consistent and patient; it is a long process and will take time. Even for US medical students, this process is typically time-consuming. It is often said that it takes 10,000 hours to master a skill; so it is with mastering

research.

Overview—Clinical Research

Clinical research helps create new ways of taking care of patients, such as by studying or developing new devices/treatments. In general, research is one of the most important parts of the neurosurgery residency application.

The mean number of abstracts, presentations, and publications of US allopathic seniors who matched into neurosurgery in 2018 was 18.3, versus 8.9 for those who did not match. For IMG applicants who matched into neurosurgery, the mean number of abstracts, presentations, and publications was 46.6, which shows the particular importance of research productivity for IMG applicants.

Although getting involved in basic science research might be more difficult, performing clinical research still requires a set of complex skills in epidemiology and biostatistics, for example, as well as some clinical expertise. Most importantly, the variance in effort and size among different clinical research projects (e.g., a case series versus a national trial) can be immense. In addition, funding is central to clinical research, and obtaining it requires its own set of skills.

Another important aspect is that although not all US neurosurgical centers focus extensively on basic science research, all of them regularly perform clinical research studies. Getting involved here is a great way to get to know the faculty, residents, and local medical students and also to

gain insights into the clinical practice variations among the centers.

Even if you decide to focus primarily on basic science research, it can be beneficial to work on or help with some clinical research projects (if possible, although it has been noted to be very difficult to balance both together effectively). This work will usually help you generate a larger number of publications.

Furthermore, although basic science experiments are not always very fruitful in their results, almost all clinical research projects can be interpreted to some useful conclusion. Adding clinical research to your curriculum vitae (CV) would help increase your chances regardless of what type of program you apply to.

IMGs who recently graduated from medical school and do not have research experience might want to find an academic neurosurgery center in the United States that can offer a research position. Doximity, a website on which you can judge the research output of various medical centers, can be helpful.

You can check institution and lab websites to study their publishing habits and find what kind of clinical research they are currently doing; you should also try to contact the lab director of the center. Most labs provide a J1 visa. You can do a postdoctoral research fellowship, which is the best option if you find the opportunity to do so, and meet the faculty at a

center where you desire to be a neurosurgery resident. In such a case, the visa could be a J1 or an H1B, depending on the specifics of your position; you can ask for more information regarding this topic at the Department of State.

Overview—Basic Science Research

Basic science biomedical research can be defined as the pursuit of fundamental knowledge about biological systems in a laboratory setting, with or without direct relevance to a clinical problem. This type of research, especially "wet" or bench-based laboratory research, is extremely time-intensive for both experiment planning and execution. Interested medical students in the United States usually take a gap year in their medical degree program to dedicate to such projects; however, even with a gap year, it can be difficult to complete the work within this timeframe, especially in the case of *in vivo* experiments with animal models.

This practice, which is very common in the United States and usually involves a student being supervised by a postdoc and faculty in a university-affiliated lab, might not be as developed in other countries, thus revealing a significant experience gap for IMGs. IMGs who want to apply to a competitive residency position in the United States can choose to dedicate a significant amount of time to this kind of high-risk, high-reward research either before or after obtaining their medical degree.

Students can dedicate time free from lectures and exams to a

research internship in which they contribute to ongoing research projects under close supervision. More commonly, and often necessarily, IMGs can apply for a postdoc or PhD position in which they can conduct firsthand experimental basic science or translational research after graduation. In the United States, it is also more common to find MD/PhD training programs, which might not be widespread in other countries.

Despite the mentioned time constraints on and substantial effort (and sometimes frustration) by the IMG, it is important to acknowledge that successful basic science projects resulting in publications can strongly enhance the competitiveness of an IMG applicant.

Not all basic science is the same, of course. The intrinsic value of the project and the independence and actual contribution of the applicant to the publication are important factors. For maximal benefit and to increase the appeal of their application, IMGs should aim to be the first author of publications in high-impact journals.

Also, because a neurosurgeon's fundamental interest is the improvement of patient outcomes, basic science research and translational projects related to clinical neuroscience topics are appreciated most easily by neurosurgery residency programs. Despite these considerations, a strong commitment to research and a valid publication can make you stand out even if the topic addressed by your research has no direct clinical implications.

Do not underestimate what is needed to reach such a goal. The research environment in basic science is rather different from the clinical environment. During part-time or full-time research experience(s), students are asked to contribute to the work of more experienced scientists, whose primary objective is purely conducting basic science research, whereas IMGs willing to apply for residency plan to dedicate a limited and fixed amount of time. This straightforward consideration has several implications, including the following:

- First, basic science research can require several attempts before producing results worth publishing. The time you invest for this purpose might not result in a valuable article by the time you expect to apply for the residency match. Well-designed projects can take years to complete. Plan carefully which projects to join and speak plainly about your publication goals with your supervisor, but do not expect to receive first authorship for few months of intense research. Experienced PhD students and postdocs work full time for years before obtaining such results.
- Good mentorship plays a fundamental role, and surgeon-scientists with a principal investigator position might be your best pick when choosing a supervisor. The hope is that they will understand your research commitment and clinical aspirations and, thus, better accept and support your expectations. State your goals clearly, and work

hard. Neurosurgical basic science and translational research has the potential to have a large impact and can be intellectually rewarding, but an experienced guide is paramount for getting your project successfully published.

- Try to get a feel for the laboratory environment before joining, because collaboration and supervision are crucial ingredients for success. You will spend a lot of time in the lab reading previously published articles, designing experiments, and reading about techniques with which you are unfamiliar. You will need to optimize your own protocols, and you will spend even more time solving unexpected issues and overcoming existing barriers and limitations.
- Be curious, and maintain a strong work ethic in times of frustration. Results might be different than the ones you expected before starting the experiment. Ask for feedback from more experienced scientists, and spend sufficient time trouble-shooting. Repeat experiments to confirm your data. Because basic science work is highly unpredictable, it is likely that unforeseen challenges that prolong experiments, data collection, and analysis will arise.
- Consider publication time. Basic science papers are difficult to publish. The peer-review process takes time (at least a couple of months), and reviewers often ask for additional experiments. Thus, you might be required to go back to the laboratory to collect new data after you

have submitted your paper and are perhaps busy with other projects.

- Tackle the issue of authorship early. It is strongly advised to clearly discuss details about authorship in writing (via respectful e-mail) before committing to such time-consuming projects. Do not expect to receive authorship for modest contributions, and do not ask to receive more than you actually deserve. However, you also do not want to find out after months or years of time spent at the bench that your work will not be recognized. The scientific environment can be highly competitive, and internal politics can end up in bad surprises.
- Expose yourself to the US research environment. Even if successful basic research conducted in your home country is still valuable and welcome, we advise that you seek a position (at least for some time) in a US institution to gain, for example, direct exposure to US laboratory and working standards, networking opportunities, and different mentors.
- Be honest. Your aspirations must not interfere with your morality, which is fundamental for a researcher and even more for a future resident. Fabrication or manipulation of data, plagiarism, and undisclosed conflicts of interest, among other infractions, can ruin your career forever.

In summary, basic science research is very tough but can be very rewarding. Your goal should be to produce at least one first-author high-impact publication in an internationally

recognized journal.

Try to work in parallel on at least one side project so that if your main project fails, you will have some other achievements to show on your CV. Spend at least part of the time dedicated to work on such project in the United States. Be ready to commit for years to obtain results, work hard, and maintain a dedicated working attitude throughout the inevitable ups and downs of an elegant, yet sometimes frustrating, intellectual and technical exercise.

Not everybody is passionate enough to commit to such a journey, but if you manage to reach the end of the publication process, you are guaranteed an additional strength that might determine your successful match.

Obtaining Funding

Since its conception, medicine has been an evidence-based art and the doctor, or “healer,” a scientist. The doctors of the future and academic research have a major role in the training of surgeon-scientists. Unfortunately, medical schools often lack the means to fund further research for their candidates; thus, students interested in research might sometimes need to obtain funding by themselves, which involves preparing countless tedious applications. We are all aware of how frustrating application forms for grants are, but if we can maximize our chances of obtaining funding, at least the work will not have been done in vain.

Scientific research is like a market, and the same rules of

marketing apply here. The demand (research projects and applications) exceeds the resources (money available); therefore when asking for funding, you have to make sure that you are "selling" your idea properly and show that the project is cost-efficient, which means that the benefits (its translational or clinical value) and the potential income from it will be greater than its costs.

The first step of a successful application is to find where (which laboratory, research group, and institution) you would like to conduct your research. Remember that the more prestigious the institution is, the more likely it is that your application will be successful, because your research will be credited by the international scientific community. Therefore, you must choose carefully and be willing to relocate. The prestige of the institution where you are based currently (namely, your medical school) has a minimal effect on your research application; what matters is where the research will be conducted.

The second step is to find a supervisor. Once you find a couple of names in the field in which you are interested, do a quick PubMed search simply by entering their name and surname in the PubMed search bar and choosing the filter "author."

You are looking for someone with a high research output in prestigious journals; as a rule of thumb, you want to find someone with at least 5 or 6 publications per year as first or last author in journals such as the *Journal of*

Neurosurgery, *Neurosurgery*, *World Neurosurgery*, *Brain*, *Nature Neurology*, and of course the ever-present *Nature*, *New England Journal of Medicine*, *Journal of the American Medical Association*, and *Lancet*. Although this is not a strict rule, and there are amazing researchers whose work might get the recognition they deserve later, if you find a supervisor who is a "leader" in the field, you most certainly increase your chances of obtaining your funding.

Next is the topic of your research. Looking at the bigger picture, more money will be assigned to projects that are likely to have a bigger impact on the health of a population; therefore, studies of very rare diseases or niche topics (such as neurosarcoidosis) are less likely to receive funding.

Once you find your institution, supervisor, and project, you then need to formulate your proposal. Writing a proposal can be challenging, but if you look at it as an abstract for a paper, it might get a bit easier.

For clinical studies, you can start with the "PICO" format by defining your population, intervention, comparison, and outcome. This format will give your project a framework that can quickly inform the assessors about the study that requires funding. It would be good to extend a bit more on the *Methods* section, especially highlighting how much the estimated cost of each step of the process is (e.g., for buying the RNA or cell cultures for a lab project, recruiting volunteers for a clinical project, travelling to a different country for presenting the research, etc).

Make sure to also mention that you are going to present your project at a meeting, if you are willing to do so. It is also important to clearly outline the “gap of knowledge” in the *Introduction*, underlining the importance of the new insight(s) that might be gained from your research.

Another very important point is to give your research project a very clearly defined time frame, which communicates that you have planned your project in enough detail.

Before submitting an application, you also have to check the eligibility criteria for that specific grant. For example, some will require you to be of a specific age or to have a specific background or major field of study. Therefore, read the instructions carefully to avoid wasting your time applying for funding for which you are not eligible.

In the United Kingdom, for example, the Medical Research Council (MRC) and the Wellcome Trust offer great bursaries and awards for undergraduate research projects. In most countries and at most universities, similar funding opportunities will be available and can be identified online. If you have completed research projects, it can be beneficial to submit them to national neurosurgical societies, which often offer endowed young researcher prizes for the best research works.

Last, remember that “[r]ejection is merely a redirection; a course correction to your destiny” (Bryant McGill).

Presenting your Research

If you are in the process of conducting research, it is not enough to simply publish it. For your career, CV, and acceptance of your research in the scientific community, it is crucial to ensure that your research is seen by peers in the field. You can accomplish this by presenting the work at scientific meetings or by promoting your research online.

At Scientific Meetings

First, scientific meetings are a great venue for promoting your research. You can mention your research to experts in your field, and articles presented orally at a meeting often receive many more citations—as a marker of importance of a study—than those that are not. During a meeting, you will also be able to learn about many topics other than your own research.

Second, scientific meetings are among the best opportunities for networking as a medical student. Aim to make as many new connections as possible. This effort will often open new possibilities for research collaborations and possibly even research positions.

Prepare your presentation on time. Try to have it ready at least 1 week before the meeting, and practice it a couple of times. Arrive 15 minutes before the start of your session. You can use this time to prepare mentally, to inspect the stage, and to ask the technical assistant about any questions but also, most importantly, to introduce yourself to the chair of

your session. This meeting often leads to a more relaxed atmosphere when you are giving your presentation and can help you stand out from the rest of the often-many speakers in the eyes of the session chair.

Online

In the 21st century, it is becoming increasingly important to market yourself. You can market your research by creating a strong online presence and making your research available. Create a LinkedIn account to make your research CV available publicly, and create Google Scholar and ResearchGate accounts to track your own research.

These profiles are publicly available, help you promote your research, and allow you to track your research statistics (e.g., citations and h-index). They sometimes also allow you to make new connections through people who are interested in your research and who proceed to contact you.

Platforms such as ResearchGate also enable you to follow other important researchers in your field of interest, thus providing a very concise overview of updated publications in your specific field. This process helps you keep pace, which is hard to do otherwise in light of the large number of articles published in neurosurgical journals every week. You might even elect to start a social media account on Instagram, Twitter, or YouTube to market yourself and your neurosurgical research.

Participating in Peer Review

For those taking part in any form of scientific research, participating in peer review can be a very instructive experience. You might ask yourself if you, as a medical student or young researcher, can review such work. Of course you can. In fact, many journal editors appreciate working with young researchers from time to time, because they can provide a different view on a manuscript than many of their older, more experienced colleagues.

When performing peer review, you are forced to critically assess other research submissions on a whole different level than you normally would. You scrutinize every single sentence and every methodological step. This work trains your eye to spot any mishaps, even in your own future research.

You can also learn about new methods and novel concepts when reading interesting submissions. Honing these critical thinking skills and being able to critically appraise someone else's (and your own) research is invaluable. In addition, this process provides you with better insight into the editorial process and what reviewers look for in your manuscripts, which can benefit your future manuscript submissions.

Do not spend more than 1 or 2 hours per manuscript; take your time, but do not waste your time writing down scores of corrections for a manuscript that is clearly not of sufficient quality and prepared with little care. Be respectful, precise, and fair in the comments that you do make. Begin your comments to the authors with a nonjudgmental summary of

the findings. Then, list your major and minor concerns. Finish your report with a short conclusion, but do not announce your personal decision to the authors.

In your comments to the editor, provide your personal decision for or against publication and the rationale for it, and proceed to thank the editor for the opportunity to participate in the review. The details of performing peer review can vary depending on the specific policy of each journal, which is also something to keep in mind.

After the final decision has been made by the editor, read the comments made by the other reviewers. This can then serve as feedback for you, and you can also ask the editor for feedback about your performance as a reviewer. This feedback is crucial for becoming a good peer reviewer.

How can you get involved in scientific peer review? First, you might be invited as an ad-hoc reviewer for submissions on topics on which you have published a few journal articles. Second, you can write an e-mail to the editors of journals that you enjoy reading, those in which you have published, or those for which you personally know one of the editors and respectfully inquire about the opportunity to be put on the reviewer list.

Last, take credit for your reviews. Register a profile on Publons. Then, every time you submit a review of a journal article, simply forward the “thank you for reviewing” e-mail that you receive to reviews@publons.com. Publons will then

verify with the journal that you have indeed reviewed the article and update your record online. It is beneficial to track your peer-reviewing efforts, and it is useful to put a link to your Publons profile in your CV.

MSc and PhD Perspectives

Being in medical school is a busy time, and residency is even more so. Although you might find time to do some research during medical school, it is often advisable—and no less enjoyable—to take a dedicated year off for research. In this year, you can fully focus on mastering research skills and specializing on a particular subtopic, which will help you to find a topic that is of major interest to you and to determine if research in general is something that you enjoy doing.

If you end up enjoying research and want more, there is no better option for you than to start an MSc or PhD program. These programs can often be done in combination with medical school (in MD-PhD or MD-MSc programs), but even taking a few years off to specialize in research after medical school might be quite beneficial.

In general, these additional qualifications will help you with matching into the neurosurgery residency of your choice. The requirements for application to an MSc or PhD program, as well as cost, effort required, and quality, can differ vastly from university to university and from research field to research field. It is crucial to spend time learning about different programs to which you can apply while also making a visit to

the host institutions before applying. For an IMG who wants to match into neurosurgery residency in the United States, it is of particular value to obtain a research position at a US institution. Obtaining a research position in a Canadian program is also an excellent alternative option.

MSc programs usually run for 1 to 2 years, whereas PhD programs usually require 3 to 5 years of dedicated work. The MSc programs are generally more structured than PhD programs, which allow you to do independent research on your topic of choice while obtaining some teaching experience, and they usually include a small curriculum of lectures. For medical students and future clinicians, MSc programs in epidemiology, biostatistics, data science, public health, or a basic science subject in your field of interest are recommended.

Online Resources

Nowadays, the internet enables you to obtain a reasonable level of theoretical knowledge. Here, we present some valuable online resources that can help you obtain essential skills. This list is by no means restrictive, and for any specific topic of interest, you will likely be able to find a quality resource that is freely available through a simple online search.

Build up your personal toolkit of research skills, but also try to take every opportunity to apply them in practical clinical or basic science research. You will be astounded by how many

differences and unforeseeable circumstances emerge once you try to apply your learned theoretical knowledge into a scientific study.

- edX—This platform offers courses and lectures held by some of the best university faculty and corporate experts from around the world on almost any topic, from obtaining a micro-MBA to gaining programming skills for machine learning. For medical research, we recommend the HarvardX introductory courses to R—the de-facto state-of-the-art programming language for biostatistics—which are the "Data Analysis for Life Sciences" and "Data Science" series. These courses cover topics ranging from basic R programming for simple statistical analyses all the way to analyzing genomic data. The courses are free of charge. Optional certificates issued by the teaching university are available for $40 - $100.
- Nature Masterclasses—The masterclasses provided by the Springer Nature publishing group offer guidance on a variety of topics ranging from scientific writing and publishing to how peer review works. Most courses are free of charge, although more in-depth courses require a subscription. However, most research universities are subscribed to this program; ask your university library about such subscriptions.
- BMJ "Research to Publish"—The *British Medical Journal* (BMJ) offers similar courses in collaboration with the University of California San Francisco. Access is

structured similar to that for Nature Masterclasses.

- EQUATOR Network—The Enhancing the Quality and Transparency of Health Research (EQUATOR) network was pioneered by Oxford biostatistician Douglas G. Altman after realizing the variance in reporting among medical research articles. The EQUATOR network offers checklists for all types of research manuscripts, from case reports to study protocols or systematic reviews, that can greatly help you structure your manuscript. However, potentially more interesting are the online "toolkits" that provide concise help on topics such as research writing and peer review. These resources are free.
- stackoverflow—Consult stackoverflow for any problem you run into while programming in any programming language.
- Peter Sedgwick's Biostatistics series in the BMJ —This comprehensive and well-explained tutorial series of biostatistics is freely available. Each contribution is structured in the same way, that is, as an introductory multiple-choice question based on a BMJ publication, followed by an explanation of the technique/concept in question on 2 to 3 pages. Peter Sedgwick's amassed tutorials are freely available on ResearchGate.
- ClinicalTrials.gov—This database of ongoing and finished prospective studies can be usedto find yet-unpublished studies that are in areas of your interest or similar to the

ones that you are planning to perform. It may help you prevent duplicate studies, but you can also take a look at other trial protocols as guidance when you are writing your own trial protocol. If you are starting on a prospective clinical study, register it here and report the registration number in your manuscript.

- PROSPERO—This database can be used to search for essentially the same data as one would seek in ClinicalTrials.gov, but for systematic reviews and meta-analyses. Similarly, if you are starting on a systematic review, register it on PROSPERO and report the registration number in your manuscript.

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