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Top ten strategies to enhance grant-writing success

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ABSTRACT

Mastering the art of grant writing is one of the most essential skills to obtaining research funding. Given the importance of pursuing high-quality surgical research and supporting the academic goals of surgeon-scientists, ensuring that surgeons have the necessary skills to write effective and successful grants is of paramount importance. In this article, we present 10 strategies for composing a strong research grant application. These strategies apply to federal or nongovernmental funding agencies and are broadly relevant to basic, translational, and clinical investigators. We believe these recommendations can help surgeon-scientists be effective grant writers and compete successfully for research funding.

Introduction

Widespread concern exists over declining numbers of successful physician-scientists. This trend is chiefly pronounced among surgeons,[1] with the consequence of decreasing influence in biological sciences.[2,3] The problem is particularly pronounced for early-career scientists, whose average age at the time of their first National Institutes of Health (NIH) R01 award has risen steadily over time.[4] Given the critical importance of sustained grant funding, we offer a series of recommendations to surgeon-scientists to maximize likelihood of success in their grant applications (Table I).

1. *Give the process enough time*

One common error among junior faculty and trainees is not devoting sufficient time to develop and write a grant. This is a serious error, since the process is lengthy and iterative. Slapdash proposals hastily prepared in the final days before a deadline inevitably stand out to reviewers. A competitive application for an NIH R01 award routinely requires 100 to 200 hours of work over many months (no less than 3 months from the deadline). This includes time for reviewing relevant literature, compiling preliminary data figures, identifying and collaborating with a team of coinvestigators, writing a compelling proposal, putting together a budget and all the other required documents, seeking feedback from mentors and colleagues, obtaining letters of support and biosketches from key personnel, ensuring pages are properly formatted, and so on. Importantly, this does not include time needed to generate preliminary data, which ideally is collected before the grant writing process commences (although new data may arise as the grant is being written).

Drafting a Specific Aims page is the first step for a grant application.[5] The Specific Aims serve as a foundation for the rest of the proposal and will receive the greatest scrutiny from reviewers. Reviewers use this page to generate their overall impression about the grant and then use the remainder of the application to confirm that the investigator has truly thought through the proposed research in detail. Aside from the assigned reviewers, other study section members will probably only read this page. A successful Specific Aims page will look remarkably different in its final form compared to early drafts. Significant time and thought are required to write, edit, and rewrite. Feedback should be sought from colleagues and mentors, and even from trainees or technicians in the laboratory who have knowledge of the topic and specific

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Table I
Ten grant writing strategies for surgeon-scientists

1. Plan to spend significant time on each grant application
2. Follow the funding agency's instructions
3. Write clearly and concisely
4. Make sure you have an appropriate team of collaborators
5. Accentuate the significance and novelty of your ideas
6. Limit the scope of your proposal to a realistic scale
7. Do not propose interdependent "domino aims"
8. Include enough preliminary data to establish feasibility
9. Ensure the scientific plan is easy to comprehend
10. Keep applying. Don't get discouraged

techniques. If the grant will involve collaboration or support from other researchers, it is wise to involve them early in the process, and to allot time for them to respond to inquiries and provide feedback. Engaging statistical support from the start of the process will ensure rigor by generating a feasible proposal that fits within budget with the appropriate sample size. Remaining open to constructive criticism with a willingness to address concerns that improve the content is crucial during this iterative process. Conventional wisdom suggests crafting a Specific Aims page takes as long as writing all subsequent parts of the application.

After drafting a strong Specific Aims page, proceed with the rest of the grant. Be sure to allot sufficient time to circulate drafts to collaborators and other colleagues. Expect to alter and rewrite large segments. Although constructive feedback is difficult to hear, people who only say nice things about your grant during the writing process are not helping you. Even the most self-critical applicant can become blind to weaknesses in their proposal, so it is critical to seek feedback from mentors and colleagues throughout the process. Feedback should be a continual process of discussing ideas and refining the application. At a minimum, have one or two trusted colleagues, preferably funded investigators with knowledge of the field, review the final version of an application before submission. Doing so will inevitably bring unnoticed weaknesses to light. Many institutions have internal grant review opportunities, and these should be taken advantage of. The more feedback an applicant solicits before submission, the better the grant will be. Plan to have a final draft completed with enough time to proofread and check for spelling and grammatical errors. Some departments will send grants out to senior scientists at other institutions to review and provide feedback. Alternatively, professional editors can proofread grant applications. Although this is not always necessary, asking an associate to proofread the final version is beneficial.

Finally, it is important to be cognizant of institutional deadlines. The research management office at each institution typically requires a final version of the grant before the funding agency's deadline (eg, 1–2 weeks). Internal deadlines are often inflexible, so be sure to know what they are at your institution. Some institutions (such as the Veterans' Administration) require additional administrative or leadership approval, and those requests must be made well in advance.

2. *Follow the instructions*

NIH funding opportunities are accompanied by a Request for Applications (RFA), which will state the purpose of the award. The RFA lists which grant mechanisms are being funded by the award. Nongovernmental funding agencies also provide instructions stating eligibility criteria for a given award and what sort of projects they fund. Before beginning an application, carefully read the RFA or similar announcement to ensure your proposal matches the funding agency's goals. Failure to do so could result in an enormous amount of effort expended, only to be summarily disqualified or rejected.

Particularly for NIH awards, confirm the grant mechanism fits the proposed project. Mechanisms providing smaller amounts of funding or with shorter duration may not simply be intended to fund smaller projects but may be targeted toward different types of projects. For example, R21 awards (which are nonrenewable, 2-year grants with a maximum budget of $275,000 in total direct costs) are not simply small R01 awards (which can last up to 5 years and provide up to $500,000 in direct costs per annum). The R21 is specifically intended to fund early stage, exploratory projects that may be high-risk in nature and may lack preliminary data. Similarly, novice applicants may erroneously assume smaller awards are less competitive than larger grants. In actuality, the funding success rate for R21 applications has been lower than for the R01 mechanism in recent years. The National Institute of Allergy and Infectious Disease has published an online guide to determining which R mechanism best fits your project, which can be a valuable resource for investigators to consult (https://www.niaid.nih.gov/grants-contracts/research-project-grants).

It is prudent to reach out to the NIH program officer at this stage, especially if you are uncertain what mechanism or RFA is the best match for your proposal or if you are uncertain about your eligibility. Program officers help investigators navigate the application and postaward process, and they want to ensure the applications they receive suit their funding priorities. A few emails or phone calls early in the process can prevent significant time and effort from being wasted on an application with no hope for success. Prior to meeting with the program officer, it is critical to have a strong Specific Aims page to use as the foundation for your conversation. Meeting with a program officer with undeveloped aims is unsatisfying and a waste of time for both parties.

After ensuring your proposal is a good fit for the award, be sure to read instructions regarding page length, word limits, and formatting (for NIH awards, these guidelines are available at https://grants.nih.gov/grants/how-to-apply-application-guide/format-and-write/format-attachments.htm). These requirements vary between NIH and nongovernmental agencies. Biosketches must also be formatted to the funding agency's specifications and have recently changed for the NIH. Grant formatting requirements can change between application cycles and should be checked for each new application, including what is allowed in the appendix and whether hyperlinks are permitted within the text. Failure to comply will likely result in rejection of the application. Even if the agency agrees to review an improperly formatted application, the aberrations will likely stand out to reviewers and give the impression of carelessness. Your institutional grant administrators should assist with edits for content and formatting.

If the agency permits resubmission of previously unfunded applications, take note of applicable rules and guidelines, including addition of a cover letter or, as in the case of NIH grants, a 1-page response to the review. Respond to all reviewers' comments, briefly thank them for their input, and state how their recommendations have improved the submission. If you disagree with a reviewer's comment, provide a thoughtful and respectful justification of your position.

3. *Make the grant easy to understand*

Grant applications are reviewed by busy scientists, typically without substantial remuneration. Each reviewer must read many applications, and it is time consuming to do so. Furthermore, reviewers may not be experts in your specific field. Regardless of the reviewer's qualifications, there is a need to be as clear and concise as possible. A grant that reads poorly is likely to be set aside long before the final page.

To make a grant clear, write in a style accessible to a general scientific audience. Assume reviewers lack in-depth knowledge of your

field. Use active voice and avoid jargon as much as possible. Although abbreviations can be useful for saving words, do not overuse them and do not invent abbreviations. Limit abbreviations to those that will be used repeatedly. Italics and boldfaced fonts should be used, albeit sparingly, to provide emphasis. We recommend beginning each paragraph with a topic sentence to make clear what information follows, because this style makes it easier for reviewers to scan your application and locate relevant details. Formatting with clear section headings and subheadings will help reviewers navigate the document and facilitate rereading of critical sections.

Make the application visually pleasing, as this will entice reviewers to spend more time with your proposal, as opposed to a haphazard appearance that can distract reviewers from the content. Pay attention to white spaces on the page, which are often best placed between paragraphs. A sheer wall of text is intimidating and exhausting for reviewers to slog through. Use boldface text judiciously to call attention to critical items. Avoid jolts of bold text mid-paragraph or midsentence, which will disrupt the flow of the narrative. Ensure figures, tables, and charts are easy to comprehend. Very small fonts are difficult to read and may be skipped over by reviewers. Finally, it is essential to avoid typographical errors, spelling errors, and grammatical mistakes, all of which give the impression of sloppy work. As you will have reread the grant many times before submission, these can be challenging to catch. Finding new eyes to proofread just before submission can prevent these simple errors.

4. Assemble the proper team

In the current era, scientific research is rarely undertaken by a single investigator. The expertise of several multidisciplinary investigators is usually required. Although your application should center on your laboratory's area of expertise, adding collaborators who provide additional expertise will enhance the application. For example, if your laboratory has extensive experience with animal models of short bowel syndrome and you wish to extend your studies to investigate consequences for skeletal growth, adding a developmental biologist whose lab studies bone formation as a collaborator is likely to improve your chances of getting funded. Having the correct collaborators is critical if you intend to propose complex techniques in which you do not have demonstrated expertise through preliminary data or prior publications. If your proposal involves complicated statistical analyses, include a statistician as a collaborator or coinvestigator. Statistical analysis is a critical part of any application, and inclusion of a trained statistician will reassure reviewers that the proper expertise is available.

Individual career development awards, such as the NIH's K awards, are mentored awards that are assessed with emphasis on preparing the applicant to compete for independent funding. Although the research plan is considered in the scoring, the training plan and mentoring team are weighted equally when the grant is reviewed. Choosing a mentor who is committed to the applicant's training goals, mentoring, and skill acquisition is essential. One effective approach is to propose a "mentoring committee" in addition to the primary mentor. Such a committee should be composed of funded investigators both internal and external to the applicant's institution, and your application should highlight the unique traits each member contributes to the award. Each mentoring committee member should enhance the applicant's training by imparting new skills or offering valuable career guidance.

5. Emphasize significance and innovation

Significance and innovation are key grant-scoring criteria and deserve careful attention in the application.[6] Clearly define the significance of the problem you seek to address and convince reviewers you will bring new ideas and/or approaches to the field. "Incremental advance" is one of the most damning phrases a reviewer can use to describe an application, suggesting that the proposal is not innovative or only repeats prior work in a slightly different setting. Highlight the relevance of the clinical or scientific problem to generate excitement for the proposed work by contextualizing the problem as it relates to a critical public health issue or scientific impasse. Emphasize the precise knowledge gap and explain how closing this gap will improve health. Describe the prevalence, cost, morbidity, and overall impact of a disease. Demonstrate how your project will generate new data to improve patient care.

The innovation if your proposal should derive from the scientific principles you plan to explore. This can be challenging, both because innovative ideas are difficult to develop and because reviewers' interpretations of innovation are subjective. Begin by succinctly explaining the current state of the field, and then describe ways you will expand these frontiers. Proposing novel tools, instruments, and concepts can strengthen a grant if they permit testing of previously inaccessible hypotheses. If you or one of your collaborators has developed new approaches to measure relevant variables, emphasize how these methods open new questions to investigation. Although state-of-the-art methods or technologies will demonstrate innovation, be sure to show sufficient preliminary data to convince reviewers you have the required expertise to apply novel approaches. Regardless of whether the techniques are novel, highlight the intellectual innovation of your approach.

6. Avoid an overly ambitious proposal

One common error, particularly for novice grant writers, is to propose an amount of work that is challenging to complete within the duration of the award. A focused, clear, and thorough application is superior to a more ambitious proposal that is either not feasible or poorly described. If one aim clearly requires substantially more work than others, consider dropping other aims or splitting the large aim into more manageable parcels. Although most investigators propose 2 or 3 aims in a grant, it is rare for funding agencies to require a specific number of aims.

To keep the grant focused, ensure that each aim proposes well-controlled experiments to rigorously test a clearly stated hypothesis. Do not propose more experiments than are necessary and do not propose complex or "cutting edge" methods if simpler, well-known approaches suffice. Although applicants often hope that proposing new technologies will give their grant an innovation boost, such a strategy can be counterproductive. For example, the proposal's innovation should derive from the science rather than from use of a poorly understood tool. In general, screens, descriptive studies, or "fishing expedition" projects that are open-ended and not hypothesis driven are ill advised. Such proposals tend to involve large amounts of work with no guarantee of an important result. Use of a conceptual model or a clear explanation in the significance section why your approach is likely to succeed will help alleviate such concerns. On occasion, a funding agency will specifically seek descriptive projects or "high risk/high reward" studies. In these cases, a clear plan for how the large amount of data to be generated will be analyzed and interpreted is critical.

7. Be sure your aims are not interdependent

So-called domino aims occur when the premise of one aim rests on the success of an earlier aim. For example, if your first aim proposes to determine whether patients in a subset of primary care practices are more likely to relapse after colon cancer resection

followed by a second aim that proposes to test whether a protocolized intervention can improve outcomes of patients in high-risk practices, reviewers are likely to penalize your application. If the first aim is unsuccessful, there is no basis for undertaking the second aim. Although all aims should revolve around a central theme, each aim should be a self-contained project that can be pursued to completion even if other aims fail or result in unanticipated findings.

8. *Include sufficient preliminary data*

Preliminary data has 2 roles in a grant application. First, and most important, it establishes feasibility for the project. This is particularly important if you propose methods and technologies that are not well established in the field, such as cutting-edge sequencing tools, computationally intensive analyses, or invasive procedures requiring technical expertise. Reviewers will question the ability to perform experiments and troubleshoot technical hurdles unless you demonstrate competence with the proposed methods. To establish feasibility, it is not necessary for preliminary data to directly relate to the proposed project. For example, if you propose to perform RNA sequencing on breast cancer specimens, preliminary data or your prior publication showing successful sequencing and interpretation from thyroid cancer specimens may suffice.

Another purpose of preliminary data is to help build a compelling case for the central hypothesis. Some of these data can come from published literature, but some should also come from your own laboratory's publications and unpublished preliminary work, which establishes your expertise and prior success in the field.

The preliminary data burden is different for different funding mechanisms. NIH K and F awards are training grants designed to facilitate skill acquisition by trainees and early-career investigators. Reviewers for training grants are seeking evidence the applicant will gain critical skills and experience. As a consequence, it is generally only necessary to display sufficient data to prove feasibility. In contrast, reviewers for R and P award mechanisms often expect significant preliminary data to support the central hypothesis and specific aims. Some mechanisms, such as R21 grants, are designed for exploratory preliminary studies.

9. *Provide a clear and concise scientific plan*

Reviewers need enough detail regarding the experimental plans to properly evaluate a grant. This can be challenging to achieve within the page and word limits allowed, particularly if the proposal is overly ambitious. Although including every minute detail of your protocol is unnecessary, it is critical to walk reviewers through your approach, from the selection of experimental and control groups through data analysis. Explain the study design and comparator groups, stating clearly what controls will be included and why. You also need to provide a clear data analysis plan, including both specific statistical tests to be used and an explanation of why the selected tests are appropriate. If working with animal models or patients, include power analyses to justify the number of subjects proposed. Anticipate confounding variables and explain how you will mitigate their influence.

Each component of the experimental approach should be described separately. Consider each component as being a distinct "bin," and avoid mixing these bins as doing so can confuse reviewers and make your approach difficult to understand. For example, if your proposal involves enrolling patients in a clinical trial, one section of your approach should describe the inclusion and exclusion criteria that define the study population, whereas a separate section should describe how patients will be approached, consented, and enrolled. We recommend giving each section a unique heading to make the delineation clear.

The grant should include a section detailing potential pitfalls and alternative approaches. In this section, be honest regarding shortcomings of the approach. No research plan is perfect, and it is better for the applicant to acknowledge flaws than for reviewers to discover them. The study section is likely to forgive imperfections that are acknowledged and discussed in the application. Remember to include alternative strategies in this section. For studies with human subjects, insufficient enrollment is always a concern and should be specifically addressed. Because it can be challenging for applicants to critically evaluate their own plans, seek feedback through repeated reviews at grant-writing groups or from attentive colleagues who will rigorously and candidly evaluate the proposal.

Related to point 2 above ("Follow the instructions"), be sure to include any details the funding agency requires. As one example, most funding agencies will request demographic details of the study population. All NIH grants are required to include an explicit statement about sex as a biological variable, and you should clearly describe a plan for accounting for sex effects in your study. This discussion should be included even if your study population includes only 1 sex, such as if you are studying prostate cancer. Failure to include these mandatory components will automatically reduce the score of your application.

10. *Keep applying*

One of the most consistent traits of well-funded investigators is their persistence in applying for grants, even at times when they have already secured funding. It is tautological that the only grant that is certain not to be funded is the grant that is not submitted. A recent survey by Keswani et al found that among academic surgeons, the number of applications submitted correlates with the likelihood of achieving funding. Surgeons in either basic sciences or clinical research approached nearly 100% likelihood of having funding if they had submitted at least 5 grants over the preceding 3 years, whereas surgeons who had submitted a single grant had less than a 20% chance of being funded.[7] We recommend surgeon-scientists submit at least 1 major grant application per year. Every time your research group publishes a high-impact article, follow up with an application designed to build on the momentum.

Like other surgical skills, grant writing is a skill that can be learned and needs to be practiced to achieve expertise. Attaining excellence in grant writing requires deliberate practice and coaching. By continually writing, rewriting, and applying, this skill will grow and provide exciting returns. Having a supportive environment in which to write the grant, review grant critiques, and rewrite with mentors, colleagues, or collaborators is critical for improvement. An excellent way to hone grant-writing skills is to become a reviewer. Consider participating in the NIH Early Career Reviewer (ECR) Program (https://public.csr.nih.gov/ForReviewers/BecomeAReviewer/ECR) to gain firsthand experience with peer review.

There is necessarily a trade-off between time spent on grant applications and other activities. Although it can be difficult to let go of ideas, it is important to recognize when a proposal is unlikely to be funded. The significant effort of reworking and resubmitting a grant is sometimes not worthwhile. When in doubt, discuss the matter with mentors and colleagues. People who have not invested the time, energy, and emotion in a project will often see more clearly when the time has come to move on.

In conclusion, obtaining grant funding is challenging for any physician-scientist, and surgeons and other procedural specialists face particularly daunting challenges. In addition to a difficult

funding environment, surgeons face high clinical demands, administrative responsibilities, and work-life balance issues. To overcome these challenges, surgeons need to do everything possible to maximize their odds of success. We believe academic surgeons can increase their research funding by adhering to the grant writing principles suggested here.

The first step should be to draft a Specific Aims page with active feedback from collaborators, colleagues, and mentors.[5] This should be followed by a careful crafting of a research plan, with attention to providing sufficient preliminary data and the necessary experimental details. Make sure you have put together the right team and collect the necessary letters of support, biosketches, and other supporting documents. Feedback should be sought frequently, and colleagues should be asked to review a final draft well in advance of the submission deadline. Constructive criticism will help avoid the common pitfalls of co-dependent aims, an overly ambitious proposal, lack of sufficient preliminary results, or insufficient experimental details. Outside viewpoints will also help identify opportunities to highlight the significance and innovation of the work. Most importantly, give the process enough time. With these guiding principles in mind, aspiring academic surgeons can compete successfully for research funding.

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