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Anesthesiology Physician Scientists in Academic Medicine:

A Wake-up Call

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Physician scientists perform biomedical research ranging from fundamental molecular studies to clinical trials. As such, physician scientists have a pivotal role in the biomedical research enterprise. The foundation for physician scientist leadership in the subspecialty of anesthesiology is highly dependent on the success of young investigators as they develop independent careers involving basic and clinical investigation. Hence, a leading priority of anesthesiology must be to nurture the academic careers of physician scientists within the specialty.

Over the past decade, during a period of budgetary expansion by the National Institutes of Health (NIH), the number of NIH grant applications from physicians, in contrast to the number of grant proposals from Ph.D. scientists, has been slow to increase. Likewise, growth in NIH awards to physicians working in anesthesiology departments has also been slow.[1] Junior clinical anesthesiology faculty across the country find their ability to develop NIH-funded research programs limited by inadequate or overly fragmented research start-up time and by inconsistent approaches to research mentoring. In concert, the recent abrupt decrease in rate of growth of NIH funding now threatens not only the pace of our progress, but survival of physician scientist activity within anesthesiology.

Based on these observations, anesthesiology is at risk of losing its status as a respected academic discipline within the broader biomedical community. Based on historic analysis of periods of limited NIH budgets, critical analysis of anesthesiology research training programs relative to peer academic specialties,[1] and considering the forecasted continued high demand for clinical manpower in our academic medical centers, we present the case for radical change in our approach to training within the specialty. Although effective solutions will require significant sacrifice by all sectors of the specialty, we propose that modest steps are far too late and will no longer succeed. This article, while seeking to inform and educate, is above all a passionate call for decisive action.

The Physician Scientist in Challenging Times

Interdependence between clinical insight, attention to disease conundrums, and formulation of basic research hypotheses has driven many key discoveries in biomedical science. Physician

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scientists are uniquely trained to work in the nexus where science is translated into practice and are playing a pivotal role as new opportunities surrounding the human genome and proteome mature.[2–8] Physician scientists also play a major role with federal agencies and legislators as advocates for directing scarce resources into key sectors of the biomedical research enterprise,[9–11] especially as new opportunities to improve human health emerge.

Over the past 50 yr and for the foreseeable future, the NIH has been the dominant resource for peer-review funding in academic medicine. Most working in and around academic health care are aware of the recent decade-long NIH expansion[12] and are also acutely aware that this expansion has ended. The NIH budget increased at an unprecedented average rate of 15% from 1999 to 2003[13] but only 2.7% in fiscal 2004.[14–17] Those closest to the budget process are predicting that NIH budget growth is likely to remain at less than 1% for the next few years and could even decrease.[14,18,19] The decrease in NIH budget growth rate will cause a significant reduction in the overall rate of funding of grant applications submitted for peer review.[17‡] This immediate decrease in award success rates is partly due to the necessity to manage and maintain out-year funding commitments made by the NIH to investigators and universities during the recent period of rapid growth.

To determine the impact of this scenario, we examine the early 1990s, when funding rates decreased to an all-time low in the modern era.[§] Throughout the 1970s and most of the 1980s, aggregate funding rates (which include all revisions to a grant proposal) in most years were in the 30–40% range. Then, rather abruptly, budget cuts caused overall success rates to decrease from 35.7% in 1987 to 24.5% in 1989. Success rates reached a nadir in 1993 (23.5%), with new applications funded at a rate of only 17.9% to maintain competing continuation "renewal" success rates for established programs at a marginally tolerable level of 40% (*i.e.*, during this era, 60% of all funded investigators lost their funding at the point of competitive renewal at the end of the original funding period). Although overall success rates recovered to 30.5% by 1997, the prolonged period of extreme competition for financial support in the early 1990s had a decisive impact on physician scientist careers. Numerous studies identified an ominous national decline in the number of physician scientists participating in basic and clinical research from all medical specialties by the late 1990s,[20–25] and several well-cited editorials identified the decrease in the number of research-intensive physician scientists as a "crisis" for the nation's medical research infrastructure.[26–28] The number of M.D. applicants for NIH competing research project support decreased from 7,283 in 1994 to 6,338 in 1996,[‖] and the number of M.D. grants actually awarded per year remained relatively unchanged (1,792 in 1994, 1,787 in 1996).[#]

What about anesthesiology? Table 1 indicates that NIH funding to anesthesiology departments has steadily increased since 1975. At first glance, this increase in funding seems encouraging, especially considering it has kept up with the 12-fold increase in total NIH funding to all disciplines (absolute dollars, not inflation adjusted). However, the percentage of total NIH budget going to anesthesiology departments has remained flat, never reaching 1%, despite the fact that anesthesiologists represent 6% of the total medical workforce.[1] Before taking comfort in the fact that anesthesiology funding has not declined in terms of percentage of overall NIH funding, one must remember that many current NIH-funded investigators in anesthesiology

‡Report of the Director, FY2006 President's Budget Request. Available at: http://www.whitehouse.gov/omb/budget/fy2006/. Accessed September 16, 2005.

§Yearly funding rates 1970–2003. Available at: http://grants2.nih.gov/grants/award/success/srbytype7003.htm. Accessed September 16, 2005.

‖http://grants2.nih.gov/grants/award/trends/prininv.htm. See "Number of Applications FY 1990-FY2001, chart." Accessed September 16, 2005.

#http://grants2.nih.gov/grants/award/trends/prininv.htm. See "Number of Awards FY1990-FY2001, chart." Accessed September 16, 2005.

departments are now relatively mature, and as we describe below, few young physician scientists are training in research to follow their senior faculty mentors. Perhaps most revealing is the fact that only 40% of the current 132 academic anesthesiology departments (defined at those with accredited residency programs) have even one NIH grant credited to a faculty member or trainee in their department. Therefore, anesthesiology departments have been and continue to be severely underrepresented in NIH funding relative to the rest of academic medicine.

Over the past decade, well-described financial and manpower pressures in the clinical sector of our specialty have also grown,[29,30] no doubt causing anesthesiology departments in academic centers to limit their investments in new faculty seeking substantial research careers. This timing is unfortunate, because it resulted in our specialty missing an opportune time to capture vital ground in the academic landscape. Beyond performance of anesthesiology as "departments," close examination of the funding activity of M.D. scientists within anesthesiology raises even greater concerns. Since 1996, the number of M.D. applicants for NIH grants across all specialties had recovered substantially from the impact of budget cuts earlier in the decade. In fact, by fiscal 2001, M.D. competing applications across all disciplines had increased by 26%.[**] Unfortunately, in anesthesiology, the growth in NIH applications during this time has not been sufficient to significantly increase the number of physician scientists working in our field. In 1999, anesthesiology M.D.s submitted 132 competing applications to the NIH, and 41 of these grants were awarded. In 2003, our peak year, 181 grants were submitted by M.D.s, and of these 57 were funded. In 2004, however, from 164 applications, only 35 new grants were funded (data provided by Alison Cole, Ph.D., Program Director, Anesthesia and Integrated Systems, National Institute of General Medical Sciences, National Institutes of Health, Bethesda, Maryland, written communication, March 2005).

Hence, although anesthesiology research expanded proportionally to the growth in the NIH budget, we did not make progress in terms of our fractional proportion of NIH grants relative to other specialties or relative to the size of our academic workforce. Given we did not "make our move" during an unprecedented period of growth in biomedical science, during which the NIH budget nearly doubled in magnitude, how will anesthesiology physician scientists respond to another sustained period where overall NIH funding rates once again decrease to 25% (the pre-1997 period) and below? As we consider these serious issues, we will ask the specialty to consider extremely difficult solutions, remedies that only a few years ago would have been viewed as radical and impractical. Because the situation in which we find ourselves developed slowly over decades, it is naive to suggest that anything short of resolute action will allow us to move our specialty back into the sunlight, on a healthy direction toward distinction as a respected academic discipline in the broader community of biomedical science.

Myths Surrounding the Scientific Success of Anesthesiologists

It has been suggested that lagging NIH funding to anesthesiology departments is a Ph.D. *versus* M.D. issue. Perhaps Ph.D. or M.D./Ph.D. researchers have better success at receiving NIH funding than M.D. researchers; in this paradigm, basic science departments with large percentages of Ph.D. investigators might fare better than clinical departments in terms of NIH funding. However, data from the NIH do not support this hypothesis.[28] Although it is true there are more Ph.D. applicants competing for research support from the NIH "across the board" compared with M.D. applicants, a *per capita* comparison of success rates over time (1979–present) reveals that M.D. and Ph.D. applicants have roughly equal success rates[††] and obtain their first independent NIH grant (R01) at approximately the same age (42–44 yr).[31]

[**] http://grants2.nih.gov/grants/award/trends/mdsphds7001.htm. Accessed September 16, 2005.
[††] http://grants2.nih.gov/grants/award/trends/mdsphds7001.htm. Accessed September 16, 2005.

However, the issue may be slightly more complex. Many M.D. researchers submit basic science laboratory-based proposals, and perhaps those receive the same funding rates as Ph.D. researchers; a recent study indeed suggests that clinical research proposals tend to do slightly less well in the NIH peer review process.[32] But because NIH statistics do not differentiate between types of research performed by M.D. researchers and the differences are fairly small, overall there seems to be general parity. Therefore, to increase NIH funding in a clinical department, increasing the overall number of faculty capable of applying for such awards is most important. However, as a final comment, clinical departments in medical schools are uniquely placed to provide translational (bench to bedside) research.[32,33] If Ph.D. researchers perform all research in a clinical department, translational projects might not be a priority or as effective; further, a disconnect between basic researchers and clinical faculty sometimes occurs.[34] Optimally, a blending of Ph.D., M.D./Ph.D., and M.D. researchers best facilitates translational projects.[34–36] Such collaborations require the presence of a cadre of trained physician scientists expert in perioperative medicine.

Another possible reason for low NIH funding in anesthesiology might be a bias against anesthesiology grants. It is therefore reassuring to note that if one examines NIH Web sites comparing grants awarded to departments of anesthesiology with those from other medical specialties, NIH grant application funding rates are roughly equal. Between 2000 and 2002, success rates (defined as ultimate funding of a submitted grant, including all revisions) ranged between 27 and 29% for grants from anesthesiology compared with approximately 32% for all other departments (clinical and basic science) (data provided by Alison Cole, Ph.D., Program Director, Anesthesia and Integrated Systems, National Institute of General Medical Sciences, National Institutes of Health, Bethesda, Maryland, written communication, March 2005).

Greater success rates tend to occur for individual K series training grant awards to junior faculty. K08/K23 proposals submitted from individuals residing in anesthesiology departments achieved 40–66% success rates in 1999–2002 compared with 30–60% for similar awards across the NIH.‡‡ Unfortunately, the absolute numbers of K series training applications from all anesthesiology departments across the United States are astonishingly low, ranging between 9 and 20 total per year (table 2). Inspection of the funding patterns within the National Institute of General Medical Sciences (a NIH institute funding many research *training* grants in anesthesiology [T32 and K08/K23]), it is clear that at least from 1998 to the present, no bias occurs because comparable (if not slightly better) success rates occur for NIH grants awarded to anesthesiology departments compared with basic science departments (*e.g.*, chemistry) or clinical departments (*e.g.*, surgery).

Perhaps the small number of applications for NIH grants from anesthesiology junior faculty relates more to high debt among medical school graduates and the lure of high-paying private practice jobs after residency to pay such debt.[37] Although the high cost of medical education does have negative impact on trainee decisions whether to pursue research, this is not an isolated problem among anesthesiology residents; pediatric, internal medicine (and medicine subspecialties), surgery, family practice, emergency medicine, and psychiatry residents all face the same challenges. Clearly, soaring medical school debt is a problem for all new physicians (according to the American Association of Medical Colleges, the average medical student debt upon graduation was $115,218 in 2004).§§ Increased student debt has been shown to decrease the number of primary care physicians, decrease diversity of physicians in the work-force, and

‡‡http://grants2.nih.gov/training/data/k_awards/sld012.htm and http://grants2.nih.gov/grants/award/training/comrcp7003.htm. Accessed September 16, 2005.

§§Reported on American Medical Association Web site, available at: http://www.ama-assn.org/ama/pub/category/5349.html. Accessed September 16, 2005.

promote unsafe physician behaviors (increased moonlighting and depression)[38–40]; in fact, the NIH has targeted educational loan repayment as an important aspect of helping physicians choose research careers.[41] However, despite high debt and its limitations, one might argue that adding a few more years of academic training is less burdensome for anesthesiologists than for those in other medical specialties (because anesthesiology research fellows have the ability to moonlight in general anesthesiology for higher pay and/or repay loans from a generally more favorable faculty salary). A recent study documents that the small percent of residents pursuing subspecialty training did not change when postgraduate year 4 was added to anesthesiology residency training in 1989, suggesting the choice of subspecialty training in anesthesiology may relate to factors other than duration of training[42]; this is similar to internal medicine subspecialties.[43] It is also noteworthy that those going on to clinical subspecialties such as critical care, pain, or pediatric anesthesia are only required to train 1 additional year, unlike most other subspecialties. Hence, although payment of looming medical school loans certainly detracts some anesthesiology graduates from pursuing further research training, the specialty is no worse off (and perhaps better off) in this regard than other medical disciplines. Nonetheless, formal training in anesthesiology ends after residency for more than 99% of all US-trained anesthesiologists. This lack of interest in subspecialty training after anesthesiology residency may at least partly relate to the lack of emphasis that we, as a specialty, have placed on subspecialty board certification as a necessary credential for practice of anesthesiology "subdisciplines," particularly relative to other clinical disciplines such as internal medicine and pediatrics where subspecialties now thrive in both their clinical and academic pursuits.

If We Are Failing to Make Progress, What Does Success Look Like?

The initial steps to progress will require a clear definition of success. First, the goals of research in the specialty must mirror the broader scope of clinical perioperative practice and, as such, should not be narrowly limited to investigation of anesthetic agents and techniques. This begs the question, "What research disciplines should we encourage within the scope of the perioperative physician scientist?" The answer, of course, is that the finest hypothesis-driven clinical and basic science studies focusing on questions important in nearly all disease areas have direct applicability to perioperative and intensive care settings, and the success of this research will be essential to creating the highest quality, cost-effective clinical care in this acute period of patient care. Indeed, all perioperative morbidity should be considered the legitimate domain of academic anesthesiology. As such, our trainees should seek mentoring for investigative careers in the best laboratories and clinical research environments in our universities (not just within anesthesiology departments), pursuing topics of broad relevance to health care such as cardiovascular disease, neurologic injury, nanotechnology (with its application to intraoperative monitoring), mechanisms underlying innate immunity and sepsis, congenital heart disease, perioperative genomics, the role of adult stem cells in wound healing, and many other cutting-edge topics. The perioperative period is a time of robust, reproducible human physiologic stress that can be strategically used as a "pharmacologic" perturbation uniquely applicable to almost any area of medical research. Dedicated research time and a combination of cutting-edge science and exciting, successful mentors should enable the best of our graduates to take their rightful place on the stage of scientific discovery that reverberate throughout medicine.

But how can we measure success of our trainees in science? Measures of scholarship within any discipline should include indicators of both volume and quality. In the case of volume, research advances more rapidly when a critical mass of investigators spawns a healthy competition for scientific achievement within a field of endeavor. The total amount of competitive peer-reviewed grant funding from agencies such as the NIH is a fair "apples to apples" comparator of the volume of research taking place in our specialty relative to academic medicine in general. As noted previously, funding to anesthesiology departments represents

only 0.9% of the total NIH budget, whereas our faculty represent approximately 6% of the medical workforce. We cannot claim that this discrepancy is a result of our unique work environment because general surgery, with a similar (or smaller) workforce in academic medicine, secures 2.6% of the NIH budget, more than threefold the funding of anesthesiology.

In addition to research volume, if anesthesiology departments wish to sit at the same table with other disciplines in major academic medical centers, our publications must also have the same quality and worldwide impact as research manuscripts in all other disciplines.[44] It is positive to note that some of the best clinical and basic science research in anesthesiology today is published in high-impact journals that draw readers from all venues, such as the *Journal of the American Medical Association*, *New England Journal of Medicine*, *Nature*, *Proceedings of the National Academies of Sciences of the United States of America*, and others.[45–56]

One way to determine whether a journal is having broad impact is to examine its impact factor. Impact factor measures the impact of medical research by the number of times other authors cite the work in their own research publications. It should be remembered that the impact factor is not necessarily an index of quality *per se*,[57] but literally does what it says—it measures the impact of a published article in the broader context of medicine. At the same time, because high-quality articles tend to be cited heavily, impact and quality are inescapably linked. *Citation Index* is the name given to the yearly publication listing biomedical journals along with their impact factors.|||| Table 3 lists the impact factors of a range of high-profile journals and compares them with subspecialty journals. Although it is pleasing to note that several anesthesiology subspecialty journals have excellent impact factors compared with other subspecialties, it is nonetheless consistent that subspecialty journals have lower impact factors compared with those journals recognized by the broader community of science and clinical medicine. Simply stated, articles published by even the highest quality specialty journals (such as ANESTHESIOLOGY) tend to be read and cited far less by investigators and healthcare providers working outside the field but are critical nonetheless to advancing the science within these disciplines. Clearly, a healthy balance between publications in the broader venues and subspecialty venues should be the goal of our next generation of trainees.

Indeed, when applying the metrics of volume and quality, we would suggest that the relatively small number of anesthesiologists who have chosen research careers have, as a group, been as successful in producing a balanced portfolio of research with impact equal to the best faculty from other disciplines. The key issue, as reflected in the small number of NIH grants secured by anesthesiology faculty, is one of volume: Vanishingly small numbers of faculty with a commitment to research remain in our discipline. This conclusion provides essential clarity, because it highlights both the problem and the set of possible solutions. As a specialty, we must find a means to train the best and brightest graduates from medical school in a way that attracts them to research in our discipline and also provides for them the tools to ensure ongoing success in the competitive landscape of academic medicine.

Anesthesiology Training Investments: A Call for Change

It is clear that anesthesiology departments are not training an appropriate number of academicians capable of successfully competing for NIH level funding. Given the recent decade of worldwide shortages in clinical anesthesiology,[58–60] convincing talented, clinically trained academicians to pursue further research training has been difficult.[29,30,61] One uniformly accepted marker of quality training environments for clinicians across medical

|||| See the Web of Science for impact factors, available at: http://isi9.isiknowledge.com/portal.cgi?DestApp=JCR&Func=Frame. (A subscription to the “ISI Web of Knowledge” is needed to access this Web site, but medical libraries can provide readers with their own link to alternative journal impact factor listings if such a subscription is not available.) Accessed September 16, 2005.

specialties is the availability of department-sponsored NIH training grants (T32 awards). Training grants foster high-quality research training broadly in basic science, clinical science, or population-based research and thus are not limited to laboratory investigation.[33] There is broad recognition that exposure to a rigorous research environment whets the appetite for research in many individuals who would otherwise not have been exposed.[62] Internationally, recognition that early exposure to research is important for developing clinician scientists can be seen by the initiation of programs for anesthesiology trainees such as the Cambridge SMART course.[63] Overall success rates for T (training) series NIH awards are very high, ranging between 53 and 65%, including all revisions.[##] However, out of the total 132 current Accreditation Council for Graduate Medical Education (ACGME)–approved US anesthesiology residency training programs,[***] only 10 had been awarded NIH-funded department-sponsored research training grants in 2003 (table 2), increasing to 11 by 2004 (see individual listing in table 4); in comparison, 354 have been awarded to medicine subspecialties, 41 have been awarded to general surgery, and 81 have been awarded to pediatrics.

The number of anesthesiology residents represents 5.6% of the total resident workforce, whereas all medicine subspecialty fellowships (pooled) equal only 8.7% of the workforce; hence, our extremely low number of training grants cannot be ascribed purely to a disparity in numbers of trainees. Internal medicine does not seek training grants for its general internal medicine residency, but rather focuses its efforts in research on clinical fellows committed to further training in medicine subspecialty divisions. All ACGME-approved internal medicine and pediatric subspecialty fellowships have significant required research components.[64,65] In contrast, as a specialty, we have no recognizable commitment to providing research experience during subspecialty fellowship training. None of our ACGME-approved fellowships have a research *requirement* (although some have such a recommendation), in contrast to those of our peer specialties.

Moreover, anesthesiology has been slow to seek accreditation of most its subspecialty disciplines (*i.e.*, obstetric/gynecologic, cardiothoracic, neurologic), although efforts by the Society of Cardiovascular Anesthesiology have been made in terms of standardizing training within cardiothoracic anesthesiology fellowships.[66] Unfortunately, unlike our colleagues in medicine and pediatrics, we have not created a sufficient number of high-caliber academic fellowships that could provide a platform to foster substantial numbers of physician scientists across the anesthesiology disciplines. In contrast, our peers continue to value and support the compulsory research components of their subspecialty training programs and even continue to form new ones, with a conviction that science and medicine must be integrated in the training of subspecialist physicians, even for those who ultimately pursue private practice.[67] The academic leadership in these specialties, particularly medicine and pediatrics, are absolutely clear in their commitment to continue and invigorate their research-based subspecialty fellowships and believe these programs provide the deep “bench” that supports the academic future of their professions.

Although department-sponsored NIH training grants are a general measure of research interest and activity at the postdoctoral stages of training, investigator-initiated NIH career development (K series) grants remain the key indicator of continued interest in research at the ever-critical junior faculty career stage. The most common K series career development awards in clinical departments include the K08 (clinicians performing basic science research) and K23 (clinicians performing clinical research).[33] K series awards are usually 5 yr in duration, require (and provide partial salary support for) 75% research time, and also require the financial support and direct supervision of a senior faculty mentor with a successful NIH-funded research

[##] http://grants1.nih.gov/grants/award/training/train9603.htm. Accessed September 16, 2005.
[***] http://www.acgme.org/adspublic/. Accessed September 16, 2005.

program. NIH committees not only evaluate the applicant and his or her research plan and preliminary data, but also consider the quality of the proposed mentor, including his or her funding and publication record and track record for managing trainees into successful independent research careers. As shown in table 2, the number of all K series grants awarded to anesthesiology departments in the United States lags far behind other subspecialties, paralleling the overall poor performance of the specialty in other types of NIH funding. When our training practices are considered relative to the higher expectations for subspecialty training of academic faculty in other specialties, the root cause behind the small number of proposals being submitted to the NIH and other agencies by anesthesiology fellows and junior faculty becomes clear. In simple terms, we set extraordinarily low expectations in regard to the research accomplishments of our finest trainees at the terminal phase of their training. Our peer specialties view this as a critical time to reinforce, not back away from, compulsory research training.[67]

It is our view that we, as a specialty, have reaped what we have sown. Students correctly see anesthesiology as a specialty that does not view research as essential. “After all,” students astutely tell us, “fellowships in anesthesiology are great because they aren’t so long and don’t even require research.” Without substantive research training in either basic or clinical research, anesthesiology does not produce individuals capable of or even interested in applying for NIH K award funding as junior faculty members. As such, we consistently and painfully hear from medical students in our own institutions, as well as from faculty colleagues in medicine and pediatrics who outnumber us and counsel those students on their career choices, that they consider anesthesiology to be weak in its commitment to research training because of its lack of commitment to subspecialty fellowship training with compulsory research years. Such advice has kept at least some of the best and brightest medical students, those completing a combined M.D./Ph.D. degree, from ultimately choosing anesthesiology for their career.

From the discussion above, it should be clear that solid clinical subspecialty training of a much larger number of our residency graduates, with compulsory research training at the fellowship level, would have a profoundly positive impact on the future “product” of our training programs and, among other solutions (including improved efforts to recruit research-oriented medical students, bolstering research experiences within the residency years, congressionally mandated careful consideration of anesthesiology research proposals, and so on), has the potential to help reverse the current direction of the academic base of our specialty. As such, we suggest that the number of ACGME-accredited clinical fellowships should be increased to include all of the legitimate subdisciplines in anesthesiology and lengthened and redesigned to encourage deep engagement in research activity. Fellowship directors must be committed to ensuring that these research experiences are successful. This idea was suggested before by US academic anesthesiology chairs at their annual meeting in 2000 in discussing the role of ACGME-accredited fellowship training in anesthesiology.[68] Five years later, it is ever more clear that such action would have a decisive impact, as the dramatically changing support for NIH-funded research becomes increasingly scarce, creating greater competition among the specialties, and forces us to recognize that we are at a crucial decision point in our history.

Any such efforts to strengthen anesthesiology subspecialty training will undoubtedly fail without the strong support of our board and accrediting agencies. “Optional” research electives are poorly subscribed in all centers and will never suffice for changing our future. There must be a willingness to establish new anesthesiology subspecialty training programs and to apply firm criteria to all such programs, because improving the standing of research and scholarship within our specialty will require a difficult cultural shift. The economic realities of research training are never easy[69] and will require a commitment to seeking training grants and other opportunities at institutions across the United States, coupled with strong support from medical school deans. Moreover, we cannot understand the often-argued position that supply–demand

issues and high salaries in the private sector prevent anesthesiology from taking these decisive steps. Has cardiology, including the interventional areas such as electrophysiology, not flourished both clinically and investigationally, even as cardiology has increasingly lengthened its subspecialty (and even sub-subspecialty) clinical and research training requirements? Cardiology research funding dwarfs anesthesiology in all of the top 20 NIH-funded medical centers in terms of total and federal research awards, despite having similar salary issues, outside competition from the private sector, and fewer total faculty. It would seem to us that the real issue is commitment to uniform standards of training that include a commitment to academic side of the specialty, not adverse economics. In fact, one could argue that as long as anesthesiology remains "friendly" to those students seeking the most rapid route to a high-salary, procedure-intensive medical career, we will continue to remain what we seem to our peer specialties: weakly committed to academic medicine.

Although these steps may seem difficult to for many to contemplate, we are seeking only the level of investment in our specialty that nearly all other specialties in academic medicine already demand of themselves. We advocate that anesthesiology rapidly establish compulsory subspecialty fellowship training with at least 1 yr of required research in all anesthesiology subdisciplines, rewarded by board certification. These should include (at a minimum) pediatric anesthesiology, pain medicine, and critical care medicine, as well as obstetric anesthesiology, cardiothoracic anesthesiology, and neuroanesthesiology. It is the rare individual who voluntarily forfeits his or her income in exchange for additional training in research, and as such, the academic leadership of other medical specialties require this training investment from those who seek to become their peers. We call on the American Board of Anesthesiology and the American Society of Anesthesiologists, as well as other academic anesthesiology organizations, to initiate this change through appropriate ACGME and Residency Review Committee channels. A sea change in graduate fellowship training is needed if our specialty is to establish and maintain parity and respect within the framework of academic medicine. We take the position that this is the single most important metamorphosis required in anesthesiology to ensure that our specialty remains recognized as a "peer" in the landscape of academic medicine. We acknowledge that our view is flavored partly by our own developmental experiences with academic careers and extensive exposure to mentors, colleagues, and trainees working at the interface between anesthesiology and the medicine, pediatric, and surgical subspecialties, particularly in the cardiovascular sciences.

We respect that there are many anesthesiology faculty who have had no subspecialty beyond residency training and have still become outstanding academicians in all respects. We also acknowledge that although we make a case in support of expanded fellowship training, we are in the end offering an opinion that deserves to be challenged. We invite others to consider our position in light of other alternatives for "corrective action," and to advocate for these positions. Sir William Osler (1849–1919), the noted internist and academician at the turn of the century, recognized that only a subset of doctors are happy in their professional lives when he stated, "To each one of you the practice of medicine will be very much as you make it—to one a worry, a care, a perpetual annoyance; to another, a daily joy and a life of as much happiness and usefulness as can well fall to the lot of man."[70] We hope that actions taken by the leaders of our specialty today will enable some of our graduates to become leading academicians of the future—individuals who not only change patient lives, but perhaps also achieve days full of joy pushing back the frontiers of medical science in our unique perioperative setting.

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Table 1

Total NIH Funding to Anesthesiology Departments Has Risen Steadily since the Mid-1990s in Absolute Dollars but Still Remains < 1.0% Total NIH

Year	Anesthesiology			Total NIH, $, Millions	Anesthesiology, % Total NIH
	$, Millions	No. of Grants	No. of Departments Funded*		
1975	6.1	61	26	871	0.7%
1980	8.9	91	25	1,480	0.6%
1985	12.3	96	35	2,460	0.5%
1990	19.8	134	35	3,300	0.6%
1995	34.1	170	43	4,870	0.7%
2000	59.5	248	48	7,440	0.8%
2003	97.2	320	55	10,800	0.9%

Total awarded research grant dollars (including funding through training mechanisms) are listed above. Web sites located at http://grants1.nih.gov/grants/award/rank/anesthesiology03.htm (accessed September 18, 2005) and http://grants1.nih.gov/grants/award/rank/medttl03.htm (accessed September 18, 2005) provide the most recent (2003) figures. Yearly totals since 1993 are at http://grants.nih.gov/grants/award/trends/fund9303.htm (accessed September 18, 2005).

*Anesthesiology department with at least one National Institutes of Health (NIH) grant of any kind.

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Table 2

Comparison of the Number of Department-sponsored NIH Training Grants (T32 Series) and Individual Career Development (K Series) Awards across Selected Medical Specialties in the United States in 2003–2005

	Anesthesiology	Internal Medicine (All Subspecialties)	General Surgery	Pediatrics
T32 grants in US	10	354	41	81
% Total T series awards	0.8%	27.6%	3.2%	6.3%
Number of specialty departments with T series awards	8	64[§]	27	32
Number of K series grants	9	158		
% Total K series awards in US	0.7%	12.8%	2.4%	2.0%
Departments with any NIH funding	54	107	83	93
Number of academic residency/ fellow programs in US*	132	1,462	252	203
Total number of trainees in US†	5,062	8,966	7,577	788
% Total US residency or fellow training positions[‡]	5.6%	8.7%[||]	8.6%	9.1%
No. of 2003 awards	299	6,329	838	1,411
Total grant $	$92,263,241	$2,868,355,974	$284,154,301	$551,251,535
% Total NIH budget	0.8%	26.5%	2.6%	5.1%

National Institutes of Health (NIH) training grants (T32) and career development awards (K series) data are from 2003 (latest data available; total T awards = 1,281, K series awards = 1,230 [http://grants1.nih.gov/grants/award/rank/medttl03.htm; accessed September 18, 2005]). Web sites where total numbers of awarded grants per specialty (T and K series) are as follows:

Anesthesiology: http://grants1.nih.gov/grants/award/rank/anesthesiology03.htm (accessed September 18, 2005) (this list does not include isolated cases where T32 grants [*e.g.*, in pain] might be awarded through another department or institute [*e.g.*, neurosciences] instead of directly through a department of anesthesiology).

Internal medicine: http://grants2.nih.gov/grants/award/rank/internal03.htm (accessed September 18, 2005).

Surgery: http://grants1.nih.gov/grants/award/rank/surgery03.htm (accessed September 18, 2005).

Pediatrics: http://grants1.nih.gov/grants/award/rank/pediatrics03.htm (accessed September 18, 2005).

Total NIH funding for 2003: http://grants1.nih.gov/grants/award/rank/medttl03.htm (accessed September 18, 2005).

Information on number of programs and trainees per specialty is 2004–2005 data from the Accreditation Council on Graduate Medical Education (ACGME). ACGME statistics can be found at the following Web sites: * http://www.acgme.org/adspublic/(accessed September 18, 2005) (under report entitled “list of programs by specialty”) and † http://www.acgme.org/adspublic/(accessed September 18, 2005) (under report entitled “number of all accredited programs for a specific academic year [excluding combined programs]”), both year 2004–2005.

[‡]Where percent is not directly listed on ACGME Web site (same denoted by * note above), it was calculated by dividing by the total number of residency/ fellowship programs for all specialties n = 8,005 or the total number of trainees n = 102,483 (data from the same Web site as † note above).

[§]Departments of medicine often have multiple department-sponsored training grants. The University of Pennsylvania led the way in 2003 with a total of 21—more than the total number of medicine subspecialties!

[||]While internal medicine residents consist of 25.4% of the medical training workforce and 9.9% of all training programs, research is taught primarily in medicine subspecialty fellowships. Therefore, for purposes of comparison, only medicine subspecialties (pooled) are listed in this table.

Table 3

Impact Factors of a Selection of a Spectrum of Medical Journals (2003)*

Journal	Impact Factor
Very-high-impact journals	
Cell	26.6
Journal of the American Medical Association	21.5
Lancet	18.3
Nature	31.0
Nature Genetics	25.7
Nature Medicine	30.6
New England Journal of Medicine	34.8
Science	29.8
High-impact journals	
Annals of Internal Medicine	12.4
Circulation	11.2
Circulation Research	10.1
FASEB Journal	7.2
Gastroenterology	12.7
Journal of Biological Chemistry	6.5
Journal of Clinical Investigation	14.3
Molecular Pharmacology	5.7
Trends in Pharmacology Science	13.7
Subspecialty journals	
Annals of Surgery	5.9
American Journal of Cardiology	3.1
Anesthesia & Analgesia	2.2
Anesthesiology	3.5
British Journal of Anaesthesia	2.4
Canadian Journal of Anaesthesia	1.2
Journal of Clinical Anesthesiology	1.0
Hypertension	5.6
Journal of the American College of Cardiology	7.6
Journal of Cardiovascular & Vascular Anesthesia	0.8
Journal of Pediatrics	2.9
Journal of Thoracic & Cardiovascular Surgery	3.3
Pain	4.6
Pediatrics	3.8
Stroke	5.2
Journal of Thoracic & Cardiovascular Surgery	3.3

* See the Web of Science for impact factors, available at: http://isi9.isiknowledge.com/portal.cgi?DestApp=JCR&Func=Frame. Accessed September 18, 2005.

Table 4

Anesthesiology Departments That Held NIH Department-sponsored Research Training Grants in 2004*

Columbia University Health Sciences (New York, New York)
Duke University (Durham, North Carolina)
Harvard University (Massachusetts General Hospital) (Boston, Massachusetts)
Medical College of Wisconsin (Milwaukee, Wisconsin)
University of California at San Diego (San Diego, California)
University of California at San Francisco (San Francisco, California)
University of Chicago (Chicago, Illinois)
The University of Iowa (Iowa City, Iowa)
University of Pennsylvania (Philadelphia, Pennsylvania)
University of Pittsburgh at Pittsburgh (2) (Pittsburgh, Pennsylvania)
Yale University (New Haven, Connecticut)

* Listed alphabetically.

Data from the National Institutes of Health (NIH) IMPAC II database provided by Alison Cole, Ph.D., Program Director, Anesthesia and Integrated Systems, National Institute of General Medical Sciences, National Institutes of Health, Bethesda, Maryland, written communication from Alison Cole to Debra Schwinn, June 2005.