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The Neurointerventional Bubble

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data seem to indicate that most researchers are generally satisfied with results obtained from only one of these services. The term "deep Web" refers to high-quality Internet contents that are not immediately obvious without specific browsers. The contents of the deep Web are growing at a much faster pace than those of the surface Web. Brightplanet is a Website that "harvests, federates and normalizes regardless of source language, document encoding, format, or storage mechanism these data and provides qualified, relevant data for analysts, analytic technologies and data enrichment technologies."[12] Unlike the information found in libraries, data from the deep Web are not indexed and not accessible by using popular search engines. If one uses only standard Web searches, most information contained in books, journal databases, and other scholarly materials will be missed.[8] Fortunately for many of us, larger academic medical libraries nowadays offer most of the content in digital formats accessible from our computers.

The concept of a virtual library has received mixed attention. The WWW Virtual Library (http://vlib.org) is the oldest voluntarily supported catalog that contains sections ranging from law and medicine to less common topics such as Chinese and Japanese Art to Egyptology. ITT Technical Institute offers different degrees (including one on health information technology services), and because it has more than 100 campuses in the United States, it houses its library electronically (http://itt-tech.edu). The states of Alabama and Kentucky host on-line libraries that contain basic books (including several encyclopedias) and magazine and journal collections that may interest the general public and help students (www.avl.lib.al.us and www.kyvl.org). Florida State University offers a mathematics-only on-line library (www.math.fsu.edu/Science). The University of Pittsburgh began digitizing its collection in 1998 and their system now hosts 70 collections (www.library.pitt.edu). These are just some of the virtual library offerings that can be found on the Web. Libraries are no longer only for warehousing books but are becoming gathering places for the virtual community.

It is obvious that the ways in which we access music, radio, cinema, and television have changed more in the last 10 years than in the last 100. A few days ago I told a radiology resident that I needed to go to the library and search the meaning of a word in a dictionary and she looked at me as if I lived in a different world. I guess she was right, as I went to my office and found the same dictionary on-line, saving me a trip to the library.

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EDITORIAL

The Neurointerventional Bubble

There will be no interruption of our permanent prosperity.
Myron Forbes, 1928

Could the neurointerventional specialty be heading into a market-like bubble? The term "bubble" is generally applied to products or assets with inflated values. The inflated values in a bubble are due to a speculative mania. There seems to be a widespread perception that there is a great demand for neurointerventional services,[1,2] which results in a large number of physicians seeking neurointerventional training and a large number of hospitals hiring them. I believe that the potential market for neurointerventionalists is undergoing an inflated valuation due to speculative mania, which will lead to an excessive number of neurointerventional providers. I will lay out some relevant facts, and you can decide for yourself.

During the past 2 decades, the demand for neurointerventional services has increased substantially. Most of that growth has been due to the development and adoption of effective endovascular therapies for cerebral aneurysms. Most who work in the neurointerventional field seem to think that there must be a next "big thing" coming, and acute stroke intervention seems to be it. Moreover, some even think that acute stroke therapy is such a "big thing" that it is going to create a shortage of neurointerventionalists.[1,2] Stroke is the third leading cause of death in the United States, after heart disease and cancer, so it is tempting to speculate that neurointerventions for stroke must be headed for rapid expansion. Would not a denial of the need for expansion of neurointerventional services for stroke be a horrific example of callous disregard for the more than 700,000 Americans who face death and disability from stroke each and every year? As far as I can tell from the available relevant statistics, it would not.

Let us review some relevant statistics to help us decide if we should expect a huge demand for stroke intervention or if it might be speculative mania. Hirsch et al[1] estimated that the number of intra-arterial ischemic stroke therapies performed in the United States in 2006 was 3500–7200. The number is undoubtedly increasing, but it is unclear how high it will rise. It will certainly not reach the level of 720,000, which is sometimes inappropriately suggested.[2] Hirsch et al recently came up with an estimate of 10,400–41,500 potential cases per year. In the Mayo Clinic analysis of demand in the United States for intra-arterial ischemic stroke therapy, we found that the demand is quite likely to be no more than 20,000 cases per year,[3] which fits nicely within the range estimated by Hirsch et al. An

additional factor not considered in previous estimates[1,3] is that advanced stroke imaging has much potential to reduce the number of intra-arterial treatments, because it could allow the exclusion of many patients with completed infarctions from futile intra-arterial therapy. Trials of intra-arterial therapy report good outcomes (modified Rankin Scale score, 0–2) in less than half of patients treated,[3] which was likely due to the presence of large infarctions before treatment and which might now be easily identified and excluded from futile therapy with advanced stroke imaging. For now, however, I will avoid speculating on the impact of new imaging technology.

Consider for a moment that there were approximately 136,000 carotid endarterectomies performed in the United States in 2005.[4] Based on the highest estimate of annual number of cases of intra-arterial ischemic stroke therapy at 41,500, the best case scenario is that the number of intra-arterial ischemic stroke interventions is one-third the number of carotid endarterectomies. Because few physicians are building careers exclusively around the practice of carotid endarterectomies, it is doubtful that an even less common procedure like acute ischemic stroke intervention will create much demand for additional neurointerventionalists. Even if we were to reach that theoretic maximum level of 41,500 cases per year, with a current supply of at least 500 neurointerventionalists, that would yield an average of 83 cases per neurointerventionalist per year. If the theoretic maximum number of ischemic stroke cases is fewer than 2 cases per week for existing neurointerventionalists, how can growth in ischemic stroke therapy be expected to create a shortage of neurointerventionalists?

I wonder if some of the speculative mania regarding ischemic stroke cases is a paradoxic reaction to neurointerventionalists finding their aneurysm business beginning to plateau or even decline. A neurointerventionalist is in competition with an increasing number of other area neurointerventionalists for a rather fixed number of cerebral aneurysm cases and comforts him- or herself by thinking, "It will be okay because we will all be very busy soon performing acute ischemic stroke interventions." If this is indeed the case, it is particularly worrisome because it would mean that many are overlooking an oversupply of neurointerventionalists because they have been convinced that there is a pending shortage of neurointerventionalists.

Regardless of what I think or say about the supply of practitioners, neurointerventional fellows continue to be trained at a rather high rate. Proliferation of fellowships and fellows is completely unregulated because accreditation of neurointerventional training has not yet taken root. While the accreditation for neurointerventional training was established in 2000 by the Accreditation Council for Graduate Medical Education, it has not been pursued except by a handful of programs. Neurointerventional training has always been and continues to be essentially an apprenticeship. The basic defining characteristic of a neurointerventional fellowship is that at least 1 individual agrees to be the teacher and at least 1 person agrees to be the fellow. Each year, there seem to be a few more fellowships, and thus, every year more fellows are produced than in the previous year.

I see evidence of rapid proliferation of neurointerventionalists with each passing year as hospitals that refer cases to my tertiary care center stop doing so as they hire their own neurointerventionalist. If you are training someone, you might be asking yourself where they will get a job and whose market share they will impact. I am not aware of a lot of pent-up demand. I do not personally know many neurointerventionalists who are turning away case referrals because they are too busy. In fact, I commonly hear from my neurointerventional colleagues throughout the United States that it is rather difficult to expand their case volumes, and many are struggling to maintain case volumes at previous levels from year to year. Aneurysm and arteriovenous malformation cases are likely to remain the core of our practice, and numbers of those cases are not likely to change much.

While it might be nice to hope for a neurointerventionalist at every hospital in the United States, it is not likely to occur any time soon. Systems for trauma and myocardial infarction are much more mature than stroke care systems, and regional shortages remain.[5-7] Producing more intra-arterial ischemic stroke providers will not be an easy fix for regional shortages. Rather, it will only create increased competition for cases in areas where neurointerventional services are already available. Does anyone really think that there are many people just out of neurointerventional fellowship who are going to accept positions in rural areas or small suburban community hospitals? The reason that those areas will remain "underserved" is that only a handful of subarachnoid hemorrhages and severe ischemic strokes warranting intra-arterial therapy present to such a hospital each year. We would probably need to supersaturate urban areas with neurointerventionalists before any of them spill over and practice in an underserved rural area. I am not trying to say that only a desperate person would live in rural America. I happen to live and practice in rural America and I like it. However, I have a very unusual practice that allows me a reasonable number of cases despite my rural location. Neurointerventionalists will go where the cases are, and there are not many cases in low-population areas or small community hospitals.

The best way to serve patients in sparsely populated areas and at smaller community hospitals is not to expect that we can send them a neurointerventionalist who is inactive all year except for the 1 or 2 times that someone needs neurointerventional treatment, at which time they will spring into action as a rather unpracticed operator. It is also not in the best interest of the patient to expect that a non-neurointerventionalist is going to be able to expertly offer neurointerventional services after attending a hands-on workshop. The most practical solution is to rapidly transfer the patients to regional centers that have volumes of patients to justify employing a neurointerventionalist who does enough cases to maintain a high skill level. Apart from the neurointerventionalist's skill, high-volume stroke centers have been shown to have better clinical outcomes and lower mortality than low-volume centers.[8]

Unfortunately, more and more hospitals are deciding that they want to "get into stroke" and are tempted to offer intra-arterial interventions without having a comprehensive stroke program, which may be critical for optimal outcomes. This desire for increasingly smaller hospitals to get into the stroke business is, I believe, a sign of the sort of speculative mania that leads to a market bubble. If everyone else is buying a stock, then it is time for the wise investor to sell. Similarly, if every hospital thinks that they are going to get into the business of

stroke, then it would be wise for many of them to pursue another plan.

If there really is a neurointerventional-provider bubble that bursts, the *Wall Street Journal* will probably not cover the story. There will not be widespread national and international economic challenges on the scale of the Internet bubble of 2000 or the housing bubble of 2008. What will happen if speculative mania inappropriately drives up the number of neurointerventionalists and hospitals offering neurointerventions? Probably not a single one of us who are trained neurointerventionalists will be unemployed. Physicians who practice exclusively in neurointerventions are rather uncommon, so nearly all of us have other marketable skills that we are using to supplement our practice. Additionally, there is an overall shortage of physicians, so we should all be able to keep getting a paycheck with some subset of our skills. What will probably happen is that each of us will be doing fewer cases and interest in training will drop off. The Society of Neurointerventional Surgery may increasingly become an organization of part-time practitioners. Some neurointervenionalists may see case volumes drop to the point that they no longer feel comfortable and decide to opt out of performing neurointerventions. Unfortunately, if there are too many providers in many regions, the quality of care will suffer because experience will be diluted among the abundant operators. It would, therefore, be in the best interest of patients for neurointerventionalists to avoid overpopulating the United States with their specialty. If other countries are not becoming as overpopulated with neurointerventionalists, then practitioners outside the United States may become the most highly experienced in the world. This will make it increasingly difficult for Americans to be leaders in the field. Indeed, I think we are already seeing evidence of such a trend.

Perhaps you think that I am behaving like Chicken Little and trying to convince everyone that the sky is falling. Certainly, undue pessimism is not going to drive the field forward. I am actually not pessimistic in that I am excitedly optimistic that the safety and efficacy of neurointerventional procedures will continue to improve with time. However, I am skeptical that there will be enough expansion of applicability of our techniques to support a rather rapid expansion of providers. You might think that I am out of my mind because I am disagreeing with a popular and powerful trend, but bubbles occur precisely because nearly everyone in the herd speculates in the wrong direction. In 1999, selling on-line pet supplies with a sock puppet at Pets.com seemed like a really viable business plan, as did innumerable other "dot-com" ideas. Yet by 2000, reality was sinking in, and the dot-com bubble burst. The Internet did not disappear when this bubble burst, and neither will endovascular neurointerventions. As when other bubbles burst, the number of speculators involved in the field will likely fall for reasons of economic necessity. Companies like Amazon, Google, and eBay survived the bursting of the Internet bubble, and so too will high-quality comprehensive stroke centers survive a bursting neurointerventional bubble.

Perhaps in 10 years, I will be proved to have been spectacularly wrong about the neurointerventional bubble. In the meantime, I get some consolation from knowing that I am rather diversified in my skill set. If there are not enough neurointerventional cases to support the expanding number of providers during the remainder of my career, I can supplement my practice with my diagnostic neuroradiology skills. Sadly, I am doubtful that patients will get optimal care if they are treated by increasingly less specialized and less experienced neurointerventionalists.

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