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Surgeons as critical innovators in the future of healthcare

Cirurgiões como inovadores críticos no futuro dos cuidados de saúde

Joseph F Amaral, MD

Vice President Surgical Science, Johnson & Johnson
Professor of Surgery Emeritus, Warren Alpert School of Medicine at Brown University

Surgery is a discipline that is filled with innovators and innovation. If one considers the evolution of surgery from trepanation in the period of 6000 BC to the English-barber surgeons of the 1500's to surgical care today, one cannot help but be amazed by the remarkable progress that has occurred. Whereas the risk of dying from a surgical procedure in the 1800s was over fifty percent, a majority of surgical procedures today, such as hernia repair, gallbladder removal and appendectomy, are performed on an outpatient basis with close to zero mortality.

Since the inception of the Noble Prize in 1915, no less than ten individuals who were surgeons or innovated in surgery have won the noble prize. These notable individuals are 1. Theodor Kocher, 1909, thyroid gland pathology; 2. Allvar Gullstrand, 1911, dioptrics of the eye; 3. Alexis Carrel, 1912, vascular suture and organ transplant; 4. Robert Barany, 1914, vestibular system; 5. Frederick Banting, 1923, discovery of insulin; 6. Walter Hess, 1949, midbrain function; 7. Egas Moniz, 1949 frontal lobotomy 8. Werner Forssmannn, 1956, cardiac catheterization; 9. Charles Huggins, 1966, hormones and cancer; 10. Joseph Murray, 1990, organ transplantation. While awe inspiring to consider that almost 10% of Noble Prizes have been granted to surgeons or surgical procedures, it is equally amazing to consider all the significant innovative contributions that have occurred by surgeons over the centuries that have not gained the lofty recognition of Noble but have been remarkably important in the care of patients. As Knut Hager noted in the History of Surgery; "Sophisticated medical equipment is perhaps the best sign that surgery-which began as a manual and magical art-has matured into an integral aspect of science and technology. The revelations and inventions have many purposes. But they will always affect the ability of surgeons, and indeed all physicians, to maintain and improve the life of mankind."

This raises the question of what is innovation. If one were to search the internet, there would be dozens of descriptions, definitions, and methodologies for innovation. The following describes this authors view of innovation, how we as surgeons can innovate and what are key areas to consider in the future of surgery and healthcare. Simply put, innovation is something that improves the lives of people. It makes your life easier and better. As a result, it usually comes from the difficulties we face and requires a creative new solution. Albert Szent-Gyorgyi, the Nobel Prize winning Hungarian physiologist who discovered Vitamin C noted "Discovery consists of looking at the same thing as everyone else and thinking something different.

In fact, Innovation and creativity are inexorably linked. Consider a significant innovation and one will

always associate it with a very creative person. Apple – Steve Jobs; Software – Bill Gates; Liver Transplant – Tom Starzl; Renaissance Art-Rembrandt; Pop Music Michael Jackson. The list goes on and on. After all innovation, requires generating or recognizing ideas, alternatives, or possibilities that may be useful in solving problems. So ask yourself, "Are you creative?" There is no doubt that the discipline of surgery requires a large amount of creativity in everyday practice and as a group, surgeons are extremely creative in the everyday practice of surgery. This is apparent when we consider how each procedure may vary and each patient may require a different solution. So as Seth Godin has stated, we are all creative. It is part of our human nature. All of us in our everyday life at home and at work exercise creativity to solve the problems we face each day.

Now ask yourself another question: "Are you innovative?" Although the definition may vary, innovation has three characteristics that exist no matter what definition is considered. First and foremost, innovation solves a problem. As a result, when considering innovation, investors and companies always begin with the key question;" What is the unmet need you are solving". Second, it solves the problem in a meaningful way. To be meaningful it must solve the problem of more than one person and offer a significant improvement over the existing situation. It is not incremental and it is not just for one person. It should be a problem faced by many who will want the solution. While solving an individual's problem may be creative, it would not be considered an innovation. Consider art for example. An artist may be extremely creative but if no one wants the art, one would hardly consider it an innovation. On the other hand, if that artist creates a movement like Rembrandt, Picasso or Dali, that others mimic and others want to see, it is innovative. Finally, to be an innovation, the solution must generate a profit. Why? A truly meaningful solution is something people will want to buy. As a result, the profit it generates is a measure of the meaningfulness and importance of the solution. In that regard, physicians are often embarrassed by profit making when considering innovation. They are not motivated by profit but by helping patients and solving the problem. It is their heuristic nature at work. However, with few exceptions true innovation is rarely free. In large measure because so many people want it there must be a cost to keep up with the demand. When considering profit, it is also important to consider the advice of Dr. Kevin Murphy at the University of Chicago; The greatest downside to research isn't failure but unaffordable success." In that regard, the value and therefore cost of a solution is proportional to how close it comes to solving the problem in the ideal way and how important the problem itself is.

So are you innovative? If you have acted on your creative ideas to create meaningful solutions that have entered into the marketplace and generated a profit the answer is yes otherwise, you are like most of us who have great ideas that go nowhere. As Seth Godin points out, the difference between innovate people and creative people is the innovative people act on their ideas.

Another area of confusion in innovation is the interchangeable use of the words idea, invention and innovation. All of us have great ideas. These are the needs, the beginnings of the solution or the key insight that allows the solution to be generated. Insights are critical to innovation as they define the real problem that needs to be solved not what surgeons or people are necessarily asking for. If is often stated by innovators that their role is not to bring people what they asked for or wanted but what they never dreamed they wanted and when they get it they recognize it as something they wanted all the time. The classic every day example is the DVD player. In the era of videocassette players, people wanted a faster way to rewind a tape. A solution would have been to make a tape rewinder. But the insight was that they didn't want to have to rewind the tape at all and wanted control over their ability to watch what they wanted on the tape easily. Hence the DVD player. In surgery, one may observe a surgeon elevate the blood pressure at the end of the procedure to ensure that hemostasis is adequate and another surgeon may seal a vessel with energy on both sides prior to cutting it in the middle. In the former one could make a device that would automatically elevate the pressure at the end of the procedure and in the latter a device that would

seal on both sides and then seal again in the middle while cutting the vessel. Unfortunately, it is unlikely that those solutions would be meaningful and adopted because the insight buried in these observations is that the surgeon lacks confidence in the vessel seal they currently have, not that he or she needs more devices.

Getting to the true insight often requires considerable insight and disbelief of what is known. An excellent practice to follow is known as the "Five Whys". The 5 Whys is an iterative interrogative technique used to explore the cause-and-effect relationships underlying a particular problem developed formally by Sakichi Toyoda at the the Toyota Motor Corporation during the evolution of its manufacturing processes. For example, the problem on the surface might be you need to purchase a lawn mower. Why do you need a lawn mower? To cut the grass. Why do you have grass? It looks pretty. Why do you need to cut the grass? The grass grows. Why is the grass growing a problem that needs to be cut? Because my wife complains. Why does your wife complain? The Neighbors complain it too long and looks bad. So what you really need isn't a lawn mower it is grass that doesn't grow.

Often times this concept of the unmet need is summed up by the statement of Theodore Levitt in stating that "people don't want a quarter inch drill, they want a quarter inch hole." In other words, how they judge the product, service or solution is not on the basis of the product itself but on the basis of the outcome of the product. It's not the drill, it's the hole. This thought has played a critical role in helping develop meaningful innovation but I for one think it is incomplete and potentially misleading, especially in surgical care and healthcare in general. For example, my wife has never asked me to drill a quarter inch hole. What she has asked me to do is to put together a swing set or fix a piece of furniture for which I do need a quarter inch hole. We do not judge a product or service on an individual step in the procedure but on the outcome of the entire procedure. The same is true for surgeons. They do not judge the performance of a product solely by the specific outcome the product performs but by the entire procedure they performed. They focus on three important aspects of the entire procedure. How efficient was it, how reliable and predictable did the product or service perform during the entire procedure and finally what positive outcomes did it improve or negative outcomes (complications) did it reduce?

So if an idea is the insight or conceptualization, what is an invention? An invention is an idea that is proven to work in meaningfully way in solving a problem. It only needs to do so once. A patent is a detailed public disclosure of an invention that represents a product or process and is defined by variable number of claims regarding the invention that define the invention. To be granted a patent, the invention must demonstrate it is novel, has utility, and that it is not obvious. Thus an invention is simply an idea that is proven as workable and unique. It is not necessarily the best solution, the most scalable process or the most affordable idea. One can consider the invention as the prototype. Thus, if a person has a potentially novel solution that is meaningful and not obvious it is critical to obtain patent protection. In fact, one should never disclose the idea in a written scientific paper or to industry or even a colleague without first seeking patent protection. Why, once it is published or disclosed it is part of the public domain and no longer patentable. You have lost the ability to protect your idea. The major issue to patenting your idea is no doubt the cost of doing so, especially if it is your first such endeavor. Nevertheless, nothing can replace that process. As you think about whether to pursue a patent or not, you should consider sending the idea with drawings and claims to yourself in a self-addressed envelope and not opening it. In many countries, the postmark will serve as proof of when you developed the idea and help should a patent conflict arise. Such a process however is limited to one year so it is important to move forward with the patent if you believe it is worthwhile.

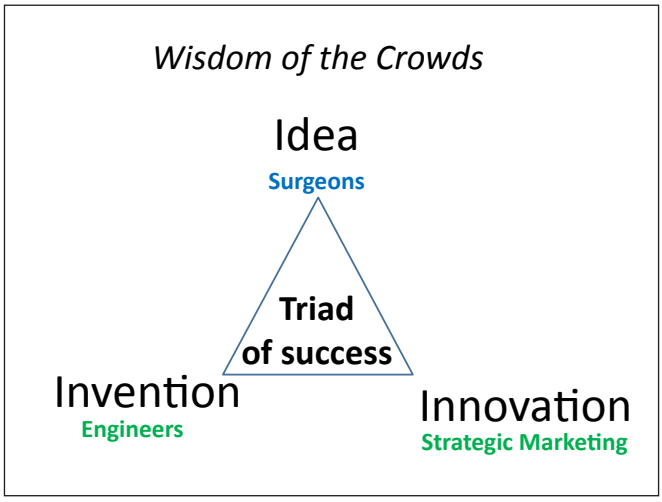
As noted previously, an innovation is the process of commercialization of the invention. To qualify it must be replicable at an affordable cost, and it must satisfy a specific need. Implied is widespread adoption often as the standard of care or standard solution and it must balance cost of goods with price of sale. It is

obvious that a solution that costs more to make than it can generate in revenue is not an innovation. First, the inability to garner the appropriate revenue suggests it is not very valuable. Second, it also fails on being the best solution since a lower cost alternative should have been considered. Third, it will soon be unavailable because it can't be made anymore.

Taken together, idea, invention and innovation define the triad for success in innovating in healthcare that is composed of three distinct groups of knowledge domains (Figure). Inventions require the skill and knowledge of engineers to not only determine the best solution but the most affordable and scalable one. Engineers also play an important role by observation. As summarized in the Japanese concept of Genchi Gembutsu, it is critical to observe the problem and get a fresh look at potential solutions. To quote Yogi Berra, "You can observe a lot just by watching.

Innovation requires the skill and knowledge of strategic marketers to clearly define the attributes of the solution from the customer's viewpoint, the size of the market, the value to price ratio and the commercialization process. One must always be mindful however, that market research only tells you about the past and present experience. Since there is no experience about the future, it is important to not only observe but to also consider potential derailers or competitive threats. You certainly would not be the first person to have a great invention that never fulfilled its innovation potential because something changed you could not predict or did not consider. A great example is the Nano Tata vehicle. While on the surface a wonderful invention, by allowing families in India to eliminate family travel on motorcycles at essentially the same cost in a small car, what was not predicted was the lack of space for parking of these small vehicles and the reduction of maneuverability in the heavy traffic of Indian cities.

So where do the significant ideas come from? While anyone one can come up with a significant idea, the most important and significant innovations in surgery have come from physicians and surgeons. This makes sense since they are the ones with the deep knowledge domain



of patient care and in the case of surgery, surgery itself. Imagine for example you were to sit in the cockpit of a Boeing 747 or Airbus A380. I know I would find the array of instruments and devices confusing and could probably come up with some ideas on how to make it more manageable…to me. However, if the pilots are not having issues with them then my ideas are only of value to me. On the other hand, a pilot having put in his 10,000 hours as noted by Malcom Gladwell will be able to understand what the real problems are, what the key insights are and come up with meaningful ideas and solutions that will apply to all pilots. Now imagine an engineer in the operating room. Isn't it likely they will come up with many ideas that are meaningful to them but not the cause of problems or concerns for surgeons? For example, one might note that the determination of blood loss is rudimentary and imprecise. Hence an idea for a really precise method and device to measure blood loss. The problem is that surgeons are not interested in precise blood loss measurement since they are satisfied with the more imprecise method they use today. Hence as documented by Dr. Eric von Hippel, surgeons and physicians are the primary source of ideas for invention in healthcare. The list of significant innovations inspired by the ideas of surgeons is endless and include Organ Transplantation, the Fogarty embolectomy catheter, the Von Sonnenberg catheter, the Harmonic scalpel and

laparoscopic organ surgery to name a few. Perhaps this is summed up in the quote by Von Neuman "There is no sense being precise about something when you don't even know what you're talking about." Hopefully surgeons in addressing surgical problems are the most knowledgeable to understand and address them.

However just because important innovation often comes from the ideas of surgeons and physicians, it is critical to realize that your great idea might be only important to you! As a result, it is important to evaluate the jobs to be done, what is the importance of the unmet need that has been identified. One common way to do this is through the Jobs, constraints and Outcomes evaluation, or the JOC process. In this method one rates the importance of a particular job, limitation or constraint that are preventing that job from being done well, and the outcomes or desired result of the particular job. This is often evaluated through market research in which the satisfaction and the importance of a series of jobs, constraints and outcomes are asked of surgeons or consumers. From these data a non-scientifically proven opportunity score is often calculated (Opportunity = 2* Importance – satisfaction) with the highest Opportunity scores reflecting the biggest opportunities to address.

Typically, the biggest areas for innovation can be defined by three attributes. The first and most important is an unsatisfied and important job. This can be a big job like curing cancer or a smaller but very important job like preventing bile leak after liver surgery. Although unsatisfied jobs are often obvious, many times we don't realize they even exist because we have developed a cumbersome work around to solve the problem. A common example of a work around might be using the back of a screwdriver when we don't have a hammer. Since we tend to use what we have at our disposal in the operating room even if it is not the ideal tool, identifying workarounds in surgery is an important area for innovation by increasing efficiency and reliability. A great example of a workaround solution is the Fogarty embolectomy catheter. Since there was no way to efficiently and reliably clean an artery of clot, a long arterieotomy was made to expose the entire clot. This was a work around solution since what was really needed was a device to pass by the clot and pull it out avoiding a long arterial incision and its potential complications. Hence the innovation of Dr. Thomas Fogarty resulted in a simple way to declot a vessel using a balloon catheter.

The third area to consider are barriers to consumption of an existing product or solution. Often times a very good solution exists but is too difficult to learn, requires expensive equipment, is not intuitive or requires a complicated setup. For example, surgeons often settle for a lesser alternative when the time required to set up a device is long or the assistant is unsure how to do so. Thus, improving the experience with a technology is as important if not more important than the cost. A perfect example of innovation success by improving the experience is the iPhone. Although much less costly phones exist, the user experience with the iPhone and the multifunctionality of the iPhone have made it the preferred phone in use today.

As one considers the big problem to solve it is equally if not more important to clearly define the problem or need and what the attributes are for success. Imagine having solved a problem only to learn you solved for the wrong thing. As management guru Peter Drucker had noted; "There is nothing so useless as doing efficiently that which should not be done at all". We all tend to rush to the solution with inadequate framing of the problem and the attributes that must be true for the solution to work. Some of the attributes are obvious but others not so obvious having been taken for granted. Often referred to as table stakes, as is the entry fee in a poker game, they are the price of entry or the things than cannot be made worse. For example, a surgical tool was marketed that significantly improved hemostasis in orthopedic surgery. Unfortunately, it also increased procedure time and the fixed costs of the procedure. Since speed was more important to orthopedic surgeons in gaining access than hemostasis (a tourniquet worked well) and since administrators did not want longer procedures that were costlier, the device failed to gain traction. In defining the problem then it is important to consider three aspects of a new solution. What are the current attributes that cannot get worse (table stakes),

what are the attributes that must work to provide value and what are the attributes that are nice to have but not necessary to success? Heading the advice of Albert Einstein is a good way to achieve this. When Einstein was allegedly asked how he would save the world in one hour, he said he'd "spend 55 minutes defining the problem and five minutes solving it".

So we have identified a significant problem and now it is time to consider solutions. It is likely that you are not the first to identify the problem. The issue is coming up with the best solution. For that reason, I believe there are three key factors to consider when ideating solutions to a problem. The first is to have a beginner's mind. Often times we settle for the first solution that comes to mind. In fact, as experts, we get trapped by our experiences and our thoughts. Shunryo Suzuki has stated: "In the beginner's mind there are many possibilities, in the expert's mind there are few." We also tend to become emotionally attached to one solution and fail to consider all options. The value of evaluating multiple solutions is summed up by Roger von Oech. "There are many right answers – all depending what you are looking for. But if you think there is only one right answer, you'll stop looking as soon as you find one". It is probably for this reason that breakthrough innovation often comes from the intersection of very different disciplines and highly diverse knowledge domains. It is also why the success of innovation usually comes from a multidisciplinary team. As Joy's law states; "No matter who you are, most of the smartest people work somewhere else".

A second consideration in arriving at a solution is to keep it simple. The master painter Leonardo da Vinci recognized it when stating:" Simplicity is the ultimate sophistication" as did the famous German surgeon Lorenz Heister. "In every surgical intervention, one should prefer the method which can be used with few and simple instruments over that which requires a big apparatus difficult to work with. Most such tools have been invented out of pomposity rather than utility" in the 1700's. Perhaps that's why Einstein was able to dish energy to E=mc2. He believed "Everything should be made as simple as possible, but not simpler". In part this relates to the concept of experience noted above. In general, complicated solutions have long learning curves, complex set up and lack of intuitiveness. Given the nature of humans to follow the path of least resistance (principle of inaction), a complex solution will not be met with favor if a simpler alternative exists. As noted previously, efficiency is paramount in our judgement and simplicity usually leads to efficiency. In fact, Clayton Christensen has identified the key attributes of disruptive innovation embodying the ability to democratize a solution, deskill a procedure and decentralize the care. Each of these elements clearly embodies simplicity

Finally, even though difficult problems to solve may require new technologies and complex solutions, it is remarkable how often an existing technology can be repurposed for a new outcome. The repurposing of existing technology speeds the path to regulatory approval and market adoption because the technology is already known. For example, even though the development of the Harmonic scalpel created a new area of simultaneous, effective and efficient cutting and coagulating in surgery, it did so by repurposing industrial ultrasonic devices to surgery. Such repurposing also significantly reduces research and development costs by leveraging existing experience and knowledge.

Often times innovation is thought of in the context of an apple falling on Newton's head or a stroke of genius in a bathtub as attributed to Archimedes. The reality is that all great innovators have spent vast time understanding the problem and usually experienced multiple failures in arriving at a solution. Roger von Oech has noted "Remember there are two benefits to failure First, if you do fail, you learn what doesn't work; and second, the failure gives you an opportunity to try a new approach and one of the world's greatest statesman, Sir Winston Churchill, noted; "Success consists of going from failure to failure without loss of enthusiasm." While failure is certainly a critical aspect of innovation luck is as well.

The story of the development of Harmonic Scalpel and technology highlights the aspect of luck and repurposing technology in the innovation process. The concept of transducing electrical energy to mechanical

energy dates back to Pierre and Marie Curie when they described the piezoelectric effect in 1880. This discovery led Paul Langevin to invent the sandwich transducer in 1915 for converting electrical to mechanical energy. By 1940, man-made piezoelectric ceramics were developed and used in industrial applications. By the 1950's, the application of ultrasonic energy was routinely applied to cut materials such as rubber and sailcloth, for cleaning materials and for precise milling of materials.

Energy and Minerals, a Pennsylvania based company, was the manufacturer of the Ultra Knife for use in industrial applications to cut difficult materials. Allegedly, an ultrasonic knife fell on an employee's foot and despite a cut there was no bleeding. (The first stroke of luck and brilliant observation). Harry Stewart and Alan Thomas, two engineers at Energy and Materials, took this insight to create a device for tissues and then tested it in skin at the University of Pittsburg under the direction of Dr. Patricia Hambley. The results showed remarkable reductions in tissue damage when compared to electrosurgery or a laser. Armed with this information, Stewart and Thomas engaged Jim Martin to determine the viability of starting a company based on this technology in 1988. To further evaluate the technology and its utility, Martin asked Dr. Tom Davison to determine its merit and build a business case. This ultimately led to the founding of Ultracision, Inc. in 1989 and venture capital was raised. Working with Dr. Rox Anderson at MIT, the initial work positioned the technology as an alternative for dermatologic surgery in general and Mohs surgery in particular because of the low thermal profile produced by ultrasonic energy in the research they had performed.

I had started performing laparoscopic surgery simultaneous with the startup of Ultracision, in 1989. At the inception of laparoscopic cholecystectomy, controversy existed over what the best energy modality was for performing the procedure. Many surgeons and of course laser companies argued and promoted that as a result of the inherent dangers of monopolar electrosurgery in the closed and gaseous environment of laparoscopic surgery, lasers were the ideal energy for cutting and coagulating tissue during these procedures. I struggled with this notion. While recognizing that electrosurgery indeed did have inherent dangers, most of which could be managed, lasers were cumbersome to use, often required difficult setups in the operating room, required special protective eyewear, carried risks of fires and most notably were very difficult to control by the surgeon. In fact, during the weekly training courses we provided, surgeons struggled to remove the gallbladder safely with lasers and the procedures always resulted in multiple perforations in the gallbladder and bile spillage. Clearly there was a problem. Further thought lead to a problem statement that what was needed was a method for hemostatically removing the gallbladder that was multifunctional, ergonomic, safe to the patient, safe to the surgeon, did not require special setup or protective tools, that provided precision, reliability and minimal tissue injury and that did not cause charring or impairments in visibility. The benchmarks to compare to were the coagulating power of a monopolar device and the cutting ability of a cold steel scalpel. I frankly had no idea how to solve for that.

In 1990, I had a chance encounter set up through a mutual acquaintance with Tom Davison at the American College of Surgeons in San Francisco. His device amazed me as I cut an orange and immediately struck me as the solution I was searching for. It met all the criteria that were important to solve the problem of hemostasis in laparoscopic surgery. Unfortunately, funding had been raised for skin surgery so at first there was reluctance to proceed in a new direction. We were, however, able to meet on a common ground after I offered my laboratory for free for their product development and in return their effort to develop it for laparoscopic surgery. Through this process we joined efforts with the foundational research moving to RI Hospital/Brown University. In fact, we both believed this was a better positioning for ultrasonic energy given the need and the rapidly emerging area of minimally invasive surgery. (Tom was just a better negotiator than me!). Initial efforts led to the development of a blade configuration for laparoscopic cholecystectomy and myomectomy. These were soon followed by a scissor configuration that was capable of sealing vessel up to

five mm vessels by applying compression of the energy against a stationary pad. This was the first application of the principles of good compression combined with heat to seal large vessels. As a result of its effectiveness, multifunctionality and efficiency, the technology was rapidly adopted for procedures such as laparoscopic Nissen fundoplication, hysterectomy and colectomy. In 1995, the company was acquired by Ethicon Endo-surgery and today it is one of the mainstays of laparoscopic surgery. In hindsight it is important to recognize that all of this was possible because of the luck derived from a chance encounter in San Francisco between two individuals' unknown to each other… one with the problem and the other with the solution. To summarize the importance of luck in innovation Bo Peabody, founder of Tripod, noted "luck is part of life, and everybody at one point of another gets lucky. But luck is a big part of business life and perhaps the biggest part of entrepreneurial life."

Armed with a problem to solve, solution and a patent for the invention it's time to do something about it. After all the difference as noted by Scott Godin between a creative person and an innovator is that the innovator does something with their creativity while the others let it laps. There are two options. One is to start a company yourself and the other to seek an industrial partner. Both options have pros and cons and both will require courage and commitment. The advantages of the startup approach are that you are in control and have the highest potential reward from the innovation. On the other hand, you have the highest personal, economic and profession risk. Starting a company is a full time endeavor and not something to do on your spare time. It will also require significant economic investment. Given that the success of any new medical venture is on the order of ten to twenty percent at best, the risk of failure is high and given limited experience and the complexity and amount of knowledge needed high, the time to success will also likely be long. In addition, as profession investors join the company, your control will be diminished.

The second option is to identify a partner in industry that is willing to take this on. For that to occur, the industrial partner will need to have a specific strategic interest in the area the idea addresses. You may have the best idea and solution but if it is not a strategic fit there will be no interest. For example, a surgery company who sells surgical drapes may do so but not as a priority area of focus. Therefore, your new super duper environmentally friendly, reusable self-cleaning drape idea will not be a fit. The industrial partner will also want to be sure it will move the needle on revenues and profits since they will measure this investment against all other potential areas for them to invest in. Finally, they will determine if they have the technical capabilities to bring this to fruition. For that reason, most ideas and solutions never find a home in industrial partners making it a choice of start-up or nothing at all.

Given that, the advantages of an industrial partner are aimed at improving the success rate from the 10-20% in startups to a higher percent, at accelerating the introduction and adoption of the solution through their distribution scale and by reducing the cost of development by leveraging existing expertise. The disadvantages however are also apparent. One loses control over the solution's development and the financial reward is dramatically less given that the risk to you is remarkably reduced. In this regard, the value of the solution to the company is proportional to how far along the development path the solution has gone. A solution and patent alone are not worth a significant amount to a company since they incur all the development costs and risks, whereas a fully developed solution with market use is worth much more. Thus a middle ground exists to partially develop the idea on your own until larger scale funds are needed since the further along the process you are the greater the likelihood of acceptance and the greater the value. In the end, the choice is yours.

At this point it should be clear that the process of innovation is never easy and never straight forward. Therefore, one should pick high value targets to innovate rather than focusing on small incremental improvements. Fortunately, there are many opportunities in surgery despite its dramatic evolution over the past decades. If

we focus on surgery itself where might be a good place to start? One can focus on a disease state, a system approach or on an overarching surgical problem. I was recently struck by a paper published by Merkow and associates that evaluated the results of 498, 875 surgical procedures of all types entered into the American College of Surgeons NSQIP database. The startling finding of this study was that 5.7% of these patients were readmitted to the hospital within thirty days, usually for reasons that were not predictable. These included infection, dehydration, obstruction/ileus, deep venous thrombosis, bleeding not to mention leaks and hernias. It is remarkable to think that such a high percentage of patients are re-admitted and speaks volumes to the need to improve surgical care. This has never been more true than in the current healthcare environment where precious resources are too few to take care of an ever expanding and aging population in the world. Imagine how much money is lost through readmission and further care. How much more care could be provided if that were not the case. Obviously as often stated the goal of surgical innovation should be to never have to operate on anyone. Were that the case then readmissions would not occur. Given that that scenario is unlikely to happen in a revolutionary hospital what are the key areas to consider in reducing this readmission rate?

In my mind there are three key areas to focus on. If we consider common complications such as wound infection, hernia, DVT and wound failure, a common denominator is the creation of the wound itself. Over the past three decades, remarkable progress has been made in reducing the size of incisions and in minimally invasive approaches. The old dogma that incisions heal from side to side not end to end has been replaced by incisions hurt from end to end. This raises the notion that we need to continue the progress made and completely eliminate the need for skin and fascial incisions. POEM to treat achalasia is such an example.

Leaks, bleeding, hernia, and wound failure also point to the need for improvements in tissue fusion. Clearly, infection, tissue tension and inflammation play an important role in the genesis of these problems but the past decades have seen little in the way of improvement in these problems. By and large, methods and principles of tissue fusion have remained relatively constant and so have the results. While more research in best practice and better education and awareness are critically important to address these issues, more reliable and predictable methods of tissue closure are needed.

Finally, Bleeding, infection leaks, fibrosis and adhesions call out for better solutions in addressing the inflammation that commonly occurs in and from surgical procedures we perform. Despite all our advances, we do not have any better solution today for managing inflamed tissues during procedures or preventing an adverse inflammatory response following a procedure than we did fifty years ago.

In conclusion, surgeons have always exerted an important role in meaningful innovation in surgical care and the need for continued innovation in surgery is critical to the future of surgery and healthcare delivery. As a creative group, surgeons must put their ideas to action and lead innovation not just adopt it. This will be accelerated by partnering with others with diverse knowledge domains and experiences to identify and solve meaningful surgical problems that will simplify surgical care and improve patients' lives. To quote the great Jedi Master Yoda…"do or do not. There is no try"

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Correspondência:
JOSEPH AMARAL
e-mail: jfamaral@mac.com

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