

## Next Generation Surgeons

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Surgery as a discipline has progressed tremendously over the last century. It has been an ever evolving science, achieving feats never imagined before. William Halstead regarded, as one of the founders of the modern surgery had once stated "The future of surgery now, is not what it used to be."

Though many factors, such as changing financial trends and legislative interferences have contributed to the changing landscape, the introduction of the world of technology has made a major impact. A new term, "disruptive technology" has been used (coined by Richard M Satava [1]), to signify such abrupt and radical change. Robotics has already entered the market and virtual reality with its whole armamentarium is ready to make an impact; the surgical labs are already over-clocked.

A comment on next generation surgeons is important to understand the true destiny of this specialty. When asked about the status of the current trainees, most of the current surgeons are of the perspective that they are different from the previous generations. The common comments that one would come across are, that they work to live; they have a sense of entitlement and lack hierarchy observance. The Millennials (students born in the late 1980s to 2000) have arrived and the generation alpha is already in the making; with widely different outlooks, motivations and aspirations which will have far reaching effects on the future of surgery.

Before analyzing the future it is important to gain the perspective of the present. The current trainees involved in surgical residencies are the part of the Generation Y, (the Millennials). Millennials are essentially the children of Baby boomers (born from 1940s to 1960s) and grew up with cultural events of cross border terrorism, mobile phones and social networking. This group is skilled, comfortable with technology and self confident. Though accused to have adolescent behavior with lack of independent judgment, they are accustomed to have frequent evaluations and have clearly set goals for their future. With the information readily available at their finger tips and they demand instant results. Their expectations with availability and usefulness of technology are insatiable. They believe in team effort and value being connected to others. In contrast to the Millennials, the generations involved in teaching these residents are either a part of the Baby Boomers or Generation X (1960s – 1980s). Baby boomers were shaped by introduction of television, space race and fight for civil rights and have typical characteristics defined as being competitive, optimistic, consumeristic, and they are quoted as a generation that lives to work. On the other side Gen X has been dubbed as being cynical, skeptical and pessimistic. This so called "Me generation" is known to be self motivated, independent and pragmatic [2].

With this overview of where we stand today, we would like the reader to take a leap of imagination where the Millennials would be the teachers of tomorrow, shaping the academic curriculum and practice standards. Being comfortable with technology, they would prefer education being

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presented in an entirely different format, one that is globally accepted and practiced. The student – teacher relationship would no longer be confined to a four walled room. Online learning modules, blog discussions, podcast reviews would be an essential part of the training modules. The student surgeon of the future would no longer be tutored locally but would be mentored globally like never before.

Being a generation of multitaskers it will not be surprising to see virtual rounds where consultants are present as holographic images simultaneously at various places examining the patients and training the trainees at the same time. A recent experiment by the RP-6 mobile telemedicine robot (In-Touch, Inc) a robotic platform with telemedicine connection, to have virtual rounds had surprisingly good acceptance from patients and students alike [3]. The surgeon of the future will also enjoy close relationships with the authorities as they have learnt the art of teamwork since the inception of their training, leading to dilution of hierarchies and birth of team oriented mentorship where no single person is the boss.

Training programs will have to change from "chronology based training", which is dominant today, to "proficiency based training" in the future; the students will no longer train for a given time period in operating room rather would be judged by a benchmark criterion on simulators of an expert before they operate on their first patient. The Yale university study on surgical simulators have demonstrated that criterion based training could decrease operating time by 30% and errors by 85%. Future learning principles would emphasize on achieving better scores on simulators before the student could actually "practice" on a patient [4].

It is not difficult to imagine that the future surgeon will require longer training and would be older than average surgeon today. But the essence of surgical training would not have changed much [5]. As the French proverb places it correctly "*plus ça change, plus c'est la même chose*," translated as "the more things change, the more they stay the same", (an epigram by Jean-Baptiste Alphonse Karr) [6]. The models of anatomical dissection and pathological specimens have stood the test of pedagogical scrutiny since time immemorial and would be hard to replace. Though real-time models created with next generation 3D bio-printers would become a part of the curriculum, not much would change in the approach to study the specific organ systems and there pathophysiology. What might be interesting to imagine is that the students might have to put in a number of mandatory hours under guidance of artificial intelligence (AI) for such skill oriented modules.

Postgraduate training would become more competitive and most of the graduate schools will have mandatory additional degrees that would also help in maintaining numbers in substantive positions. The next generation of trainees would know a little about the international boundaries, with increasing stress on global standardization of surgical curriculum and

assessment, the prospects of main stream tele-surgery (Lindenbergh Operation) have never been so real.

A trained Gen-Nex Surgeon will be no less than a bio-machine himself; with an armamentarium so unique it would give him capabilities to explore the limits of human body itself. The magnitude of change would be heavily dependent on the radical change offered by the age of bio-information. To understand this framework I would suggest the reader to gain a view of principles that might govern these systems. The first of which would be to represent the real world and people as information equivalents. Cyber-man, a surrogate for the patient in the information space, in form of holographic representation of a human would permit various simulations over the image before actually providing a medical diagnosis and treatment for the person. The US military virtual soldier prototype is a living example of this technology. The purpose of obtaining the cyberman would be not to discover a disease but rather provide a baseline or control. The surgeons of the future would be providing evidence based medicine in its true form.

Surgery would be dealt as an information management system. With the capabilities of real time simulations, the surgical console, where the human body itself is nothing but a piece of information on which the surgeon is operating (read editing), would help in simultaneously assessing each step a thousand of different ways in a fraction of millisecond before it is actually performed. Imagine being able to zoom into the organs microscopic image before we actually make the cut, a feat to savor at the moment that would be our successor's finger tips.

As imagined in a recent article titled "*How the future of surgery is changing*" by Richard M Satava et al., [7] the clinical trials performed by this generation would be a lot different than that performed in the labs of today. As an intermediary step a computerized environment would be developed to stimulate an experiment. It would be possible to acquire data about hundreds of patients (read cyber-man), and conduct an experiment over a decade in a fortnight on a computer. The writing on the wall is as sharp as it can get, modeling and simulation would be the heart of transformation of the next generation surgeons; which would be implemented not only in surgical teaching but also, pre-operative planning and surgical rehearsals.

The most important concept of this bio-intelligence age would be that of a multidisciplinary approach. Until now research was primarily limited to engineers making machines, biologists understanding the living and the information guys integrating and analysis data. But the dawn of disciplinary intersection has already arrived. The age of bio-informatics or bio-mechanics would give rise to new set of surgical capabilities, the Bio-surgeons and the Surgineers if we may take the liberty to label them.

Imagine a surgeon being able to open up a cell without damaging it, like a skin incision without scarring, and be able to manipulate the genetic material and come out annealing the defect. If this was to occur the results of surgery could change the very biology of cell and we would truly cure our patients rather than removing the structure that refuses to heal. If it sounds too futuristic to my fellow readers, may I take this opportunity to introduce them to femto-lasers that can actually make this cut [8].

The level of integration does not stop here, with the help of computational mathematics and material physics we have been able to build a vascular framework using a bioresorbable substrate from the biologists which under the influence of various stems cells resulted in working bladder. The next generations of surgeons are actually looking towards a dawn of an era of surgery where functional human spare parts would be available for replacement [9].

The concept of work station especially in robotic surgeries may actually be very different from what we perceive at present. Numerous universities are working to enable the surgeons with a direct neural control. The first

clinical trials began on a quadriplegic man in 2005 who could control the cursor on the video monitor, turn the television on or off and even open and close a prosthetic arm simply by thinking. we like to imagine a future where a surgeon could wear a head gear and control a whole robotic system [10].

With rapid changes in robotics and computers it is clear that not only the surgeon but his work place, "the operation theater" will no longer remain a passive interface. The next step of integration for the future surgeons would be a place where the peri-operative period is assessed and recorded to observe the procedure make the necessary amends. In the automobile industry when an instrument is changed, an automatic tool changer is used or if new tool is required a supply dispenser is used, there are no people interacting with the robots. In a suggested concept of a futuristic operating room, patient would be brought to an operating room, placed in proper position and anesthetized. A cyber -man would be created; the surgeon would then rehearse the operation on the work station. During the actual process, a robotic nurse (Penelope) would be utilized to respond to requests to instruments improving the efficacy of the procedure by achieving personnel reduction.

In an interesting analogy with the advancement in the aerospace science, until 2002, fighter pilots were at the peak of their performance. Technological advancement during this period integrated with human skills with the help of flight simulation software's gave rise to Unmanned Aerial Vehicles, which today have superseded their biological counterparts. If there is a lesson here for the next generation surgeons then it needs to be explored.

What is pure fantasy today will become tomorrow's undisputed fact. With the combination of technologies and new training programs the GenNex will be able to reach it all and see it all. As stated by Dr. Catherine Mohr we would be able to heal the disease, and leave the patient whole and intact and functional afterwards [11]. But the horrors of the present would still be challenges to the future; increasing antibiotic resistance with depleting alternatives, presence of the epidemic of the elderly, the malady of cancer and its associated morbidity, the changing administrative powers with questions regarding financial securities in the public and private domains would be a task to tackle. All of the technology and integration of knowledge would boil down to a point where the next generation of surgeons would need to re-evaluate the then existing principles of scientific knowledge and expand the ever changing surgical horizon to find answers to these problems with due considerations to the moral and ethical concerns.

It is tempting to imagine the surgeon of 2050 as working in a new, environmentally friendly tertiary centre with the latest teams, equipment and expertise to hand as they perform an operation via an endoscope or remote control. However, this will not be a reality for most. Globally, there will still be surgeons striving to perform open operations in dirty environments without appropriate medications, anesthesia or even electricity [12].

We would end this note by quoting Yoshihiro Fukuyama, "Today walks a species on this planet so powerful that it can control its own evolution, at its own pace; the homo sapiens. What tomorrow holds for us is very much what we are able to imagine in it." [13].

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