Why to move from video-assisted thoracic surgery to robotically video-assisted thoracic surgery? —a chronicle

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Why to move?

We are living in the best of the times with the explosion of exponential advances in science and technology. In fact, Ray Kurzweil, a renowned North-American scientist, believes that we will experience progress of 20,000 years, scientifically speaking and at today's rate in the 21st Century (1). Twenty thousand years in one century!!! Can you imagine that? From virtual reality to quantum computing, from artificial intelligence (AI) to solar power roads, from augmented reality to ultra-small health monitors and brain-computer interfaces, among hundreds of others incredible devices and advances.

The human-race always was afraid of the unknown. Sudden advances in technology have been repeatedly misunderstood and feared throughout time. One can never forget that critics of early steam-spewing locomotives thought "*that women's bodies were not designed to go at 50 miles an hour*", and worried that "*female passengers' uteruses would fly out of their bodies as they were accelerated to that speed*". Others suspected that the human body would completely melt at such speeds (2)! Not too long nor too far, even the genius and entrepreneur Elon Musk rose the important alert about how we should be cautious and conscientious with the development of AI. In 2014, in remarks at the Massachusetts Institute of Technology (MIT), the CEO of Tesla and SpaceX pointed that "*If we recreate some digital superintelligence that exceeds us in every way…by a lot…it's very important that it be benign!*". In our own best interest, he's created with others the nonprofit OpenAI.com, which hopes to discover and enact "*the path to safe artificial general intelligence*".

So, should we be afraid of technology? Or should we interact with it at best and possible way? Is the singularity so near that we need to be afraid of the machines? Remember Isaac Asimov in "I, Robot" and Thomas Rid in "The Rise of the Machines: A Cybernetic History"? What are the ethical considerations and practical risks for incorporating new technologies? We know that in history, societies have almost always found ways of incorporating technological advances and use them in their advantage (3).

Technology has made us more informed, wealthier, safer and, in some ways, happier. In medicine, during the last hundred years, all sorts of technological advances allowed humans to live nearly twice as much. Including other science fields, technology tends to expand human capabilities, produce new opportunities and increase productivity (2). Why not use and abuse of technology?

Time magazine of June 12, 2000, more than 18 years ago, showed in its "Vision 21 Special Issue" (at the start of the 21st Century) several articles about "The Future of Technology". In this number, 21 stellar authors (Joel Stein, Bill Gates, Ray Kurzweil, Stephen King, and others) wrote about 21 controversial issues (cybersex, smart-cars, video games, digital word, robots, Internet, AI, etc.). The last articles were tremendously interesting: "Is Technology Moving Too Fast?" by Stewart Brand and "Will Low Tech Replace High Tech?" by Nana Naisbitt. In these two final articles the authors concluded that technologies will proceed at various rates, some hyper accelerating and some completely stalled, and expressed their concern about limitations of the Earth in giving the resources that we

need to boom technology. In fact, several of the predictions done in *Time* magazine are not yet accomplished, but in few years, maybe by 2,025 all of it will possibly be real. The transformation from an industrial society to an information society has, in fact, already occurred. All that is now required is for society's perception to catch up with the realities involved (4).

Let's take a deeper look at AI—exactly the disruptive technology that best characterizes our information society, the same one that's behind advances in a variety of fields, and precisely the one Elon Musk pointed out so fearfully. Several US academic institutions are applying AI to tackle some of the world's most difficult economic and social challenges. For example, the University of Southern California launched the Center for Artificial Intelligence in Society (CAIS), targeting the use of AI to address socially relevant problems, such as homelessness. At Stanford, researchers are using AI to analyze satellite images to identify which areas have the highest poverty levels.

Very few technologies have been so popular—although mostly superficially understood—and so remarkably associated with the newborn information society concept as AI. Looking deeper into its history, it's remarkable to find out that neural networks, one of AI's most used predictive models, started been developed quite early, in the 1950s, and nearly 20 years later, a book by MIT's Marvin Minsky and Seymour Papert, called "Perceptrons", proved mathematically that neural networks could perform only the most basic functions—therefore having a negligible impact. At the time, limited by computational and human capabilities, neural nets had only 2 layers (one for input, one for output), which narrowed drastically the power of this technique. Except for a few holdouts like Geoffrey Hinton, a British cognitive psychologist and computer scientist, "Perceptrons" made most scientists give up on neural networks entirely. Geoff, who is now a leading figure in the deep learning community, had a breakthrough in his work in 1986, finding that backpropagation could be used to train neural networks with more than 2 layers. But the interesting fact here is that it took another 26 years before increasing computational power made good on the discovery (5). Therefore, only in 2012 Hinton showed the neural networks, trained with backpropagation, beat state-of-the-art systems of image recognition.

Again, human society's capabilities are the final threshold to be moved forward so that technology can truly accomplish the outcomes we project on it.

So, why to move from video-assisted thoracic surgery (VATS) to robotically VATS (R-VATS)? Progress, science, technology, machines, robots, computers, AI are here to stay. Technology is our ally. We need to accept and interact with it, taking of course considerations about ethics, environment, culture, infrastructure, security, costs, training, mentoring and optimization of all the processes before incorporating them to the real world.

Minimally invasive surgery (MIS) is fully established, and is a reality. It is safe and effective. It is defined as a procedure done with small incisions, no excessive retraction, being associated with less blood loss, tissue trauma and consequently less pain, faster healing, minimum complications, and shorten admission time and return to daily activities, with improved cosmetic results. MIS is also expanding the indications of some procedures, that are now accessible for high-risk and/or elderly patients.

According to Sihoe in 2014 (6), the single greatest advance in thoracic surgery of this generation has been the advent of VATS. He states also that since its introduction in the early 1990s, very few advances really happened with the technique and the search of the "next big breakthrough" of the scale of VATS has been in vain for many years, with MIS reaching a stage beyond which no further great advance was possible. According to Sihoe the recent emergence of uniportal VATS (U-VATS) has now promise a breath of fresh air to purge stagnation.

U-VATS is a fantastic idea and its results are excellent and well known, but it is not easily reproducible and we will take a risk to affirm that, in 2018, R-VATS is the natural evolution of VATS and U-VATS.

R-VATS is a technology that surpasses VATS and U-VATS in several critical items. VATS and U-VATS have its use limited because of difficult and longtime training to surpass the learning curve, bad ergonomics, contra-intuitive movements, rigid instruments, rigidity of chest wall and 2D visualization. R-VATS in the other hand has full-HD and 3D visualization, accurate sense of profundity, magnified visualization (until 12×), intuitive and delicate manipulation, great mobility of camera and instruments (endo-wrist technology, not limited by rigidity of chest wall), comfortable ergonomics. R-VATS instruments have seven degrees of freedom (*Figure 1*) which facilitates delicate manipulation and dissection. It has an easier and shorter learning curve, is totally reproducible, and It is not inferior to VATS and U-VATS in any technical and operational item.

Endo-wrist technology:

- ❖ Seven degrees of freedom:
1. Insertion/extraction;
2. External yaw;
3. Internal yaw;
4. Internal pitch;
5. External pitch;
6. Roll;
7. Grip
- ❖ Ninety degrees of articulation.
- ❖ Intuitive movements, control at the finger-tips and tremor filter.

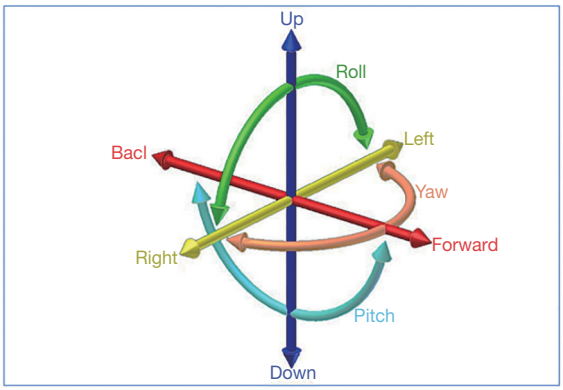

Figure 1 Endo-wrist technology.

R-VATS, in the same way as occurred to VATS is at the beginning of its consolidation, and is being more expensive than the others. Novellis *et al.* (7) concluded in relation to comparative costs among R-VATS, VATS and open lobectomies that "*robotic surgery for early lung cancer was associated with shorter stay and more extensive lymph node dissection than VATS and open surgery. Duration of surgery was shorter for robotic than VATS. Although the cost of robotic thoracic surgery is high, the hospital makes a profit*", or the costs of robotics are not related to important losses from the health-care providers. The short- and long-term results of R-VATS and VATS and U-VATS are at least comparable.

Why not to move from VATS to R-VATS?

The future of robotic surgery is wide open. We need to deal with these new surgical technologies to make everyone understand that they work together and maximize the abilities and capabilities of surgeons, instead of replacing them. In fact, Ricciardi *et al.* (8) from the group of Franca Melfi, the pioneer of robotic thoracic surgery, in a very recent publication, expressed very well the same idea that we have about R-VATS and we reproduce here their final remarks: "*the unquestionable benefits and the continuous upgrade of robotic system allow to put the highest available technology in the hand of the surgeon to perform a broad range of different procedure in a safe, effective and ergonomic way. The advantages of RATS (R-VATS as we name it), both for patient and for the surgeon, suggest the superiority of this MIS technique. In fact, even though in its infancy the robotic system has limitless potentiality and increasing applications persuading us that this is the best minimally invasive procedure in thoracic surgery.*"

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