Telemicrosurgery

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Editors

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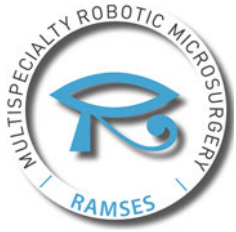
Robot Assisted Microsurgery



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Foreword

Robotic assisted surgery may conjure images of science fiction; however, it has become a modern reality. Some traditionalists within the medical community have expressed skepticism about this approach, questioning the cost of this technology. However, it is difficult to ignore the fact that robotic assisted surgery has extraordinary potential. Some of our colleagues are testing the outer limits of microsurgery with preliminary work on suturing capillary vessels. We may question the benefits of applying this technology. Is our primary purpose the achievement of a surgical prowess? Perhaps the cynic may draw this conclusion, but in fact we have likely only begun to tap into the vast potential of this emerging discipline. When Pasteur enlightened about the existence of microbes, and the necessity for strict hygiene and sterile technique, a famous English surgeon uttered the short-sighted sentence: "Anyway, microbes, I do not see them, and if they exist I cut them in half with my knife!"

So as we evaluate dramatically new technological advances, let us not forget that many concepts and devices that we would now consider indispensible to modern medicine likely were not initially embraced. Amongst the tremendous enhancements that robotics has enabled are:

- Improved comfort and ergonomics of our workstation
- Increasing safety in sterilization of the operative field
- Creation of a three dimensional "augmented reality"
- Ultra-precise instrument control through the de-multiplication effect, resulting in improvement of our surgical procedures

In this book you will discover many facets of ultra-modern robotic assisted surgery. Philippe Liverneaux has pioneered many of these techniques. Along with his colleagues and co-authors from the RAMSES society, he provides world class educational experiences at the magnificent Ircad training facility in Strasbourg, France. The mission of these training courses, the RAMSES society and this text are to raise awareness of the expanded applications of Robotic Surgery. This will help move this technology to its rightful place at the forefront amongst surgical advances and hopefully will add a great tool to our daily practices.

Paris, France — Christophe L. Mathoulin M.D

Preface

Participating in February 2007 at an EWAS lecture (European Wrist Arthroscopy Society) organized by Christophe Mathoulin, I was given the opportunity to take a tour of IRCAD-EITS in Strasbourg (Institut de Recherche sur les Cancers de l'Appareil Digestif – European Institute for Tele-Surgery).Taking a peek through an open door at the back of the conference room, I was pretty much awed to find myself looking at some sort of giant metallic spider, no different from those in horror movies, attempting to swallow a little pig fast asleep. I was told the beast's name was "Zeus", and that it was a remote controlled surgical robot for surgeons to practice laparoscopy. It happened Zeus was as a matter-of-fact the ancestor of the DaVinci® robot. It had already been used in 2001 by Jacques Marescaux during an outstanding surgical performance, a transatlantic cholecystectomy, transatlantic because the surgeon operated in New York a patient anesthetized in Strasbourg, separated by more than 5,000 km [1]. I was furthermore allowed to experience Zeus for a little while, far much time than necessary for me to succumb to the robot's swiftness and docility.

From this day on, I decided I would not rest until I could adapt such a robot to the surgical discipline I performed daily for so many years: microsurgery. Why should robotics be solely reserved to general surgeons? I spoke to Didier Mutter, Jacques Marescaux's assistant, who introduced me to David Douglas, technical engineer at Intuitive Surgical™, the company which builds and sells DaVinci® robots, precisely at the time when the latter tended to replace obsolescent Zeus robots. David told me IRCAD-EITS was a training center in robotics, training surgeons worldwide in order to help them master the DaVinci® robot. I was invited by David to such a training session, provided I committed myself to developing innovative surgical techniques using the robot. I had no other restriction than to be creative!!! I needn't be told this twice… I quickly had the opportunity to work at the task in May 2007 when Chihab Taleb, a resident in Strasbourg, asked for a thesis for the Microsurgery Diploma. I proposed that his work focused on a neologism, *telemicrosurgery*, so as to transpose the telesurgical concept to microsurgery. Eric Nectoux, another resident coming from Lille and at the time spending 6 months in Strasbourg, offered his help to develop this new technical concept. This is how telemicrosurgery, alias robotics applied to microsurgery, all begun…

The first studies focused on the rat, then pigs and eventually human cadavers. While Chihab focused on vascular anastomosis, Eric worked on nervous sutures

[2, 3], both studies leading to major papers as first authors. During 6 months, week after week, we worked for hours attempting to define the best way to perform surgical repair of many different histological tissues: arteries, nerves, veins, tendons, muscles, ligaments, skin, etc. We learned step by step progressively how to install the robot, display its arms, and master the multiple pedals and handles. After a few months, we decided we were geared up to perform one of the most microsurgically challenging procedures: a macro-replantation of the limb. After a preliminary feasibility study in a pig cadaver, I bought a live pig from IRCAD-EITS and Brice Hérain, one of David Douglas' colleagues, booked an operating room between two DaVinci® training sessions. A go-getting surgical team was about to experience an outstanding March 31, 2008: Brice installed two robots, Dominique Lazner and Muriel Renard (our scrub nurses) managed the surgical field and all surgical needs, while three surgeons Chihab, Eric and I took turns on both surgical consoles. The procedure last 5 h including installation of the robots, amputation of the forelimb of the pig and its replantation [4].

We felt the need to share our experience by creating a scientific society, the RASH Society (Robotic-Assisted Surgery of the Hand/www.rash-society.org) and a bi-annual workshop at IRCAD-EITS promoting telemicrosurgical teaching on biological models (earthworms, chicken thighs, etc.). Participants came from Europe, South and North America with Mike Bednar (USA), Gustavo Mantovani (Brazil) and Stacey Berner (USA) as guest experts to coach the surgeons attending the workshops.

After having developed laboratory telemicrosurgery, a new step had to be taken forward: clinical practice. I first thought difficulties would arise from our using the robot for microsurgery, as in the USA the FDA (Food and Drug Administration) delivers authorizations for the robot to selected surgical disciplines with regard to selected surgical procedures! In France, there are no such restrictions, provided the robot is used for a surgical procedure, regardless of the surgery performed. As a matter of fact, logistical, practical and financial difficulties were eventually at stake. Financially speaking the University Hospitals of Strasbourg (HUS) had bought a DaVinci® robot a couple of years previously, and the surgical teams involved in using the robot had to resign to postpone for 2 years the acquisition of other biomedical equipments. I therefore had to comply myself to these financial decisions, and at this point my warmest thanks go to Michèle Brid, our operating room manager, for having managed to save 20,000€ in a year, allowing us to enter the very select club of surgical teams in Strasbourg licensed to use DaVinci®. Practically speaking, I then had to sign the charter clearly stipulating that there were no scrub nurses attributed to DaVinci®, my own surgical team being responsible for the surgical procedure when using the robot. My team is located 10 km from the hospital where the robot is located, and the robot could not be moved away easily. It suddenly became evident that difficulties would arise, since my surgical team would have to operate in an "unknown" hospital, in an "unknown" surgical ward, with all new surgical equipment. Nothing stopped us. Muriel and Dominique were always by my side when the mood was down. Surgical procedures were performed at a steady rhythm of 1 per month, while thinking of new vascular or nervous indications

with Sybille Facca and Stéphanie Gouzou. Time passing by, along with our increasing experience, it seems peripheral nerve microsurgery is the best indication for telemicrosurgery. The first case of peripheral nerve surgery was performed by Stacey Berner in the USA. For legal reasons, authorizations for this procedure with a DaVinci® robot were given provided I assisted him as a hotline. Unfortunately, video transmission between Baltimore and Strasbourg was unavailable, and we managed to perform this ulnar nerve graft together thanks to Skype™! However the robot was no bonus compared to a conventional microscope, since this telemicrosurgery was performed through an open approach.

Thus, it was urgent to redefine new openings for telemicrosurgery; the concept of minimally-invasive soft tissue surgery of the limbs became evident. Using a robot for telemicrosurgery isn't *per se* of great interest, since the same procedure can be performed by conventional microsurgery. We went back to IRCAD-EITS labs to study the feasibility of minimally-invasive telemicrosurgery. The forearm, and more precisely the median nerve, was our surgical experimental paradigm. The number and width of surgical approaches needed to be defined, along with both the possibility to create a surgical cavity where all surgical instruments would rejoin and the topographic maintenance of such a cavity during all the procedure. These solutions are still under development, with help of Kiyohito Naito (Japan) and Thierry Lequint (Belgium), both very actively concerned by minimally invasive approaches. Some time later we developed a minimally-invasive technique for brachial plexus surgery using carbon dioxide insufflation with Gustavo Mantovani (Brazil) and Catherine Mohr (USA) from the labs at Intuitive Surgical™, Sunnyvale, CA.

Since we already had a reasonable experience of surgical repair of brachial plexus with Frédéric Lebailly and Sybille Facca, we performed the minimally-invasive technique developed at Sunnyvale in our first cases. The first case was a brachial plexus biopsy for a nervous tumor, and the second case was the removal of a recurrence of a 5 cm long desmoid tumor of the brachial plexus by an approach less than a centimetre long. Minimally-invasive telemicrosurgery was born!

It was in Sunnyvale, at the Intuitive Surgical™ headquarters, that all six founders of the RAMSES (Robotic Assisted Micro-Surgery and Endoscopic Surgery/www.roboticmicrosurgeons.org) first met (that is Stacey Berner (USA), Mike Bednar (USA), Sijo Parekattil (USA), Jesse Selber (USA), Gustavo Mantovani (Brazil) and myself). It was Jesse who first thought of RAMSES, inside the white limo which was bringing us to the labs. Sijo organized the first congress of the RAMSES at Orlando in November 2011. What will be the next step?

This book takes stock of telemicrosurgery since its birth until now. History of both microsurgery and telesurgery is told by pioneers in these domains, Yoshikazu Ikuta and Jacques Marescaux. Telemicrosurgery goes upriver to the source of both disciplines. Firstly surgical robots and their functioning are precisely described by renowned experts who master this technology. Secondly training is seriously framed by precise pedagogic protocols and well standardized models. Authors who define telemicrosurgery do not leave any room for improvisation. Thirdly come all experimental models proposed by founder members of the RAMSES. At last, the most complete description of clinical applications is given by means of several

transversal surgical disciplines: peripheral nerve surgery, skin/muscle flap surgery, plastic surgery and urology. It is Catherine Mohr, woman whose scientific culture is as vast as a university library, along with an acute practical sense, which will give us hints as for the future of surgical robots. Special thanks go to Christophe Mathoulin and Terry Whipple, famous names in arthroscopy, who provided by their insight a parallel between their accomplished discipline and the rising telemicrosurgery.

Strasbourg, France Philippe André Liverneaux, M.D., Ph.D

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