Editorial

Robotic-assisted thoracoscopic surgery: state of the art and future perspectives

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Background and state of the art

With interest I read the article of Du and co-authors (1), describing their meticulous technique for robotic lung segmentectomy. Robot-assisted thoracic surgery (RATS) has come a long way, with the first robotic lung resections being reported in 2002 by Melfi *et al.* (2). Since then, various different approaches for lung resection have been described using the da Vinci Surgical System (Intuitive Surgical Inc., Sunnyvale, CA, USA) by thoracic surgeons all over the world (3-7).

Despite the obvious advantages of robotics, such as 3D vision, increased dexterity and improved ergonomics for the operating surgeon, the robotic approach has not at all advanced to the gold standard for anatomic lung resection so far. An analysis of the U.S. National Cancer Data Base showed that the percentage of robotic lobectomies increased from 3% in 2010 up to 9% in 2012 (8). A more recent market analysis that has been conducted in the U.S. by the end of 2015, showed that already around 15% of lobectomies were performed by RATS. Although robotic lung resections are increasingly performed, one of the main factors still impeding a more wide-spread use of the robotic technique is without a doubt the increased overall costs, at least when compared to VATS approaches (9-12). Another concern which is an ongoing point of discussion among surgeons is the safety of the surgical procedure, since the main operating surgeon is not present at the operating table itself. While some authors observed an increased risk of bleeding during RATS (when compared to VATS) with consecutive conversion (11,13), this was not observed neither by us, nor others, when appropriate measures were taken in order to prevent or properly manage intraoperative complications with the robot (14,15).

In summary it can be stated that to the present day, as demonstrated by the two largest available systematic literature analyses (16,17), RATS comes with an increased cost but does not seem to offer any advantages compared to VATS in terms of complications (intraoperative as well as postoperative), postoperative pain, hospital stay and oncological outcome for early-stage lung cancer.

More than that, the invasiveness of the surgical approach has been further challenged by the introduction of the single-incision VATS approach, reducing chest wall trauma to only one small single incision. This 'uniportal' approach is spreading rapidly all over the world and evidence is growing that this approach results in equivalent or even improved patient outcomes compared to multiport minimally invasive approaches (18). As a consequence, also Intuitive Surgical has made corresponding efforts and has developed software that allows Single-Site^{TM} Instrumentation (Introduction of the camera and two instruments in a crosswise manner through the same incision) compatible with the Si^{TM} Surgical System in 2011. During the following years finally a 'real' single port platform has been developed and was approved by the FDA in 2014 in form of the da Vinci Sp Single Port Robotic Surgical System, compatible with the latest da Vinci Xi^{TM} robot. Nevertheless, technical limitations including suitable instruments and the relatively large and rigid trocar with a diameter of 2.5 cm will most likely prevent the device from being used for thoracic surgical procedures.

A more important feature, which was introduced by Intuitive also in 2011, is an integrated near infrared fluorescence imaging system, which is capable of detecting infrared light reflected by indocyanine green (ICG). After intravenous injection, ICG distributes within seconds to minutes (maximum concentration in the lung after around 1 min) through the pulmonary arteries and can thus be helpful in the identification of the intersegmental plane during segmentectomy after ligation of the segments' arterial blood supply (19).

Future perspectives

More than 5 years ago, Intuitive in collaboration with Mimic®, released a dedicated Skills Simulator which allows surgeons to train their skills on the robotic console and get familiar with all the existing features the robotic platform has to offer. Furthermore recently Mimic released different Maestro AR™ (Augmented Reality) Modules, which even enable surgeons to train specific surgical procedures on the console and interact with anatomical regions within augmented 3D surgical video footage (available modules: Partial Nephrectomy, Hysterectomy, Inguinal Hernia Repair and Prostatectomy). In the near future hopefully also thoracic surgical procedure modules will be available in order to help improve the quality of the robotic surgical training for thoracic surgeons. But what we are really hoping and waiting for is the possibility to integrate patient data (i.e., preoperative CT-scan) into these simulations, in order to allow us to train a specific procedure on the console before even touching the patient. Furthermore, especially for more complex procedures such as anatomical segmentectomies, another future perspective is the creation of an augmented reality in which the anatomical structures (i.e., segmental artery, bronchus and vein) can be superimposed onto the real-time 3D image during the surgical procedure. Both aforementioned options would not only allow us to be perfectly prepared for any surgical procedure thanks to realistic training before surgery, but also would enable us to possibly anticipate and avoid intraoperative complications as the operating surgeon is fully aware of the given anatomy at any point of the surgical procedure.

All of the possible developments discussed above are mainly based on the already existing and/or possible developments of Intuitive and collaborators, but one also has to consider other companies that are soon entering the marked with their innovative robotic platforms (i.e., Senhance™ by TransEnterix, Inc.—with a similar Master and Slave design as the da Vinci platform). Furthermore Johnson & Johnson and Google announced in 2015 that they would be working on the development of a robotic platform which might be released in the near future. These new developments will hopefully not only reduce the cost of robotic surgery in general, in order to allow a more widespread use of this advanced technology, but also introduce new advanced features such as for example improved instruments, tactile feedback, "enhanced" reality and many more.

Bottom line

At the present time prospective multicenter randomized trials are needed in order to investigate for which kind of resections (segment and/or lobe) and for which tumor stages there are advantages of RATS over VATS, which could possibly justify the actual higher cost. Furthermore realistic simulations of thoracic surgical procedures are soon to become reality, which is an important step in the development of robotic thoracic surgical training programs. Further improvements in preoperative simulations with the integration of patient data combined with the availability of an augmented reality for specific 'tailored' operations could finally boost robotic surgery to the next level. However, one of the prerequisites for a more widespread use of this technology will be a markedly improved cost-effectiveness, which will hopefully evolve shortly not least because of a more vivid competition between the companies that manufacture robotic surgical platforms.

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Footnote

Conflicts of Interest: The author has no conflicts of interest to declare.

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