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Current 'robotic surgery': a real breakthrough or a misleading definition of laparoscopy with remote control of mechatronic instrumentation?

Most articles focused on robotics applied to general surgery and published in recent years give the overall impression that, at present, so-called robotic surgery is the best and most advanced surgical option in the treatment of many if not all major abdominal diseases. There are several reasons why this might be misleading. I will try to explain my concerns as a lover of new technologies and their application to surgery and as a surgeon who had the privilege of being an active member of and then chairing the Technology Committee of the European Association for Endoscopic Surgery for many years. I do this while aware my views might look upstream; nonetheless, I do hope to give readers some interesting food for thought.

Let me start with the first issue: the very definition of robotic surgery, as it is at present, is not realistic or true. As early as 1993, Richard Satava listed the existing grades of automation applied to surgery and its remote performance. They were (1) teleoperation, consisting in a master-slave one-to-one connection that allows the operator at the master console to manipulate the slave arms that reproduce his/her movements in the operatory field; (2) telerobotic surgery where the master only selects the task and the robotic arms perform it; (3) supervisory control, where the operation is independently programmed by the robot under master supervision during execution; (4) telepresence, where the master receives multisensorial inputs that create the illusion of being on the remote site; and (5) virtual reality (cyberspace), comprising a total sensorial immersion in an artificial world, simulating the real world, with the realistic illusion of manipulating imaginary objects [1,2].

Thus, all current so-called robotic procedures have nothing to do with true robots. Robots are autonomous machines that perform fixed (pre-programmed) tasks independently. We should better say we are performing telemanipulation surgery, with the major difference from a standard laparoscopic procedure being that the operator stands (sits) at a remote console instead of standing by the patient lying on the table (Satava grade 1 of automation). Furthermore, and this is a crucial issue, the arms reproduce the operator's movements, and the operator's intentions and strategies are fully respected. With a good surgeon working at the console, a good job will be done—without one, the procedure will be a bad procedure, notwithstanding the use of 'robotic technology'.

Lately, this concept has been very well expressed by Michel Gagner, who in an in-depth critical analysis of current robotic surgery calls it just a new laparoscopic-assisted approach [3]. This technology was introduced in the early nineties and was directly translated from technology used in nuclear facilities. At that time, I was working in Tuebingen with Gerhard Buess, who developed one of the first master-slave systems for surgical application, and I took part in the preliminary meetings at the Karlsruhe Nuclear Research Center when this project started and was implemented. Basically, current 'robotic systems' are not that different from those of about 25 years ago. What they need to make them true robotic surgery is the addition of artificial intelligence to enable possible improvement in surgical performance, the correction of wrong inputs/moves from the master console, or even superior intraoperative decision making. I do agree with Ugo Boggi when he writes in an editorial published at the end of 2021 that from the mechanical point of view the present systems are close to perfection [4]. The image provided is steady throughout the whole procedure, and systems provide wristed dexterity and adjust the hand-to-instrument movement ratio with significant tremor reduction at the instrument's tip. But we are mostly talking about hardware!

One of the added values of robotic technology is improved ergonomics that reduce surgeons' stress, stress response, and fatigue when performing defined tasks [5,6]. This is likely the only significant benefit that has been objectively proven in comparing current robotic surgery with standard laparoscopy. However, interestingly, subjective fatigue self-perception by surgeons does not match objective fatigue measurements, according to a study published in 2020 showing a significant decrease in self-reported fatigue after performing basic tasks by standard laparoscopy but not by working at a robotic console [7].

Finally, there is an ethical issue: most papers published on this subject fail to prove that 'robotic surgery' is superior to standard laparoscopic surgery, but the final take-home message always seems to be 'this is the best surgical approach' to use in treating our patients, and the patients themselves are misled with similar statements. This is true despite the present evidence. I will just mention the 2014 EAES consensus statement on the use of robotics in general surgery, a 2021 systematic review on the evidence behind robotic abdominopelvic surgery, and the 2019 EUnetHTA (European net Health Technology Assessment) on robot-assisted surgery in thoracic and visceral indications [8–10]. The eight conclusions of the latter report may

be summarized as follows: There is insufficient evidence that robotic surgery is superior to standard laparoscopic surgery, and there is evidence that there are increased costs and longer operating times. There is low-level evidence that robot-assisted rectal resection improves some aspects of quality of life but worsens others and that it may increase intraoperative complications and decrease postoperative complications. There is low-level evidence that robot-assisted gastrectomy may reduce postoperative complications compared with standard laparoscopy [10]. These are the facts!

I have read several assertive sentences by enthusiastic colleagues, such as this one from the above-mentioned editorial: '… it is clear that robotic assistance in surgery is essential, especially for complex procedures requiring fine intracorporeal dissections and multiple or delicate reconstruction' [4]. There is no scientific evidence in the past and present medical literature that gives strength to such a statement. What we should stress instead is that we might need current robotic surgical systems when performing procedures with limited access or in a reduced space, and when we have to overcome physical limitations such as those of single access or transanal surgery, and in thoracoscopic surgery when the ribcage further limits the freedom of movement possible in a minimally invasive approach [11]. They may also be needed when the surgeon is presented with difficulties that either cannot be overcome by human hands driving instruments with few degrees of freedom or that might require maneuvers demanding inordinately high skill or posing excessive risk. This means that we should properly define the real and effective clinical indications of current robotic surgery, keeping in mind that, at present, whenever we are performing minimally invasive surgery through a robotic approach we are most likely increasing treatment and overall health-care costs [10].

So what's left? The basic goal of robotic surgery systems is to reproduce in a closed cavity the degrees of freedom of human hands. To do that with optimal control we need 3D imaging. The integration of mechatronics and advanced imaging technologies has been an unavoidable consequence. 'Robotic surgery' may be not the present reality but most likely will be the future of surgery. While there is still a long road to run, to implement miniaturization, embed sensors for haptic feedback, add artificial intelligence to enhance the effectiveness of surgical tasks, and improve existing augmented-reality modules, robotics will be the core technology in future operating theatres, and this will happen within a few decades. We do need centers where this technology may be further developed and applied. What we do not need is to give readers and patients misleading, if not wrong, messages: this is not only scientifically improper but even counterproductive to the ideal development and dissemination of robotic technology.

Disclosure statement

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