

The widespread of Robot-Assisted Surgery: the urologist perspective

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Since its introduction, the Robot-Assisted Surgery (RAS), application has been extremely rapid and constant in medicine (1-3). Currently, surgeons can use robotic technology for almost any district, both using endoscopic or trans-cutaneous devices of many different developmental generations (4-6). RAS allows to maintain the benefits of laparoscopy with additional advantages including magnification of operative field due to three-dimensional vision, greater accuracy to perform the challenging task of suturing by the wristed technology of the instruments with seven degrees of motion, primary surgeon camera control, tremor filtration (1, 3).

The introduction of novel technologies in the operating theatre opens new questions on how much and in which way the safety can be further improved in enhancing the capabilities of surgeons with different degrees of experience. These had provided not only direct patient advantages but also process-specific support in the surgical field (7-9).

The historical main disadvantages referred to robotic surgery are the lack of haptic feedback, the image processing, and the high costs. However, recently introduced technology provides to the surgeon's fingertip with pneumatic actuators and vibratory motors multimodal haptic feedback, including normal force, vibratory feedback and kinesthetic feedback, mounted on the master console. This system is capable of inducing a significant reduction in grip force, reduced visual-perceptual mismatch, decreased suture failure, enhanced knot quality, and

superior tissue characterization. Kinematic analysis is conducted to optimize the workspace and the surgical instruments enable multi-axis force sensing, including three-axis pulling force and single-axis gripping force (10-12).

Concerning the image processing the magnified, three-dimensional stereo-endoscope vision is superior to the conventional laparoscopy (bi-dimensional images). Furthermore, the application of Augmented Reality (AR) tools could represent a relevant step towards safer clinical procedures, improving the quality of healthcare. This technology permits to model an AR, with new advanced machine vision algorithms, by leveraging the intraoperative high-resolution optical surface data acquired from the patient. As a consequence, RAS permits to reproduce the same surgical step of open surgery with the benefits of the minimally invasive technique, overcoming some limitations of the laparoscopy: in particular, RAS allows to reduce physical strain and to simplify the learning curve.

Surgeon and support staff training includes learning the operation of the system and leverages existing laparoscopic technique and equipment (13, 14).

Thanks to more accurate dissection of tissues, lower bleeding, and less ischemic suture, robotic surgery allows reducing the presence of necrotic tissue and hematomas. This leads to less systemic stress, improved immunologic response, and less local tissue trauma. It was also demonstrated to reduce the blood loss with respect to open surgery: this allows to maintain higher serum levels of albumin and globulin necessary for controlling infection through the immune system; moreover, mini-invasive surgery (MIS) was associated with lower rate of transfusion.

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RAS has become the gold standard approach for the treatment of many urological diseases. In particular, the robotic approach is currently applied in more than half of patients undergoing surgery for prostate, kidney and bladder carcinoma, according to data from North American and European population-based registries (2, 15, 16). Because of the increasing diffusion and its continuous technological innovations, the applications of RAS has been further extended. The safety and feasibility of robotic treatment of metastasis, paraganglioma, colovesical fistula, retroperitoneal lymph nodes have been recently reported (17-19).

Surely the use of robotics turns out to be particularly advantageous as regards the pelvic district. Not by chance, Robot-Assisted Radical Prostatectomy (RARP) has become the gold standard in the treatment of prostate cancer, ensuring exciting results in terms of intraoperative blood loss, transfusion rates, duration of catheterization, length of hospital stay, readmission rates (20). Concerning functional outcomes, these results are due to better visualization of vascular and nervous structures and more accurate dissection: this allows better preservation of anatomic components that control potency and urinary continence (20-22). The expected advantages of robotic surgery seem to influence particularly early recovery of both potency and urinary continence recovery. Conversely, Open Radical Cystectomy (ORC) still represents the gold standard treatment of muscle-invasive bladder cancer and BCG resistant non-muscle-invasive one (23). Recently, a systematic review and meta-analysis comparing open RC with Robot-Assisted Radical Cystectomy (RARC) find out similar oncologic outcomes in terms of positive surgical margins, overall survival, cancer-specific survival, and recurrence-free survival; compared to open, RARC showed longer operative time and 1 to 1,5 days shorter mean length of hospital stay. Intra-operative, 30-day complication rate and mortality were similar, but grade 3, 90-day, complication rates favored robotic technique. Lower blood loss and consequently transfusion rate was significantly lower in robotic RC and this finding is due to better visualization of the operative field and to more accurate dissection in demolition

time of intervention (24). However, RARC is actually reported in the European Association of Urology Guidelines as an experimental procedure.

Concerning the kidney cancer, Robot-Assisted Partial Nephrectomy (RAPN) is the gold standard treatment of T1 renal tumor, with reduced ischemia time (25). Nevertheless, many different laparoscopic techniques of partial nephrectomy are reported in Literature and it has now been demonstrated that in some cases renal ischemia could be carried out only on demand (26). However, postoperative renal damage is mainly due to the quantity of preserved healthy parenchyma. Although there are no trials evaluating the possible relation between the type of suture, remaining healthy tissue and postoperative renal function, a more accurate suture of resection bed with respect to laparoscopy can be achieved using robotic approach. Evenly, Robot-assisted pyeloplasty has shown excellent results with a success rate ranging from 94 to 100%. However, in a recent systematic revision of the Literature and meta-analysis comparing clinical outcomes of 277 robotic pyeloplasties with 196 laparoscopic ones no significant differences were observed between the two procedures except shorter operative time for the robotic technique (27).

Concerning adrenal surgery, the laparoscopic approach is today the standard procedure. Nevertheless, many trials showed exciting results when the adrenalectomy was performed by robotic technique. The main advantages allow more carefully to detect the adrenal vascular pedicles as well as to identify the cleavage plane between tumor and healthy tissue as suggested in a recent meta-analysis (28).

The application of robotic approach guarantees better functional results in urological procedures, reducing bothersome surgical induced side effects. We can say that robotic surgery seems to offer particular advantages in localized or early-stage diseases. An early diagnosis will allow treating a greater number of patients by less destructive and oncologically safe surgery (22). Therefore, the future perspective should address to the development of new and more accurate biomolecular markers to reduce cancer-specific mortality, improving patients' quality of life (29-32).

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