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Technology Innovations in Urology

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Abstract

Technological developments have entered our daily lives, and they have made many innovations possible in urology. Over the last decade, robotic surgical technology has had significant impact on clinical practice. Techniques that require microsurgical precision and advanced reconstructive skills and inaccessible areas of surgery can be optimized with the help of robotic surgery. This new robotic technology has led to the use of the laparoscopic surgeon in lifting the limitations of the urologist in daily practice. The source data obtained by the imaging methods are visualized in two dimensions. With finite processing tools and algorithms, it is possible to produce multiplane reformations and three-dimensional views of the anatomy. Anatomical three-dimensional models are used to help complex operations, implement precise training procedures, and understand the patient's preoperative surgery better. In addition to technological improvements, standard percutaneous nephrolithotomy operations were evolved into miniperc, microperc, and ultraminiperc, which were also suitable for stone volume. Thus, operation-related injuries in the kidney were reduced. Proliferation of the mpMRG system with recent advances in technology has allowed us to examine the prostate in detail. With the introduction of the mPMRG-derived data in the prostate biopsy, steps have been taken to directly remove the prostate biopsy sample from the tumor tissue. This method allows the biopsy sample to be directly taken from the area, which is a radiologically suspected cancer. The future of medical treatments goes beyond "minimally invasive surgery." A more complex approach involving new variables, such as new imaging, gene coding, molecular biology, nanotechnology, and tissue environment is certainly ahead.

Keywords: Innovation, technology, urology

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INTRODUCTION

Although technological developments have entered our daily lives, there have been many innovations also in the field of urology. The developing technology creates different usage areas. We have tried to summarize the surgical use of robotic technology, which is one of primary innovations of current medicine in urological diagnosis and treatment, the use of 3D printers, the process of taking tissue from tumoral focus with the MR fusion biopsy for diagnosis, and the use of developments of minimization in endoscopic surgeries in urology.

The Use of Robotics in Urology

Robotic surgery is often described as revolutionary. Over the past decade, it has been surgically applied. Eagerness to renew the technology, consideration of the laparoscopic surgery's limitations, easy acceptance of robotic technology by surgeons, and attractive marketing has resulted in the use of the robot in our daily practice. The long-term results of procedures performed with robotic surgery technique are published in the literature, and a critical analysis of these data continues to define the role of robots in clinical practice.

Surgical application of robotic technology has been developed over the last 30 years, but clinical practice has had a significant impact in the last 10 years. Surgical techniques that require microsurgical sensitivity and advanced reconstructive skills and inaccessible surgical sites can be optimized by robotic surgery. Advanced robotic surgical systems, such as Da Vinci are effectively equipped with three-dimensional (3D) and high-resolution (HD) visualization, advanced manual skill, ergonomic position, elimination of vibrations, and scalability of movements. To overcome some of the limitations of traditional laparoscopy, urologists have now embraced surgical robots. In many parts of the world, the robot-assisted urological surgeries have become everyday clinical practice (1).

Experienced centers in robotic surgeries applied clinical application to other minimally invasive urological surgeries. In addition to its widespread use in oncologic surgery, pyeloplasty, ureteral reimplantation, appendicovesicostomy, and augmentation enterocystoplasty are increasingly being performed with robotic assistance. The long-term results will describe the role of robots in these operations (1).

Minimally invasive laparoscopic techniques have replaced many open urological surgeries. The addition of robotic assistance has enabled surgeons to progress and overcome many technical limitations of traditional laparoscopy. The long-term results of robot-assisted urological surgery are comparable to those of traditional open surgical methods. According to currently collected data, they have been shown to be associated with fewer complications. Surgical robots continue to develop everyday. The robotic engineers are working hard to synthesize and evaluate robotic platforms, to make equipment smaller, to develop robotic surgery experience, and to develop flexible tools and new technologies to broaden the practice (1).

Use of 3D Printers in Urology

Rapid advances in medical imaging have revolutionized the field of medicine. Computed tomography (CT), magnetic resonance imaging (MRI), and other imaging methods noninvasively allow for a more detailed view of the anatomy of an object and to perform field and volume measurements on it. This plays an active role in helping scientists and physicians almost communicate with anatomical structures and learn potentially life-saving information. Today, the role of medical imaging is not limited to simple visualization and observation of anatomical structures. It is used in areas such as disease diagnosis, advanced surgery planning and simulation, and radiotherapy planning (2).

The source data obtained by any imaging method is typically visualized in two dimensions. It is possible to produce multi-planar reformations and 3D views of anatomy with finishing tools and algorithms. The process chain from image acquisition to the production of a 3D rapid prototype model consists of three stages. It will be discussed in detail in the following sections: "Image capture," "processing after image," and "3D printing" (3).

In urology, 3D printing is used for patient information, assistant training, and preoperative planning. The 3D models of the pelvicalyceal system structure and stone volume were formed by using the data obtained from the CT images particularly before percutaneous nephrolithotomy (PNL) operations. These models provide additional information about the different possible operative approaches, and they are useful in the rehearsal and modification of the operative technique (4).

Anatomically, the creation of 3D models that are anatomically identical to the patient's kidney collecting system demonstrates that it is a more effective way of learning for assistants than the traditional imaging methods are. It is evident that the assistants can understand kidney anatomy, calyx number and placement, and preference of appropriate access by using models created by 3D printing method better than preoperative evaluation performed by using traditional imaging models. It increases self-confidence of the assistant during the surgery (5).

3D printing, when combined with medical imaging, is a powerful diagnostic tool. It contributes to assistant education. Anatomical 3D models are visually used to assist in complex surgeries, to perform delicate procedures for educational purposes, and to help patient better understand the process preoperatively. As both medical imaging and 3D printer technology continue to progress, new opportunities for combined usages in urology will arise (2).

Minimization in Urological Surgery

Over the past decade, the indications for PNL have seen a paradigm shift. In previous years, the PNL was performed for complex multiple calculus and large-volume stones, such as staghorn calculi. Several studies confirmed that reducing the size of the tract decreased potentially percutaneous surgical complications (6). This led to the concept of the miniaturization in urological surgery. Smaller sheaths, smaller endoscopes, and miniaturization of the tools in the development of energy resources emerged. The miniaturization of the surgical instruments was also responsible for the paradigm shift in the PNL operations. These miniature instruments and accessories have eliminated the need to expand the path by more than 20 Fr (7).

With technological developments, the standard PNL operations have been evolved into miniperc, microperc, and ultimately ultraminiperc in ones with suitable stone volume. The use of tiny instruments has been very useful especially in the pediatric patient group. Thus, postoperative bleeding rates and the damage caused by the operation in the kidney decreased. The most important component of the ultraminiperc, which has the narrowest canals, is a new 6-Fr miniperoscope. This miniperoscope can be passed through an 11-14-Fr metal sheath. The stones are broken by laser. One-step dilatation can be performed under ultrasound or fluoroscopy control. A unique feature of this technique is the availability of the lateral canal on the metal sheath. This can be used for irrigation and/or removal of fragmented stones (8).

Standard PNL is used in the treatment of stones larger than 2 cm in size. New techniques with miniperc are suitable for stones 1.5-2 cm in size. Microperc and ultraminiperc can be suitable for stones <1.5 cm in size. They are also suitable for special conditions, such as diverticular stones and pediatric mid-size stones (7).

MR-Transrectal Ultrasound (TRUS) Fusion Biopsy

Prostate biopsy is the standard method to diagnose prostate cancer, which constitutes 15% of all cancers diagnosed among men in the world. A standard prostate biopsy is the systematic tissue sampling from the prostate under the guidance of TRUS. Tissue is taken from at least 12 foci. However, this method has its limitations. Cancerous tissue cells cannot be obtained from randomly taken samples. In addition to the possibility of standard biopsy to overlook cancer, it may also not detect "clinically insignificant cancer," which does not cause problems to the patient throughout life (9). With the development of technologies in recent years, the increased use of multiparametric prostate magnetic resonance imaging (mpMRI) system has enabled the prostate to be examined in detail. With the adaptation of the data obtained by mpMRG to prostate biopsy, steps were taken to take the prostate biopsy directly from the tumoral tissue. The most advanced method in this regard is MR-TRUS fusion biopsy. In this method, the images of the patient who underwent mpMRI are processed with computer software programs, and a 3D prostate is created. Then, the data are transferred to the TRUS device, where the biopsy is performed using a special biopsy platform and software. The images obtained from the TRUS device used during the biopsy are given a 3D form by the same device, and the MRI and TRUS images are overlapped to perform the process of fusion. With the help of a robotic arm, samples are taken from the areas determined with the help of MR and TRUS images and marked. This method allows us to take biopsy directly from the area having radiologically suspected cancer, and to minimize the likelihood of the detection of clinically insignificant cancer (10).

CONCLUSION

We live in a world with fast and compelling changes. Technological developments come and go, but robotics technology will continue to remain in the practice of medical procedures. In addition, robotic applications at this point, miniaturizations in surgical instruments, 3D technologies, and innovations in imaging methods represent the infancy of technology, and they are open to growth. The technological future developments of these innovations can be scaled to potentially unimaginable heights. We expect much more advanced robotic interfaces and even robots combined with imaging and energies, which aim to provide accurate and reliable treatments to be precisely targeted with biogenetic information. The future of medical treatments goes beyond the "minimally invasive surgery" and a more complex approach that includes new variables, such as new imaging, gene code, molecular biology, nanotechnology, and tissue environment is certainly ahead of us.

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