The era of robotic flexible ureteroscopic management of urinary calculi and the domain of ‘surgeons’ in the endoscopic surgical procedures

INTRODUCTION

The surgical treatment method for urolithiasis started with open nephro- or ureterolithotomy. It gradually improved in a less-invasive direction with the advancement of endoscopic technology and eventually developed into endoscopic surgery using a natural orifice [1]. Urolithiasis is biomineralization caused by the biochemical aggregation of supersaturated crystals of urine excreted from the glomeruli, collecting tubules, and papilla into the renal collecting system [2].

The treatment of urolithiasis is a complex process that requires the appropriate application of treatment methods with various levels of surgical difficulty in consideration of the nature and size of the stone, different anatomical characteristics and variations, etc.

Accordingly, various treatment methods such as extracorporeal shock wave lithotripsy, ureteroscopy, laparoscopic nephro- or ureterolithotomy, and percutaneous nephro- or ureterolithotomy have been applied in the last several decades. Eventually, approaching all the complex calyceal structures is directly related to the success rate and the safety of stone surgery [3].

DOMAINS OF ENDOSCOPIC SURGICAL PROCEDURES FOR STONE REMOVAL AND WHAT THE ‘CONVENTIONAL FLEXIBLE URETEROSCOPIC SURGERY’ IS

The surgical procedures for stone removal are the field in which the combined system of domains such as the surgeon, hardware of the endoscopic tower, stone crushing energy source, concomitant irrigation system, and disposable auxiliary equipment such as stone basket, guidewire, stent, etc.

The decisive change was the development of an outstanding flexible ureteroscope that is feasible with excellent usability, like the Flex-X2® (KARL STORZ, Tuttlingen, Germany), which can access all of the complex calyceal structures with the primary deflection. Since then, the surgical treatment of kidney stones has been rapidly developing. In Korea, the first abstract about the use of a flexible ureteroscope was published in 2001. It achieved explosive growth in stone surgery in around 2010 because of the improvements in the endoscopic performance as well as advances in the therapeutic armamentarium [4]. As a result, managing multiple renal stones in various calyces was replaced mainly by surgical methods using flexible ureteroscopes [4].

However, there are many issues to overcome the limitations of ‘conventional’ retrograde intrarenal surgery. The challenge in the endoscope domain is the mechanical limitations of technology in the flexible ureteroscopes, such as the low durability and cost-effectiveness of recycled endoscopes. One of the limitations of the energy source domain is the low energy efficiency of removing large stones. Currently, the issues in the surgeon’s domain are work-related musculoskeletal fatigue and radiation exposure risk. The combination of the prolonged standing and static postures under wearing heavy protective lead gowns, as well as the repetitive action of stepping on foot pedals coupled with continuous strain on muscles of the wrist and thumb, and the knee pain while holding the endoscope, undoubtedly have had detrimental effects on surgeons physically [5].

The shortcomings related to the heavy weight of the flexible endoscopes have been gradually improving because of the spread of digital endoscopes and disposable endoscopes, as well as the development of new laser or focused ultrasound with less prolonged operative time, excluding the ‘surgeon’ domain [6]. Additionally, percutaneous renal
surgery, the first treatment of choice for large renal stones, has been partially replaced by flexible endoscopic surgery because of the safety issues associated with complications such as massive bleeding and morbidity. New high-efficiency lasers are expected to drive this trend with improved stone fragmentation efficiency.

EMERGING TECHNOLOGY OF ROBOTIC FLEXIBLE URETEROSCOPIC SYSTEM AND THE ‘SURGEON’ DOMAIN

The state-of-the-art robotic surgical systems that can rapidly upgrade the ‘Surgeon’ domain of endoscopic surgical procedures for stone removal have been introduced in urology. The robotic systems have been receiving much attention as it is linked with the development of the da Vinci robot in the field of urologic laparoscopy.

To date, various flexible ureteroscopic robots have been released, and these robots have different specifications depending on each company’s technology. All of these systems are expected to improve the operator’s surgical convenience. They are progressing toward maximizing convenience by providing integrated functions to the surgeon sitting in the master console. The master console provides a handle controller that enables an operator to teleoperate with the ureteroscope, a stone basket, a laser fiber, and an irrigation system. Since the system integrates the control of a stone basket and a laser fiber, the operator can perform laser dusting and stone retrieval techniques in the master console. The location of the laser fiber tip is fixed, and stable endoscopic fragmentation is available. In addition, the system has an automated path-finding capability that can record and play the ureteroscopic motion, which can be effectively activated in a repetitive task of multiple stone retrieval. The system provides a safety function that detects the grasping and retrieving of an oversized stone to avoid ureteral injury or ureteral avulsion compared to the diameter of the ureteral access sheath. And we can imagine remote surgery by using the robotic platform in the future.

The robotic flexible ureteroscopic system reduces musculoskeletal or articular fatigue and mental fatigue for surgeons through automated procedural functions. It is also beneficial regarding less radiation exposure, stable endoscopic movements, and easier control of energy sources or the irrigation system. These advantages and the improved video system are leading to changes that bring significant advances to the ‘surgeon’ domain.

LIMITATIONS

Endoscopic stone surgery is expected to continue development in the future to improve safety by reducing complications such as bleeding and urinary tract infection and improving efficiency through technological advancements such as better endoscopes and energy equipment. The indications of flexible ureteroscopic surgery are expected to expand further as technology advances. In the past, innovative techniques such as trans-urethroscope or laparoscope were introduced as a human treatment modality and always confronted with similar debates until they were recognized as the standard of care [7]. Now, it is our responsibility to observe and deduce the surgical outcomes as real-world evidence if robotic flexible ureteroscopic surgery, which is as clear as its pros and cons, pushes it aside and proudly replaces it, by adding a new modifier such as “conventional or classical” in front of the hand-held retrograde intrarenal surgery.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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AUTHORS’ CONTRIBUTIONS

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