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Review Article

Research progress on surgical factors related to early urinary control after laparoscopic radical prostatectomy

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Abstract: Radical resection of prostate cancer is the first choice for the treatment of early localized prostate cancer, but urinary incontinence is prone to occur after the operation, especially early urinary incontinence, which seriously affects the quality of life of patients. This article discusses the surgical methods, approaches, and techniques to clarify the effects of surgical-related factors on early postoperative urinary control, in order to provide the best treatment for patients with prostate cancer.

Keywords: Prostate cancer, laparoscopic radical prostatectomy, early urinary control

Introduction

Prostate cancer is the most common malignancy among middle-aged and elderly men [1]. The choice of treatment methods differs according to the different clinical stages. One or more methods such as surgery, endocrine therapy, radiotherapy, and chemotherapy can be used for treatment. Radical prostatectomy (RP) is the primary treatment for early localized prostate cancer [2]. The incidence of postoperative urinary incontinence, especially early urinary incontinence, is very high, which seriously affects the quality of life and mental health of patients. The occurrence of urinary incontinence after RP is related to a variety of factors (e.g., general state, surgical method and approach, surgical technique, postoperative recovery). This article reviews the factors related to postoperative urinary control after RP.

Operation mode

RP can be divided into traditional open surgery, laparoscopic surgery, and robot-assisted laparoscopic surgery according to the different surgical instruments used. In 1992, some scholars took the lead in completing laparoscopic RP (LRP), and then Gaston standardized LRP in 1997 [3]. With the popularization of technology, LRP is widely performed in large medical centers worldwide. Compared with open RP, LRP can significantly reduce intraoperative bleeding and postoperative complications. With the continuous progress of medicine and science and technology, to meet the needs of minimally invasive and accurate surgery, robot-assisted LRP (RALRP) was developed. In 2001, Binder et al. [4] first reported RALRP. Compared with LRP, RALRP has the following advantages. (1) The Da Vinci robot has high resolution and stereoscopic vision, which is convenient for the operator to accurately identify important organs, blood vessels, nerves, and other anatomical structures in the pelvis. (2) Robotic laparoscopy has seven mechanical wrists with high degrees of freedom, which greatly reduce the difficulty of laparoscopic suture and increase the accuracy of anastomosis. (3) The manipulator operates flexibly in the narrow pelvic space, which improves the operator's control and greatly reduces the operation time. (4) The handshake of the operator can be filtered out by the mechanical arm, making the separation more precise during the operation and preserving the important anatomical structure [5]. RALAP is gradually replacing LRP as the preferred treatment for prostate cancer.

Surgical approach

Different surgical approaches to treat the same disease are the result of continuous exploration and innovation by urologists in the field of prostate cancer diagnosis and treatment. In 2001, Binder et al. [4] reported for the first time that RALRP is still conducted in a forward approach. Due to the separation of more peripheral tissues of the prostate, normal blood vessels and nerve bundles are destroyed, and the postoperative urinary control and erectile function of the patient are disturbed. Galfano et al. [6] proposed the posterior RALRP approach (i.e., Bocciardi approach) 9 years later. The anterior approach RALRP is similar to that of traditional LRP, which is suitable for operators who have little experience with RALRP. The main feature of the anterior approach RALRP is to open the Retzius space, and then cut the pelvic floor fascia and suture the dorsal deep vein complex (DVC). During the operation, the pubic prostate ligament is cut off, the prostatic venous plexus is damaged [7], and a series of urethral support structures that are important for urinary control are damaged. Compared with the traditional anterior approach, preserving the Retzius space is the biggest feature of the posterior RALRP approach [8-10], thus avoiding damage to the pubic prostate ligament, numerous small blood vessels, and other supporting structures in this space. Preservation of the DVC during surgery also protects the urethral sphincter below [11], which has a positive role in the recovery of postoperative urinary control in patients with RALRP [12-14]. Because the Retzius space is reserved, the posterior RALRP approach requires the operator to have superior anatomical skills and rich surgical experience. At the same time, due to the narrow operating space, the difficulty of the operation is significantly increased. Therefore, preoperative digital rectal examination and imaging evaluation can clarify the size of the prostate and its relationship with adjacent tissues and organs, and provide a meaningful reference for the selection of RALRP operation. Surgeons should pay attention to whether the anterior or posterior approach is selected, and the tumor-free principle is fundamental. The ultimate goal of surgery is to retain the normal anatomical structure as much as possible and restore urinary control and sexual function as soon as possible while completely resecting the tumor. Urologists should select appropriate surgical methods and approaches according to the patient's condition and their own surgical experience [15].

Operation skills

The intraoperative techniques vary according to the experience of the operator. The operative techniques for improving postoperative urinary control during RP surgery mainly include two aspects: (1) retaining anatomical structures with urinary control function such as the urethral sphincter and related nerve vessels, functional urethra of sufficient length, bladder neck, pubic prostate ligament neurovascular bundles (NVBs), and the lateral fascia of prostate; and (2) reconstruction of the tissue structure related to urinary control [16]. Studies have shown that there are many ways to improve urinary control rate after RP, of which the most mainstream approaches are anterior, posterior, total, and anatomical total reconstruction.

Retaining anatomical structure with urinary control function

Pubic prostate ligament: The pubic prostate ligament is located outside the pubic symphysis and at the junction of the external urethral sphincter and the prostate. It starts from the pelvic fascia and ends below the pubic bone. It can support the external sphincter and maintain the position of the urethra at the pelvic floor. Initially, it was believed that the pubic prostate ligament was on the surface of the prostate, so it was named the pubic prostate ligament. With subsequent research, it was found that the pubic bone and anterior wall of the bladder are connected through this ligament. Therefore, some scholars suggested that it should be renamed the pubic bladder ligament, which is still called by clinicians at present. Some studies have found that preserving the pubic prostate ligament is conducive to maintaining the integrity of the anterior urethra to the greatest extent, and is beneficial to the early recovery of urine control after surgery.

Bladder neck: The bladder neck is composed of the bladder detrusor, internal urethral sphincter, and proximal prostate tissue. The internal sphincter of the urethra is involuntary and is in a tense state in the urine storage period, playing a very important role in urine control. At the same time, it can close the bladder neck and prevent retrograde ejaculation during ejaculation, which is of great significance for maintaining normal sexual activity. Therefore, to improve postoperative continence, it is necessary to preserve the bladder neck during RP. Nyarangi-Dix et al. [17] reported that 85% of patients with an intact bladder neck can achieve urine control within 3 months after surgery. Meta-analyses have shown that the urinary control of patients after 3 to 6 months of operation has been significantly improved by using bladder neck retention technology, but there is no significant difference in urinary control 2 years after operation.

Functional urethral length: The functional urethra is a part of the posterior urethra. There is an external urethral sphincter in this segment of the urethra, which can increase the effective resting pressure of the urethra, improve the tension of the urethra, and is one of the important factors for effective urinary control. When the functional urethral elasticity decreases, the abdominal (pelvic) internal pressure and pressure of the external urethral sphincter cannot completely close it, which affects urine control [18]. Preservation of functional urethra with sufficient length during RP is beneficial to the early recovery of urine control after operation. Because 10-40% of the functional urethra is covered by the tip of the prostate, to extend the length of this segment of urethra as much as possible, preserving the membranous urethra in the prostate is the key operation. Therefore, it is necessary to accurately identify the anatomy of the junction between the membranous urethra and the tip of the prostate during the operation. Preoperative imaging examination is helpful to determine the length of the functional urethra and the shape of the tip of the prostate, which is very useful for preserving the functional urethra as much as possible during the operation. Schlomm et al. [19] used the stratified anatomical separation method to expose the striated sphincter and smooth sphincter layer by layer, and preserve the full length of the functional urethra. After pulling out the catheter for 1 week, the complete urinary control rate reached 50.1%, and the social urinary control rate was about 76.2%. Nakane et al. [20] used magnetic resonance to measure the length of the membranous urethra and found that the average membranous urethra length was 18.5 mm in patients with early recovery of urinary control function, while 16.9 mm in patients with delayed recovery, with a statistically significant difference (P=0.038). However, preserving the functional urethra as long as possible will also increase the positive rate of the incision margin [21]. Therefore, it is necessary to accurately evaluate the tumor stage before operation, and even determine the length of the functional urethra in combination with the rapid pathology during operation.

NVB: Many studies have shown that retaining NVB has a clear role in urine control after RP, especially in early urine control [22]. Prostatectomy usually has three routes, namely, extrafascial, interfascial, and intrafascial resection. Intrafascial resection is mainly performed along the surface of the pseudocapsule of the prostate, preserving the anterior, posterior, and posterior fascia of the prostate fascia (PPF)/peripheral fascia of the prostate in front of the seminal vesicle fascia (SVF), so that NVB is completely preserved. The plane of interfascial resection is between the peripheral fascia of the prostate. Due to the different layers of resection, the integrity of the preserved NVB is different. Interfascial resection is safer than intrafascial resection in tumor control. Extrafascial resection is mainly performed along the posterior side of the levator ani muscle fascia and PPF/SVF. This operation can achieve the most satisfactory tumor control effect, but NVB is completely removed. If this operation is performed on both sides of the prostate, it will lead to complete erectile dysfunction [23]. Unlike patients with prostate cancer in developed countries in Europe and the United States, the grading of prostate cancer patients in China is high and the stage is late. It is very difficult to retain NVB completely. Meta-analyses have shown that if baseline is postoperative urine control after bilateral intrafascial resection (maximum preservation of bilateral NVB); the risk of postoperative urinary incontinence is 2.8 if NVB is not reserved on both sides; the risk of partial NVB reserved on one side is 2.0 and the risk of bilateral interfascial resection (partial NVB reserved on both sides) is 1.6; and if there is interfascial resection on one side and intrafascial resection on the other side (one side is completely reserved, one side is partially reserved), the risk is 1.03 [24]. Therefore, NVB plays an important role in postoperative urine control. Urologists should consider the local condition of the patient's tumor, and based on the principle of no tumor, completely resect the tumor as far as possible and retain the NVB.

Reconstruction of tissue structure related to urethra

Rear reconstruction: Posterior reconstruction includes restoring the continuity of Di's fascia and reconstructing the supporting structure of the posterior triangle of the bladder. After complete resection of the prostate, reconstruction of the posterior urethra can provide support for the posterior wall of the urethra, prevent the contraction of the urethra, and improve the tension of the pelvic floor and sphincter. Therefore, the early urinary control rate of the reconstruction group was significantly higher than that of the non-reconstruction group, and the urinary incontinence rate was significantly lower, whether the double-layer posterior reconstruction of Coelho et al. [25] or the complete posterior reconstruction of Dalmoro et al. [26] was used.

Reconstruction: Anterior reconstruction is used to reconstruct the supporting structure in front of the prostate, such as preserving or reconstructing the pubic prostate ligament and suspending the deep DVC or suspension of bladder neck [27]. Through anterior reconstruction, the urethra and urethral sphincter are kept in the normal anatomical position, and support is provided for the anterior wall of the urethra to improve the urine control and improve the postoperative urine control rate of patients. There are no relevant randomized controlled trials (RCTs) on anterior reconstruction only, and existing RCTs have mainly focused on joint reconstruction of the anterior and posterior sides [28]. The goal of anterior reconstruction is to fix the anastomosis on the supporting structure in front of it, reduce the pressure of intra-abdominal pressure on the anastomosis, and reduce postoperative urinary incontinence [29].

Total reconstruction and anatomical total reconstruction: Tewari et al. [30] first proposed the concept of total reconstruction, believing that it was necessary to adopt techniques such as preserving the pelvic fascia, pubic prostate ligament, anterior suspension, and arch tendon reconstruction on the basis of anterior and posterior reconstruction. The concept of total pelvic floor reconstruction was proposed by Hoshi et al. [31]. With the exception of slightly different expression methods, its content is basically the same as that of total reconstruction. Complete anatomical reconstruction was first elaborated by Porpiglia et al. [32], which added techniques such as preserving the bladder neck and anterior multi layer reconstruction to complete reconstruction. Anatomic total reconstruction not only emphasizes reconstruction but also preserves normal anatomical structures such as pubic prostate ligament, functional urethra, and NVB. Therefore, anatomical total reconstruction includes both the preservation and reconstruction of anatomical structures. Porpiglia et al. carried out a retrospective non-randomized study on 252 patients with anatomical total reconstruction and found that the urinary control rates were 71.7%, 77.8%, 89.3%, 94.4%, and 98.0% immediately and at 1, 4, 3, and 6 months, respectively, after removal of the catheter 5 to 7 days after the operation, which was superior to previous literature reports. The incidence of postoperative complications of anatomical total reconstruction is extremely low. Only 3.2% of patients have urinary retention and 1.2% have urinary fistula within 6 months after the operation.

Summary

RP has become one of the most difficult operations in urology because of the complex anatomical structure of the prostate, narrow surgical field, and the need to reconstruct the urethra. The positive surgical margin after RP, recovery of postoperative urinary control, preservation of sexual function, and postoperative biochemical recurrence have become the most concerning aspects [33]. Especially, early postoperative urinary incontinence is the most common complication after RP, and has become an important factor affecting the quality of life of patients and disturbing mental health [34]. To achieve a good early postoperative urinary control effect, urologists should continuously improve their surgical skills. The key points of intraoperative operation are mainly focused on protection and reconstruction. With the progress of science and technology, robotic laparoscopic technology provides a new platform for achieving more accurate and minimally invasive surgical treatment of prostate cancer. In clinical work, urologists should formulate personalized surgical plans based on the patient's physical conditions, tumor characteristics, and other conditions to provide the most ideal results to patients with prostate cancer.

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Disclosure of conflict of interest

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