ORIGINAL RESEARCH ARTICLE

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Comparative Analysis of Clinical Efficacy Between 3D and 2D Laparoscopic Radical Prostatectomy (LRP) for Prostate Cancer

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Abstract: Objective: To compare and analyze the clinical efficacy of 3D and 2D laparoscopic radical prostatectomy (LRP) in treating prostate cancer. **Methods:** Seventy prostate cancer patients admitted to our hospital from January 2019 to January 2024 were randomly divided into a control group (n = 35) and an observation group (n = 35). The control group underwent 2D-LRP, while the observation group received 3D-LRP. **Results:** Compared to the control group, the observation group demonstrated better therapeutic outcomes and a lower incidence of urinary incontinence ($P < 0.05$). The observation group also exhibited significantly reduced intraoperative blood loss, operative time, urethral reconstruction time, and catheterization duration ($P < 0.05$). **Conclusion:** Compared to 2D-LRP, 3D-LRP offers higher efficacy and safety in the treatment of prostate cancer, with added benefits for postoperative recovery.

Keywords: 3D; 2D; Laparoscopic Radical Prostatectomy; Prostate Cancer

Introduction

Prostate cancer, as one of the most common solid organ malignancies, ranks as the second leading cause of cancer-related deaths among men. Radical prostatectomy is an effective treatment method that significantly improves patients' quality of life and extends survival time[1]. In recent years, with the continuous advancement of laparoscopic technology, laparoscopic radical prostatectomy (LRP) has become a crucial approach for treating prostate cancer. The emergence of 3D laparoscopic technology has brought new breakthroughs to the surgical treatment of prostate cancer. While traditional 2D-LRP has achieved significant clinical efficacy, it still faces challenges such as limited surgical visualization and high operational difficulty[2]. By using high-definition systems, 3D laparoscopic technology combines images from two cameras to create a stereoscopic effect, allowing surgeons to perceive a fully high-definition three-dimensional view and spatial depth during the operation. This enhanced perspective enables more accurate judgment of tissue structures and surgical distances, thereby reducing surgical complexity and improving precision[3]. This study aims to compare and analyze the clinical efficacy of 3D and 2D-LRP in the treatment of prostate cancer.

Vol 1 Issue 2 2024

1. Materials and Methods

1.1 General Information

A total of 70 prostate cancer patients admitted to the hospital between January 2019 and January 2024 were selected and randomly divided into an observation group (35 cases) and a control group (35 cases). The average age of the observation group was 56.39±7.25 years, and the average age of the control group was 56.58±7.21 years. There was no significant difference in the baseline data between the two groups ($P > 0.05$).

Inclusion criteria: (1) Patients must have been pathologically confirmed to have prostate cancer through prostate systematic biopsy; (2) Clinical staging of prostate cancer should be between T1b and T2c, indicating localized tumors that are completely resectable; (3) Patients must have a life expectancy of over 10 years, be in good general health, and be able to tolerate surgical treatment; (4) Patients must not have severe diseases of major organs such as the heart, lungs, liver, or kidneys, or coagulopathy that could affect surgical outcomes.

Exclusion criteria: (1) Imaging examinations (e.g., CT, MRI) and laboratory tests (e.g., serum PSA) must confirm the absence of distant metastases, such as lymph node or bone metastasis; (2) Patients with surgical contraindications, such as severe abdominal infection or adhesions, were excluded; (3) Patients unable to tolerate surgery due to advanced age or poor physical condition were also excluded.

1.2 Methods

The surgical procedures were identical in both groups. General anesthesia was administered, and the patient was placed in a supine position with the legs slightly apart. After disinfection and draping of the abdomen, multiple operative channels were established at specific locations, with one serving as the camera port for visualizing the surgical area, while the other channels were used for the operation of surgical instruments. The extraperitoneal space was expanded beneath the rectus abdominis to create sufficient room for the surgery. The tissue surrounding the prostate, including the anterior bladder wall and pelvic floor fascia, was carefully dissected to facilitate the subsequent prostatectomy. The main blood supply to the prostate, the deep dorsal vein complex, was carefully ligated to minimize intraoperative bleeding. The urethra was transected just below the apex of the prostate, and the prostate, including tumor tissue and surrounding normal tissue, was completely removed. During the resection, careful attention was paid to maintaining the anastomosis between the urethra and bladder neck to ensure postoperative urinary function. Hemostasis was thoroughly achieved, ensuring no active bleeding points in the surgical field. The bladder and urethra were sutured together, completing the anastomosis and ensuring proper postoperative urinary function. A urinary catheter was left in place postoperatively to monitor urine output and detect and manage any potential complications promptly.

1.3 Observation Indicators

(1) Treatment Effectiveness

Effective: Prostate cancer tissue was completely excised, and pathological examination confirmed no residual cancer cells. Postoperative PSA levels significantly decreased and remained stable for a long period. Imaging studies such as ultrasound, CT, or MRI confirmed the complete disappearance of the tumor with no signs of recurrence. Patients experienced improved urinary flow, good recovery of sexual function, and no complications such as incontinence. Survival was prolonged, and quality of life significantly improved.

Partially Effective: Most of the prostate cancer tissue was removed, but a small number of cancer cells remained. Postoperative PSA levels decreased, but regular monitoring was still required. Imaging studies showed a reduction in tumor size, but further treatment was necessary. Patients experienced some improvement in urinary flow, partial recovery of sexual function, and may have had mild incontinence or other complications. Survival was relatively stable, and quality of life showed some improvement.

Ineffective: Prostate cancer tissue was incompletely excised, with a large amount of cancer cells remaining. Postoperative PSA levels did not decrease or continued to rise. Imaging studies showed no change or a continued increase in tumor size. Patients experienced no improvement in urinary flow, severe sexual dysfunction, and may have had significant incontinence. Survival was shortened, and quality of life decreased.

(2) Incidence of Urinary Incontinence

(3) Intraoperative Blood Loss, Duration of Surgery, Urethral Reconstruction, and Duration of Catheterization

1.4 Statistical Analysis

Statistical analysis was performed using SPSS 22.0 software. Intraoperative blood loss, duration of surgery, urethral reconstruction, and duration of catheterization are expressed as "($\bar{x}\pm s$)." The "t" test was used for comparisons. The total effective rate and the incidence of urinary incontinence are presented as [n(%)] and analyzed using the "x^2" test. The P value of < 0.05 was considered statistically significant.

2. Results

2.1 Treatment Effectiveness

The observation group showed a higher total effective rate compared to the control group ($P < 0.05$), as shown in **Table 1**.

Table 1. Total Effective Rate [n(%)]

Group	n	Effective	Partially Effective	Ineffective	Total Effective Rate (%)
Observation	35	20	13	2	33 (94.3)
Control	35	16	9	10	25 (71.4)
x^2					6.135
P					< 0.05

2.2 Incidence of Urinary Incontinence

The observation group had a lower incidence of urinary incontinence compared to the control group ($P < 0.05$), as shown in **Table 2**.

Table 2. Incidence of Urinary Incontinence [n(%)]

Group	n	Number of Cases	Number of Cases
Observation	35	3	3(8.6)
Control	35	9	9(25.7)
x^2			
P			< 0.05

2.3 Intraoperative Blood Loss, Duration of Surgery, Urethral Reconstruction, and Catheterization

The observation group had lower values for all indicators compared to the control group ($P < 0.05$), as shown in **Table 3**.

Table 3. Intraoperative Blood Loss, Duration of Surgery, Urethral Reconstruction, and Catheterization ($\bar{x}\pm s$)

Group	n	Intraoperative Blood Loss (ml)	Surgery Time (min)	Urethral Reconstruction Time (min)	Catheterization Time (days)
Observation	35	110.32±25.36	187.62±28.52	24.58±4.65	9.35±2.11
Control	35	132.52±31.02	206.38±29.33	32.62±6.35	11.24±2.35
t		6.385	9.625	7.225	9.336
P		< 0.05	< 0.05	< 0.05	< 0.05

3. Discussion

Prostate cancer, as one of the most common malignant tumors in the male urinary system, has shown an increasing incidence worldwide year by year. This disease not only seriously threatens men's life and health but also has a significant impact on their quality of life[4]. With the continuous advancement of medical technology, LRP has become an important treatment method for prostate cancer. Among these, 3D laparoscopic surgery and 2D laparoscopic surgery, as two main surgical approaches, have each demonstrated their own characteristics and advantages in clinical efficacy[5].

2D-LRP is a mature and widely used surgical treatment method for prostate cancer. This technology utilizes a two-dimensional laparoscopic system, providing surgeons with a clear and intuitive surgical view, allowing for precise prostatectomy without the need to open the abdominal cavity. During the 2D-LRP procedure, the surgeon inserts a laparoscope through a small incision in the abdominal wall, using the two-dimensional images transmitted by the scope to observe the surgical area. However, despite meeting certain surgical needs, the limitation of a two-dimensional view in traditional 2D laparoscopic technology makes it difficult for surgeons to gain depth perception during the procedure, increasing the difficulty and risks associated with the surgery. To overcome this limitation, the 3D laparoscopic technology was developed. 3D-LRP is an advanced, high-precision surgical treatment method specifically used for the radical treatment of prostate cancer. The emergence of this technology marks a new era in prostate cancer surgery, providing patients with safer and more effective treatment options[6]. The core of 3D-LRP lies in the 3D laparoscopic system it employs. This system, through advanced imaging technology, offers surgeons an unprecedented three-dimensional surgical view. The 3D laparoscope can more accurately reproduce the anatomical structures of the surgical area, allowing for a more precise assessment of the spatial relationships between the prostate and surrounding tissues. This article compares and analyzes the clinical efficacy of 3D and 2D LRP in the treatment of prostate cancer. The results show that the observation group had a higher treatment effectiveness, lower incidence of urinary incontinence, and less intraoperative blood loss, as well as shorter surgery time, urethral reconstruction time, and catheterization time ($P < 0.05$). The reason is that with the enhanced 3D view, surgeons can more accurately locate the tumor during the procedure, ensuring that the excision margin is neither too large nor too small. This high-precision operation not only improves the success rate of the surgery but also helps reduce the recurrence rate of the tumor postoperatively. The refined manipulation during 3D-LRP also minimizes damage to surrounding tissues, promoting faster postoperative recovery[7]. Furthermore, the 3D-LRP technology provides surgeons with a more realistic surgical view. By simulating the human eye's stereoscopic vision, 3D-LRP technology enables objects in the surgical field to appear three-dimensional, greatly enhancing the intuitiveness and depth perception of the surgery. This three-dimensional effect allows surgeons to more accurately assess the anatomical structure of the prostate and surrounding tissues, including key structures such as the urethral sphincter, in terms of their position and shape. As a result, while excising the prostate tumor, surgeons can more effectively protect the urethral sphincter, avoiding unnecessary damage to it during the procedure and thereby reducing the risk of urinary incontinence. Additionally, 3D-LRP technology facilitates faster surgery. Due to the clarity and depth perception of the surgical view, surgeons can perform the procedure more smoothly, reducing the overall surgery time and difficulty. This not only increases surgical efficiency but also lowers the risk of bleeding and complications associated with prolonged surgery. A shorter surgery duration also means a reduced exposure to anesthetic drugs, further lowering the risk of bleeding caused by anesthesia. Moreover, due to faster healing in the surgical area and fewer complications, doctors can guide patients earlier in bladder function training, urethral dilation, and other rehabilitation exercises to promote the recovery of urinary function. This early rehabilitation training not only helps reduce the occurrence of postoperative complications like urinary incontinence but also improves the patient's quality of life, further promoting postoperative recovery.

In conclusion, compared with 2D-LRP treatment, 3D-LRP offers superior efficacy in treating prostate cancer, a lower incidence of urinary incontinence, and better surgical outcomes, which are favorable for postoperative recovery. In summary, 3D laparoscopic technology, with its more realistic and three-dimensional surgical view, provides a more precise and safer surgical treatment option for prostate cancer patients. In terms of reducing intraoperative blood loss, shortening surgery time, lowering postoperative complication risks, and promoting rapid recovery, 3D laparoscopic technology has shown significant advantages. These benefits not only provide strong assurance for patients' quality of life but also open new pathways for surgical treatment of prostate cancer. Future developments should include more clinical studies on 3D laparoscopic technology in prostate cancer treatment to further verify its efficacy and safety, and promote the continued maturation and refinement of the technology.

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