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Application Experience of Monopolar Low-Temperature Plasma Knife in Unilateral Breast-Conserving Surgery

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Abstract: *The Purpose of the paper is to explore the application of monopolar low-temperature plasma knife in unilateral breast-conserving surgery. Forty patients with breast cancer admitted to First People's Hospital of Nantong from April 2023 to August 2023 were selected. They were randomly divided into a control group and an experimental group, with 20 cases in each group. The control group underwent surgery using a high-frequency electric knife, while the experimental group underwent surgery using a monopolar low-temperature plasma knife. The clinical indicators of the two groups were compared, including operative time, intraoperative blood loss, postoperative 24-hour drainage volume, duration of axillary drainage tube placement, intraoperative incidence of secondary vascular injury, postoperative wound healing, and incidence of postoperative complications. Results were as follows. The operative time and duration of axillary drainage tube placement in the experimental group were shorter than those in the control group, $P<0.05$. The intraoperative blood loss and postoperative 24-hour drainage volume in the experimental group were less than those in the control group, $P<0.05$. The experimental group had a lower incidence of intraoperative secondary vascular injury than the control group, $P<0.05$. The postoperative wound healing in the experimental group was better than that in the control group, $P<0.05$. The experimental group had a lower incidence of postoperative complications than the control group, $P<0.05$. It is concluded that the application of a monopolar low-temperature plasma knife in breast cancer-modified radical mastectomy can simplify the surgical procedure, reduce operative time and intraoperative blood loss, facilitate early removal of drainage tubes, shorten the tube retention time, improve patients' quality of life, and is worthy of adoption and application.*

Keywords: *Monopolar low-temperature; Plasma knife; Unilateral; Breast-conserving surgery; Complications*

1. Introduction

Breast cancer refers to the uncontrolled proliferation of breast epithelial cells due to various carcinogenic factors. It is more common in females and clinically manifests as breast lumps, abnormal breast skin, nipple or areola abnormalities, nipple discharge, axillary lymph node enlargement, etc., seriously affecting patients' lives and health [1]. Although breast-conserving surgery is becoming increasingly popular among female breast cancer patients, traditional modified radical mastectomy still holds a significant position. Monopolar low-temperature plasma knife is widely used in surgical procedures such as cancer treatment, spinal surgery, orthopedic surgery, etc. It can significantly alleviate patient pain, enhance surgical effectiveness, and simplify operation, effectively reducing surgical time. It leads to less intraoperative bleeding and a lower incidence of postoperative complications, contributing to patients' postoperative recovery [2]. Based on this, this study further explores the application effect of the monopolar low-temperature plasma knife in unilateral breast-conserving surgery and conducts a comparative analysis of medical records of 40 patients. The summary is presented below:

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2. Materials and Methods

2.1. General Information

Forty patients with breast cancer admitted to our hospital from April 2023 to August 2023 were selected and randomly divided into a control group and an experimental group, with 20 cases in each group. Control group: Age ranged from 31 to 62 years, with an average of (43.61±5.83) years; TNM stages: 6 cases in stage I, 10 cases in stage II, 4 cases in stage III; Tumor locations: 11 on the right, 9 on the left; Tumor sizes ranged from 1.2 to 3.5 cm, with an average of (2.57±0.69) cm. Experimental group: Age ranged from 33 to 64 years, with an average of (44.25±6.18) years; TNM stages: 8 cases in stage I, 9 cases in stage II, 3 cases in stage III; Tumor locations: 8 on the right, 12 on the left; Tumor sizes ranged from 1.3 to 3.6 cm, with an average of (2.51±0.72) cm. There were no significant differences in general characteristics between the two groups, with $P > 0.05$. Inclusion criteria: (1) Confirmed diagnosis of invasive breast cancer through physical examination, imaging (mammography, breast ultrasound, breast magnetic resonance imaging), histopathology, breast cancer tumor marker examination, and immunohistochemistry; (2) All patients were females with no abnormalities in cognition, consciousness, mental status, or communication ability; (3) All patients underwent unilateral breast-conserving surgery. Exclusion criteria: (1) Severe damage to organs such as heart, liver, or kidneys; (2) Coagulation disorders; (3) Low compliance and poor cooperation.

2.2. Methods

Both groups of patients received general intravenous anesthesia. After confirming the effectiveness of anesthesia, modified radical mastectomy was performed using a Stewart transverse shuttle-shaped incision. The surgical scope extended from below the clavicle to the upper edge of the rectus abdominis muscle, medially to the side of the sternum, and laterally to the anterior border of the latissimus dorsi muscle. After achieving the standard range of flap detachment and completing flap detachment, some subcutaneous fat layer was retained. The breast tissue was separated from the surface of the pectoralis major fascia and extended to the axillary side.

Control Group: The entire separation process was conducted using a high-frequency electric knife (ANONG-II, registered by ANENG Medical Instruments (Changshu) Co., Ltd., with registration number 20152010884). Larger perforating vessels were ligated using No. 1 sutures, while smaller vessels were directly coagulated using the electric knife. During axillary lymph node dissection, larger vessels were ligated using No. 1 sutures, and both lymphatic vessels and blood vessels were coagulated using the high-frequency electric knife.

Experimental Group: Surgery was performed using a monopolar low-temperature plasma knife. Both lymphatic vessels and blood vessels were separated, coagulated, and cut using a monopolar low-temperature plasma knife (PSG–60A main unit and PS–01 electrode, registered by Hunan Jingyi Medical Technology Co., Ltd., with registration number 20203010474). During axillary lymph node dissection, both lymphatic vessels and blood vessels were coagulated and cut using the monopolar low-temperature plasma knife, and vessels larger than 5 millimeters in diameter were ligated using No. 1 sutures.

After completing the surgery, one drainage tube was placed in the axillary region and another one was placed near the sternum on the affected side in both groups. The wound site was dressed with pressure dressings. The drainage volume was recorded every 24 hours, and the presence of drainage tube obstruction was observed. If the drainage volume was less than 20 milliliters for three consecutive days, the drainage tube could be removed.

2.3. Observational Parameters

(1) Clinical indicators include operative time, intraoperative blood loss, postoperative 72-hour drainage volume, and duration of axillary drainage tube placement. (2) The second parameter is Intraoperative incidence of secondary vascular injury. (3) The third parameter is postoperative wound healing assessment. Grade A refers to good wound healing with no adverse reactions. Grade B refers to suboptimal wound healing with inflammatory reaction but no suppuration. (4) Postoperative complications include hematoma, subcutaneous fluid accumulation, flap necrosis, and fever.

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2.4. Statistical Analysis

The statistical analysis was conducted using SPSS 20.0 software. Counting and measuring data were presented as percentages (%), and ($\bar{x}$±s), respectively. Chi-square (χ^2) and t-tests were performed, with P<0.05 indicating statistical significance.

3. Results

3.1. Comparison of Clinical Indicators

The experimental group had a shorter operative time and axillary drainage tube placement duration compared to the control group, with P<0.05. Additionally, the experimental group exhibited lower intraoperative blood loss and 24-hour postoperative drainage volume compared to the control group, with P<0.05. As shown in Table 1.

Table 1: Comparison of Clinical Indicators ($\bar{x}$±s)

Group	Cases	Operation Time (min)	Intraoperative Blood Loss (mL)	Postoperative 72h Drainage (mL)	Axillary Drainage Duration (d)
Control	20	110.75±10.25	70.32±9.70	175.00±12.69	15.35±2.23
Experimental	20	90.25±6.38	50.15±10.23	90.23±8.77	12.15±1.90
t-value	-	8.624	6.398	24.576	4.885
P-value	-	P<0.05	P<0.05	P<0.05	P<0.05

3.2. Comparison of Intraoperative Secondary Vascular Injury Incidence and Postoperative Wound Healing

The experimental group had a lower incidence of intraoperative secondary vascular injury compared to the control group, with P<0.05. Additionally, the postoperative wound healing in the experimental group was better than that in the control group, with P<0.05. As shown in Table 2.

Table 2: Comparison of Intraoperative Secondary Vascular Injury Incidence and Postoperative Wound Healing [Cases (%)]

Group	Cases	Intraoperative Secondary Vascular Injury Incidence	Postoperative Wound Healing	
			Wound Healing Grade (A)	Wound Healing Grade (B)
Control	20	0 (0.00)	20	0
Experimental	20	5 (25.00)	16	4
x²-value	-	5.714	4.444	
P-value	-	P<0.05	P<0.05	

3.3. Comparison of Postoperative Complication Rates

The experimental group had a lower incidence of postoperative complications compared to the control group, with P<0.05. As shown in Table 3.

Table 3: Comparison of Postoperative Complication Rates [Cases (%)]

Group	Cases	Hematoma	Subcutaneous Fluid Accumulation	Flap Necrosis	Fever	Incidence of Postoperative Complications
Control	20	3	3	2	2	10 (50.00)
Experimental	20	0	0	0	0	0 (0.00)
x²-value	-	-	-	-	-	13.333
P-value	-	-	-	-	-	P<0.05

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4. Discussion

Breast cancer is a prevalent concern in breast surgery, and according to relevant data, the number of breast cancer patients in China has increased significantly in recent years, with a majority being female patients [3]. Early symptoms of breast cancer are often subtle and can be easily overlooked. As the condition progresses, patients may experience symptoms such as loss of appetite, anorexia, weight loss, fatigue, anemia, and fever. In a minority of cases, metastatic symptoms might occur due to the spread of the disease. If metastases occur in the lungs and pleura, symptoms such as hemoptysis, cough, chest pain, and difficulty breathing may emerge. Bone metastases could lead to bone pain and hypercalcemia, while liver metastases might result in jaundice and ascites. Brain metastases could present with symptoms like headaches and vomiting, posing a threat to the patient's life. Currently, modified radical mastectomy is frequently employed to treat breast cancer, aiming to completely remove the affected tissue, reduce the risk of disease recurrence, and enhance the quality of life for patients [4].

In the past, modified radical mastectomy often utilized high-frequency electrosurgery to excise breast tissue and perform axillary lymph node dissection. High-frequency electric currents and voltages were generated through electrodes to heat and coagulate tissues upon contact, achieving tissue separation and coagulation for cutting and hemostasis purposes [5]. During tissue cutting and hemostasis using a high-frequency electrosurgical device, it's not the heated blade that accomplishes the task; rather, tissues in contact with the high-frequency current are thoroughly disrupted, and the temperature of the electrode-tissue interaction rises, causing protein denaturation to achieve coagulation effects. When clearing axillary lymph nodes, the abundant vascular distribution in the tissue makes it prone to bleeding and oozing when using a less maneuverable electrosurgical tool for free dissection [6]. Moreover, during the procedure, there's a potential for local tissue, fat, and lymph node degeneration, which hampers the smooth progression of surgery. The smoke and odor generated during tissue cutting using a high-frequency electrosurgical tool not only impede the operator's visibility but also impact patient health. Contact between the electrosurgical tool and patient tissue, along with the limitations of electrotomy and electrocoagulation, can increase the risk of skin edge necrosis and subcutaneous fluid accumulation. In contrast, the principle behind the use of monopolar low-temperature plasma scalpel involves exciting sodium chloride in the cellular fluid of human tissues into a plasma state. This process disrupts tissue molecular bonds and achieves the goals of coagulation and cutting. Monopolar low-temperature plasma scalpel effectively alleviates patient pain, shortens surgical time, and reduces intraoperative blood loss. Since the range of action of the accelerated ions in the thin plasma layer is short, its effects can be precisely controlled to the tissue in contact with the electrode surface, without affecting deep-seated tissues. Therefore, it causes minimal damage to the incision site [7]. The arc-confinement technology of the scalpel head enables precise energy control, achieving tissue decomposition at temperatures as low as 40-70°C while minimizing thermal damage. Furthermore, the monopolar low-temperature plasma scalpel induces collagen protein contraction, achieving hemostasis during cutting [8].

This study demonstrates that in the experimental group, the surgical duration and duration of axillary drainage tube placement were shorter than those in the control group ($P < 0.05$). The experimental group exhibited lower intraoperative blood loss and lower drainage volume at 72 hours post-surgery compared to the control group ($P < 0.05$). The application of monopolar low-temperature plasma scalpel in modified radical mastectomy for breast cancer effectively reduces surgical duration and axillary drainage tube placement time while decreasing intraoperative blood loss and drainage volume at 24 hours post-surgery. The experimental group had a lower occurrence rate of intraoperative vascular damage compared to the control group ($P < 0.05$), and the postoperative wound healing was better in the experimental group than in the control group ($P < 0.05$). The application of monopolar low-temperature plasma scalpel in modified radical mastectomy for breast cancer appears to prevent intraoperative vascular damage and promote wound healing. Furthermore, the experimental group had a lower incidence of postoperative complications compared to the control group ($P < 0.05$). The application of monopolar low-temperature plasma scalpel in modified radical mastectomy for breast cancer could reduce the risk of postoperative complications, enhance surgical safety, and have a positive impact on patient postoperative recovery.

5. Conclusion

In summary, the application of monopolar low-temperature plasma scalpel in modified radical mastectomy for breast cancer streamlines the surgical procedure, reduces surgical duration and

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intraoperative blood loss, facilitates early removal of drainage tubes, shortens the time with tubes in place, and improves patients' quality of life. This approach is worth adopting and implementing. Monopolar low-temperature plasma scalpel holds significant promise for use in unilateral breast cancer modified radical mastectomy. However, there are still several shortcomings in this technology that require further research.

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