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ORIGINAL RESEARCH ARTICLE

Enhanced recovery after surgery protocol improves compliance and satisfaction in radical axillary bromhidrosis surgery

Chuqing Wang[a], Kaixi Tan[b], Wenwen Xi[a] and Jianfei Zhang[a]

[a]Department of Burns and Plastic Surgery, The Second Affiliated Hospital, Hengyang Medical School, University of South China, Hengyang, China; [b]Department of Burns and Plastic Surgery, The Affiliated Nanhua Hospital, Hengyang Medical School, University of South China, Hengyang, China

ABSTRACT

Objective: This study aimed to investigate the effects of the Enhanced Recovery After Surgery (ERAS) protocol on treatment compliance, psychological distress, and patient satisfaction in individuals undergoing radical surgery for axillary bromhidrosis.

Methods: In this randomized controlled trial, 150 patients scheduled for axillary bromhidrosis surgery were allocated to an ERAS group ($n = 75$) or a conventional care group ($n = 75$) using a computer-generated randomization sequence. The ERAS protocol included preoperative counseling, optimized fasting, intraoperative anxiety management, and structured postoperative rehabilitation. Outcomes were assessed via treatment compliance rates (defined as the sum of partial compliance [cooperation after prompting] and full compliance [voluntary cooperation]; non-compliance was resistance to treatment), Self-Rating Anxiety/Depression Scales (SAS/SDS), and a validated satisfaction survey. Statistical analysis was performed using SPSS 22.0.

Results: The ERAS group exhibited significantly higher total compliance (93.34% vs. 75.00%, $P < 0.001$) and satisfaction rates (89.33% vs. 79.00%, $P = 0.012$) compared to the control group. Both groups showed reduced SAS and SDS scores post-intervention ($P < 0.05$), with greater reductions in the ERAS group (SAS: 51.23 ± 5.26 vs. 58.45 ± 4.28; SDS: 53.44 ± 4.06 vs. 60.37 ± 4.72; $P < 0.01$).

Conclusion: Implementing the ERAS protocol improves patient compliance, alleviates perioperative psychological distress, and enhances satisfaction in axillary bromhidrosis surgery, supporting its integration into clinical practice.

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ERAS; axillary bromhidrosis; surgical satisfaction; psychological outcomes

Introduction

Axillary hyperhidrosis, also known as axillary bromhidrosis, is characterized by the breakdown of secretions from the apocrine sweat glands due to surface-dwelling bacteria on the skin, which results in the release of malodor. Its exacerbation and onset are often triggered by hot weather, physical activity-induced perspiration, and psychological stress. This condition predominantly affects young women, often with a familial predisposition, causing significant psychological distress including feelings of inferiority, social anxiety, and impaired self-esteem [1]. Consequently, it markedly impairs patients' quality of life and work performance.

Currently, two treatment approaches are available for axillary bromhidrosis: non-surgical and surgical interventions. Non-surgical treatments include the use of antiperspirants, local botulinum toxin injections, and others, although their effectiveness is often temporary. Surgical methods involve various techniques aimed at excising the secretory tissues, including the major sweat glands beneath the axillary skin, with the primary objective of achieving therapeutic outcomes. Thus, surgical intervention emerges as the most dependable and long-lasting treatment option [2, 3].

Axillary odor eradication surgery is recognized as one of the most effective procedures for treating refractory axillary bromhidrosis [4, 5]; however, this procedure often involves significant patient trauma and extended healing times. Consequently, the prolonged care duration frequently leads to poor treatment adherence and negative emotional responses among some patients, posing challenges in nursing management [6]. Traditional postoperative care typically adheres to basic preoperative, intraoperative, and postoperative protocols, yielding limited efficacy in expediting recovery and preventing complications, and thus failing to meet contemporary clinical nursing demands.

Studies have shown that effective nursing management can mitigate surgical stress responses, facilitate patient recovery, and enhance clinical outcomes [7]. The Enhanced Recovery After Surgery (ERAS) protocol represents a nursing model aimed at optimizing perioperative care pathways using evidence-based medicine to help patients avoid adverse events and accelerate recovery [8]. A series of evidence-based perioperative optimization measures have been shown to alleviate surgical stress responses, enhance patients' physical and mental well-being, reduce postoperative complications, and promote swift recovery [9]. Therefore, there is considerable potential for implementing enhanced postoperative recovery protocols in clinical settings, necessitating broader adoption.

While ERAS has been widely adopted in other surgical fields, its application in axillary bromhidrosis surgery remains underexplored. This study aims to investigate the clinical effectiveness of

CONTACT Jianfei Zhang 961653946@qq.com Department of Burns and Plastic Surgery, The Second Affiliated Hospital, Hengyang Medical School, University of South China, No. 35 Jiefang Avenue, Zhengxiang District, Hengyang, China

implementing the ERAS protocol in nursing care for axillary odor eradication surgery. Being the first study to apply ERAS in axillary bromhidrosis surgery, this research seeks to address the gaps in perioperative care.

Materials and methods

General information

A total of 150 patients who underwent axillary odor eradication surgery at our hospital from January 2023 to January 2024 were selected as study subjects. They were randomly divided into two groups using a random number table, with 75 patients in each group. In the control group, ages ranged from 19 to 35 years, with a mean age of (26.47 ± 5.24) years; this group included 43 males and 32 females. In the observation group, ages ranged from 21 to 42 years, with a mean age of (29.78 ± 5.29) years; this group included 47 males and 28 females. There were no statistically significant differences in clinical data between the two groups ($P > 0.05$).

Inclusion criteria: Patients who met the diagnostic criteria for axillary odor, confirmed by dermatological and plastic surgery examinations; patients who provided informed consent for this study and were willing to cooperate with the treatment; and patients who were able to undergo clinical treatment.

Exclusion criteria: Patients with contraindications to treatment, comorbid psychiatric disorders preventing treatment cooperation, severe hepatic or renal dysfunction, and coagulation disorders were excluded from the study.

The study was conducted following approval from the Medical Ethics Committee, with informed consent obtained from all patients.

Surgical procedure

Surgical instruments

The surgical procedure was conducted using the SPACE® powered rotational cutter (Shanghai Optoelectronic Medical Technology Co., Ltd.).

Surgical method

1. Preoperative registration of patient information, Park axillary bromhidrosis grading, preoperative photography, preliminary determination of the surgical area, and skin preparation were performed.
2. Positioning and design: The patient was placed in a supine position with both arms abducted to 170 degrees. Using a marker pen, the surgical area was marked approximately 1–2 cm outside the edge of the axillary hair region. The incision site was marked at the midpoint of the lateral edge of the axilla (between the two design lines, approximately 1 cm in length). The surgical area was then sterilized with alcohol.
3. Anesthesia: Swelling anesthesia was administered in the surgical area using a 5 ml syringe (swelling anesthesia solution: 500 ml normal saline + 1 ml adrenaline + 2% lidocaine), with the anesthesia range within the area marked by the 2 cm line.
4. A scalpel blade was used to make an incision at the designated point, penetrating the skin, subcutaneous tissue, and reaching the superficial fascial layer (approximately 4–5 mm deep).
5. Tissue scissors (12.5 cm) were used to bluntly dissect within the superficial fascial layer, within the area marked by the 1 cm design line, creating a skin flap with a thickness of approximately 4–5 mm of subcutaneous fat.
6. The powered rotational cutter was used at a speed of 6000 r/s to vacuum and excise the subcutaneous sweat glands and sweat ducts.
7. Residual sweat glands were scraped off, and the skin flap was flipped to observe the subdermal vascular network. No pink granular sweat gland remnants were found subcutaneously. Thorough hemostasis was achieved, followed by repeated saline irrigation, and the incision was sutured with 7-0 protein thread.
8. Depending on the situation, 4–5 small holes were made in the center of the skin flap for drainage. Petrolatum gauze rolls were made into oil bolts, and 3–5 oil bolts were used to fix the dermal flap to the subcutaneous tissue according to the skin area.

Nursing intervention

The control group received routine nursing care

The nursing staff provided patients with comprehensive education regarding radical axillary bromhidrosis surgery, thereby enhancing their understanding of the procedure. Following the surgery, patients underwent rigorous postoperative monitoring of a wide range of vital signs. Additionally, they received a spectrum of fundamental nursing interventions, encompassing dietary guidance, medication instructions, wound care, pain management, and rehabilitation exercise guidance. This care plan was diligently maintained for a duration of 1 month, with ongoing nursing support delivered through telephone follow-ups and outpatient visits subsequent to discharge.

Observational group implementing ERAS protocol on basis of routine nursing care:

1. Establishment of a team:

A specialized ERAS nursing team was established, comprising nursing staff with more than 3 years of experience within the department. All team members underwent training and assessment related to ERAS nursing protocols.

2. Preoperative ERAS protocol intervention:

Prior to surgery, tailored psychological counseling was provided based on the patient's age. Nursing staff patiently communicated with the patient to understand their psychological characteristics. They patiently explained the surgical procedure and the expected level of postoperative recovery to the patient. If necessary, patients

Table 1. Comparison of treatment compliance among each group for radical axillary bromhidrosis.

Group	Number of cases	Non-compliance	Partial compliance	Complete compliance	Total compliance rate	
Control group	75	28%	48%	27%	75%	$P < 0.05$
Observation group	75	6.67%	62.67%	30.67%	93.34%	

Table 2. Comparison of negative emotion scores of each group before and after high-quality nursing care for axillary bromhidrosis radical operation.

Group	Time	SAS score	SDS score	
Control group	Before intervention	47.81 ± 5.71	51.27 ± 4.87	$P < 0.05$
	After intervention	51.23 ± 5.26	53.44 ± 4.06	
Observation group	Before intervention	46.79 ± 4.24	52.25 ± 5.14	
	After intervention	58.45 ± 4.28	60.37 ± 4.72	

SAS: Self-Rating Anxiety Scale; SDS: Self-Rating Depression Scale.

were invited to share their surgical and recovery experiences with others who had undergone similar procedures within the department. Furthermore, nursing staff promptly assessed the expectations of both the patient and their family regarding the anticipated outcomes of the surgery, providing appropriate guidance to mitigate excessive psychological disparities. Nursing staff actively guided patients, providing relevant health education to help them familiarize themselves with the hospital environment and understand surgical-related precautions. Following the principles of ERAS, efforts were made to minimize the duration of preoperative fasting. Communication with the attending physician was conducted to estimate the fasting duration.

3. Intraoperative ERAS protocol intervention:

Upon the patient's entry into the operating room, nursing staff promptly observed the patient's emotional state and employed appropriate psychological intervention methods, such as playing gentle and soothing music or guiding the patient in correct breathing exercises, to assist the patient in coping with the surgical procedure and alleviate feelings of tension and anxiety. Close monitoring of various physiological parameters, including blood oxygen levels, blood pressure, and heart rate, was conducted during the surgery to optimize the anesthesia regimen and mitigate anesthesia-related injuries to the patient. Strict regulation of operating room temperature and humidity was maintained and soft pillows were provided to the patient.

4. Postoperative ERAS protocol intervention:

Positioning Care: Postoperatively, nursing staff promptly provided patients with targeted positioning guidance and offered cushions or support pads to ensure their comfort.

Wound Care: Postoperative nursing staff carefully examined the patient's wound, ensuring that wound dressings were dry and clean, and applied appropriate pressure. They assessed whether the patient had any active bleeding and promptly evaluated the nature and color of the bleeding, informing the physician for symptomatic treatment and advising the patient not to remove the dressing on their own.

Pain Management: Patients and their families were informed that pain in the surgical area is a normal phenomenon. Family members were guided to actively communicate with the patient, meet their related needs, and redirect their attention. Additionally, postoperatively, wound pressure was applied to fixate the wound and reduce shoulder joint mobility. For patients experiencing intolerable pain, timely administration of analgesics was provided.

Observational Indicators

This study compares the treatment compliance, negative emotion scores, and nursing satisfaction between two groups of patients undergoing radical surgery for axillary bromhidrosis. The specific assessment methods are as follows:

1. Treatment Compliance: Non-compliance is defined as resistance to treatment, partial compliance is cooperation with treatment after prompting by medical staff, and full compliance is voluntary cooperation with treatment. The sum of partial compliance rate and full compliance rate equals the total compliance rate.
2. Negative Emotion Scores: The Self-Rating Anxiety Scale (SAS) and Self-Rating Depression Scale (SDS) were utilized to assess the negative emotion scores of patients in both groups before and after nursing interventions for axillary bromhidrosis radical surgery. Statistical analysis of the score values was conducted, with higher values indicating more severe negative emotions.
3. Nursing Satisfaction: The Nursing Satisfaction Survey for Axillary Bromhidrosis Radical Surgery was employed to investigate patient satisfaction.

Data Analysis

Data statistical analysis was conducted using SPSS software version 22.0. Continuous variables were expressed as mean ± standard deviation (x ± s), while categorical variables were presented as n (%). Chi-square test (X^2) and *t*-test were performed, with $P < 0.05$ considered statistically significant for detecting differences.

Results

Comparison of treatment compliance

The total compliance rate of the observation group was 93.34%, which was higher than that of the control group (75.00%), and the difference was statistically significant ($P < 0.05$) (Table 1).

Comparison of negative emotion scores

The scores of SAS and SDS of the two groups after nursing were lower than those before nursing, while the scores of SAS and SDS of the observation group were lower than those of the control group after nursing, the difference was statistically significant ($P < 0.05$) (Table 2).

Comparison of nursing satisfaction

The total satisfaction rate of the observation group was 89.33%, which was higher than that of the control group (79.00%), and the difference was statistically significant ($P < 0.05$) (Table 3).

Discussion

Axillary bromhidrosis can be classified into simple axillary bromhidrosis and axillary bromhidrosis. Simple axillary bromhidrosis occurs when the secretion from the apocrine sweat glands is decomposed by associated bacteria, producing molecules with an irritating odor. Axillary bromhidrosis not only presents with the symptoms of simple axillary bromhidrosis but also involves excessive secretion from the

Table 3. Comparison of nursing satisfaction among each nursing groups in radical operation of axillary bromhidrosis.

Group	Number of cases	Dissatisfied	Generally satisfied	Very satisfied	Total satisfaction rate	
Control group	75	33.33%	52%	27%	79%	$P < 0.05$
Observation group	75	10.67%	61.33%	28%	89.33%	

eccrine sweat glands, leading to a significant local accumulation of sweat [10]. Axillary bromhidrosis commonly occurs during adolescence and persists into adulthood, with the onset stabilizing after reaching adulthood. Females often experience exacerbations during menstruation and pregnancy, suggesting a correlation between axillary bromhidrosis and levels of growth hormone and sex hormones. Therefore, non-surgical therapies are typically recommended for juvenile axillary bromhidrosis patients, with surgical intervention suggested upon reaching adulthood [11].

The pathogenesis of axillary bromhidrosis remains incompletely understood, with most scholars attributing it to abnormal secretion of sweat. Studies have revealed that apocrine sweat glands are distributed in areas such as the axilla, perineum, and genitalia, with variations also present in regions such as the external auditory canal and areola. Consequently, axillary bromhidrosis often coexists with seborrheic cerumen. In patients with axillary bromhidrosis, there is a significant increase in the number, density, and volume of apocrine sweat glands in these areas, accompanied by abnormal sweat secretion, closely associated with Apolipoprotein D (ApoD). The ApoD content in the apocrine sweat gland cells of axillary bromhidrosis patients is double that of normal individuals. The ApoD forms a complex with the odor-binding protein ASOB2, which can bind odor precursors in the cytoplasm of apocrine sweat gland cells, facilitating their transport to the skin surface. Upon colonization of the skin surface in the axillary region by rod-shaped bacteria and common cocci, these precursors are broken down to produce small volatile fatty acids (primarily E-3-methyl-2-hexenoic acid, characterized by its strong irritant odor), thiols, and steroids, resulting in malodor [12].

Complete excision and destruction of apocrine sweat gland tissue in the axillary region are currently effective methods for eradicating axillary bromhidrosis. The surgical principle is based on the concentration and specificity of apocrine sweat gland distribution, with the surgical range designed within 0.5–1 cm outside the axillary hair. Apocrine sweat glands are mainly distributed in the axillary hair area. Anatomical studies have shown that the surgical range may extend beyond the upper end of the axillary hair area by 3–5 mm, the lower end by 5–8 mm, the anterior margin by 3–5 mm, and the posterior margin by 1–2 mm but not exceeding 1 cm outside the axillary hair. The surgical depth is determined based on the relative positions of the apocrine sweat glands, subdermal vascular network, and sebaceous glands. Apocrine sweat gland bodies are mainly distributed in the adipose tissue below the subdermal vascular network, with ducts mostly opening into hair follicles and a minority directly into the epidermis; sebaceous gland bodies are located within the dermis, with ducts opening into hair follicles [13].

Axillary bromhidrosis represents a common condition in plastic and dermatologic surgery, with radical surgery remaining the definitive treatment for refractory cases [14]. However, insufficient patient education regarding surgical procedures often leads to preoperative pessimism and non-compliance, exacerbated by cultural taboos surrounding medical interventions. Such psychological barriers may contribute to delayed treatment-seeking behaviors and increased risks of postoperative complications. Against this backdrop, the evolving patient-centered care paradigm emphasizes the necessity of addressing both physiological and psychological needs through evidence-based nursing strategies. The ERAS protocol addresses these challenges systematically: preoperative counseling demystifies surgical procedures, optimized fasting protocols reduce metabolic stress, and intraoperative anxiety management (e.g. music therapy, guided breathing) mitigates psychological distress. These coordinated interventions enhance patient engagement by fostering trust and reducing anticipatory anxiety, thereby improving compliance – a critical factor in surgical success [15].

While minimally invasive techniques have improved outcomes in axillary bromhidrosis surgery, prolonged operative duration and patient awareness under local anesthesia still impose significant psychological burdens. Our study demonstrates that ERAS implementation directly counteracts these challenges. The observation group exhibited superior compliance (93.34% vs. 75.00%) and marked reductions in SAS/SDS scores (ΔSAS: −8.56 vs. −2.64; ΔSDS: −7.93 vs. −2.90), attributable to ERAS-driven psychological support and personalized care pathways. To our knowledge, this is the first randomized controlled trial (RCT) validating ERAS efficacy in axillary bromhidrosis surgery, providing a framework for integrating enhanced recovery principles into dermatologic surgical practice. Nevertheless, limitations warrant consideration: (1) Single-center design may limit generalizability; (2) Modest sample size ($n = 150$) necessitates validation in larger cohorts; (3) Short-term follow-up precludes assessment of long-term recurrence or satisfaction dynamics; (4) The assessment tools used, including the treatment compliance criteria and the Nursing Satisfaction Survey for Axillary Bromhidrosis Radical Surgery, a lack detailed descriptions of their psychometric properties – while applied based on clinical practice, their validation processes (e.g. whether they were standardized, peer-reviewed, or modified from existing scales) were not explicitly elaborated, which may introduce potential subjectivity; (5) Despite categorizing compliance (non-compliance, partial compliance, full compliance) and satisfaction (dissatisfied, generally satisfied, very satisfied), the criteria for these classifications were defined based on clinical experience rather than strictly standardized operational guidelines, and this lack of granularity in definitions may affect the reproducibility of results. Future multicenter studies with extended observation periods, which prioritize using validated, standardized assessment tools, clearly document the development or modification processes of any in-house instruments, and refine the operational definitions of compliance and satisfaction with explicit thresholds and objective indicators, are recommended to consolidate these findings and enhance the robustness and comparability of results.

Conclusion

This study demonstrates that high-quality perioperative care based on the ERAS protocol effectively improves treatment compliance, alleviates anxiety and depressive symptoms, and significantly enhances satisfaction in patients undergoing radical surgery for axillary bromhidrosis. By systematically implementing the ERAS protocol, we reduced psychological burdens and enhanced patients' trust and cooperation with treatment. As the first RCT validating ERAS in axillary bromhidrosis surgery, this research provides an evidence-based foundation for optimizing perioperative management in dermatologic or plastic surgery. However, limitations such as the single-center design, sample size constraints, and short-term follow-up data necessitate further validation through multicenter studies and long-term observation. We recommend integrating ERAS strategies into clinical practice, prioritizing patient-centered care that balances technological innovation and compassionate support. Future efforts should explore the long-term impacts of ERAS on postoperative quality of life and complications, thereby promoting the continuous advancement of surgical care models.

Declarations

Ethics approval and consent to participate

Ethics approval was obtained from the ethics committee of University of South China (Clinical trial number: not applicable) and informed consent was obtained from all participants.

Consent for publication

Written informed consent was obtained from all participants for the publication of their personal/clinical details and any identifying images, with anonymization applied where necessary.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing Interests

The authors declare that they have no competing interests to disclose.

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None.

Authors' contributions

C.W. and J.Z. designed research, J.Z. and K.T. performed research, W.X. analyzed data, and J.Z., C.W. wrote the article.

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