Wu et al. World Journal of Surgical Oncology (2025) 23:179
https://doi.org/10.1186/s12957-025-03794-2

World Journal of Surgical Oncology

RESEARCH

Open Access

Efficacy and safety of robotic-assisted versus endoscopic-assisted axillary lymph node dissection in node-positive breast cancer: a retrospective comparative study

Zhijie Wu[1,2†], Qiwen Liu[1,2†], Zongyan Li[1,2†], Zuxiao Chen[1,2], Yongxin Wu[1,2], Yunxiang Luo[1,2], Lina Wei[1,2], Qiongyu Hu[2,3*] and Haiyan Li[1,2*]

Abstract

Background Robotic surgery is increasingly being adopted for breast cancer treatment. However, robust clinical evidence regarding its effectiveness and safety remains limited. This retrospective cohort study aimed to compare the surgical quality and short-term outcomes of robotic-assisted axillary lymph node dissection (R-ALND) and endoscopic-assisted axillary lymph node dissection (E-ALND) in patients with node-positive breast cancer. Here, we report the short-term outcomes of this trial.

Methods This single-center retrospective study compared the short-term efficacy and safety of R-ALND and E-ALND in patients with node-positive breast cancer. Patients who underwent surgery at the Sixth Affiliated Hospital of Sun Yat-sen University between January 2022 and October 2024 were included. Clinical and pathological characteristics, surgical outcomes, and postoperative complications were analyzed.

Results A total of 56 patients were included, with 29 undergoing E-ALND and 27 undergoing R-ALND. The R-ALND group demonstrated significantly shorter operative times (43.37 ± 12.40 min vs. 60.10 ± 19.37 min, $p < 0.001$) and lower mean intraoperative blood loss (3.26 ± 2.40 ml vs. 9.24 ± 4.29 ml, $p < 0.001$). Postoperatively, the R-ALND group exhibited better upper limb function and sensation, as evidenced by significantly lower DASH scores at 1-month (10.87 ± 1.35 vs. 14.64 ± 3.49, $p < 0.001$) and 3-month (6.68 ± 1.86 vs. 9.24 ± 2.74, $p < 0.001$) follow-ups. Additionally, the R-ALND group had fewer postoperative complications, including a reduced incidence of sensory disturbances, burning sensations, and numbness in the upper limb.

Conclusion Compared with E-ALND, R-ALND significantly reduces intraoperative blood loss and postoperative complications, with less impact on upper limb function and sensory outcomes. These findings indicate that R-ALND may provide better clinical benefits for patients requiring axillary lymph node dissection in the management of breast cancer.

[†]Zhijie Wu, Qiwen Liu and Zongyan Li contributed equally to this study.

*Correspondence:
Qiongyu Hu
huqy@mail.sysu.edu.cn
Haiyan Li
lihy27@mail.sysu.edu.cn
Full list of author information is available at the end of the article

Keywords Robotic-assisted axillary lymph node dissection (R-ALND), Endoscopic-assisted axillary lymph node dissection (E-ALND), Node-positive breast cancer, Postoperative complications, Upper limb function

Introduction

Breast cancer is one of the most prevalent malignant tumors among women, with high incidence and mortality rates globally [1]. For patients initially diagnosed with breast cancer without systemic metastasis, treatment planning must consider both tumor size (T stage) and the presence of lymph node metastasis (N stage) [2]. When axillary lymph node metastasis is present, axillary lymph node dissection (ALND) is a critical component of surgical management. ALND not only aids in accurate tumor staging but also serves as a cornerstone for guiding treatment strategies and predicting prognosis [3].

However, ALND is associated with several complications, including lymphedema, wound infection, fat necrosis, sensory disturbances in the arm, and restricted range of motion [4]. With the advancement of minimally invasive surgical techniques, endoscopic technology has been increasingly adopted in breast cancer treatment [5]. This approach provides an enlarged and more precise visual field, thereby minimizing damage to microstructures. Although several studies have demonstrated the efficacy and safety of endoscopic axillary lymph node dissection (E-ALND) [6], the current evidence is largely derived from low-quality, small-scale randomized controlled trials. Notably, there is a significant lack of multicenter prospective clinical studies. Therefore, the effectiveness and safety of E-ALND remain controversial.

Compared with endoscopic surgery, robotic surgery offers distinct advantages, including a magnified three-dimensional surgical view and enhanced stability during surgical manipulation. The robotic arms, equipped with wrist-like joints that provide seven degrees of freedom, enabling 540° rotation and precise movements within confined spaces. Robotic surgery has been successfully applied in various lymph node dissections, including retroperitoneal, cervical, and inguinal regions [10]. The robotic system allows surgeons to access narrower surgical fields and more clearly identify microstructures, thereby improving surgical precision and safety [11]. Theoretically, these features render robotic surgery particularly suitable for axillary lymph node dissection. However, given the higher cost associated with robotic surgery compared to endoscopic techniques, robust evidence is needed to justify its clinical application [13]. Currently, there is a paucity of studies focusing on robotic axillary lymph node dissection (R-ALND), and comparative analyses between endoscopic and robotic approaches are lacking. Therefore, this study aims to compare the short-term efficacy and safety of endoscopic and robotic axillary lymph node dissection in patients with breast cancer.

Materials and methods

Patient enrollment

Patients who underwent single-port endoscopic-assisted axillary lymph node dissection (E-ALND) or robotic-assisted axillary lymph node dissection (R-ALND) for breast cancer at the Sixth Affiliated Hospital of Sun Yat-sen University between January 2022 and October 2024 were recruited for this study. A total of 56 patients were included, with 29 undergoing E-ALND and 27 undergoing R-ALND (Fig. 1). The study protocol was approved by the Ethics Committee of the Sixth Affiliated Hospital of Sun Yat-sen University (approval number: 2024ZSLYEC-467). Written informed consent was obtained from all participants prior to enrollment.

Clinical and pathological characteristics, including age, estrogen receptor (ER) status, progesterone receptor (PR) status, HER2 status, Ki-67 index, histological grade, tumor size, TN staging, and the use of neoadjuvant chemotherapy, were included in the analysis. Additionally, surgical outcomes, such as the number of axillary lymph nodes dissected, the number of positive axillary lymph nodes, operative time, intraoperative blood loss, and postoperative complications (including upper limb dysfunction, wound infection, seroma, and lymphedema), were also evaluated.

The inclusion and exclusion criteria were determined based on demographic and tumor characteristics.

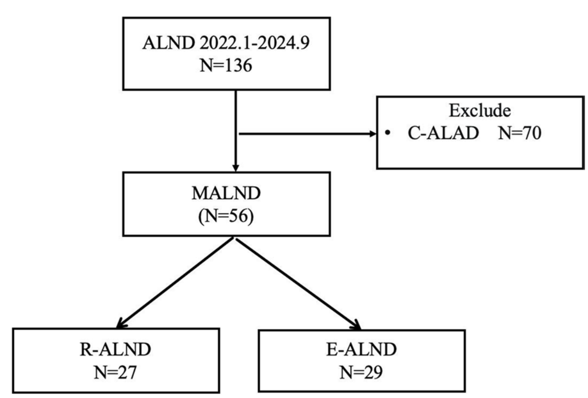

Fig. 1 Flow chart of patient selection. Abbreviations: E-ALND,endoscopic axillary lymph node dissection; R-ALND,robotic axillary lymph node dissection;C-ALND, conventional axillary lymph node dissection

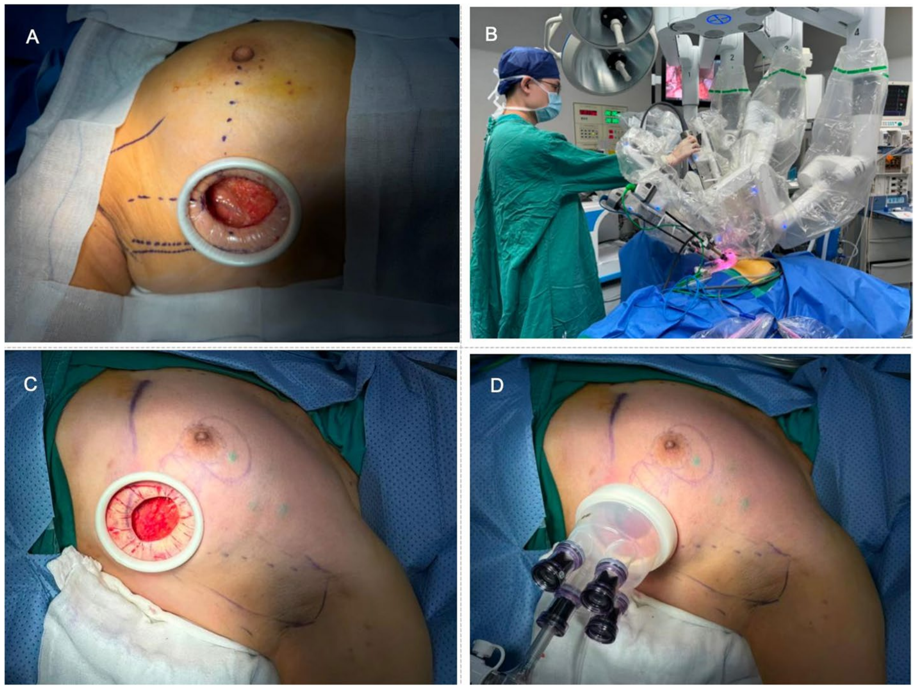

Fig. 2 Representative surgical images show robot-assisted axillary lymph node dissection (R-ALND) and endoscopy-assisted axillary lymph node dissection (E-ALND). **A**-**B** R-ALND surgical images; **C**-**D** E-ALND surgical images

Inclusion criteria were as follows: 1) age between 18 and 75 years; 2) pathologically confirmed breast cancer; and 3) presence of positive axillary lymph nodes. Exclusion criteria included: 1) presence of distant metastasis; 2) inability to tolerate surgery due to cardiopulmonary dysfunction; and 3) concurrent diagnosis of other malignant tumors.

Surgical procedure

Robotic-Assisted Axillary Lymph Node Dissection (R-ALND) (Fig. 2A-B)

For R-ALND, a small incision is made on the lateral chest wall with minimal dissection to create a surgical cavity. A single-port four-channel trocar is inserted, followed by the placement of three 8-mm trocars. The da Vinci Xi robotic arms are then connected to these trocars, and the cavity is insufflated to maintain a pressure of 8–10 mmHg.

The R-ALND procedure follows a systematic "bottom-up, back-to-front" approach. The dissection begins at the lower posterior wall of the axilla and progresses superiorly, followed by the medial wall, lateral wall, central axilla, and finally the apex of the axilla. The specific steps are as follows: 1) Axillary Floor Dissection: The procedure starts with the dissection of the axillary floor, where the reticulated fascia is separated to identify and protect the lowest intercostobrachial nerve. 2) Posterior Wall Dissection: The dissection proceeds medially to isolate the anterior branch of the thoracodorsal vessels, continuing until the main trunk of the thoracodorsal vessels is reached. Subsequently, the dissection moves laterally to separate the circumflex scapular vessels, extending to the point where the thoracodorsal vein joins the axillary vein. 3) Medial Wall Dissection: The medial wall is carefully dissected to protect the thoracodorsal nerve anterior to the serratus anterior muscle. CO_2 insufflation is utilized to dissect along the membrane space superiorly toward the axillary vein angle, which represents the uppermost part of the axilla. 4) Lateral Wall Dissection: The lateral wall is dissected along the outer side of the intercostobrachial nerve to visualize the axillary vein. 5) Anterior Wall Dissection: The anterior wall is dissected with attention to protecting the medial cutaneous nerve of the arm. The dissection follows the axillary vein from lateral to medial. 6) Intercostobrachial Nerve Dissection: The intercostobrachial nerve at the level of the axillary vein is dissected from medial to lateral, separating the upper and lower layers of axillary tissue to preserve the nerve. The lowest intercostal nerve, being finer, may be transected during this process. 7) Lymph Node Clearance and Irrigation: After thorough dissection and complete clearance of the axillary lymph nodes, the cavity is irrigated with warm distilled water, and drains are placed to ensure proper postoperative management.

Endoscopic-Assisted Axillary Lymph Node Dissection (E-ALND) (Fig. 2C-D)

For E-ALND, a 5-cm incision is made at the lateral edge of the chest wall. Subcutaneous tissue extending 2–3 cm around the incision is separated to facilitate the insertion of a disposable incision fixator. The port of the single-hole cavity mirror is placed over the outer mouth of the notched fixator to maintain the cavity pressure at 8 mmHg. The surgical steps are consistent with those of R-ALND.

Evaluation of postoperative upper limb function

Range of motion (ROM) of the shoulder joint was assessed at baseline and 3 months postoperatively. The shoulder joint ROM comprises three movements: abduction, flexion, and horizontal abduction. Based on our clinical experience, a goniometer was used to measure ROM for all subjects.

The Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire is a widely used [14], standardized tool for assessing upper limb function. It is a patient-reported outcome measure that consists of 30 items, 23 of which evaluate upper limb function and 7 that assess symptoms, including pain (at rest, during activity, and at night), strength, and stiffness.

The DASH score is calculated by summing the scores of the 30 items and then applying the following formula: DASH score = (Total sum of the 30 items—30 [minimum score]) / 1.20. This transformation scales the raw score to a range of 0 to 100, where 0 indicates normal upper limb function and 100 indicates severe impairment.

Statistical analysis

Continuous variables were analyzed using the Mann–Whitney U test and are presented as medians with their respective minimum and maximum ranges. Categorical variables were compared using Fisher's exact test. All statistical analyses were conducted using SPSS software. A p-value of less than 0.05 was considered statistically significant.

Results

Patient characteristics

A retrospective analysis was conducted on the medical records of 136 patients who underwent ALND at our center from January 2022 to October 2024. After applying the inclusion and exclusion criteria, 80 patients from the conventional surgery group were excluded, resulting in the inclusion of 56 patients. Of these, 29 underwent E-ALND, and 27 underwent R-ALND. The demographic and clinical characteristics of the patients are summarized in Table 1. There was no statistically significant difference in age between the two groups (R-ALND group: 55.83 ± 14.89 years vs. E-ALND group: 49.81 ± 10.4 years, P = 0.084). Additionally, no significant differences were observed between the two groups in terms of pathological staging, hormone receptor status, HER2 status, Ki-67 expression, histological grading, preoperative chemotherapy, or type of breast surgery.

Table 1 Clinicopathologic characteristics of E-ALND and R-ALND

Variables	Mean ± SD or n (%)		
	E-ALND (*n* = 29)	R-ALND (*n* = 27)	*P* value
Age (Y)	55.83 ± 14.89	49.81 ± 10.40	0.084
Pathologic stage			0.556
I	3 (10.3%)	2 (7.4%)	
II	15 (51.7%)	18 (66.7%)	
III	11 (38.0%)	7 (25.9%)	
Estrogen receptor			0.570
Negative	9 (31.1%)	8 (29.6%)	
Positive	20 (68.9%)	19 (70.3%)	
Progesterone receptor			
Negative	13 (44.9%)	11 (40.8%)	0.485
Positive	16 (55.1%)	16 (59.2%)	
HER2 status			0.424
Negative	20 (68.9%)	17 (62.9%)	
Positive	9 (31.1%)	10 (37.1%)	
Ki-67			0.266
< 14%	8 (27.5%)	12 (44.4%)	
> 14%	21 (72.4%)	15 (55.6%)	
Histological grade			0.892
1	1 (3.2%)	2 (7.4%)	
2	23 (79.3%)	20 (74.0%)	
3	5 (17.2%)	5 (18.6%)	
Preoperative chemotherapy			0.576
No	19 (65.5%)	18 (66.7%)	
Yes	10 (34.4%)	9 (33.3%)	
Breast surgery			0.398
Partial	13 (44.9%)	14 (51.8%)	
Total	16 (55.1%)	13 (48.1%)	

Abbreviations: E-ALND,endoscopic axillary lymph node dissection; R-ALND,robotic axillary lymph node dissection

Comparison of surgical outcomes

The primary surgical outcomes revealed that the mean operative time for the E-ALND group was significantly longer than that for the R-ALND group (60.10 ± 19.37 min vs. 43.37 ± 12.40 min, p < 0.001). Additionally, the R-ALND group demonstrated significantly lower mean intraoperative blood loss (3.26 ± 2.40 mL vs. 9.24 ± 4.29 mL, p < 0.001).

Secondary surgical outcomes included total axillary drainage volume, postoperative axillary drain retention time, postoperative hospital stay duration, and postoperative axillary pain. The total axillary drainage volume was 247.66 ± 198.42 mL for the E-ALND group and 192.48 ± 139.06 mL for the R-ALND group, with no statistically significant difference between the groups (p = 0.237). The postoperative axillary drain retention time was similar for both the E-ALND group (8.48 ± 3.65 days) and the R-ALND group (7.88 ± 2.51 days, p = 0.485). However, the R-ALND group had a significantly shorter postoperative hospital stay (9.03 ± 2.38 days vs. 10.69 ± 3.20 days, $p = 0.033$). Postoperative axillary pain occurred in 37.0% of the R-ALND group and 72.4% of the E-ALND group, indicating that the R-ALND group experienced less postoperative pain than the E-ALND group (p = 0.008). There were no significant differences between the two groups in the mean number of axillary lymph nodes dissected or the number of positive nodes (Table 2).

Comparison of postoperative complications

In this study, the severity of postoperative complications was assessed using the Clavien-Dindo classification system [15]. Neither the E-ALND nor the R-ALND group experienced postoperative bleeding or wound infection. One case of axillary hematoma occurred in the E-ALND group, which was successfully managed with aspiration and pressure dressing. Additionally, the E-ALND group had one case of poor wound healing and two cases of lymphatic leakage, which improved with persistent pressure dressing in the axillary area. In contrast, the R-ALND group had no occurrences of hematoma, poor wound healing, or lymphatic leakage (Table 3).

Table 3 Postoperative clinical outcome of E-ALND and R-ALND

Variables	Mean ± SD or n (%)	
	E-ALND (*n* = 29)	R-ALND (*n* = 27)
Complications		
Hemorrhage	0	0
Wound infection	0	0
Axillary seroma	0	0
Poor wound healing	1	0
Lymphorrhagia	2	0
Lymphedema of the upper limbs	0	0

Abbreviations: *E-ALND* endoscopic axillary lymph node dissection, *R-ALND* robotic axillary lymph node dissection

Postoperative ROM outcomes

Preoperatively, no significant differences were observed in shoulder abduction, shoulder flexion, or horizontal abduction ROM between the two groups. However, at the 3-month postoperative follow-up, the R-ALND group showed significantly greater ROM in shoulder abduction (174.03 ± 5.35° vs. 165.75 ± 5.53°, $p < 0.001$) and shoulder flexion (173.04 ± 5.35° vs. 167.03 ± 4.62°, $p < 0.001$) compared to the E-ALND group. Similarly, the horizontal abduction ROM also demonstrated a significant difference (33.48 ± 3.99° vs. 30.07 ± 3.40°, $p = 0.001$) (Table 4).

Table 2 Surgical outcomes of E-ALND and R-ALND

Variables	Mean ± SD or n (%)		
	E-ALND (*n* = 29)	R-ALND (*n* = 27)	*P* value
Time for ALND (minutes)	60.10 ± 19.37	43.37 ± 12.40	< 0.001
Blood loss (ml)	9.24 ± 4.29	3.26 ± 2.40	< 0.001
Drainage flow (mL)	247.66 ± 198.42	192.48 ± 139.06	0.237
Duration of axillary drainage (d)	8.48 ± 3.65	7.88 ± 2.51	0.485
Post-operation hospital stay (d)	10.69 ± 3.20	9.03 ± 2.38	0.033
Number of lymph nodes harvested	17.13 ± 9.45	17.88 ± 6.66	0.734
Number of metastatic lymph nodes	3.14 ± 7.00	2.96 ± 4.88	0.915
Postoperative pain			0.008
No pain (PS = 0)	8 (27.6%)	17 (63.0%)	
Mild pain (PS = 1–3)	21 (72.4%)	10 (37.0%)	
Moderate to severe pain (PS ≥ 4)	0 (0%)	0 (0%)	

Abbreviations: *E-ALND* endoscopic axillary lymph node dissection, *R-ALND* robotic axillary lymph node dissection, *PS* Pain score

Table 4 Arm morbidities in the two groups

Variables	Mean ± SD or n (%)		
	E-ALND ($n=29$)	R-ALND ($n=27$)	*P* value
Shoulder Abduction			
Preoperative	178.27 ± 1.55	178.59 ± 1.31	0.415
At 3 months after surgery	165.75 ± 5.53	174.03 ± 5.35	< 0.001
Shoulder Flexion			
Preoperative	178.21 ± 1.66	178.29 ± 1.72	0.844
At 3 months after surgery	167.03 ± 4.62	173.04 ± 5.35	< 0.001
Shoulder Horizontal abduction			
Preoperative	37.97 ± 2.15	37.81 ± 2.20	0.796
At 3 months after surgery	30.07 ± 3.40	33.48 ± 3.99	0.001
DASH score			
Preoperative	0.56 ± 0.86	0.52 ± 0.85	0.852
At 1 months after surgery	14.64 ± 3.49	10.87 ± 1.35	< 0.001
At 3 months after surgery	9.24 ± 2.74	6.68 ± 1.86	< 0.001
Arm Function			
Hypesthesia	8 (27.6%)	1 (3.7%)	0.017
Burning sensation	6 (20.7%)	0 (0%)	0.015
Numb	8 (27.6%)	1 (3.7%)	0.017
Pain	3 (10.3%)	0 (0%)	0.132

Abbreviations: *DASH* Disabilities of the Arm, Shoulder, and Hand

DASH scores and upper limb function

Preoperatively, there was no significant difference in DASH scores between the two groups. However, at the 1-month postoperative follow-up, the R-ALND group had significantly lower DASH scores compared to the E-ALND group (10.87 ± 1.35 vs. 14.64 ± 3.49, $p < 0.001$). At the 3-month follow-up, upper limb function improved in both groups, but the R-ALND group still exhibited lower DASH scores than the E-ALND group (6.68 ± 1.86 vs. 9.24 ± 2.74, $p < 0.001$) (Table 4).

Postoperative upper limb sensation and pain

At the 3-month postoperative follow-up, the E-ALND group reported a significantly higher incidence of reduced sensation (8 cases, 27.6%), burning sensation (6 cases, 20.7%), and numbness (8 cases, 27.6%) in the upper limb compared to the R-ALND group, which had only 1 case (3.7%) of reduced sensation and 1 case (3.7%) of numbness, with no cases of burning sensation. These differences were statistically significant. However, there was no significant difference in postoperative upper limb pain between the two groups (3 cases, 10.3% in the E-ALND group vs. 0 cases, 0% in the R-ALND group, $p = 0.132$). These results suggest that R-ALND had a lesser impact on postoperative upper limb sensation and function, enabling greater activity in the affected upper limb (Table 4).

Discussion

This single-center retrospective study was designed to evaluate the safety and efficacy of R-ALND compared to E-ALND in breast cancer patients.

Endoscopic surgery has been widely utilized in the treatment of breast cancer; however, its efficacy and safety remain subjects of debate. An epidemiological study reported a significantly higher mortality rate for minimally invasive surgery in patients with stage IA2 or IB1 cervical cancer compared to open surgery ($P = 0.002$) [16]. A meta-analysis also indicated that patients undergoing minimally invasive radical hysterectomy faced a 71% higher risk of recurrence and a 56% higher risk of death [17]. During endoscopic surgery, instruments are introduced into the axilla in a nearly vertical direction, with limited horizontal manipulation angles, which can result in instrument interference in the narrow axillary space. Furthermore, endoscopic surgery often requires an experienced assistant, which may not be available at all medical centers. These factors can negatively impact the quality of endoscopic surgery. Despite the safety of E-ALND being demonstrated in some studies, there remains a lack of large-scale, prospective clinical trials to definitively establish its long-term benefits.

Robotic surgery offers several advantages over endoscopic techniques by overcoming these limitations. Robotic instruments have multiple degrees of freedom, providing flexibility akin to a surgeon's hand, with enhanced stability. The magnified three-dimensional view offers a detailed surgical field controlled by the surgeon, potentially eliminating the need for an assistant [11]. These technical advantages make robotic surgery a more accurate and efficient option for axillary lymph node dissection [2]. However, few studies have focused on robotic axillary lymph node dissection, and even fewer have directly compared R-ALND with E-ALND [18]. In our study, R-ALND significantly reduced intraoperative bleeding, postoperative pain, and hospital stay duration. Moreover, it resulted in less postoperative impairment of upper limb function and sensation, allowing for greater mobility of the affected limb.

The reduction in intraoperative bleeding associated with robotic surgery can decrease surgical time and accelerate postoperative recovery. In our study, the R-ALND group exhibited significantly shorter surgical times (43.37 ± 12.40 min vs. 60.10 ± 19.37 min, $p < 0.001$) and lower mean blood loss (3.26 ± 2.40 ml vs. 9.24 ± 4.29 ml, $p < 0.001$) compared to the E-ALND group. The da Vinci robotic system, which provides up to 10–15 times magnification, offers a clearer and more detailed surgical field. This enhanced visibility facilitates the early identification of small blood vessels in the axillary region, thereby reducing intraoperative bleeding and enhancing the overall quality and safety of the surgery. Additionally, robotic surgery minimizes the shaking of the surgical field, a limitation often observed in endoscopic procedures, which further improves stability and precision. Studies comparing robotic and open axillary dissection have similarly demonstrated that robotic surgery can significantly reduce intraoperative bleeding [18].

During axillary lymph node dissection, there is a risk of damaging the intercostobrachial nerve, which can lead to postoperative sensory and functional impairments in the upper limb. These impairments are often difficult to treat and can negatively affect the patient's quality of life [19]. The intercostobrachial nerve, originating from the anterior branch of the second intercostal nerve, innervates the skin of the axilla and lateral chest wall, controlling upper limb sensory functions [20]. Due to its unique anatomical location in the axillary space, this nerve is challenging to preserve during surgery. In our study, at the 3-month postoperative follow-up, the R-ALND group showed significantly fewer cases of upper limb sensory reduction (1 case, 3.7%), burning sensation (0 cases, 0%), and numbness (1 case, 3.7%) compared to the E-ALND group, which had higher incidences of these sensory disturbances. These findings suggest that R-ALND may better preserve the intercostobrachial nerve, reducing the risk of postoperative sensory impairments.

The stability of robotic surgery, characterized by its tremor-free instruments, enables more precise dissection of delicate structures like the intercostobrachial nerve. Studies in prostate cancer lymph node dissection have shown that robotic surgery, with its enhanced precision, better preserves nerves and reduces postoperative complications such as urinary retention [21]. The robotic system's 7 degrees of freedom and 540° rotation capability allow for more efficient and precise dissections around the intercostobrachial nerve. Although the nerve does not directly control joint movements, preserving it can significantly reduce postoperative sensory abnormalities and neuropathic pain, promoting better upper limb functional recovery. Our results also showed that at 1 and 3 months postoperatively, patients in the robotic group had significantly better upper limb function, as evidenced by lower DASH scores (10.87 ± 1.35 vs. 14.64 ± 3.49, $p < 0.001$; 6.68 ± 1.86 vs. 9.24 ± 2.74, $p < 0.001$), emphasizing the potential benefits of robotic surgery in improving postoperative outcomes.

This study has several limitations. First, it is a single-center retrospective study with a small sample size. Second, the relatively short follow-up period limits our ability to assess the long-term oncological safety of robotic surgery. Future studies with larger cohorts and longer follow-up periods are needed to confirm the reliability of these findings and further evaluate the long-term outcomes.

Conclusion

Compared to E-ALND, R-ALND significantly reduces intraoperative bleeding, results in less postoperative upper limb impairment, and provides greater upper limb motion on the affected side, suggesting that robotic surgery may offer substantial advantages in the surgical management of breast cancer.

Acknowledgements
Supported by National Key Clinical Discipline.

Authors' contributions
Study concept and design: Z.W.and H.L.; analysis and interpretation data: Z.W., Z.C.,Z.L, X.F.and H.L.; drafting of the manuscript: Z.W.and H.L.; revision of the manuscript: Z.W., Z.C.,Q.L.,Y.L.,Z.H.,and H.L..; approval the manuscript: all authors.

Funding
No Funding.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This study was approved by the Ethics Committee (IEC) of the Sixth Affiliated Hospital of Sun Yat-sen University.

Cmpeting interests
The authors declare no competing interests.

Author details
[1]Department of Breast Surgery, Department of General Surgery, The Sixth Affiliated Hospital, Sun Yat-Sen University, 26 Yuancun Erheng Road, Guangzhou 510655, Guangdong, China. [2]Biomedical Innovation Center, The Sixth Affiliated Hospital, Sun Yat-Sen University, Guangzhou, China. [3]Department of Anesthesiology, The Sixth Affiliated Hospital, Sun Yat-Sen University, Guangzhou, China.

Received: 12 February 2025 Accepted: 29 March 2025
Published online: 09 May 2025

References

1. Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, Jemal A. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2024;74(3):229–63. https://doi.org/10.3322/caac.21834. (PMID: 38572751).
2. Ahn JH, Park JM, Choi SB, Go J, Lee J, Kim JY, Park HS. Early experience of robotic axillary lymph node dissection in patients with node-positive breast cancer. Breast Cancer Res Treat. 2023;198(3):405–12. https://doi.org/10.1007/s10549-022-06760-8. (PMID: 36418519).
3. Spillane AJ, Brennan ME. Minimal access breast surgery: a single breast incision for breast conservation surgery and sentinel lymph node biopsy.

Eur J Surg Oncol. 2009;35(4):380–6. https://doi.org/10.1016/j.ejso.2008.07.009. (PMID: 18757165).
4. Soares EW, Nagai HM, Bredt LC, da Cunha AD, Andrade RJ Jr, Soares GV. Morbidity after conventional dissection of axillary lymph nodes in breast cancer patients. World J Surg Oncol. 2014;12:67. https://doi.org/10.1186/1477-7819-12-67. (PMID: 24670000 PMCID: PMC3986871).
5. Wan A, Liang Y, Chen L, Wang S, Shi Q, Yan W, Cao X, Zhong L, Fan L, Tang P, Zhang G, Xiong S, Wang C, Zeng Z, Wu X, Jiang J, Qi X, Zhang Y. Association of long-term oncologic prognosis with minimal access breast surgery vs conventional breast surgery. JAMA Surg. 2022;157(12):e224711. https://doi.org/10.1001/jamasurg.2022.4711. (PMCID: PMC9535498).
6. Xiong H, Chen Z, Xu L, Chen C, Fu Q, Teng R, Chen J, Xie S, Wang L, Yu XF, Zhou J. Contrast of mastoscopic and conventional axillary lymph node dissection of patients with breast cancer: meta-analysis. Cancer Control. 2020;27(2):1073274820932987. https://doi.org/10.1177/1073274820932987. (PMID: 32602366 PMCID: PMC7328363).
7. Annerstedt M, Gudjonsson S, Wullt B, Uvelius B. Robot-assisted laparoscopic retroperitoneal lymph node dissection in clinical stage II testicular cancer. J Robot Surg. 2008;2(3):189–91. https://doi.org/10.1007/s11701-008-0093-7. (PMID: 27628259).
8. Lee SH, Kim DS, Chang SG, Jeon SH. Robot-assisted laparoscopic retroperitoneal lymph node dissection for stage IIIb mixed germ cell testicular cancer after chemotherapy. Korean J Urol. 2015;56(7):540–4. https://doi.org/10.4111/kju.2015.56.7.540. (PMID: 26175874 PMCID: PMC4500812).
9. Kang SW, Lee SH, Ryu HR, Lee KY, Jeong JJ, Nam KH, Chung WY, Park CS. Initial experience with robot-assisted modified radical neck dissection for the management of thyroid carcinoma with lateral neck node metastasis. Surgery. 2010;148(6):1214–21. https://doi.org/10.1016/j.surg.2010.09.016. (PMID: 21134554).
10. Sánchez A, Sotelo R, Rodriguez O, Sánchez R, Rosciano J, Medina L, Vegas L. Robot-assisted video endoscopic inguinal lymphadenectomy for melanoma. J Robot Surg. 2016;10(4):369–72. https://doi.org/10.1007/s11701-016-0599-3. (PMID: 27173971).
11. Feng Q, Yuan W, Li T, Tang B, Jia B, Zhou Y, Zhang W, Zhao R, Zhang C, Cheng L, Zhang X, Liang F, He G, Wei Y, Xu J. Robotic versus laparoscopic surgery for middle and low rectal cancer (REAL): short-term outcomes of a multicentre randomised controlled trial. Lancet Gastroenterol Hepatol. 2022;7(11):991–1004. https://doi.org/10.1016/s2468-1253(22)00248-5. (PMID: 36087608).
12. Aliyev V, Piozzi GN, Huseynov E, Mustafayev TZ, Kayku V, Goksel S, Asoglu O. Robotic male and laparoscopic female sphincter-preserving total mesorectal excision of mid-low rectal cancer share similar specimen quality, complication rates and long-term oncological outcomes. J Robot Surg. 2023;17(4):1637–44. https://doi.org/10.1007/s11701-023-01558-2. (PMID: 36943657).
13. Jayne D, Pigazzi A, Marshall H, Croft J, Corrigan N, Copeland J, Quirke P, West N, Rautio T, Thomassen N, Tilney H, Gudgeon M, Bianchi PP, Edlin R, Hulme C, Brown J. Effect of robotic-assisted vs conventional laparoscopic surgery on risk of conversion to open laparotomy among patients undergoing resection for rectal cancer: the ROLARR randomized clinical trial. Jama. 2017;318(16):1569–80. https://doi.org/10.1001/jama.2017.7219. (PMID: 29067426 PMCID: PMC5818805).
14. Angst F, Schwyzer HK, Aeschlimann A, Simmen BR, Goldhahn J. Measures of adult shoulder function: Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH) and its short version (QuickDASH), Shoulder Pain and Disability Index (SPADI), American Shoulder and Elbow Surgeons (ASES) Society standardized shoulder assessment form, Constant (Murley) Score (CS), Simple Shoulder Test (SST), Oxford Shoulder Score (OSS), Shoulder Disability Questionnaire (SDQ), and Western Ontario Shoulder Instability Index (WOSI). Arthritis Care Res (Hoboken). 2011;63(Suppl 11):S174-188. https://doi.org/10.1002/acr.20630. (PMID: 22588743).
15. Clavien PA, Barkun J, de Oliveira ML, Vauthey JN, Dindo D, Schulick RD, de Santibañes E, Pekolj J, Slankamenac K, Bassi C, Graf R, Vonlanthen R, Padbury R, Cameron JL, Makuuchi M. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg. 2009;250(2):187–96. https://doi.org/10.1097/SLA.0b013e3181b13ca2. (PMID: 19638912).
16. Melamed A, Margul DJ, Chen L, Keating NL, Del Carmen MG, Yang J, Seagle BL, Alexander A, Barber EL, Rice LW, Wright JD, Kocherginsky M, Shahabi S, Rauh-Hain JA. Survival after minimally invasive radical hysterectomy for early-stage cervical cancer. N Engl J Med. 2018;379(20):1905–14. https://doi.org/10.1056/NEJMoa1804923. (PMID: 30379613 PMCID: PMC6464372).
17. Nitecki R, Ramirez PT, Frumovitz M, Krause KJ, Tergas AI, Wright JD, Rauh-Hain JA, Melamed A. Survival after minimally invasive vs open radical hysterectomy for early-stage cervical cancer: a systematic review and meta-analysis. JAMA Oncol. 2020;6(7):1019–27. https://doi.org/10.1001/jamaoncol.2020.1694. (PMID: 32525511 PMCID: PMC7290695).
18. Chen KNMB, Zhang J, Reshetov IV, Nikolenko VN, Sinelnikov MY, Mikhaleva LM. Efficacy of da Vinci robot-assisted lymph node surgery than conventional axillary lymph node dissection in breast cancer - A comparative study. Int J Med Robot. 2021;17(6):e2307. https://doi.org/10.1002/rcs.2307. (PMID: 34270843).
19. Temple WJ, Ketcham AS. Preservation of the intercostobrachial nerve during axillary dissection for breast cancer. Am J Surg. 1985;150(5):585–8. https://doi.org/10.1016/0002-9610(85)90442-8. (PMID: 4061738).
20. Mewa Kinoo S, Singh B. Complex regional pain syndrome of the breast and chest wall. Breast J. 2016;22(3):366–8. https://doi.org/10.1111/tbj.12585. (PMID: 26945823).
21. Menon M, Tewari A, Baize B, Guillonneau B, Vallancien G. Prospective comparison of radical retropubic prostatectomy and robot-assisted anatomic prostatectomy: the Vattikuti urology institute experience. Urology. 2002;60(5):864–8. https://doi.org/10.1016/s0090-4295(02)01881-2. (PMID: 12429317).

Publisher's Note