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Comparison of minimal access and open breast surgery: a propensity score-matched study on postoperative immune function in breast cancer

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Abstract

Background Minimal access breast surgery (MABS) is commonly employed in the management of breast cancer, but there is limited research on the postoperative immune function associated with MABS.

Objective This study aimed to assess the postoperative immune function in breast patients who underwent MABS or conventional open breast surgery (COBS).

Methods We retrospectively analyzed the medical records of 829 breast cancer patients treated with either MABS or COBS at a single hospital between January 2020 and June 2023. Among them, 116 matched pairs were obtained through 1:1 propensity score matching (PSM). Flow cytometry was used to measure the percentages of $CD3^+$, $CD4^+$, and $CD8^+$ cells, as well as the $CD4^+/CD8^+$ ratio, on three different time points: preoperative day 1 (PreD1), postoperative day 1 (PostD1), and postoperative day 7 (PostD7).

Results Both the MABS and COBS groups demonstrated a significant reduction in the percentages of $CD3^+$, $CD4^+$, and $CD8^+$ cells, along with the $CD4^+/CD8^+$ ratio, from PreD1 to PostD1. Interestingly, the MABS group showed a reversal of these parameters, returning to preoperative levels by PostD7. Conversely, the COBS group showed an increase in these parameters from PostD1 to PostD7, but they still remained significantly lower than preoperative levels at PostD7.

Conclusion MABS treatment may result in reduced postoperative immune suppression and faster recovery of preoperative immune function compared to COBS in patients.

Keywords Minimal access breast surgery, Endoscopic, Immune function, Breast cancer

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Background

According to the latest Global Cancer Statistics report, there were approximately 19.3 million novel occurrences of cancer observed globally, with 9.23 million cases exclusively affecting the female population, further breaking down to 2.26 million incidents of breast cancer in women [1]. Breast cancer has overtaken lung cancer as the primary instigator of cancer and currently ranks as the fifth most prevalent factor contributing to cancer-related fatalities worldwide [2, 3]. The management of breast cancer requires a comprehensive approach that includes surgical interventions as the primary treatment modality, along with additional measures such as radiotherapy, chemotherapy, endocrine therapy, and targeted therapy [4–6].

Minimally invasive breast surgery (MABS), including endoscopic and robotic techniques, has become increasingly prevalent in procedures like nipple sparing mastectomy, lymph node dissection, breast conservation surgery and reconstruction [7–10]. . MABS offers multiple advantages over conventional open breast surgery (COBS), including smaller incisions, reduced trauma, less bleeding, decreased postoperative pain, faster recovery time, and improved cosmetic outcomes [11–14]. However, one challenge in MABS is the absence of a natural cavity in the breast area, requiring the administration of a lipolysis solution to create the necessary operating space. This has the potential to cause harm to the fat and surrounding tissues [15]. Tissue damage can trigger an immune response to prevent further harm, and surgical trauma may lead to a systemic inflammatory response, impacting postoperative immune function [16, 17]. Postoperative immune suppression is notably more severe in open abdomen and thoracic surgeries than in minimally invasive endoscopic procedures [18, 19]. For example, postoperative cellular-mediated immune dysfunction is significantly higher in open colectomy than laparoscopic colectomy. Similar findings have been observed in patients with pulmonary malignancies, where aggressive treatment is linked to postoperative immune suppression. The current remaining issue is whether postoperative immune suppression following MABS is equivalent to or attenuated compared to COBS.

Given the potential for postoperative immune suppression and postoperative complications linked to the open procedure, it is crucial to explore and address this particular question. To evaluate the postoperative immune suppression between MABS and COBS, we conducted a propensity score-matched (PSM) retrospective analysis in breast cancer patients treated with either approach at a single large medical institution.

Methods

Study population

Between June 2020 and July 2023, 829 breast cancer patients were included in the database of Third Hospital of Nanchang. Inclusion criteria for the study comprised female patients between the ages of 18 and 75, with cancer stages ranging from 0 to III, and no prior history of surgery. Exclusion criteria comprised of incomplete fundamental information and previous administration of neoadjuvant therapies such as radiotherapy and/or chemotherapy, and patients with immune disorders.

The surgical procedures performed on patients encompassed modified radical mastectomy, subcutaneous adenoectomy, simple-mastectomy, breast conservative surgery, and breast reconstruction with COBS, as well as endoscopic or robotic breast surgery.

Ultimately, 232 patients were included for analysis as depicted in Fig. 1. Ethical approval for the study was granted by the hospital's ethics committee in compliance with the Helsinki Declaration.

Study design

Patients were categorized into two groups: the MABS group, encompassing individuals who experienced endoscopic, endoscopy-aided, and robotic-supported surgeries, and the COBS group, encompassing those who had COBS operations. The primary outcome focused on the evaluation of postoperative immune function, assessed by the percentages of $CD3^+$, $CD4^+$, and $CD8^+$ lymphocytes, along with the $CD4^+/CD8^+$ ratio. Within each treatment group, postoperative immune function was compared at different time intervals, namely preoperative day (PreD) 1 and postoperative days (PostD) 1 and 7. Specifically, the proportion of immune cells in peripheral venous blood was measured by flow cytometry on PreD 1, PostD 1, and PostD 7. Furthermore, a comparison was conducted between the two groups at the same time interval. Additionally, demographic and clinicopathological factors, alongside postoperative morbidity rates, were also compared.

To control for potential confounding factors and ensure comparability between the two surgical groups, a propensity score matching (PSM) approach was utilized. The propensity score was calculated using logistic regression analysis, incorporating covariates such as age, body mass index (BMI), tumor size, cancer stage, and lymph node status, which could influence the choice of surgical procedure and outcomes. This analysis was performed using the MatchIt package in R software (R Foundation). A 1:1 nearest-neighbor matching technique was applied without specifying a caliper value to ensure tight matching. Following the matching process, the balance of covariates was assessed, with all P values for the matched samples exceeding 0.05, indicating a successful balance between
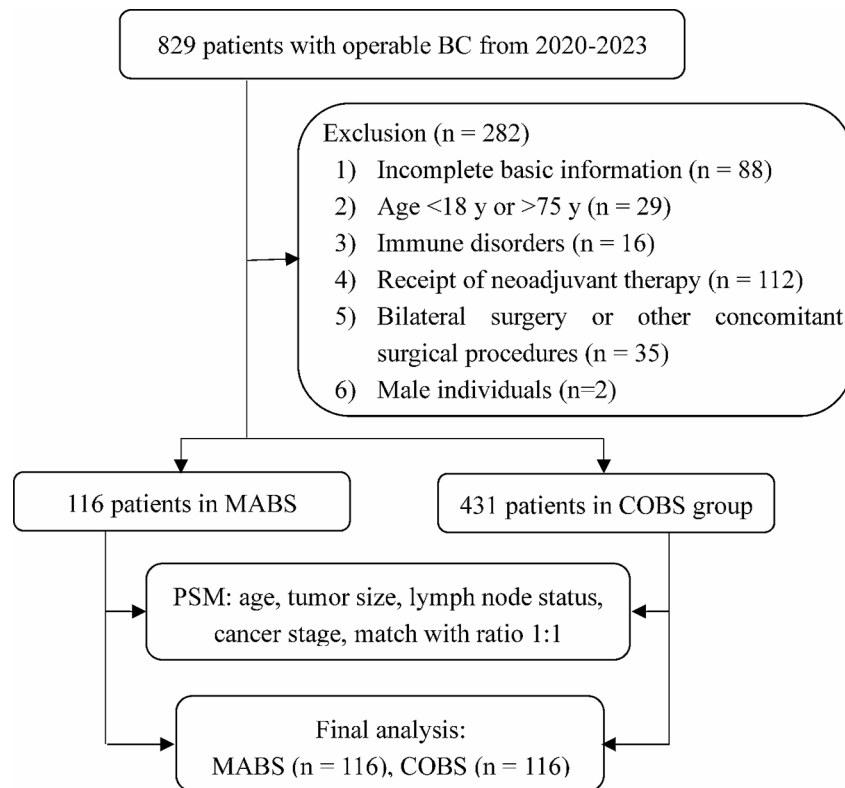
Fig. 1 Patient flow diagram. BC, breast cancer; MABS, minimally access breast surgery; COBS, conventional open breast surgery; PSM, propensity score matching

the groups. Each group, post-matching, consisted of 116 patients.

Statistical analysis

Statistical analyses were conducted using SPSS 21.0 for basic statistics, including means±SD for continuous variables and percentages for categorical data. For propensity score matching (PSM), we employed R version 4.1.2, specifically using the MatchIt package. This approach allowed us to effectively control for confounders and estimate the intervention's impact more accurately. Statistical significance was set at $p < 0.05$ across all analyses.

Results

Study population characteristics

A total of 547 patients who were treated through MABS or COBS at our hospital between June 2020 and July 2023. After propensity score matching with ratio 1:1, 232 patients were considered for final analysis, including 116 in MABS-group and 116 in COBS-group (Fig. 1). Table 1 presents baseline characteristics before and after propensity score matching. Before matching, there were no significant differences between the groups in terms of BMI, pathological type, hormone-receptor status, Her2 status, or Ki-67 status. However, significant differences were observed in age, tumor size, cancer stage, and lymph

node status. Post-matching, there were no significant differences in these variables.

T lymphocyte subsets

As shown in Table 2, both the MABS and COBS groups showed a significant decrease in the percentages of CD3+, CD4+, and the CD4$^+$/CD8$^+$ ratio from preoperative day 1 (PreD1) to postoperative day 1 (PostD1). In the MABS group, these parameters reverted back to preoperative levels by PostD7 (Fig. 2ABCD), while in the COBS group, they exhibited an increase from PostD1 to PostD7 but remained significantly lower than PreD1 (Fig. 2ABCD). The MABS group showed significantly higher percentages of CD3$^+$, CD4$^+$, and the CD4$^+$/CD8$^+$ ratio compared to the COBS group on PostD7 (Table 2, Fig. 3ABD), while CD8$^+$ percentages exhibited similar trends between the two groups throughout all time points (Fig. 3C).

Intraoperative outcomes and postoperative complications

Surgical procedures were successful in both groups. MABS group had a higher average operating time (126.68±18.59 min) compared to the COBS group (120.68±17.32 min; $P < 0.05$). Additionally, the MABS group showed significantly lower levels of intraoperative blood loss, postoperative drainage, shorter extubation
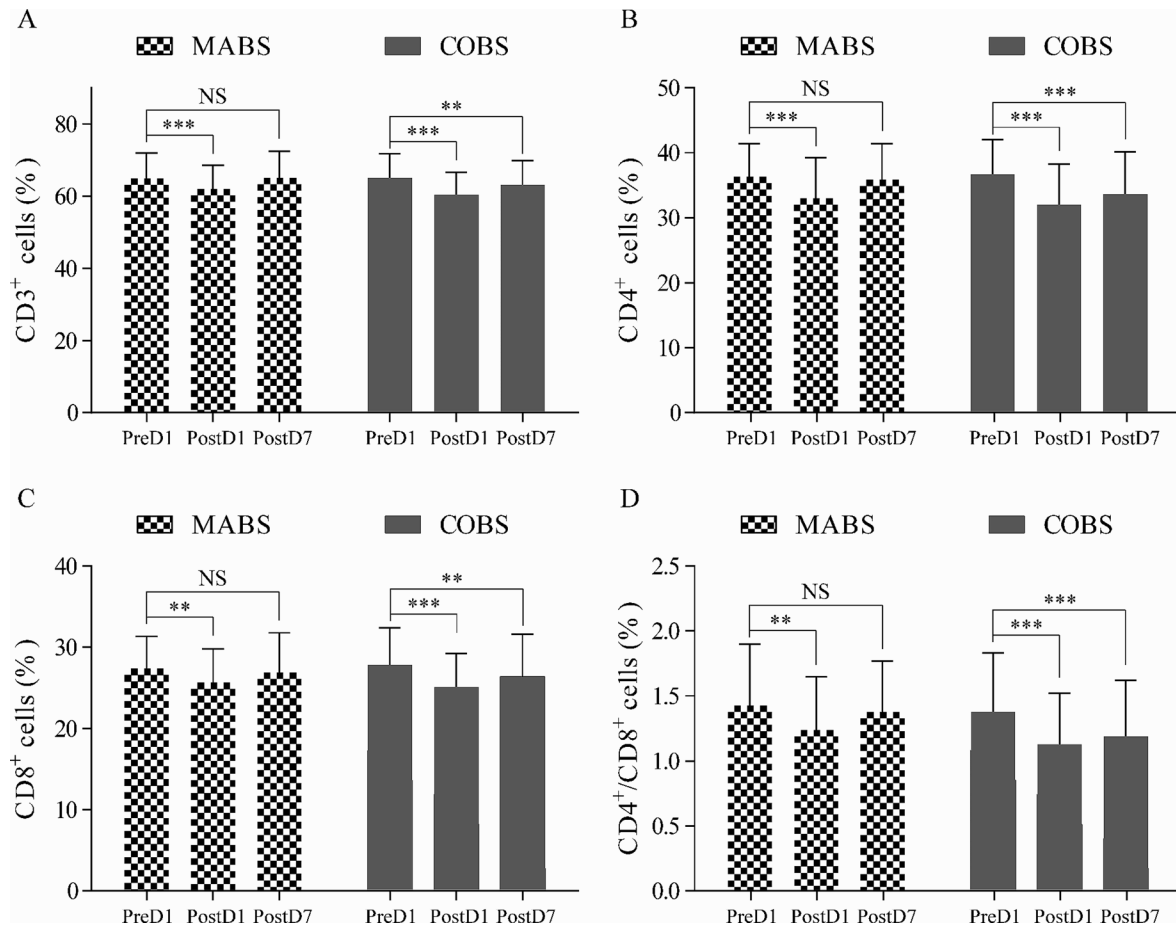
Fig. 2 Comparison of proportions of (**A**) CD3$^+$ cells, (**B**) CD4$^+$ cells, (**C**) CD8$^+$ cells, and (**D**) the CD4$^+$/CD8$^+$ ratio at various time points in patients underwent MABS or COBS. Values are expressed as mean ± SD. MABS, minimally access breast surgery; COBS, conventional open breast surgery; PreD, preoperative day; PostD, postoperative day; ns, no significance; *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

time, and hospital stays. Both groups had similar rates of postoperative complications (Table 3).

Discussion

In this study, we conducted a propensity-matched retrospective cohort analysis to compare postoperative immune function in MABS vs. COBS in treatment of breast cancer patients. The results suggest a decrease in postoperative immune function for both MABS and COBS. Notably, however, immune suppression was less severe and recovery quicker in patients who underwent MABS.

Before applying PSM, there were notable differences in age, tumor size, cancer stage, and lymph node status, all of which favored the COBS group. These disparities could potentially bias the comparison between the two surgical methods. However, after implementing the matching process, these significant differences were eliminated, indicating that the groups had comparable baseline characteristics. This crucial adjustment allows us to more confidently attribute any observed variations

in postoperative immune function to the surgical method itself, rather than to underlying differences in patient demographics or disease severity. PSM neutralized key differences in clinicopathologic variables, ensuring similar baseline characteristics between the groups. This enhanced the reliability of our analysis and confirmed that our findings accurately reflect differences due to the surgical methods, not pre-existing disparities.

Lymphocytes, pivotal elements in the immune system, are responsible for both specific and nonspecific immune tasks crucial for tumor surveillance [28]. However, major surgery has been consistently associated with a decline in the quantity and functionality of T lymphocyte subsets, resulting in significant suppression of postoperative immune function [29]. Various factors, including anesthesia, intraoperative bleeding, tumor resection, and lymph node dissection, can influence the activation of T lymphocytes following surgery [30, 31]. As the body's injury repair mechanism is initiated, immune function gradually recovers, and radical tumor resection can also

Table 1 Baseline characteristics before and after PSM

Parameters	Before PSM			After PSM		
	MABS (n=116)	COBS (n=431)	P	MABS (n=116)	COBS (n=116)	P
Age, yr	48.67±5.32	50.53±6.68	0.029	48.67±5.32	49.26±6.16	0.523
BMI (kg/m^2)	23.69±3.36	24.39±3.75	0.153	23.69±3.36	24.03±3.55	0.540
tumor size (mm)	26.15±11.52	29.86±12.34	0.023	26.15±11.52	27.12±11.67	0.602
Cancer stage	31 (39.7)	49 (25.4)	0.017	31 (39.7)	29 (37.2)	0.604
0-I	40 (51.3)	105 (54.4)		40 (51.3)	38 (48.7)	
II	7 (9.0)	39 (20.2)		7 (9.0)	11 (14.1)	
III						
Lymph node status (n, %)	23 (29.5)	87 (45.1)	0.018	23 (29.5)	26 (33.3)	0.605
Positive	55 (70.5)	106 (54.9)		55 (70.5)	52 (66.7)	
Negative						
Pathologic type (n, %)	70 (89.7)	168 (87.0)	0.539	70 (89.7)	68 (87.2)	0.616
Ductal	8 (10.3)	25 (13.0)		8 (10.3)	10 (12.8)	
Others						
Hormone status (n, %)	56 (71.8)	148 (76.7)	0.398	56 (71.8)	58 (74.4)	0.718
Positive	22 (28.2)	45 (23.3)		22 (28.2)	20 (25.6)	
Negative						
Her2 status (n, %)	23 (29.5)	49 (25.4)	0.489	23 (29.5)	21 (26.9)	0.722
Positive	55 (70.5)	144 (74.6)		55 (70.5)	57 (73.1)	
Negative						
Ki-67 status (n, %)	15 (19.2)	31 (16.1)	0.529	15 (19.2)	17 (21.8)	0.692
< 15%	63 (80.8)	162 (83.9)		63 (80.8)	61 (78.2)	
≥ 15%						

Values shown are mean±SD or n (%). PSM, propensity score matching; MABS, minimally access breast surgery; COBS, conventional open surgery; BMI: body mass index; Her2: human epidermal growth factor receptor-2

Table 2 Proportions of T lymphocyte subsets at different time points

Group and time point	Mean percent or ratio ± SD			
	CD3$^+$	CD4$^+$	CD8$^+$	Ratio CD4$^+$/CD8$^+$
MABS (n=116)				
PreD 1	64.88±7.05	36.34±5.11	27.37±3.98	1.43±0.47
PostD 1	62.05±6.54[c]	33.03±6.23[c]	25.66±4.12[b]	1.24±0.41[b]
PostD 7	65.12±7.29[d]	35.86±5.59[e]	26.92±4.85	1.38±0.39[f]
COBS (n=116)				
PreD 1	65.05±6.65	36.67±5.36	27.83±4.54	1.38±0.45
PostD 1	60.42±6.17[c]	32.03±6.23[c]	25.13±4.12[c]	1.14±0.39[c]
PostD 7	63.12±6.72[b]	33.63±6.52[c]	26.36±5.22[b]	1.19±0.43[c]

Abbreviations PreD, preoperative day; PostD, postoperative day; MABS, minimally access breast surgery; COBS, conventional open breast surgery. [a]$P<0.05$, [b]$P<0.01$ or [c]$P<0.001$, PostD1 or PostD7 vs. PreD1 in same group; [d]$P<0.05$, [e]$P<0.01$, or [f]$P<0.001$, MOBS vs. COBS on PostD7.

contribute to the restoration of T lymphocyte function [32].

To investigate the impact of different surgical approaches on immune function, we compared peripheral blood T lymphocyte subsets between the MABS and COBS groups during the perioperative period. At PostD1, CD3$^+$, CD4$^+$, CD8$^+$, and CD4$^+$/CD8$^+$ ratios were lower in both groups compared to their preoperative levels at PreD1, indicating short-term immune suppression in both groups. However, as postoperative recovery progressed, immune function improved. At PostD7, immune indexes significantly improved in both groups, but the MABS group recovered to preoperative levels ($P>0.05$), whereas the COBS group did not fully recover ($P<0.01$), suggesting a slower recovery of immune function after COBS surgery. Furthermore, at PostD7, CD3$^+$, CD4$^+$, and the CD4$^+$/CD8$^+$ ratios were significantly lower in the COBS group compared to the MABS group, suggesting more severe postoperative immune suppression in the COBS group. These results of this study demonstrates that MABS treatment preserves and restores preoperative immune function more effectively than COBS surgery, highlighting the potential advantages of MABS in enhancing patients' immune responses.

Minimally invasive surgery, compared to open surgery, offers several advantages, including gentler tissue and organ traction, finer anatomical manipulation, reduced damage to blood vessels and lymphatic vessels, decreased trauma, fewer postoperative complications, and faster recovery [11, 33–36]. In our study, we observed that patients who underwent MABS experienced less bleeding, lower drainage volume, shorter extubation time, and shorter hospital stays compared to those who underwent COBS. These findings suggest that the favorable outcomes associated with minimally invasive surgery, such as reduced blood loss and trauma, may contribute to the less severe immune suppression observed in patients undergoing this approach.
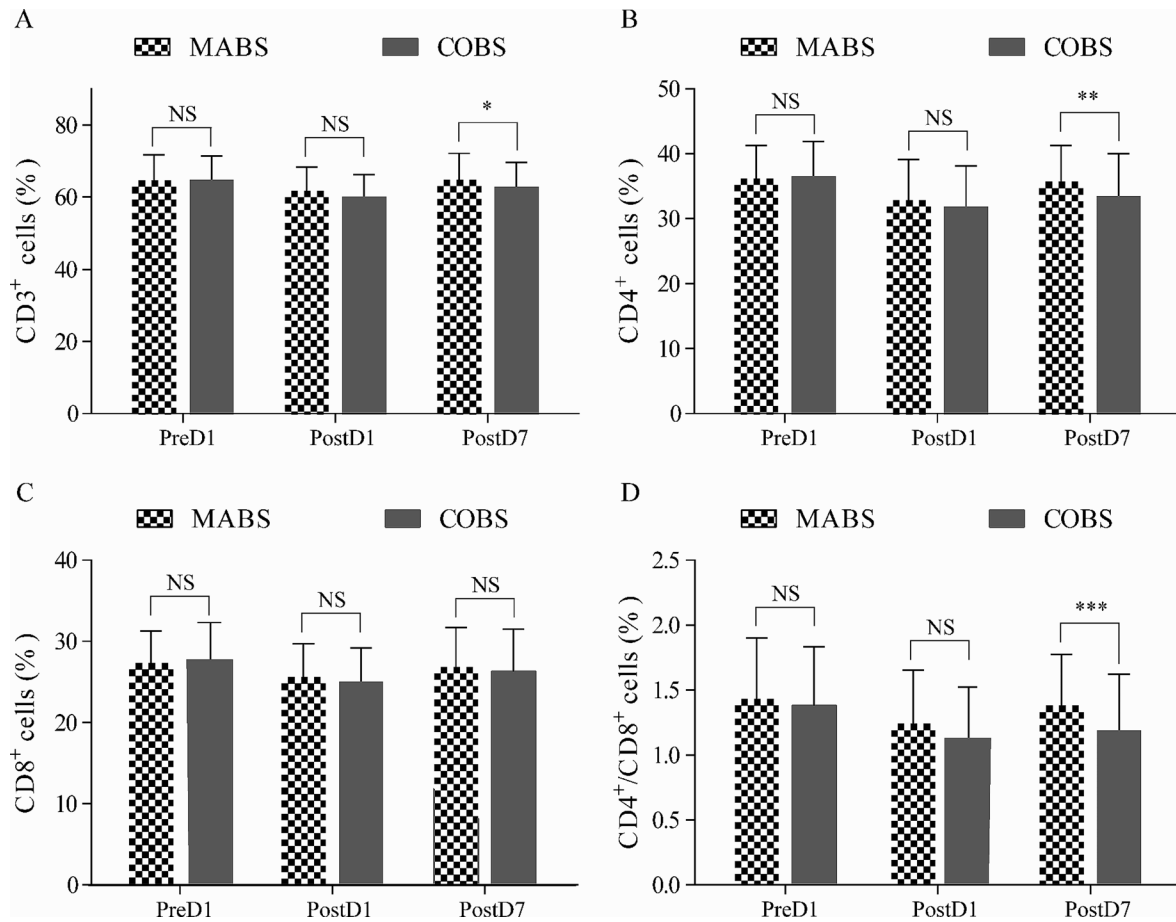
Fig. 3 Comparison of proportions of (**A**) CD3$^+$ cells, (**B**) CD4$^+$ cells, (**C**) CD8$^+$ cells, and (**D**) the CD4$^+$/CD8$^+$ ratio between MABS and COBS at various time points in patients. Values are expressed as mean ± SD. MABS, minimally access breast surgery; COBS, conventional open breast surgery; PreD, preoperative day; PostD, postoperative day; ns, no significance; *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

Table 3 Intraoperative outcomes and postoperative complications in patients

Parameter	MABS (n = 116)	COBS (n = 116)	P
Operating time, min	126.68 ± 18.59	120.68 ± 17.32	0.012
Retrieved lymph node	16.35 ± 3.92	15.15 ± 3.46	0.014
Intraoperative blood loss, ml	37.63 ± 5.13	58.63 ± 8.68	< 0.001
Drain removal time, d	6.62 ± 1.53	8.82 ± 1.92	< 0.001
Postoperative drainage volume, ml	182.75 ± 39.62	347.83 ± 62.39	< 0.001
Postoperative complications	2	3	0.651
Infection	6	7	0.775
Seroma or hematoma			
Skin or nipple necrosis	4	5	0.734
Flap loss or ischemia	1	1	1.000
Fat necrosis	2	3	0.651
Postoperative hospital stay, d	11.12 ± 3.87	15.17 ± 4.54	< 0.001

Values shown are mean±SD or n (%). MABS, minimally access breast surgery; COBS, conventional open breast surgery

Despite slower immune recovery in the COBS group, there was no significant rise in postoperative infection rates, which can be attributed to multiple factors. Firstly, not only immune status but also effective intraoperative and postoperative measures, including antibiotic use and good hygiene, likely helped prevent infections. Secondly, the expected direct link between immune function and infection risks may not be as strong, with individual health differences also impacting outcomes. Additionally, variations in how infections are diagnosed and recorded, as well as study limitations like sample size, could influence data interpretation. Therefore, despite delayed immune recovery, effective management and other variables ensured stable infection rates, suggesting the need for more research into how immune function affects infection risks post-surgery.

Our study has limitations that should be acknowledged. It was a retrospective study, which may introduce selection bias despite our efforts to minimize it. Further confirmation through multi-center, prospective, and larger sample studies is necessary. Additionally, our

immune function assessment was limited to specific time points before and after surgery. Extending the observation period and exploring additional immune indicators would enhance our understanding. It is also important to directly examine cellular immune function in tumor specimens to validate our findings. These limitations emphasize the need for further research to strengthen and broaden our understanding in this field.

Conclusions

Despite these limitations, our study provides evidence to support the potential of MABS in minimizing postoperative immune suppression. This highlights the necessity for larger randomized clinical trials and mechanistic studies to elucidate the immune preservative mechanisms of MABS.

Author contributions
Q.H.J., J.L., and J.T.T. contributed equally to the design of the study and the collection of data. Q.H.J. and J.L. conducted the statistical analysis. J.T.T. and H.H. supervised the study, provided critical revisions that were important for the intellectual content, and is the corresponding author. All authors participated in the writing and review of the manuscript. All authors read and approved the final manuscript.

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 medical ethics committee of the Third Hospital of Nanchang, approval number K-lw2023002. All of the methods were performed in accordance with the 1964 Declaration of Helsinki and its later amendments, and the ethical standards of the institutional research committee.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

References
1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, Bray F. Global Cancer statistics 2020: GLOBOCAN estimates of incidence and Mortality Worldwide for 36 cancers in 185 countries. Cancer J Clin. 2021;71:209–49.
2. Maajani K, Jalali A, Alipour S, Khodadost M, Tohidinik HR, Yazdani K. The global and regional survival rate of women with breast cancer: a systematic review and meta-analysis. Clin Breast Cancer 2019.
3. Yamamoto S, Chishima T, Sugae S, Yamagishi S, Yamada A, Narui K, Misumi T, Ishikawa T, Endo I. Evaluation of aesthetic outcomes of breast-conserving surgery by the surgeon, nurse, and patients. Asian J Surg. 2022;45:131–6.
4. Wan A, Liang Y, Chen L, Wang S, Shi Q, Yan W, Cao X, Zhong L, Fan L, Tang P et al. Association of Long-Term Oncologic Prognosis with Minimal Access breast surgery vs conventional breast surgery. JAMA Surg 2022, 157.
5. Huang NS, Liu MY, Chen JJ, Yang BL, Wu J. Surgical management of breast cancer in China: a 15-year single-center retrospective study of 18,502 patients. Medicine. 2016;95:e4201.
6. Wang S, Sultana F, Kavanagh A, Nickson C, Karahalios A, Gurrin LC, English DR. Benefits and harms of breast cancer screening: Cohort study of breast cancer mortality and overdiagnosis. Cancer Med 2023.
7. Lai HW, Chen ST, Lin YJ, Kuo SJ. Minimal Access (endoscopic and robotic) breast surgery in the Surgical treatment of early breast Cancer—Trend and Clinical Outcome from a single-surgeon experience over 10 years. Frontiers in oncology; 2021.
8. Lai HW, Lin SL, Chen ST, Kuok KM, Chen SL, Lin YL, Chen DR, Kuo SJ. Single-axillary-incision endoscopic-assisted hybrid technique for nipple-sparing mastectomy: technique, preliminary results, and patient-reported Cosmetic Outcome from preliminary 50 procedures. Ann Surg Oncol 2018.
9. Wang ZH, Xin P, Qu X, Zhang ZT. Breast reconstruction using a laparoscopically harvested pedicled omental flap after endoscopic mastectomy for patients with breast cancer: an observational study of a minimally invasive method. AME Publishing Company; 2020.
10. Park HS, Lee JS, Lee JS, Park S, Park BW. The feasibility of Endoscopy-assisted breast conservation surgery for patients with early breast Cancer. J Breast Cancer. 2011;14:52–7.
11. Xiong H, Chen Z, Xu L, Chen C, Fu Q, Teng R, Chen J, Xie S, Wang L, Yu X-F, Zhou J. Contrast of Mastoscopic and Conventional Axillary Lymph Node dissection of patients with breast Cancer: Meta-Analysis. Cancer Control 2020, 27.
12. Lai HW, Toesca A, Sarfati B, Park HS, Mok CW. Consensus Statement on Robotic Mastectomy—Expert Panel From International Endoscopic and Robotic Breast Surgery Symposium (IERBS) 2019. *Annals of Surgery* 2020:1.
13. Lai HW. ASO author reflections: single-Port three-Dimensional (3D) videoscope-assisted endoscopic nipple-sparing mastectomy in management of breast Cancer. Ann Surg Oncol 2021:1–2.
14. Hou Y, Hu Y, Song W, Zhang J, Luo Q, Zhou Q. Surgical site infection following minimally invasive lobectomy: is robotic surgery superior? Cancer Med. 2022;11:2233–43.
15. Luo C, Zhang J, Ji. Xiaoxin, Lin, Hua, Yang, Qi: experience of a large series of mastoscopic axillary lymph node dissection. J Surg Oncol 2008.
16. Mccombe PA, Read SJ. Immune and inflammatory responses to stroke: good or bad? Int J Stroke 2008.
17. David S. Miha, Skvarc: Effective Strategies for Diagnosis of Systemic Inflammatory Response Syndrome (SIRS) due to Bacterial Infection in Surgical Patients. *Infectious disorders drug targets* 2015.
18. Whelan RL, Franklin M, Holubar SD, Donahue J, Fowler R, Munger C, Doorman J, Balli JE, Glass J, Gonzalez JJ. Postoperative cell mediated immune response is better preserved after laparoscopic vs open colorectal resection in humans. Surg Endosc. 2003;17:972.
19. Surgical trauma induces. Postoperative T-cell dysfunction in lung cancer patients through the programmed death-1 pathway. Cancer Immunol Immunotherapy Cii. 2015;64:1383–92.
20. Hung-Wen, Lai S-T, Chen D-R, Chen S-L, Tsai-Wang C. Chang: current trends in and indications for Endoscopy-assisted breast surgery for breast Cancer: results from a six-year study conducted by the Taiwan Endoscopic Breast Surgery Cooperative Group. PLoS ONE. 2016;11:e0150310.
21. Sakamoto N, Fukuma E, Teraoka K, Hoshi K. Local recurrence following treatment for breast cancer with an endoscopic nipple-sparing mastectomy. Breast Cancer. 2016;23:552–60.
22. Du J, Liang Q, Qi X, Ming J, Liu J, Zhong L, Fan L, Jiang J. Endoscopic nipple sparing mastectomy with immediate implant-based reconstruction versus breast conserving surgery: a long-term study. Sci Rep. 2017;7:45636.
23. Park HS, Lee J, Lee DW, Song SY, Lew DH, Kim SI, Cho YU. Robot-assisted Nipple-sparing Mastectomy with Immediate Breast Reconstruction: An Initial Experience. *Scientific Reports*.
24. Sarfati B, Struk S, Leymarie N, Honart JF, Mazouni C, Rimareix F, Saghatchian M, Delaloge S, Kolb F. Robotic nipple-sparing mastectomy with immediate prosthetic breast reconstruction: a prospective study. Eur J Cancer. 2018;92:S32.
25. Braitman LE. Rare outcomes, common treatments: Analytic Strategies using propensity scores. Ann Intern Med. 2002;137:693–5.

26. Austin PC. The use of propensity score methods with survival or time-to-event outcomes: reporting measures of effect similar to those used in randomized experiments. Stat Med 2014, 33.

27. Wang WH, Xu HY, Zhao ZM, Zhang GM, Lin FW. Dynamic and significant changes of T-cell subgroups in breast cancer patients during surgery and chemotherapy. Int Immunopharmacol. 2018;65:279–83.

28. Heath WR, Carbone FR. The skin-resident and migratory immune system in steady state and memory: innate lymphocytes, dendritic cells and T cells. Nat Immunol. 2013;14:978–85.

29. Yokoyama M, Itano Y, Mizobuchi S, Nakatsuka H, Kaku R, Takashima T, Hirakawa M. The effects of epidural block on the distribution of lymphocyte subsets and natural-killer cell activity in patients with and without pain. Anesth Analgesia. 2001;92:463–9.

30. Mantovani G, Macciò A, Madeddu C, Mura L, Massa E, Gramignano G, Lusso MR, Murgia V, Camboni P, Ferreli L. Reactive oxygen species, antioxidant mechanisms, and serum cytokine levels in cancer patients: impact of an antioxidant treatment. J Environ Pathol Toxicol Oncol. 2003;22:17–28.

31. Cara C. Stephen, Duff: adrenergic, inflammatory, and Immune function in the setting of oncological surgery. Int Anesthesiol Clin 2016.

32. Vollmer-Conna U, Bird KD, Yeo BW, Truskett PG, Westbrook RF, Wakefield D. Psychological factors, immune function and recovery from major surgery. Acta Neuropsychiatrica 2009.

33. Luo C, Wei C, Guo W, Yang J, Sun Q, Wei W, Wu S, Fang S, Zeng Q, Zhao Z, et al. 17-Year follow-up of comparing Mastoscopic and Conventional Axillary dissection in breast Cancer: a Multicenter, Randomized Controlled Trial. Adv Therapy. 2022;39:2961–70.

34. Luo C, Guo W, Yang J, Sun Q, Wei W, Wu S, Fang S, Zeng Q, Zhao Z, Meng F, et al. Comparison of Mastoscopic and Conventional Axillary Lymph Node dissection in breast Cancer: long-term results from a Randomized, Multicenter Trial. Mayo Clin Proc. 2012;87:1153–61.

35. Lv W, Ding B, Qian L, Wu W, Wen Y. Safety of breast Cancer mastoscopic surgery from the perspective of immunity and Adipokines. J Invest Surg. 2021;35:632–8.

36. Lai HW, Chen ST, Liao CY, Mok CW, Lin YJ, Chen DR, Kuo SJ. Oncologic outcome of endoscopic assisted breast surgery compared with Conventional Approach in breast Cancer: an analysis of 3426 primary operable breast Cancer patients from Single Institute with and without propensity score matching. Ann Surg Oncol 2021:1–13.

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