



Correlation between Arterial Feeding Embolization and Pleural Effusion Dynamics in Breast Cancer Patients

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Abstract: Breast cancer is the most common malignancy in women and a leading cause of malignant pleural effusion (MPE). Arterial feeding embolization, as performed in transarterial chemoembolization (TACE), has the potential to reduce effusion production by obstructing tumor blood supply. This study aimed to evaluate the correlation between arterial embolization and pleural effusion dynamics in patients with breast cancer. This was a prospective cohort study conducted at Prof. Dr. R. D. Kandou Hospital, Manado, from 2022 to 2024. Patients diagnosed with breast cancer were randomly assigned to the TACE or control group. Superselective embolization was performed using a microcatheter and a selected embolic agent to occlude the blood supply to the target lesion. Data were analyzed using SPSS v26 with Shapiro-Wilk normality test, t-test or Mann-Whitney U test, and linear regression. Study phases included subject selection, randomization, and data analysis. The results showed that a total of 21 female patients with breast cancer (mean age 52.19 ± 9.17 years) were enrolled. Eleven patients (52.4%) underwent TACE, while ten (47.6%) did not. Pleural effusion was observed in four patients (19%), more frequently in the non-TACE group (30%) compared to the TACE group (9.1%), though the difference was not statistically significant ($p=0.439$). Multivariate analysis also revealed no significant association between arterial embolization and pleural effusion ($p=0.244$; $R^2=0.071$), indicating a low predictive value. Arterial feeding embolization via TACE demonstrated clinical potential in reducing pleural effusion among breast cancer patients, although the results were not statistically significant. The limited efficacy may be attributed to the complex tumor vascularization and heterogeneous biological responses. A multimodal therapeutic approach remains necessary for optimal MPE management. In conclusion, although arterial embolization may clinically reduce tumor perfusion and subsequent effusion formation, this study found no significant correlation between the procedure and pleural effusion reduction. Therefore, arterial embolization alone may not be sufficient as a standalone treatment strategy for managing MPE in breast cancer patients.

Keywords: breast cancer; malignant pleural effusion; transarterial chemoembolization

INTRODUCTION

According to the World Health Organization (WHO), malignant neoplasms represent a major global health burden for women, accounting for approximately 107.8 million Disability-Adjusted Life Years (DALYs), with breast cancer contributing 19.6 million DALYs. Breast cancer is the most commonly diagnosed cancer in women worldwide, with an estimated 2.26 million new cases in 2020.¹ In the United States, breast cancer accounts for about 29% of all new cancer diagnoses in women. GLOBOCAN 2018 data further indicate that the age-standardized incidence rate (ASIR) of breast cancer is strongly and positively associated with the Human Development Index (HDI), reaching 75.6 per 100,000 in very high HDI countries, and significantly lower in medium- and low-HDI countries (27.8 and 36.1 per 100,000, respectively).^{1,2}

Pleural effusion is a common complication of breast cancer, classified as malignant pleural effusion (MPE) when cancer cells are present in the pleural fluid. Most MPE cases are due to lung or breast cancer, and diagnosis typically requires thoracentesis and cytological confirmation. However, repeated sampling may be needed to detect malignant cells. One potentially life-threatening complication during pleural effusion drainage is intercostal artery bleeding. Such bleeding may result from procedural inexperience or catheter manipulation, and identifying the exact mechanism, whether from vessel transection or catheter removal, is often challenging. Mechanisms like the “ripple-hook” effect have been proposed in cases involving pigtail catheters.³

Given the vascular nature of tumors, arterial embolization, as used in transarterial chemoembolization (TACE), may theoretically reduce pleural effusion by limiting tumor blood supply.³ This study aims to investigate the relationship between feeding artery embolization and pleural effusion dynamics in patients with breast cancer. In our study, we present a case series of TACE that we used for patients in Prof. Dr. R. D. Kandou General Hospital, a type A referral hospital in North Sulawesi Province.

METHODS

This prospective cohort study was conducted at Prof. Dr. R. D. Kandou General Hospital, Manado, from 2022 to 2024. Patients diagnosed with breast cancer were randomly assigned to the TACE or control group. Superselective embolization was performed using a microcatheter and a selected embolic agent to occlude the blood supply to the target lesion. Data were analyzed using SPSS v26 with Shapiro-Wilk normality test, t-test or Mann-Whitney U test, and linear regression. Study phases included subject selection, randomization, and data analysis.

RESULTS

Table 1 showed that a total of 21 female patients were included in this study. Of these, 11 patients (52.4%) underwent TACE, while 10 patients (47.6%) did not. The mean age was 52.19±9.17 years, with a median age of 50 years. Chest radiograph findings revealed pleural effusion in four patients (19%).

Table 1. Baseline characteristics of breast cancer patients

Variables	N (%)	Mean ± SD	Median
Age	-	52.19 ± 9.17	50
Embolization Procedure			
Without TACE	10 (47.6%)	-	-
With TACE	11 (52.4%)	-	-
Chest X-Ray findings			
Pleural effusion	4 (19%)	-	-
Pneumonia	4 (19%)	-	-
Normal	13 (61.9%)	-	-

Abbreviations: N = number of samples, SD = standard deviation, TACE = transarterial chemoembolization.

Table 2 showed that among patients without TACE, pleural effusion was observed in three cases (30%), while only one case (9.1%) was reported in the TACE group. Statistical analysis using the chi-square test revealed no significant association between arterial feeding embolization and pleural effusion findings in breast cancer patients ($p=0.439$).

Table 2. Association between arterial embolization and pleural effusion

Thorax findings		Embolization procedure		p-value**
		Without TACE	With TACE	
Pleural effusion	N	3	1	0.439
	%	30	9.1	
Pneumonia	N	2	2	
	%	20	18.2	
Normal	N	5	8	
	%	50	72.7	

p-value calculated using Chi-square test. TACE = transarterial chemoembolization.

Table 3 showed that the linear regression analysis yielded a negative regression coefficient ($\beta = 0.266$), indicating an inverse trend between arterial embolization and pleural effusion, though not statistically significant. The p-value was 0.244, and the R^2 value was 0.071, suggesting that only 7.1% of the variance in pleural effusion could be explained by the model. The ANOVA F-test also indicated non-significance ($F=1.446$; $p>0.05$).

Table 3. Multivariate analysis of arterial embolization and pleural effusion

	Coeffisient	R ²	F	p-value**
Embolization arterial	0.266	0.071	1.446	0.244

* R2 (R square), F (ANOVA)

** Multivariate linear regression analysis

DISCUSSION

This study aimed to analyze the relationship between arterial embolization and pleural effusion dynamics in patients with breast cancer. Various strategies have been employed to reduce pleural effusion in such patients, one of which is the embolization of feeding arteries. Transarterial chemoembolization (TACE) is a minimally invasive procedure that delivers chemotherapeutic agents directly to the tumor through its arterial supply while simultaneously blocking the blood flow via embolization.⁴

In this study, the mean patient age was 52.19 years ($SD \pm 9.17$), with a median of 50 years. Patients were randomly assigned to two groups: 11 patients (52.4%) underwent TACE and 10 patients (47.6%) did not. Radiographic findings showed that four patients (19%) developed pleural effusion, four patients (19%) had pneumonia, and 13 patients (61.9%) showed no thoracic complications. Notably, the majority of patients in both groups had normal chest X-ray results (61.9%). Statistical analysis revealed no significant association between arterial embolization and changes in pleural effusion ($p>0.05$). However, from a clinical standpoint, embolization showed favourable outcomes: only one out of 11 patients in the TACE group developed pleural effusion post-embolization. Additionally, a high proportion of patients in this group maintained normal chest radiographic findings, suggesting that arterial embolization may contribute to reducing pleural effusion complications in selected cases.^{5,6} This result differed with the findings reported by Zhang et al⁶ where the prevalence of pleural effusion in patients with acute pulmonary embolism (APE) was noted to be 57.01%, suggesting that pleural effusion was a frequent manifestation in APE and warrants increased clinical awareness. In contrast, a retrospective analysis involving over 3,000 thoracentesis procedures revealed that APE was identified as the

underlying cause of pleural effusion in only 1.6% of cases.⁷ Moreover, two studies involving Chinese populations with APE reported lower prevalence rates of 19.9% and 23.2%, respectively. These discrepancies indicate that the true prevalence of pleural effusion associated with APE may be challenging to ascertain. Importantly, these findings highlight a potential diagnostic oversight in clinical practice, where pleural effusion of unknown etiology may lead to missed or delayed recognition of APE. Therefore, greater emphasis should be placed on considering APE in the differential diagnosis of unexplained pleural effusions.⁶

The similarity in outcomes between TACE and non-TACE groups suggests that embolization alone may have a limited impact on pleural fluid dynamics. This may be explained by several factors. First, breast tumors are characterized by complex and extensive vascular networks, and embolization may not completely occlude all feeding arteries, allowing residual blood flow to sustain pleural effusion. Second, biological variability among tumors may influence response to embolization; certain tumors may resist ischemic stress and continue producing pleural fluid despite reduced perfusion.^{8,9} According to the study conducted by Mason et al,⁸ TACE offers limited benefit in patients who develop post-embolization syndrome (PES), with a median OS of only 16 months and 3-year survival of 18%. Sequential TACE appears to improve outcomes, and its use should be prioritized over single-session procedures. Moreover, drug-eluting bead TACE (DEB-TACE) is linked to a lower risk of PES and may offer a safer alternative to conventional TACE.

Moreover, embolization carries risks such as pain, infection, and injury to adjacent healthy tissues, adversely affecting overall patient outcomes. These complications may limit the procedure's efficacy in controlling pleural effusion. Therefore, systemic therapies such as chemotherapy or targeted therapy and repeated pleural drainage may still be required for optimal fluid control in patients with malignant pleural effusion.^{10,11,12}

CONCLUSION

This study evaluated the relationship between arterial embolization and pleural effusion dynamics in patients with breast cancer. Although embolization may clinically reduce tumor perfusion and potentially decrease effusion production, the findings revealed no statistically significant correlation between the procedure and pleural effusion reduction. These results suggest that arterial embolization alone may not be effective as a standalone treatment for managing pleural effusion in breast cancer patients.

Conflict of Interest

The authors affirm no conflict of interest in this study.

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