Journal of Carcinogenesis
Covering Genesis to Therapeutics

Journal of Carcinogenesis, ISSN: 1477-3163
2026; Vol 25: Issue 1, https://carcinogenesis.com/

Immunohistochemical evaluation of Aldehyde dehydrogenase-1 A1 expression in breast carcinoma

Dr.Suryadevara Mounica[1], Dr. Clement wilfred[2], Dr Laxmi Ronada[3], Dr Usha M[4], Dr Rashmi K[5]

Postgraduate[1], Professor[2], Assistant Professor[3], AssociateProfessor[4], Associate Professor[5]

Department of pathology, MS Ramaiah medical college, MSR nagar, Mathikere, Bengaluru -560054, Karnataka

Correspondence: Dr. Suryadevara Mounica,

Department of pathology, MS Ramaiah medical college, MSR nagar, Mathikere, Bengaluru -560054, Karnataka

ABSTRACT

Background: Aldehyde dehydrogenase 1A1 (ALDH1A1) is associated with stem-cell-like properties in breast carcinoma and has been investigated as a marker of aggressive tumour behaviour. This study evaluated ALDH1A1 immunoexpression and its association with clinicopathological parameters.

Methods: This cross-sectional study included 50 breast carcinoma resection specimens received at the Department of Pathology, Ramaiah Medical College, Bengaluru, between March 2024 and February 2026. Histopathological parameters were assessed on haematoxylin and eosin-stained sections. ALDH1A1 immunohistochemistry was performed on formalin-fixed, paraffin-embedded tumour tissue. Associations were evaluated using chi-square or Fisher's exact tests, as appropriate.

Results: High, moderate and low ALDH1A1 expression was reported in 21/50 (42%), 12/50 (24%) and 17/50 (34%) cases, respectively. ALDH1A1 expression was associated with tumour T category (P=0.0033), nodal category (P=0.0056), lymphovascular invasion (P=0.0028) and age group (P=0.0148). No significant association was observed with SBR grade (P=0.184) or perineural invasion (P=0.5151). The reported association with AJCC stage grouping (P=0.048) requires verification because the stage-wise counts in the dissertation do not reconcile with the cohort total.

Conclusion: In this cohort, higher ALDH1A1 expression was associated with selected adverse pathological features, particularly higher T and N categories and lymphovascular invasion. Larger studies with standardized scoring and clinical follow-up are required before ALDH1A1 can be considered for routine prognostic use.

Keywords: *Breast Carcinoma; ALDH1A1; Immunohistochemistry; Lymphovascular Invasion; Lymph Node Metastasis; Tumour Stage.*

How to Cite: Dr.Suryadevara Mounica, Dr. Clement wilfred, Dr Laxmi Ronada, Dr Usha M, Dr Rashmi K, (2026) Immunohistochemical evaluation of Aldehyde dehydrogenase-1 A1 expression in breast carcinoma, *Journal of Carcinogenesis*, *Vol.25, No.1*, 728-731

1. INTRODUCTION

Breast carcinoma is a heterogeneous malignancy in which outcome is influenced by tumour size, nodal status, histological grade, lymphovascular invasion and molecular subtype. Identification of additional tissue biomarkers may improve understanding of tumour biology and provide complementary prognostic information.

ALDH1A1 is an aldehyde-metabolizing enzyme that has been studied as a marker of cancer stem-cell-like populations. ALDH1A1-positive tumour cells have been linked in experimental and clinical studies to tumour initiation, treatment resistance and aggressive clinicopathological features. However, reported associations with grade, nodal status and outcome have not been uniform across studies.

The present study evaluated ALDH1A1 immunohistochemical expression in breast carcinoma and assessed its relationship with clinicopathological prognostic parameters in a cohort of 50 resection specimens.

© 2026 Journal of Carcinogenesis | Published for Carcinogenesis Press by Wolters Kluwer-Medknow

2. MATERIALS AND METHODS

Study design and setting: A cross-sectional study was conducted in the Department of Pathology, Ramaiah Medical College and Hospital, Bengaluru, Karnataka, India. The study period was March 2024 to February 2026 .

Study population: Fifty breast carcinoma resection specimens, comprising modified radical mastectomy (n=45) and wide local excision with lymph node dissection (n=5), were included. The thesis describes inclusion of patients aged 18 years or older with resection specimens and lymph node dissection. Cases with biopsy/lumpectomy without nodal dissection and cases with extensive necrosis precluding assessment were excluded.

Histopathological assessment: Specimens were grossed using standard protocols. Representative tumour, margin and lymph node sections were processed, paraffin embedded and stained with haematoxylin and eosin. Histological type, Scarff–Bloom–Richardson (SBR) grade, tumour size/category, lymphovascular invasion, perineural invasion and lymph node status were assessed. Tumours were staged using the AJCC 8th edition.

Immunohistochemistry: Four-micrometre sections were mounted on adhesive-coated slides. Antigen retrieval was performed in citrate buffer using a microwave oven, followed by blocking of endogenous peroxidase with 3% hydrogen peroxide. Sections were incubated with a mouse monoclonal anti-ALDH1A1 primary antibody, followed by rabbit anti-mouse secondary antibody and streptavidin–horseradish peroxidase detection. Diaminobenzidine was used as chromogen and haematoxylin as counterstain. Positive and negative controls were included.

ALDH1A1 scoring: Cytoplasmic staining in more than 5% of tumour cells was considered positive. The percentage score was 0 (<5%), 1+ (5–10%), 2+ (11–50%) and 3+ (>50%); staining intensity was scored 0 (none), 1 (minimal), 2 (moderate) and 3 (strong).

Statistical analysis: Categorical variables were summarized as frequencies and percentages. Associations were assessed using the chi-square test or Fisher's exact test, as appropriate. A P value <0.05 was considered statistically significant.
Ethics: [Ramiah medical college : reg no ECR/215/int/K/2013/RR-22, MSRMC/EC/PG-8-03-2024]

3. RESULTS

The study included 50 cases. Patient age ranged from 30 to 78 years the largest age group was older than 60 years (16/50, 32%). Most specimens were modified radical mastectomies (45/50, 90%). The left breast was involved in 26 cases (52%). Tumour size was 2–5 cm in 26 cases (52%), and SBR grade II was seen in 36 cases (72%). Lymphovascular invasion was present in 31 cases (62%), lymph node metastasis in 24 (48%), and perineural invasion in 2 (4%).

High ALDH1A1 expression was the most frequent category (21/50, 42%), followed by low (17/50, 34%) and moderate expression (12/50, 24%). ALDH1A1 expression was significantly associated with age group, T category, N category and lymphovascular invasion. No significant association was observed with SBR grade or perineural invasion.

In T1 tumours, all six cases showed low expression. High expression was observed in 13/26 (50.0%) T2 tumours, 7/15 (46.7%) T3 tumours and 1/3 (33.3%) T4 tumours. High expression was observed in 9/26 (34.6%) N0, 6/11 (54.5%) N1, 3/8 (37.5%) N2 and 3/5 (60.0%) N3 cases. Among cases with lymphovascular invasion, 16/31 (51.6%) showed high expression, compared with 5/19 (26.3%) without lymphovascular invasion.

Table 1. Clinicopathological characteristics of the study cohort (n=50)

Characteristic	Category	n (%)
Age group (years)	31–40	4 (8.0)
	41–50	15 (30.0)
	51–60	15 (30.0)
	>60	16 (32.0)
Specimen	Modified radical mastectomy	45 (90.0)
	Wide local excision	5 (10.0)
Laterality	Left	26 (52.0)
	Right	24 (48.0)
Tumour size	<2 cm	6 (12.0)
	2–5 cm	26 (52.0)
	6–10 cm	15 (30.0)
	>10 cm	3 (6.0)

© 2026 Journal of Carcinogenesis | Published for Carcinogenesis Press by Wolters Kluwer-Medknow

Histological type	IDC-NOS	48 [VERIFY denominator/percentage]
	Mixed IDC and mucinous carcinoma	2 [VERIFY denominator/percentage]
SBR grade	I	5 (10.0)
	II	36 (72.0)
	III	9 (18.0)
Lymphovascular invasion	Absent	19 (38.0)
	Present	31 (62.0)
Lymph node metastasis	Absent	26 (52.0)
	Present	24 (48.0)
Perineural invasion	Absent	48 (96.0)
	Present	2 (4.0)

IDC-NOS, invasive ductal carcinoma, not otherwise specified; SBR, Scarff–Bloom–Richardson. Histological-type percentages in the thesis (95.2% and 4.8%) do not match a denominator of 50 and must be checked.

Table 2. Association of ALDH1A1 expression with selected clinicopathological variables

Variable	Category	Low n (%)	Moderate n (%)	High n (%)	P value
Age (years)	31–40	3 (75.0)	1 (25.0)	0 (0)	0.0148
	41–50	7 (46.7)	4 (26.7)	4 (26.7)	
	51–60	5 (33.3)	0 (0)	10 (66.7)	
	>60	2 (12.5)	7 (43.8)	7 (43.8)	
SBR grade	I	4 (80.0)	1 (20.0)	0 (0)	0.184
	II	11 (30.6)	9 (25.0)	16 (44.4)	
	III	2 (22.2)	2 (22.2)	5 (55.6)	
T category	T1	6 (100)	0 (0)	0 (0)	0.0033
	T2	9 (34.6)	4 (15.4)	13 (50.0)	
	T3	1 (6.7)	7 (46.7)	7 (46.7)	
	T4	1 (33.3)	1 (33.3)	1 (33.3)	
N category	N0	14 (53.8)	3 (11.5)	9 (34.6)	0.0056
	N1	2 (18.2)	3 (27.3)	6 (54.5)	
	N2	1 (12.5)	4 (50.0)	3 (37.5)	
	N3	0 (0)	2 (40.0)	3 (60.0)	

Percentages are row percentages. P values are reproduced from the dissertation and should be recalculated from the case-wise dataset before submission.

Table 3. Association of ALDH1A1 expression with invasion parameters

Variable	Category	Low n (%)	Moderate n (%)	High n (%)	P value
Lymphovascular invasion	Absent	12 (63.2)	2 (10.5)	5 (26.3)	0.0028
	Present	5 (16.1)	10 (32.3)*	16 (51.6)	
Perineural invasion	Absent	17 (35.4)	11 (22.9)	20 (41.7)	0.5151
	Present	0 (0)	1 (50.0)	1 (50.0)	

*The thesis prints 23.3%; 10/31 is 32.3%, which is the arithmetic percentage. Confirm against the master chart and statistical output.

4. DISCUSSION

In this cohort, high ALDH1A1 expression was identified in 42% of breast carcinomas. The principal findings were significant associations with T category, nodal category and lymphovascular invasion. These observations support a relationship between ALDH1A1 expression and selected indicators of tumour extent and dissemination, although the cross-sectional design does not establish independent prognostic value.

The association with tumour size/category (P=0.0033) is broadly consistent with reports by Yao et al. and Demir et al., who described relationships between ALDH1 expression and larger tumours or advanced disease. The significant association with nodal category (P=0.0056) also aligns with studies reporting greater ALDH1 expression in node-positive carcinomas. The association with lymphovascular invasion (P=0.0028) may reflect a link with invasive behaviour; however, the percentage for the moderate-expression LVI-positive subgroup requires correction against the original data. Unlike some published series, ALDH1A1 expression was not significantly associated with SBR grade in the present study (P=0.184). This difference may reflect the modest sample size, cohort composition, antibody and scoring differences, or biological heterogeneity. The association with age group (P=0.0148) is an observation in this cohort and should be

interpreted cautiously, particularly because the age range and mean age are inconsistently reported in different thesis sections.

No significant association was found with perineural invasion (P=0.5151); only two cases showed PNI, limiting the ability to detect a meaningful relationship. The reported AJCC stage-group association (P=0.048) cannot be interpreted until the discrepancy between stage-group totals and the stage-wise ALDH1A1 table is resolved.

This study is limited by its single-centre design, small sample size, lack of long-term follow-up and absence of survival analysis. The scoring algorithm used to classify low, moderate and high ALDH1A1 expression also requires explicit definition. These limitations preclude conclusions about independent prognostic performance or clinical utility.

5. CONCLUSION

ALDH1A1 expression was significantly associated with tumour T category, nodal category and lymphovascular invasion in this cohort of breast carcinomas. No significant association was observed with SBR grade or perineural invasion. ALDH1A1 may be a candidate marker of aggressive pathological features, but larger, standardized studies with outcome follow-up are needed to establish its prognostic significance.

Funding
No specific funding was received for this study

Ethics approval and consent to participate
[Ramiah medical college : reg no ECR/215/int/K/2013/RR-22, MSRMC/EC/PG-8-03-2024]

REFERENCES

[1] Sarkar P, Basu K, Sarkar P, Chatterjee U, Mukhopadhyay M, Choudhuri MK, et al. Correlations of aldehyde dehydrogenase-1 (ALDH1) expression with traditional prognostic parameters and different molecular subtypes of breast carcinoma. Clujul Med. 2018;91(2):181-187.
[2] Demir H, Dulgar O, Gulle BT, Turna H, Ilvan S. Prognostic value of aldehyde dehydrogenase 1 (ALDH1) in invasive breast carcinomas. Bosn J Basic Med Sci. 2018;18(4):313-319.
[3] Yao J, Jin Q, Wang XD, Zhu HJ, Ni QC. Aldehyde dehydrogenase 1 expression is correlated with poor prognosis in breast cancer. Medicine (Baltimore). 2017;96(25):e7171.
[4] Kida K, Ishikawa T, Yamada A, Shimada K, Narui K, Sugae S, et al. Effect of ALDH1 on prognosis and chemoresistance by breast cancer subtype. Breast Cancer Res Treat. 2016;156(2):261-269.
[5] Currie MJ, Beardsley BE, Harris GC, Gunningham SP, Dachs GU, et al. Immunohistochemical analysis of cancer stem cell markers in invasive breast carcinoma and associated ductal carcinoma in situ: relationships with markers of tumor hypoxia and microvascularity. Hum Pathol. 2013;44(3):402-411.
[6] Ricardo S, Vieira AF, Gerhard R, Leitão D, Pinto R, Cameselle-Teijeiro JF, et al. Breast cancer stem cell markers CD44, CD24 and ALDH1: expression distribution within intrinsic molecular subtype. J Clin Pathol. 2011;64(11):937-946.
[7] Morimoto K, Kim SJ, Tanei T, Shimazu K, Tanji Y, Taguchi T, et al. Stem cell marker ALDH1 expression correlates with histologic grade and prognosis in breast cancer. Breast Cancer Res Treat. 2009;113(2):307-316.
[8] Ginestier C, Hur MH, Charafe-Jauffret E, Monville F, Dutcher J, Brown M, et al. ALDH1 is a marker of normal and malignant human mammary stem cells and a predictor of poor clinical outcome. Cell Stem Cell. 2007;1(5):555-567.

Figure legends
Figure 1. Invasive breast carcinoma, haematoxylin and eosin stain, ×200. Alt text: Infiltrative malignant epithelial glands and nests within desmoplastic stroma.

Figure 2. High ALDH1A1 immunoexpression in invasive breast carcinoma, ×400, showing strong cytoplasmic staining in tumour cells. Alt text: Tumour cells with prominent brown cytoplasmic immunoreactivity.
Figure 3. Moderate ALDH1A1 immunoexpression in invasive breast carcinoma, ×400, showing intermediate cytoplasmic staining. Alt text: Tumour cells with moderate brown cytoplasmic immunoreactivity.
Figure 4. Low ALDH1A1 immunoexpression in invasive breast carcinoma, ×400, showing weak/focal cytoplasmic staining. Alt text: Tumour cells with faint and limited brown cytoplasmic immunoreactivity.

© 2026 Journal of Carcinogenesis | Published for Carcinogenesis Press by Wolters Kluwer-Medknow