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ORIGINAL

Maximizing diagnostic precision: Evaluating the combined Yokohama and BI-RADS scoring system for breast lesions

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KEYWORDS
Breast cancer;
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Abstract
Background: The diagnosis of breast cancer necessitates a multifaceted approach integrating cytopathological and radiological assessments. The International Academy of Cytology (IAC) Yokohama system and Breast Imaging Reporting and Data System (BI-RADS) are fundamental frameworks in this context. This study aims to evaluate the diagnostic potential of a combined Yokohama-BI-RADS scoring system for breast lesions.
Materials and methods: A retrospective analysis was conducted on fine needle aspirates from January to June 2023. The cases were classified using the IAC Yokohama system and sonomammography BI-RADS score. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were calculated using histopathological diagnoses as the reference standard. Optimal cut-off scores for the combined scoring system were determined.
Results: Among 52 patients, cytological diagnoses encompassed non-diagnostic, benign, atypical, suspicious of malignancy, and malignant categories. BI-RADS scores ranged from 1 to 5. The combined Yokohama-BI-RADS score exhibited superior diagnostic accuracy (AUC: 0.986) compared to individual systems.
Conclusion: The combined Yokohama-BI-RADS scoring system represents a promising advancement in breast lesion evaluation, providing enhanced diagnostic precision by integrating cytopathological and radiological data. This approach has the potential to optimize clinical decision-making and contribute to improved patient outcomes in breast cancer management.

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PALABRAS CLAVE
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BI-RADS;
Precisión diagnóstica

Maximización de la precisión diagnóstica: evaluación del sistema de puntuación combinado de Yokohama y BI-RADS para lesiones mamarias

Resumen
Antecedentes: El diagnóstico del cáncer de mama requiere un enfoque multifacético que integre evaluaciones citopatológicas y radiológicas. El sistema Yokohama de la Academia Internacional de Citología (IAC) y el Sistema de informes y registro de datos de estudios por imágenes de la mama (BI-RADS) son marcos fundamentales en este ámbito. Este estudio tiene como objetivo evaluar el potencial diagnóstico de un sistema de puntuación combinado Yokohama-BI-RADS para lesiones mamarias.
Materiales y métodos: Se realizó un análisis retrospectivo de aspiraciones con aguja fina realizadas entre enero y junio de 2023. Los casos se clasificaron mediante el sistema IAC Yokohama y la puntuación BI-RADS de ecografía de mama. La sensibilidad, la especificidad, el valor predictivo positivo (VPP), el valor predictivo negativo (VPN) y la precisión diagnóstica se calcularon utilizando como estándar de referencia los diagnósticos histopatológicos. Se determinaron las puntuaciones de corte óptimas para el sistema de puntuación combinado.
Resultados: En un estudio en 52 pacientes, los diagnósticos citológicos abarcaron categorías no diagnósticas, benignas, atípicas, sospechosas de malignidad y malignas. Las puntuaciones de BI-RADS variaron de 1 a 5. La puntuación combinada de Yokohama-BI-RADS mostró una mayor precisión diagnóstica (AUC: 0,986) en comparación con los sistemas individuales.
Conclusión: El sistema de puntuación combinado Yokohama-BI-RADS constituye un avance prometedor en la evaluación de las lesiones mamarias, al proporcionar una mayor precisión diagnóstica mediante la integración de datos citopatológicos y radiológicos. Este enfoque tiene el potencial de mejorar la toma de decisiones clínicas y contribuir a mejorar los resultados de los pacientes en el tratamiento del cáncer de mama.

Introduction

Within the realm of breast cancer diagnosis, the integration of cytopathological insights and radiological assessments forms the foundation of precision medicine. The International Academy of Cytology (IAC) Yokohama system and the Breast Imaging Reporting and Data System (BI-RADS) stand out as pillars of cytological and radiological diagnostic categories, respectively.[1,2]

The IAC Yokohama system, introduced by the International Academy of Cytology in 2016, was developed to have a uniform reporting system with enhanced reproducibility and improved communication between pathologists and clinicians. This system meticulously evaluates cellular architecture, nuclear characteristics, and stromal features, offering clinicians a detailed understanding of tumour behaviour and prognostic implications.[1]

In parallel, BI-RADS offers a standardized framework for interpreting mammographic findings, facilitating consistent radiological reporting and management recommendations. Developed by the American College of Radiology, BI-RADS categorizes breast lesions based on their radiographic features, calcifications, architectural distortions, and other imaging parameters, providing crucial guidance for clinical decision-making.[2]

Individually, both the IAC Yokohama grading system and BI-RADS have demonstrated efficacy in guiding diagnostic and therapeutic strategies for breast lesions. The present study aims to evaluate whether a combined scoring system – integrating the cytopathological insights of the IAC Yokohama system with the radiological findings of BI-RADS – provides a more comprehensive and refined approach to breast lesion evaluation than either system alone.

Materials and methods

This was a retrospective study in which all the breast fine needle aspirates from January 2023 to June 2023 were retrieved. Informed consent was obtained from all patients before the FNABs. At least two passes were performed for each breast lump. The final reports were based on smears stained with May-Grünwald-Giemsa and Papanicolaou stains.

All cases were categorized according to the IAC Yokohama reporting system into five categories[1]:

- Non-diagnostic
- Benign
- Atypical
- Suspicious of malignancy
- Malignant

They were given a score of 1–5 based on the category of the Yokohama system with 1 being non-diagnostic and 5 being malignant.

The clinical details and BI-RADS scores from sonomammography were extracted from electronic health records and radiological reports. Histopathological diagnoses, obtained through biopsy or surgical excision, served as the gold standard for reference.

Based on BI-RADS, the breast lesions were categorized as[2]:

- BI-RADS 0 – Need additional investigations
- BI-RADS 1 – Negative
- BI-RADS 2 – Benign
- BI-RADS 3 – Probably benign
- BI-RADS 4 – Suspicious
- BI-RADS 5 – Highly suggestive of malignancy
- BI-RADS 6 – Known biopsy-proven

For statistical analysis, non-diagnostic cases under the IAC Yokohama system and BI-RADS categories 0, 1 and 6 were excluded. Using histological diagnosis as the gold standard, the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated.

Sensitivity = True positive/(True positive + False negative)

Specificity = True negative/(True negative + False positive)

PPV = True positive/(True positive + False positive)

NPV = True negative/(True negative + False negative)

Diagnostic accuracy = (True positive + True negative)/All analysed cases

The above ratios were calculated separately for the Yokohama system and BI-RADS for the following groups:

- Group A (for Yokohama) – only the ''malignant'' category was regarded as a positive report.
- Group A (for BI-RADS) – only the ''BI-RADS 5'' category was regarded as a positive report.
- Group B (for Yokohama) – all cases in the ''malignant'' and ''suspicious of malignancy'' category were regarded as positive for malignancy.
- Group B (for BI-RADS) – all cases in the ''BI-RADS 5'' and ''BI-RADS 4'' category were regarded as positive for malignancy.

Furthermore, the cases were assigned a combined score based on the IAC Yokohama and BI-RADS scoring (adding the total score of Yokohama and BI-RADS). The performance of this combined score was also analysed. An area under the curve (AUC) analysis was conducted to compare the diagnostic performance of the IAC Yokohama system, BI-RADS, and the combined Yokohama-BI-RADS score.

Results

A total of 52 patients underwent breast fine needle aspiration biopsy in the above period, with a mean age of 39.6 ± 13.6 years. Based on the IAC Yokohama system, there were 2 non-diagnostic, 30 benign, 3 atypical, 5 suspicious of malignancy and 12 malignant cases. According to BI-RADS, the cases were classified as 2 BI-RADS 1, 11 BI-RADS 2, 14 BI-RADS 3, 13 BI-RADS 4 and 12 BI-RADS 5 cases. Table 1 depicts the cytological diagnosis, Yokohama category, BI-RADS score, combined score and final histopathological diagnosis of all the cases.

The sensitivity, specificity, PPV, NPV and diagnostic accuracy of IAC Yokohama system and BI-RADS were similar when only malignant cases or BI-RADS 5 were considered positive, with values of 63.16%, 100%, 100%, 81.58% and 86%, respectively. However, when both malignant and suspicious cases (or BI-RADS 4 and 5) were considered positive, the IAC Yokohama system exhibited higher specificity, PPV and diagnostic accuracy, while BI-RADS exhibited higher sensitivity and NPV (Tables 2 and 3).

The combined BI-RADS and Yokohama system (Table 4) exhibited higher specificity and PPV than either the Yokohama or BI-RADS systems alone, when both malignant and suspicious cases (or BI-RADS 4 and 5) were considered positive. Diagnostic accuracy, however, was comparable to that of the cytological classification system.

However, when we constructed a receiver operating characteristic (ROC) curve, the combined score displayed an area under the curve of 0.986, surpassing both the IAC Yokohama system (0.935) and BI-RADS (0.941) (Fig. 1). This suggests an enhanced capability of the combined score in distinguishing between benign and malignant breast lesions. Using the ROC curve, we identified optimal cut-off scores for the Yokohama system, BI-RADS, and the combined score, ensuring maximal specificity and sensitivity in differentiating benign from malignant lesions. The determined cut-off score was 4 for the IAC Yokohama system and BI-RADS, while it was set at 7 for the combined Yokohama-BI-RADS system.

Discussion

Breast cancer diagnosis requires a multifaceted approach that combines cytopathological and radiological assessments to ensure accuracy and inform treatment decisions. This study aimed to evaluate the diagnostic performance of the combined Yokohama and BI-RADS scoring system for breast lesions, offering insights into its potential clinical utility and areas for further investigation.

The findings of this study underscore the importance of integrating complementary diagnostic modalities in breast lesion evaluation. Both the IAC Yokohama system and BI-RADS have proven to be valuable tools in cytological and radiological assessments, respectively. Individually, these systems have demonstrated efficacy in guiding clinical management decisions.[1,2] However, their combined use presents an opportunity to leverage the strengths of each approach while mitigating their respective limitations.

The superior diagnostic performance of the combined Yokohama-BI-RADS scoring system, as evidenced by the higher area under the curve (AUC) compared to either system alone, highlights the potential synergistic effect of integrating cytopathological and radiological data. The higher specificity, positive predictive value (PPV), and diagnostic accuracy observed with the combined score suggest an improved ability to correctly identify malignant breast lesions, reducing false-positive diagnoses and unnecessary interventions.

Interestingly, while the IAC Yokohama system exhibited higher specificity, PPV, and diagnostic accuracy, BI-RADS demonstrated higher sensitivity and negative predictive

Table 1 The cytological diagnosis, BI-RADS category and final histopathological diagnosis of all the cases.

S. No.	Age/gender	Cytological diagnosis	Yokohama category	BI-RADS	Combined score	Histopathological diagnosis
1.	30/F	Fibroadenoma	2	2	4	Fibroadenoma
2.	60/F	Invasive carcinoma	5	5	10	Invasive ductal carcinoma
3.	19/F	Fibroadenoma	2	3	5	Fibroadenoma
4.	27/F	Fibroadenoma	2	2	4	Fibroadenoma
5.	61/F	Invasive carcinoma	5	5	10	Invasive ductal carcinoma
6.	50/F	Fibroadenoma	2	5	7	Invasive ductal carcinoma
7.	46/F	Suspicious for malignancy	4	4	8	Atypical ductal hyperplasia
8.	53/F	Invasive carcinoma	5	4	9	Invasive ductal carcinoma
9.	60/F	Suspicious for malignancy	4	5	9	Invasive ductal carcinoma
10.	29/F	Benign proliferative breast disease	2	4	6	Fibroadenoma with usual ductal hyperplasia
11.	55/F	Benign proliferative breast disease with atypia	3	3	6	Fibroadenoma with usual ductal hyperplasia
12.	30/F	Granulomatous mastitis	2	2	4	Granulomatous mastitis
13.	33/F	Benign breast disease	2	4	6	Suspicious of malignancy
14.	18/F	Fibroadenoma	2	3	5	Fibroadenoma
15.	29/F	Abscess	2	4	6	Abscess
16.	45/F	Invasive carcinoma	5	5	10	Invasive ductal carcinoma
17.	36/F	Fibroadenoma	2	2	4	Fibroadenoma
18.	29/F	Granulomatous mastitis	2	3	5	Tubercular mastitis
19.	45/F	Fibroadenoma with cystic change	2	4	6	Fibroadenoma
20.	32/F	Phyllodes	2	3	5	Benign phyllodes
21.	36/F	Invasive carcinoma	5	5	10	Invasive ductal carcinoma
22.	42/F	Phyllodes malignant	4	3	7	Malignant phyllodes
23.	26/F	Fibroadenoma	2	2	4	Fibroadenoma
24.	27/F	Galactocele	2	3	5	Lactational adenoma
25.	60/F	Invasive carcinoma	5	5	10	Invasive ductal carcinoma
26.	31/F	Fibroadenoma	2	2	4	Fibroadenoma
27.	62/F	Invasive carcinoma	5	5	10	Invasive ductal carcinoma
28.	21/F	Fibroadenoma	2	3	5	Fibroadenoma
29.	29/F	Fibroadenoma	2	2	4	Fibroadenoma
30.	65/F	Invasive carcinoma	5	4	9	Invasive ductal carcinoma
31.	50/F	Fibroadenoma with cystic change	2	2	4	Fibroadenoma
32.	46/F	Suspicious for malignancy	4	4	8	Invasive ductal carcinoma
33.	58/F	Invasive carcinoma	5	4	9	Invasive ductal carcinoma
34.	60/F	Suspicious for malignancy	4	5	9	Invasive ductal carcinoma
35.	29/F	Benign proliferative breast disease	2	3	5	Fibroadenoma with usual ductal hyperplasia

Table 1 (*Continued*)

S. No.	Age/gender	Cytological diagnosis	Yokohama category	BI-RADS	Combined score	Histopathological diagnosis
36.	55/F	Benign proliferative breast disease with atypia	3	3	6	Fibroadenoma with usual ductal hyperplasia
37.	35/F	Granulomatous mastitis	2	2	4	Granulomatous mastitis
38.	29/F	Benign breast disease	2	4	6	Fibrocystic disease
39.	18/F	Fibroadenoma with cystic change	2	3	5	Fibroadenoma
40.	31/F	Abscess	2	3	5	Abscess
41.	45/F	Invasive carcinoma	5	5	10	Invasive ductal carcinoma
42.	36/F	Fibroadenoma	2	2	4	Fibroadenoma
43.	29/F	Granulomatous lesion	2	4	6	Granulomatous mastitis
44.	45/F	Fibroadenoma with cystic change	2	4	6	Fibroadenoma
45.	30/F	Phyllodes	2	3	5	Benign phyllodes
46.	36/F	Invasive carcinoma	5	5	10	Invasive ductal carcinoma
47.	44/F	Phyllodes borderline	3	4	7	Malignant phyllodes
48.	26/F	Fibroadenoma	2	2	4	Fibroadenoma
49.	28/F	Lactational adenoma	2	3	5	Lactational adenoma
50.	62/F	Invasive carcinoma	5	5	10	Invasive ductal carcinoma

Table 2 Performance analysis of IAC Yokohama system.

	Taking malignant as positive	Taking malignant and suspicious of malignancy as positive
Sensitivity	63.16% (38.36–83.71%)	84.21% (60.42–96.62%)
Specificity	100% (88.78–100%)	96.77% (83.30–99.92%)
Positive predictive value	100% (73.54–100%)	94.12% (69.73–99.11%)
Negative predictive value	81.58% (71.08–88.86%)	90.91% (77.94–96.59%)
Diagnostic accuracy	86% (73.26–94.18%)	92% (80.77–97.78%)

Table 3 Performance analysis of the BI-RADS system.

	Taking malignant as positive	Taking malignant and suspicious of malignancy as positive
Sensitivity	63.16% (38.36–83.71%)	94.74% (73.97–99.87%)
Specificity	100% (88.78–100%)	77.42% (58.90–90.41%)
Positive predictive value	100% (73.54–100%)	72% (57.05–83.27%)
Negative predictive value	81.58% (71.08–88.86%)	96% (77.92–99.39%)
Diagnostic accuracy	86% (73.26–94.18%)	84% (70.89–92.83%)

value (NPV). This divergence underscores the complementary nature of the two systems and emphasizes the importance of a comprehensive approach to breast lesion evaluation. Clinicians must weigh the trade-offs between sensitivity and specificity based on the clinical context and patient preferences.

Previous studies have compared the sensitivity and specificity of BI-RADS and FNAB separately, highlighting their individual strengths. Navya et al. found a BI-RADS sensitivity of 88% and specificity of 87.5%, while FNAB demonstrated 100% sensitivity and specificity.[3] Similarly, Pandia et al. reported BI-RADS sensitivity and specificity of 88.57% and 82.46%, respectively, with FNAB achieving 100% in both metrics.[4] Umat et al. and Rahman et al. also reported high sensitivity and specificity for FNAB.[5,6] However, this is the first study to evaluate a combined BI-RADS-Yokohama score. Table 5 provides a comparison of the performance analysis reported in previous studies for BI-RADS and FNAB.

The identification of optimal cut-off scores for the combined Yokohama-BI-RADS system further enhances its clinical

Table 4 Performance analysis of combined Yokohama and BI-RADS score.

	Taking malignant as positive	Taking malignant and suspicious of malignancy as positive
Sensitivity	44.44% (21.53–69.24%)	77.78% (52.36–93.59%)
Specificity	100% (89.11–100%)	100% (89.11–100%)
Positive predictive value	100% (66.06–100%)	100% (76.84–100%)
Negative predictive value	76.19% (67.92–82.87%)	88.89% (77.12–95%)
Diagnostic accuracy	80% (66.28–89.97%)	92% (80.77–97.78%)

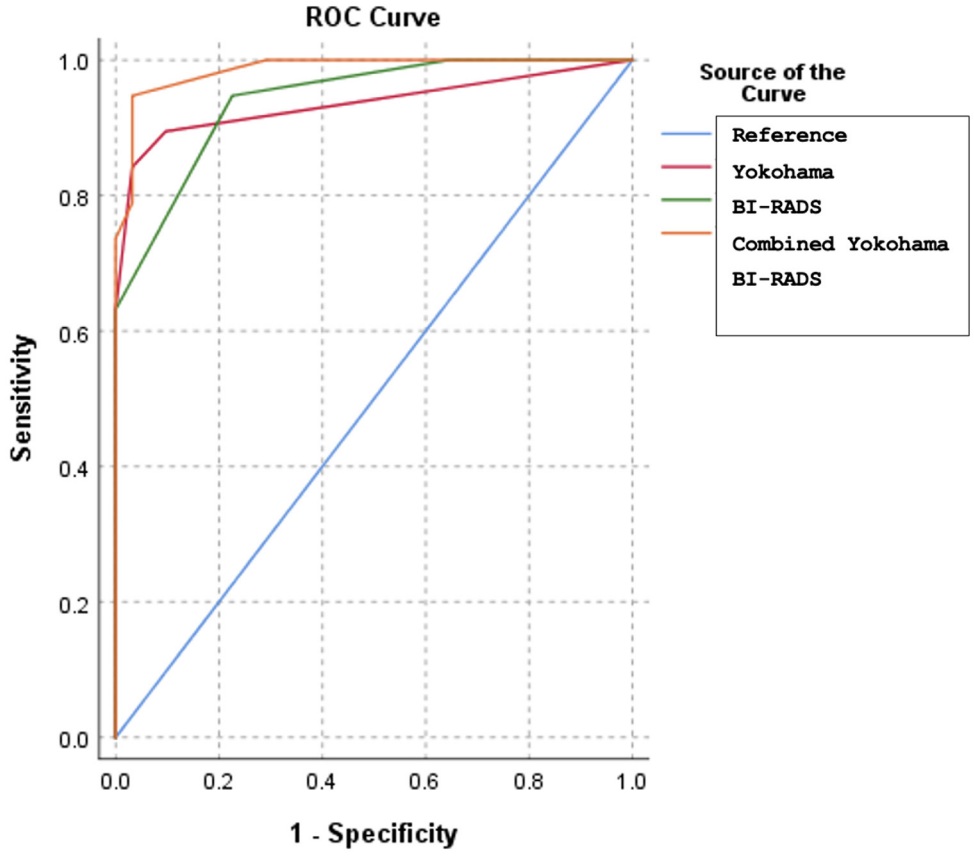

Figure 1 AUC curve to compare the diagnostic performance of the IAC Yokohama system, BI-RADS, and the combined Yokohama-BI-RADS score.

Table 5 Performance analysis parameters for BI-RADS and FNAB of previously reported studies.

Author	BI-RADS					FNAB				
	Sensitivity	Specificity	PPV	NPV	Diagnostic accuracy	Sensitivity	Specificity	PPV	NPV	Diagnostic accuracy
Navya et al.[3]	88%	87.5%	80%	93%	88%	100%	100%	100%	100%	100%
Pandia et al.[4]	88.57%	82.46%	75.61%	92.16%	84.78%	100%	100%	100%	100%	100%
Umat et al.[5]	91%	–	–	–	–	98%	–	–	–	–
Rahman et al.[6]	82.76%	90.36%	75%	93.7%	88.39%	97.2%	99.46%	97.2%	99.4%	99.9%
Present study	94.74%	77.42%	72%	96%	84%	84.21%	96.77%	94.12%	90.91%	92%

applicability, providing clear thresholds for distinguishing between benign and malignant lesions with maximal sensitivity and specificity. These cut-off scores offer valuable guidance for clinicians in decision-making and risk stratification.

An essential aspect to consider is the performance of fine needle aspiration biopsy (FNAB). Despite the growing preference for trucut biopsies in many places, FNAB remains a valuable diagnostic tool, particularly in settings where trucut biopsy is not feasible. FNAB is minimally invasive, cost-effective, and requires fewer resources, making it an ideal choice in resource-limited settings. Several studies have highlighted the utility of FNAB in accurately diagnosing breast lesions, especially when more invasive biopsy techniques are not possible.[7–9] This approach is crucial for maintaining diagnostic capabilities in diverse healthcare environments and ensuring broader access to effective breast cancer diagnosis.

Despite the promising findings, several limitations warrant consideration. The retrospective nature of the study and the relatively small sample size may limit the generalizability of the results. Additionally, the reliance on histopathological diagnoses as the gold standard introduces inherent biases and potential discrepancies between cytological and histological interpretations.

Future research endeavours should focus on the prospective validation of the combined Yokohama-BI-RADS scoring system in larger, diverse patient cohorts to confirm its robustness and generalizability. Longitudinal studies assessing its impact on clinical outcomes – such as treatment decisions, patient morbidity, and survival rates – would provide valuable insights into its real-world effectiveness.

In conclusion, the combined Yokohama-BI-RADS scoring system represents a promising advancement in breast lesion evaluation, providing enhanced diagnostic precision and supporting informed decision-making. By integrating cytopathological and radiological data, this approach has the potential to optimize patient care and improve outcomes in the management of breast cancer. Continued research and validation efforts are essential to fully realise the potential of this combined scoring system in clinical practice.

Informed consent

The study was conducted after obtaining informed consent from the patient.

Ethics approval and consent to participate

The research has been conducted in accordance with the World Medical Association Code of ethics (Declaration of Helsinki).

Consent for publication

Informed consent was obtained from patients for participation and publication of their data.

Declaration of generative AI and AI-assisted technologies in the writing process

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Conflicts of interest

The authors have no conflicts of interest to declare.

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