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ORIGINAL ARTICLE

HER2DX in HER2-positive inflammatory breast cancer: correlative insights and comparative analysis with noninflammatory breast cancers☆

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Background: The HER2DX assay predicts long-term prognosis and pathologic complete response (pCR) in patients with early-stage human epidermal growth factor receptor 2 (HER2)-positive breast cancer receiving neoadjuvant systemic therapy but has not been evaluated in inflammatory breast cancer (IBC).

Patients and methods: HER2DX was analyzed in baseline biopsy tissues from 23 patients with stage III HER2-positive IBC on a phase II trial (NCT01796197) treated with neoadjuvant trastuzumab, pertuzumab, and paclitaxel (THP). To assess the assay's predictive accuracy for pCR in IBC, clinical-pathological features and outcomes from this IBC cohort were compared with 156 patients with stage III HER2-positive non-IBC from four different cohorts. Comparative analyses included HER2DX scores, gene signatures, and expression of individual genes between patients with IBC and non-IBC.

Results: Notable differences in clinicopathological characteristics included higher pertuzumab and chemotherapy usage and lower axillary burden in patients with IBC compared with non-IBC. In the combined cohort ($n = 179$), HER2DX pCR score and pertuzumab use were significant predictors of pCR, but not IBC status. The pCR rates in patients treated with trastuzumab-based chemotherapy (including IBC and non-IBC) were 68.9%, 58.5%, and 16.3% in the HER2DX pCR-high, -medium, and -low groups, respectively. Comparative gene expression analysis indicated minor differences between IBC and non-IBC affecting individual *HER2*, immune, and proliferation genes.

Conclusions: The HER2DX pCR score could predict pCR in stage III HER2-positive IBC following treatment with de-escalated neoadjuvant systemic therapy and in stage III HER2-positive non-IBC. Elevated pCR rates in HER2-positive IBC with high HER2DX pCR scores suggest there may be a role for treatment de-escalation in these patients and confirmatory studies are justified.

Key words: inflammatory breast cancer, HER2-positive, HER2DX, pathologic complete response

INTRODUCTION

Inflammatory breast cancer (IBC) is a rare and aggressive form of breast cancer that comprises 2%-5% of invasive breast cancer cases and accounts for up to 10% of breast cancer-related deaths.[1-5] IBC is characterized by dermal lymphovascular invasion by tumor cell emboli.[6] Occlusion of lymphatic vessels causes lymphedema, which results in a rapid onset of breast warmth, erythema, and edema (peau

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d'orange), often in the absence of a palpable mass.[7] Diffuse lymphovascular invasion also facilitates early tumor cell metastasis to nearby lymph nodes and distant sites.[8] To move beyond the subjective diagnosis of IBC that relies solely on clinical criteria, a quantitative scoring system was recently proposed and is undergoing validation.[9] Because of these unique disease features, IBC presents as either locally advanced or metastatic disease. Approximately 70%-75% of patients are initially diagnosed with stage III disease, and the remaining 25%-30% present with *de novo* metastatic (stage IV) IBC.[10] Consequently, IBC is associated with an overall worse prognosis than non-IBC, with higher rates of breast cancer deaths and a higher tendency for locoregional recurrence. Unfortunately, patients with IBC are excluded from most clinical trials, and tumor biology and genomic drivers behind these tumors are yet to be uncovered.[8]

Trimodal therapy is the standard approach for patients with stage III IBC, starting with neoadjuvant systemic therapy followed by modified radical mastectomy and postmastectomy radiation therapy.[10] In patients with human epidermal growth factor receptor 2 (HER2)-positive (HER2+) disease, which represents up to 40% of IBC cases[11,12] (compared with 15%-20% in non-IBC[13]), combination regimens that incorporate HER2-targeted agents and chemotherapy can produce pathologic complete response (pCR) rates of 30%-59% and 5-year overall survival of up to 74%.[14-17] Similar to patients with breast cancer in general, patients with IBC who experience a pCR have significantly better overall survival outcomes than patients with residual invasive disease after neoadjuvant therapy.[18,19] Therefore there is a need to further optimize neoadjuvant therapy. This includes identifying biomarkers that may help predict which patients are likely to experience a pCR and those who might benefit from further treatment.

The HER2DX assay is a supervised learning algorithm that incorporates tumor size, nodal status, and expression of 27 genes encompassing four distinct signatures (immune infiltration, tumor cell proliferation, luminal differentiation, and *HER2* expression) to provide three independent scores to predict long-term prognosis (HER2DX risk score), likelihood of achieving a pCR (HER2DX pCR score), and *ERBB2* messenger RNA expression levels (*ERBB2* score) in patients with early-stage HER2+ breast cancer.[20] To date, the value of HER2DX has not been studied specifically in patients with HER2+ IBC.

We previously conducted a single-arm phase II trial of trastuzumab, pertuzumab, and paclitaxel (THP) in 23 patients with newly diagnosed stage III HER2+ IBC (NCT01796197). The overall pCR rate was 43.5% and the 4-year event-free survival was 86%. Among 21 patients who underwent surgery, the 4-year disease-free survival was 90%.[21] Analysis of tumor tissue obtained from baseline and on-treatment biopsies revealed gene expression profiles during treatment, including genes involved in immune signaling and apoptosis, that were predictive of pCR.[21]

In this study, we carried out HER2DX testing on baseline biopsy samples from patients with stage III HER2+ IBC who were treated with neoadjuvant THP in a clinical trial (NCT01796197). We compared these results with HER2DX test scores, gene expression signatures, and pCR outcomes among patients with stage III HER2+ non-IBC treated with neoadjuvant trastuzumab-based therapy from four different cohorts [DAPHNe, GOM-HGUGM-2018-05, BiOnHER (NCT05912062), and the HER2DX 268-validation cohort].[20,22,23]

METHODS

IBC clinical study

A prospective, open-label, single-arm phase II study (12-497; NCT01796197) was completed among patients with newly diagnosed stage III IBC with no evidence of metastatic disease in viscera or bone.[24] Patients had HER2+ disease according to the 2013 American Society of Clinical Oncology/College of American Pathologists (ASCO/CAP) guidelines.[25] All patients received a loading dose of neoadjuvant trastuzumab (H) 4 mg/kg intravenously (i.v.) and pertuzumab (P) 840 mg i.v. on day 1 (D1), followed by the initiation of weekly paclitaxel 80 mg/m^2 i.v. on D8. Paclitaxel was given weekly for a total of 16 weeks along with weekly trastuzumab 2 mg/kg i.v. Pertuzumab 420 mg was given i.v. every 21 days for five cycles beginning on D1. After the completion of neoadjuvant THP, patients with operable disease underwent total mastectomy and axillary lymph node dissection. Patients with residual invasive disease at surgery were treated with doxorubicin 60 mg/m^2 and cyclophosphamide 600 mg/m^2 (AC) every 2-3 weeks for four cycles. Patients who had a pCR after THP could elect to omit postneoadjuvant AC per the patient's and physician's choice. After surgery, all patients received trastuzumab 6 mg/kg and pertuzumab 420 mg every 21 days for an additional 12 cycles to complete 1 year of HER2-targeted therapy. Postmastectomy radiation therapy to the chest wall and regional lymph nodes was administered per standard of care. Patients with hormone receptor-positive (HR+) disease received standard adjuvant endocrine therapy. Fresh-frozen tumor biopsies were obtained at baseline and before D8, following a single dose of HP and before adding paclitaxel.

The primary outcome of this phase II study was pCR, defined as the absence of invasive disease in the breast and axillary lymph nodes (ypT0/is, ypN0).

The non-IBC cohort

Patients with stage III HER2+ non-IBC treated with neoadjuvant trastuzumab-based therapy in four different cohorts (DAPHNe, GOM-HGUGM-2018-05, BiOnHER, and the HER2DX 268-validation cohort) and available HER2DX results were included in the comparison group (Supplementary Table S1, available at https://doi.org/10.1016/j.esmoop.2024.104100).

DAPHNe was a single-arm, prospective, investigator-initiated phase II trial, in which 98 patients with stage II-III HER2+ breast cancer received neoadjuvant paclitaxel (80 mg/m^2 i.v. weekly for 12 weeks) in combination with

trastuzumab (H; loading dose 8 mg/kg i.v., subsequent doses 6 mg/kg i.v., every 3 weeks for four cycles) and pertuzumab (P; loading dose 840 mg i.v., subsequent doses 420 mg i.v., every 3 weeks for four cycles) before breast surgery. Patients were allowed to receive up to two additional cycles of HP in cases of surgical delay. Additional neoadjuvant therapy was allowed for patients with clinical evidence of residual invasive disease after completion of THP.[22] In this cohort, six patients had stage III disease and available HER2X results (Supplementary Table S1, available at https://doi.org/10.1016/j.esmoop.2024.104100).

GOM-HGUGM-2018-05 is a retrospective observational study of consecutive patients with newly diagnosed stage I-III HER2+ breast cancer treated with neoadjuvant therapy across seven public hospitals in Spain. All patients received six cycles of docetaxel 75 mg/m^2 i.v. every 3 weeks in combination with carboplatin area under the curve (AUC) of 6 i.v. every 3 weeks and trastuzumab (8 mg/kg i.v. loading dose and 6 mg/kg i.v. every subsequent dose) every 3 weeks (TCH). Once neoadjuvant pertuzumab was reimbursed in Spain, most patients received TCH in combination with pertuzumab (840 mg i.v. loading dose, followed by 420 mg i.v. for each subsequent dose) every 3 weeks (TCHP) depending on high-risk tumors at the clinician's discretion and/or according to the hospital's criteria for availability of the drug.[23] Among these patients, 40 had stage III disease and available HER2DX results (Supplementary Table S1, available at https://doi.org/10.1016/j.esmoop.2024.104100).

BiOnHER (NCT05912062) is a prospective, investigator-initiated, single-institution, single-arm phase II trial that enrolled 46 patients with clinical stage II-III HER2+ who were treated at the Catalan Institute of Oncology (Barcelona, Spain). All patients received one cycle of trastuzumab (loading dose 8 mg/kg i.v.) and pertuzumab (loading dose 840 mg i.v.) without chemotherapy, followed by weekly paclitaxel (80 mg/m^2 i.v.) for 16 weeks in combination with trastuzumab (6 mg/kg i.v.) and pertuzumab (420 mg i.v.) every 3 weeks. The results of the HER2DX assay are available in all patients.[26] Among these patients, seven had stage III disease and available HER2DX results (Supplementary Table S1, available at https://doi.org/10.1016/j.esmoop.2024.104100).

The HER2DX 268 validation cohort included a consecutive series of patients with early-stage HER2+ breast cancer treated at Hospital Clinic (n = 147) from June 2005 to September 2020 and at Padova University (n = 37) from February 2009 to May 2016. All patients were treated, per standard practice, with neoadjuvant trastuzumab-based multiagent chemotherapy for 3-6 months, followed by surgery. The HER2DX 268 validation cohort also included 84 patients from SOLTI-1114 PAMELA, an open-label, single group, phase II trial, where patients with stage I-IIIA HER2+ breast cancer received lapatinib (1000 mg per day) and trastuzumab (loading dose 8 mg/kg i.v., followed by 6 mg/kg i.v. every 3 weeks) for 18 weeks; patients with HR+ disease were additionally given endocrine therapy.[20] In this cohort, 103 patients had stage III disease and available HER2DX results (Supplementary Table S1, available at https://doi.org/10.1016/j.esmoop.2024.104100).

The HER2DX assay

The HER2DX standardized assay was evaluated centrally on RNA from formalin-fixed paraffin-embedded pre-treatment baseline tumor samples and has been previously described.[20,26-34] The HER2DX assay is based on four different gene signatures comprising 27 genes, including the 14-gene immunoglobulin (IGG) module[35] (i.e. *CD27*, *CD79A*, *HLA-C*, *IGJ*, *IGKC*, *IGL*, *IGLV3-25*, *IL2RG*, *CXCL8*, *LAX1*, *NTN3*, *PIM2*, *POU2AF1*, and *TNFRSF17*), a 4-gene tumor cell proliferation signature (*EXO1*, *ASPM*, *NEK2*, and *KIF23*), a 5-gene luminal differentiation signature (*BCL2*, *DNAJC12*, *AGR3*, *AFF3*, and *ESR1*), and the 4-gene HER2 amplicon signature (*ERBB2*, *GRB7*, *STARD3*, and *TCAP*). For each signature, the normalized gene expression was calculated for each patient. The HER2DX risk score was calculated based on the IGG, luminal, and proliferation signatures. The HER2DX pCR likelihood score was calculated based on HER2, IGG, luminal, and proliferation signatures. The HER2DX *ERBB2* score was calculated based on the *ERBB2* messenger RNA levels. Missing data were not imputed. Pre-established cut-offs were used to divide HER2DX scores into groups (high, medium, and low pCR; high and low risk; and high, medium, and low *ERRB2*).

Statistical analysis

The primary aim of this correlative analysis was to evaluate the pCR rate according to the HER2DX pCR score in patients with stage III HER2+ IBC and stage III HER2+ non-IBC. Secondary objectives encompassed a comparative analysis of the HER2DX scores and gene expression signatures in both cohorts, along with an investigation into the predictive capabilities of the HER2DX pCR score as well as clinicopathological factors in identifying patients who are likely to achieve a pCR.

To explore these associations, univariable and multivariable logistic regression models were applied. Odds ratios (ORs) with corresponding 95% confidence intervals (CIs) were calculated for each variable. All variables that demonstrated a significant association with pCR in the univariable analysis were included in the multivariable models. Unpaired *t*-tests were used to compare individual gene expression levels between IBC and non-IBC groups. For all statistical analyses, the significance level was set at a two-sided alpha of 0.05. All analyses were carried out using R statistical software version 4.1.2 (R Foundation, Vienna, Austria).

Ethical considerations

This is a retrospective diagnostic/prognostic analysis of previously reported trials of patients with HER2+ breast cancer. Approvals for each study were obtained from independent ethics committees. All trials were conducted in accordance with the Declaration of Helsinki and the Good

Clinical Practice. All patients reviewed and signed informed consent documents.

Data availability

The data generated in this study are available upon request from the corresponding author.

RESULTS

Clinicopathological features

Twenty-three patients with stage III IBC were included; 12 (52.2%) had HR+ disease, 21 (91.3%) had pathologically involved axillary lymph nodes, and 7 (30.4%) had N2-3 disease. By contrast, the stage III non-IBC cohort included 156 patients with a significantly higher nodal disease burden (82.1% N2-N3; $P < 0.001$) and smaller tumor size (9.0% T4, $P < 0.001$) than patients with IBC. Regarding neoadjuvant treatment, all patients from the IBC cohort received paclitaxel plus trastuzumab and pertuzumab, while 107 (68.6%) patients with non-IBC were treated with multiagent chemotherapy, 30 (19.2%) did not receive chemotherapy, and 88 (56.4%) did not receive pertuzumab. Patient characteristics are outlined in Supplementary Table S2, available at https://doi.org/10.1016/j.esmoop.2024.104100.

HER2DX results and pCR outcomes

In the IBC group, the overall pCR rate was 43.5%. Among the non-IBC cohort treated with neoadjuvant trastuzumab-based therapy, the overall pCR rate was 45.5%, and 59.1% in those who received chemotherapy plus HP ($n = 66$). In the combined cohort of patients with IBC and non-IBC ($n = 179$), pCR rates across the HER2DX pCR-high, -medium, and -low categories were 66.7%, 52.5%, and 14.3%, respectively; and in those treated with trastuzumab-based chemotherapy, pCR rates were 68.9%, 58.5%, and 16.3% in the HER2DX pCR-high, -medium, and -low groups, respectively. In patients with IBC, pCR rates were 75.0%, 45.5%, and 25.0% in the HER2DX pCR-high, -medium, and -low groups, respectively (Figure 1). The pCR rates in the non-IBC cohort in the pCR-high, -medium, and -low groups were 66.1%, 54.0%, and 12.5%, respectively. In patients with non-IBC who received chemotherapy plus HP ($n = 66$), the pCR rates in the pCR-high, -medium, and -low groups were 87.0%, 75%, and 17.4%, respectively. In the small group of patients with non-IBC who received single-agent taxane plus HP ($n = 13$), the pCR rates in the pCR-high, -medium, and -low groups were 100.0%, 60.0%, and 20.0%, respectively (Figure 1). There were no differences in the overall pCR rates between pCR probability groups in the IBC cohort and the non-IBC cohort (43.5% versus 45.5%, respectively; $P = 0.92$). Likewise, no significant differences were observed when comparing patients with IBC with those with non-IBC who received pertuzumab (35.2%, $P = 0.48$) or those treated with taxane plus HP (53.9%, $P = 0.73$).

In patients with IBC, the HER2DX pCR score distribution was high in 4 patients (17.4%), medium in 11 patients (47.8%), and low in 8 patients (34.8%). In the non-IBC group, the distribution of the HER2DX pCR score was high, medium, and low in 56 (35.9%), 50 (32.1%), and 50 patients (32.1%), respectively ($P = 0.158$; Figure 2). No differences in pCR score as a continuous variable were found between IBC and non-IBC groups ($P = 0.184$).

Twenty-two (95.7%) patients with IBC and 155 (99.4%) patients with non-IBC were classified as HER2DX high risk. No differences between IBC and non-IBC were found in the HER2DX risk score as a continuous variable ($P = 0.184$) or by predefined groups ($P = 0.241$).

Prediction of pCR in both groups

The clinicopathologic and treatment variables significantly associated with pCR in the univariate analysis in the combined IBC and non-IBC cohort ($n = 179$) were HR+ disease (OR 0.34, $P = 0.001$), use of pertuzumab (OR 2.25, $P = 0.008$), and HER2DX pCR score as a continuous variable (OR per 10-unit increase 1.41, $P < 0.001$), and group categories (OR 6.62, $P < 0.001$ for medium versus low; OR 12.00, $P < 0.001$ for high versus low). None of the following variables were significantly associated with pCR: use of chemotherapy (i.e. single agent, polychemotherapy, or none), nodal status, tumor size, or having IBC. In the multivariable analysis, the use of pertuzumab (OR 4.42, $P = 0.001$) and HER2DX pCR score (OR 1.51 as a continuous variable, $P < 0.001$) were maintained as significant predictors of pCR (Supplementary Table S3, available at https://doi.org/10.1016/j.esmoop.2024.104100). Separate univariate analyses for patients with IBC are presented in Supplementary Table S4, available at https://doi.org/10.1016/j.esmoop.2024.104100. The HER2DX pCR score performed well in the stage III IBC and non-IBC cohorts, with receiver operating characteristic curve areas under the curve of 0.75 (95% CI 0.68-0.83) and 0.69 (95% CI 0.47-0.92), respectively.

HER2DX features and genes in IBC and non-IBC

Patients with IBC had a significantly lower expression of the HER2-amplicon signature compared with the non-IBC group when assessed as a continuous variable ($P = 0.005$) (Figure 3) or as a categorical variable using the predefined cut-offs ($P = 0.001$); 32.7% of patients with non-IBC had high expression of the HER2-amplicon compared with no patients with IBC, 37.2% and 47.8% had medium expression values in the non-IBC and IBC groups, and 30.1% and 52.2% had low expression values, respectively (Figure 4). No significant differences were observed between IBC and non-IBC groups regarding the IGG, proliferation, or luminal gene expression signatures (Figure 3).

Overall, unsupervised clustering indicated similar HER2DX biology between IBC and non-IBC tumors (Figure 5). When evaluating individual expression of the 27 genes included in HER2DX, IBC showed lower expression of the immune genes *CD27*, *CD79A*, *HLA-C*, *IL2RG*, and *POU2AF1*; the proliferation genes *EXO1* and *KIF23*; the HER2 amplicon genes

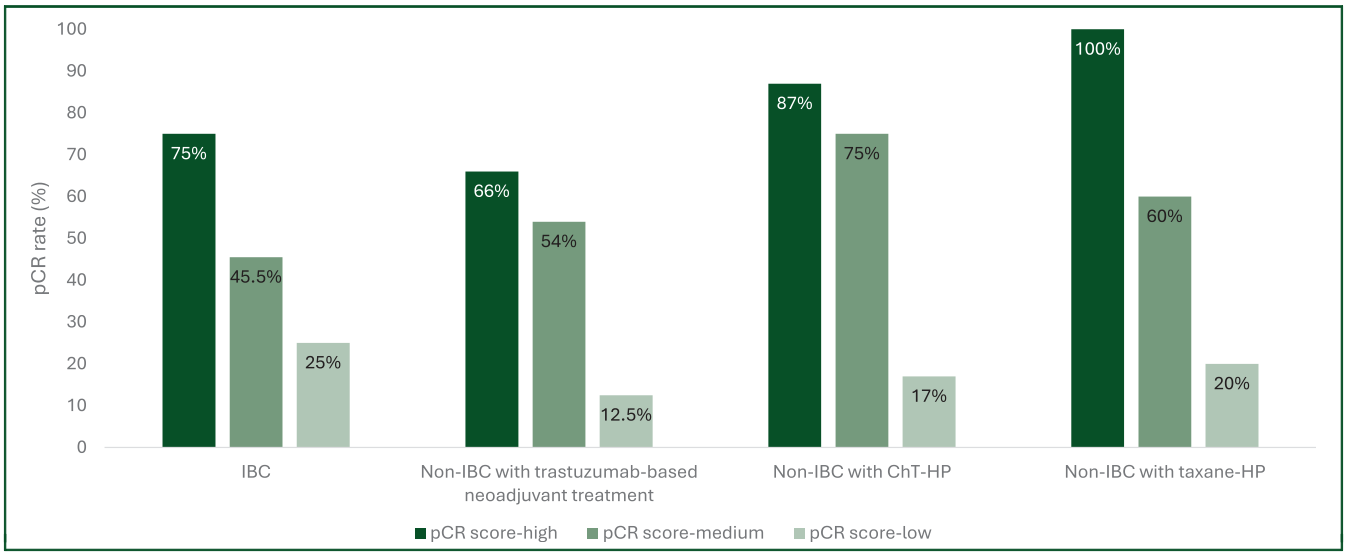

Figure 1. Overall pCR rates in each patient group and according to the type of systemic therapy.
ChT, chemotherapy; HP, trastuzumab and pertuzumab; IBC, inflammatory breast cancer; pCR, pathologic complete response.

STARD3 and *TCAP*; and higher expression of the immune gene *CXCL8* and the proliferation gene *NEK2* compared with non-IBC (Supplementary Figure S1, available at https://doi.org/10.1016/j.esmoop.2024.104100).

DISCUSSION

We present the first study evaluating HER2DX in patients with stage III HER2+ IBC treated with neoadjuvant THP and comparing results with a cohort of patients with stage III HER2+ non-IBC. Here we showed that the HER2DX pCR score was a valuable tool to predict pCR in both groups, outperforming classic clinicopathological variables such as HR status, tumor size, and nodal status. Importantly, pCR rates observed in this study did not differ from previous reports that evaluated the role of HER2DX in less clinically high-risk populations, reinforcing the notion that beyond disease burden, tumor biology is paramount to determine response to neoadjuvant therapy.[20,30,31,36]

Historically, IBC has been perceived as exceedingly high risk, associated with lower pCR rates when compared with non-IBC of the same subtype, an elevated risk of extended local and metastatic diseases, and a higher propensity for brain metastases,[37,38] thus justifying the use of combination chemotherapy regimens that often include anthracyclines. However, within our study, an impressive pCR rate of 43.5% and a 4-year event-free survival of 86% were attained using an anthracycline-free regimen. This demonstrates that there

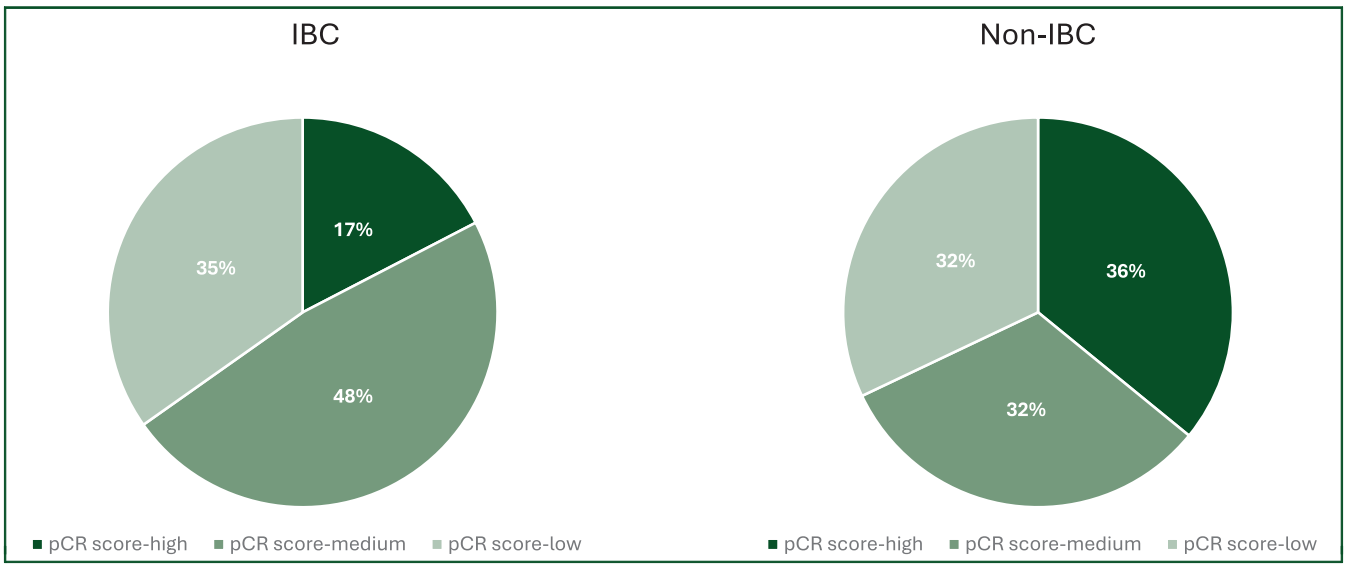

Figure 2. Distribution of HER2DX pCR score groups in patients with IBC and non-IBC.
IBC, inflammatory breast cancer; pCR, pathologic complete response.

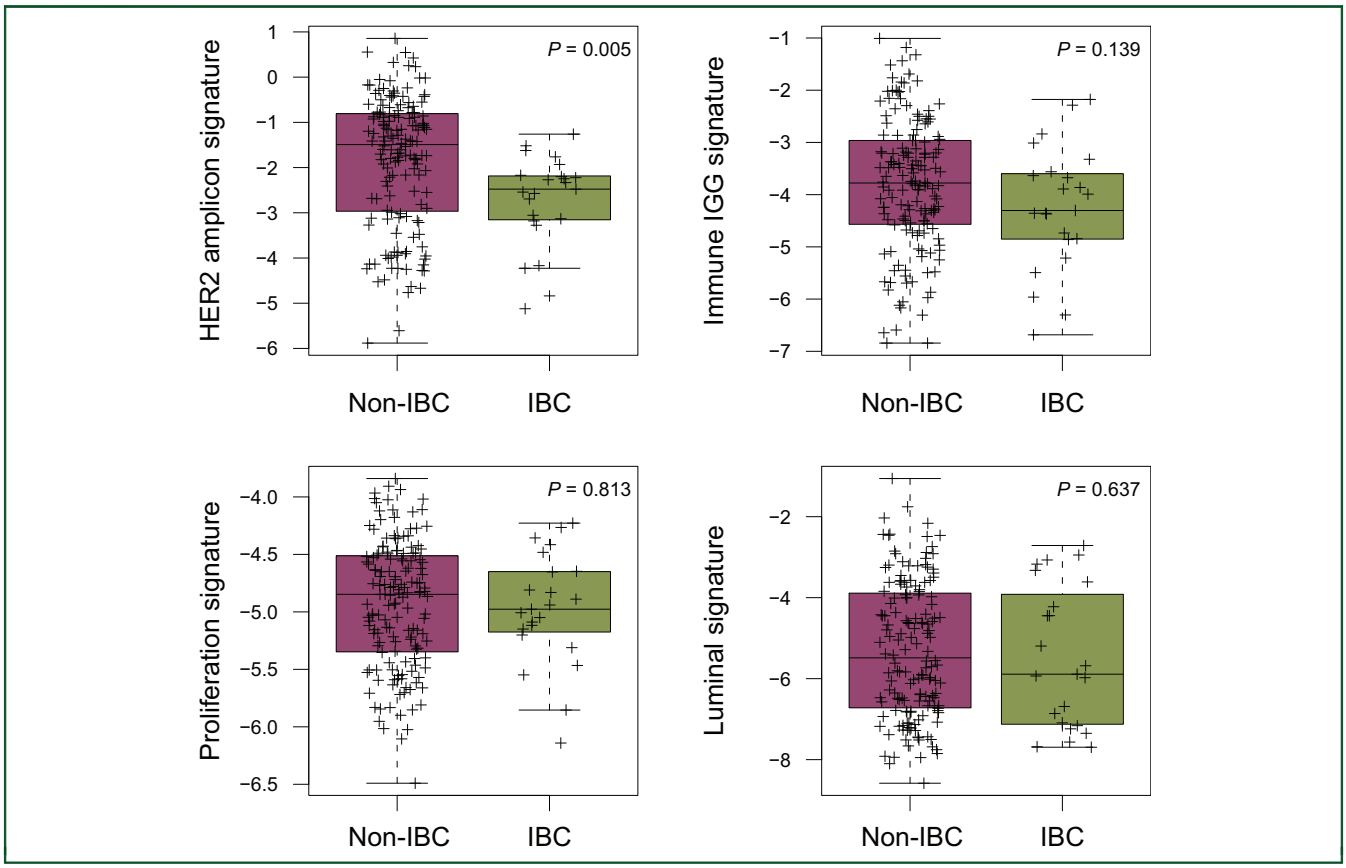

Figure 3. HER2DX signatures as a continuous variable in patients with IBC and non-IBC.
HER2, human epidermal growth factor receptor 2; IBC, inflammatory breast cancer; IGG; immunoglobulin.

may be a role for tools to guide treatment de-escalation, including in patients with higher clinical risk. However, given the small sample size of patients with IBC enrolled in this study, confirmatory studies are needed and judicious consideration of anthracycline use in these higher-risk patients remains reasonable.

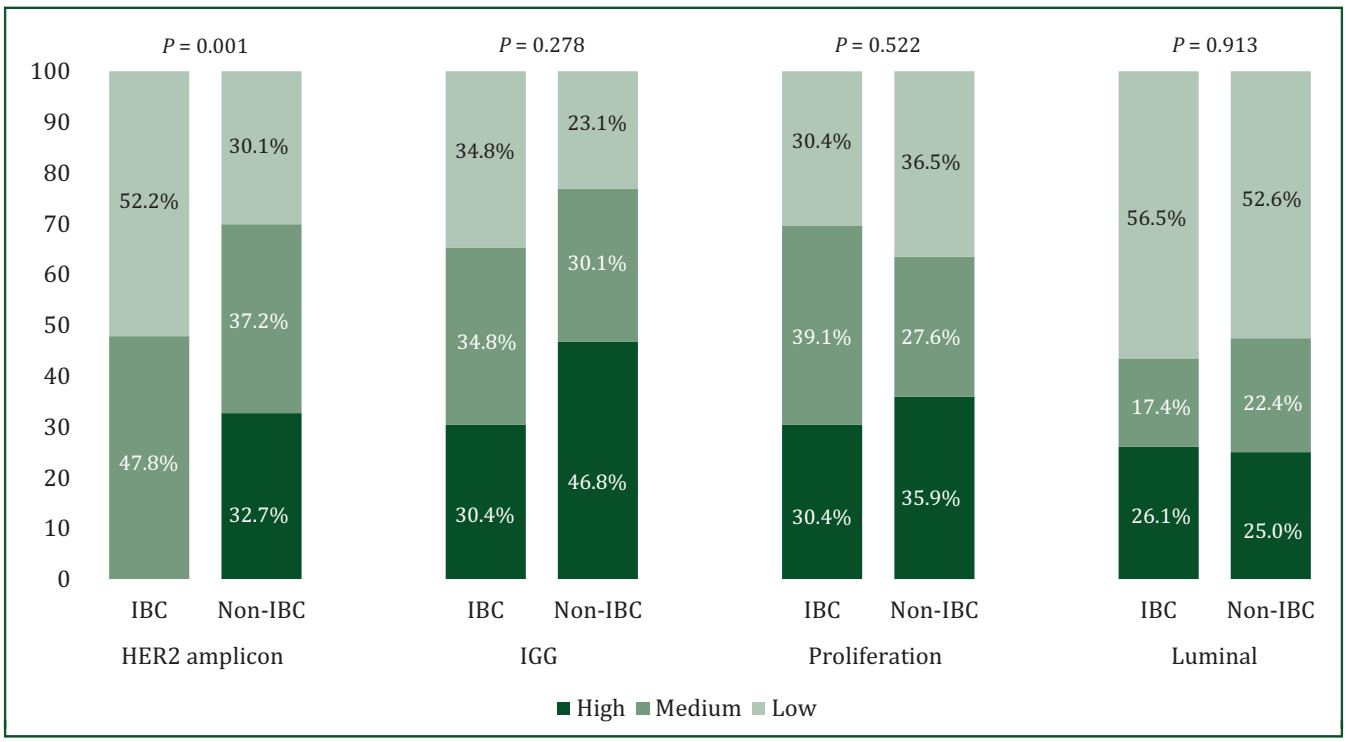

Figure 4. HER2DX signatures by groups (high, medium, and low) in patients with IBC and non-IBC.
HER2, human epidermal growth factor receptor 2; IBC, inflammatory breast cancer; IGG; immunoglobulin.

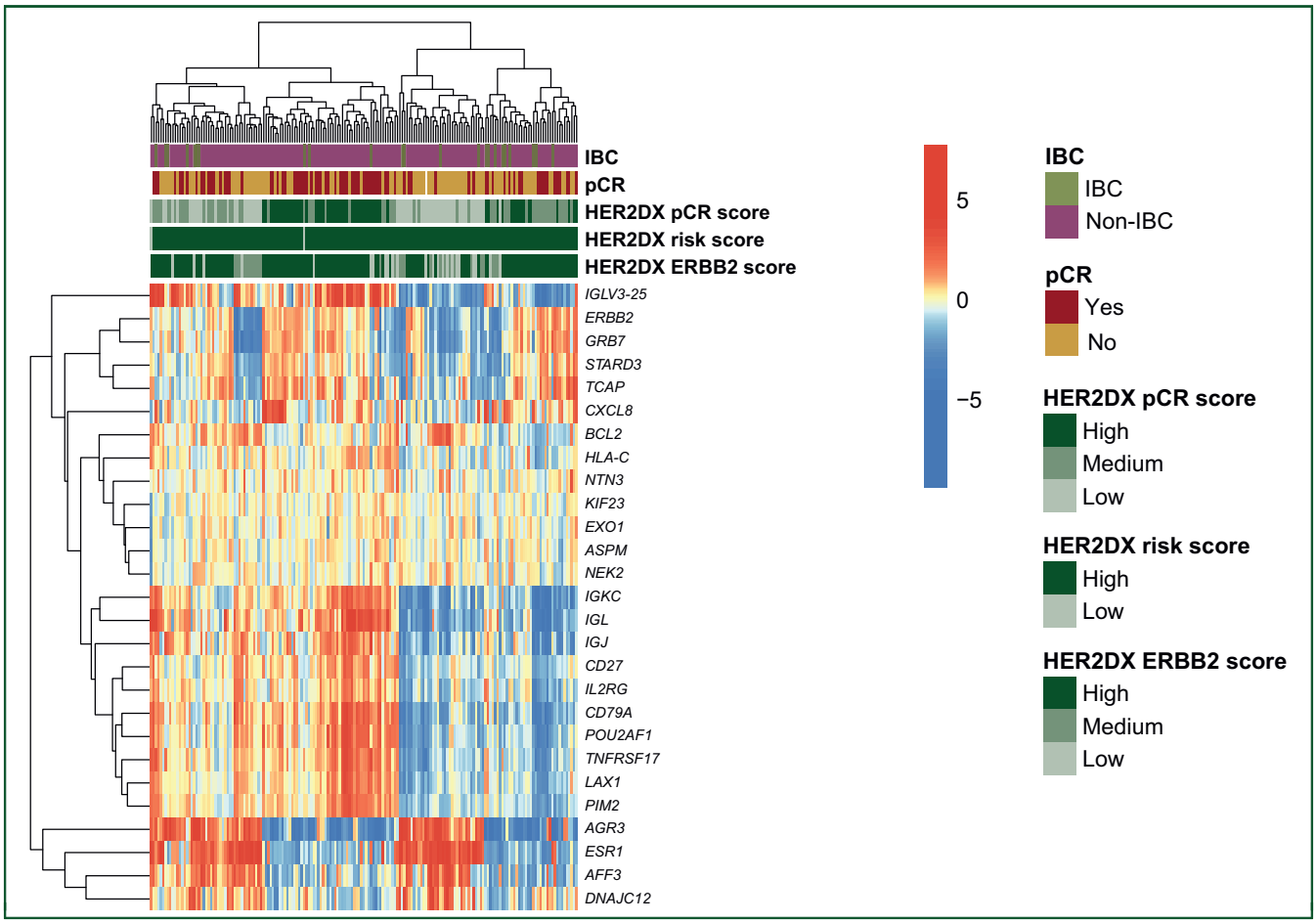

Figure 5. Unsupervised clustering of 179 patients with stage III HER2+ breast cancer with IBC ($n = 23$) and non-IBC ($n = 156$) (columns) and the expression of the 27 individual genes of HER2DX (rows).
HER2, human epidermal growth factor receptor 2; IBC, inflammatory breast cancer; pCR, pathologic complete response.

In HER2+ disease, anthracyclines have been relegated to specific subgroups due to accumulating evidence revealing comparable efficacy with nonanthracycline-based therapies but a higher incidence of cardiac toxicity and secondary leukemia.[39-42] While strategies such as docetaxel plus carboplatin or taxane monotherapy combined with HER2-directed therapy have demonstrated comparable outcomes, it is crucial to note that patients with IBC are underrepresented in these trials. A recent retrospective multi-institutional analysis suggested that a nonanthracycline-containing regimen in HER2+ IBC yields similar pCR rates but is associated with shorter locoregional recurrence-free survival.[43]

The observed numerical difference in patients grouped into the HER2DX pCR-high category in IBC versus non-IBC (17.4% versus 35.9%) and actual pCR rates following trastuzumab—pertuzumab-based chemotherapy (43.5% versus 59.1%) may be attributed to minor but significantly lower expression of the HER2 amplicon and immune genes in IBC versus non-IBC. Despite no significant differences in IGG, estrogen pathways, or proliferation signatures, the individual gene expression analysis revealed a downregulation of specific immune, proliferation, and HER2 amplicon genes. Therefore the lower expression of these key genes in IBC may underlie biological differences, highlighting the need for additional work to unveil the unique molecular characteristics of IBC. Gene expression analysis tools such as HER2DX or emerging dynamic biomarkers and functional imaging techniques could further refine treatment strategies.[44,45] Understanding early immunological changes and metabolic responses, in addition to driver mutations, may prove crucial in tailoring treatments.

A major limitation of this study was the inclusion of only 23 patients with IBC from one specific clinical trial and HER2 positivity was defined based on the 2013 ASCO/CAP guidelines. Additional studies will be required before changing our current practice. The comparison group includes a heterogeneous cohort of patients with non-IBC from four different trials, which showed significant differences in treatment strategies. For example, a large proportion of patients in the non-IBC group did not receive pertuzumab, and some did not receive chemotherapy. Moreover, the number of doses of pertuzumab in the IBC group and in patients from the BiOnHER trial was not standard. Lastly, we could not analyze the effect of different therapeutic strategies in the IBC group according to the HER2DX pCR score, and no survival outcomes were available for the non-IBC cohorts.

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CONCLUSIONS

The HER2DX pCR score emerged as a strong predictor of pCR in patients with stage III HER2+ IBC and non-IBC following trastuzumab-based therapy. High HER2DX pCR scores in IBC correlated with elevated pCR rates following a de-escalated neoadjuvant schema with taxane, trastuzumab, and pertuzumab. This finding suggests that there may be a role for HER2DX in guiding personalized treatment approaches in patients with stage III HER2+ breast cancer.

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DISCLOSURE

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