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Clinicopathological characteristics and survival analysis of different molecular subtypes of breast invasive ductal carcinoma achieving pathological complete response through neoadjuvant chemotherapy

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Abstract

Background To investigate the prognostic differences following the achievement of a pathological complete response (pCR) through neoadjuvant chemotherapy across different molecular subtypes of breast invasive ductal carcinoma.

Methods Data from the Surveillance, Epidemiology, and End Results (SEER) were identified for patients undergoing neoadjuvant chemotherapy who achieved pathological complete response for invasive ductal carcinoma of the breast between 2010 and 2019.Comparing the clinicopathological characteristics of patients across different molecular subtypes. Univariate and Cox multivariate analyses were utilized to identify independent predictors of overall survival (OS) and cancer-specific survival (CSS). The Kaplan–Meier method is used to compare OS and CSS among different molecular subtypes. After propensity score matching, subgroup analysis results were presented through forest plots.

Results This study included 9,380 patients diagnosed with invasive ductal carcinoma, who were categorized into four molecular subtypes: 2,721 (29.01%) HR + /HER-2 + , 1,661 (17.71%) HR + /HER2-, 2,082 (22.20%) HR-/HER2 + , and 2,916 (31.08%) HR-/HER-2-. HR + /HER-2- subgroup exhibited a significantly higher proportion of patients under 50 years old than the other subtype groups (54.67% vs 40.2%, 50.35% and 51.82%, $p < 0.01$), and had a higher N2 + N3 stage (11.2% vs 7.24%, 8.69% and 7.48%, $p < 0.01$). Univariate and multivariate analysis revealed that molecular subtype was the independent risk factor for OS and CSS in patients($p < 0.05$). The Kaplan–Meier curves indicated that the HR + /HER-2 + subtype had the highest OS and CSS($p < 0.05$). Next, were the HR-/HER-2 + and HR-/HER-2- subtypes, with the HR + /HER-2- group having the lowest OS and CSS($p < 0.05$). After propensity score matching, the OS and CSS of patients in the HR + /HER-2 + group remained higher compared to HR + /HER-2- group($p < 0.05$).

Conclusions Patients with invasive ductal carcinoma of different molecular subtypes exhibit varying prognoses after achieving pCR to neoadjuvant chemotherapy. Those in the HR + /HER-2- group are younger, have a higher lymph node stage, and the lowest OS and CSS, whereas patients in the HR + /HER-2 + group have the highest OS and CSS.

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Keywords Breast invasive ductal carcinoma, Pathologic complete response, Overall survival, Cancer-specific survival, Neoadjuvant chemotherapy

Introduction

The incidence rate of breast cancer has shown an annual increase in recent years. According to statistics from the Global Cancer Center in 2020, the incidence rate of breast cancer among women has surpassed that of lung cancer, becoming the most common cancer. Breast cancer is also the leading cause of cancer death among women [1]. Chemotherapy can significantly improve the prognosis of breast cancer. It plays a crucial role in the treatment regimen for breast cancer. Depending on the timing of chemotherapy and surgery, it can be divided into adjuvant chemotherapy (post-operative chemotherapy) and neoadjuvant chemotherapy (pre-operative chemotherapy). Studies show that for early breast cancer, both adjuvant and neoadjuvant chemotherapy have no significant difference in distant recurrence and breast cancer mortality rates, and both offer similar survival benefits [2]. However, neoadjuvant chemotherapy can reduce the size of the tumor and downstage it, increasing the opportunity for breast-conserving therapy. Moreover, neoadjuvant chemotherapy can serve as a means for drug sensitivity testing, allowing for the understanding of the tumor's individual sensitivity to a specific regimen, and thereby providing a basis for adjusting the treatment plan among other advantages.

The selection of neoadjuvant chemotherapy regimens is closely related to the molecular subtyping of breast cancer. According to the ASCO guidelines and the St. Gallen International Breast Cancer Expert Consensus, based on the immunohistochemical expression status of the estrogen receptor (ER), progesterone receptor (PR), human epidermal growth factor receptor 2 (HER2), and Ki67, breast cancer is classified into four molecular subtypes, including HR + /HER-2 + , HR + /HER-2-, HR-/HER-2 + , and HR-/HER-2- [3]. Based on the RECIST criteria for solid tumors, studies have shown that breast cancer patients achieving pCR after neoadjuvant chemotherapy have a longer disease-free survival and overall survival compared to those who do not reach pCR, especially in HER-2 positive and triple-negative breast cancer cases [4]. However, there is limited research on the survival differences among various molecular subtypes in breast cancer patients who achieve pCR after neoadjuvant chemotherapy. In this study, we conducted a retrospective analysis of patients with invasive ductal carcinoma who achieved pCR after neoadjuvant chemotherapy, using data from the SEER (Surveillance, Epidemiology, and End Results) database from 2010 to 2019, to investigate the correlation between different molecular types and patient prognosis.

Material and methods

Data collection

This study extracted case data of patients with invasive ductal carcinoma of the breast from the SEER database. Inclusion criteria were: (I) Pathologically confirmed invasive ductal carcinoma, (II) Female patients, (III) Pathological complete response after neoadjuvant chemotherapy, and (IV) Cases from the year 2010 to 2019. The exclusion criteria included: (I) Male patients, (II) Patients with unknown molecular subtypes, (III) Patients who had not undergone surgery after neoadjuvant chemotherapy, (IV) Cases with distant metastasis, and (V) Missing survival or other critical variable data. After the screening process, a total of 9,380 patients met the inclusion criteria and were subsequently included in the study. The data selection process is detailed in Fig. 1.

Study variables

For each patient, we collected data on the age at diagnosis, race, histological grade, TNM staging (according to the 8th edition of the AJCC staging system), estrogen receptor (ER) status, progesterone receptor (PR) status, HER-2 status, surgical treatment, radiation therapy, survival time, overall survival and cancer-specific survival. Based on the status of ER, PR, and HER-2, patients were classified into four molecular subtypes: HR + /HER-2 + , HR + /HER2-, HR-/HER2 + and HR-/HER-2-. The prognostic indicators are overall survival (OS) and cancer-specific survival (CSS).

Statistical analysis

Statistical analysis was conducted using Stata 17.0, R studio 4.0.3, and SPSS 23.0 (Chicago, Illinois, USA). Categorical variables were presented as counts and frequencies (%), analyzed using Fisher's exact test or Pearson's chi-square test. The Kaplan–Meier method was used for survival analysis between different subgroups, with the log-rank test applied to calculate the differences in survival rates between groups. Univariate and multivariate Cox regression analyses were utilized to identify independent prognostic factors. Propensity score matching (PSM) was adopted to minimize potential confounders and selection bias. After psm, the forest plot was used to evaluate differences in OS between subgroups of HR + /HER-2 + and HR + /HER-2- patients. A two-tailed

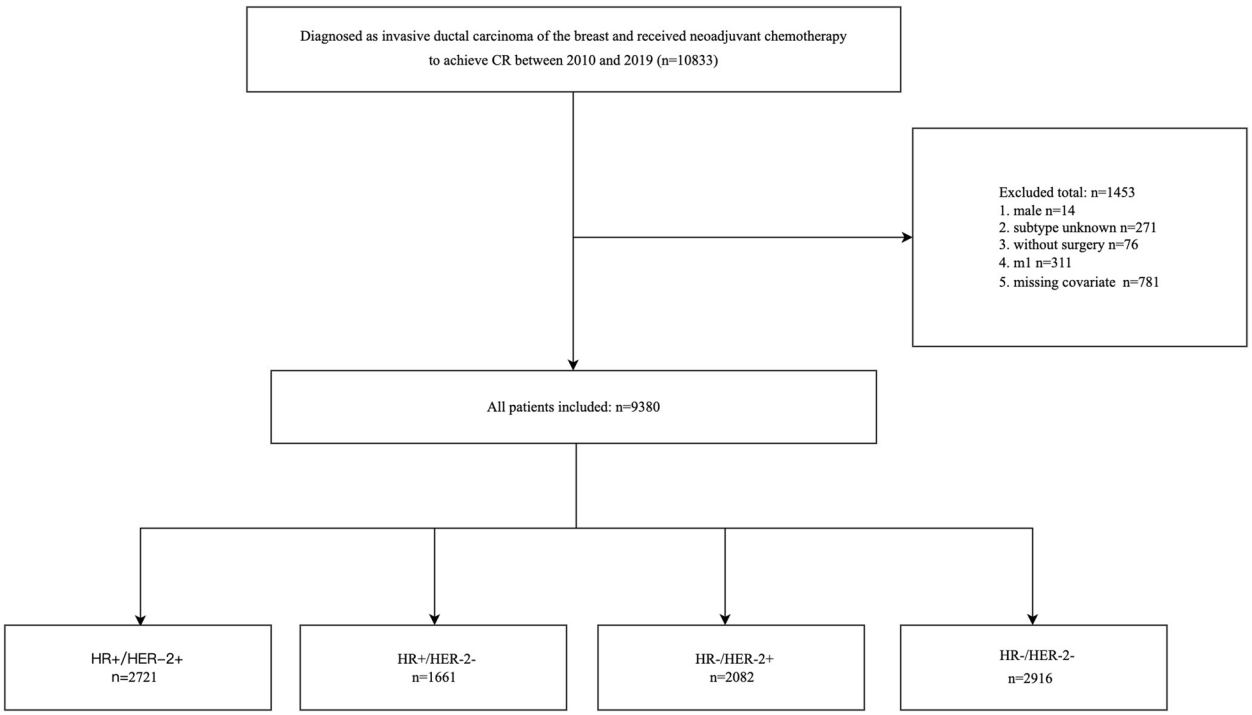

Figure1 Flowchart of data filtering process in the SEER database

P-value of less than 0.05 was considered statistically significant.

Results

This study included a total of 9380 patients with invasive ductal carcinoma of the breast, with a median follow-up time of 35 months and a maximum follow-up time of 119 months. The study population comprised White, Black, and other races (including American Indian, Asian, or Pacific Islander), with the highest prevalence among Whites at 73.31%. Furthermore, the proportions of patients under 50 years old in the HR + /HER2-, HR-/HER2 + , HR + /HER2 + , and HR-/HER2- groups were 54.67%, 40.2%, 50.35%, and 51.82%, respectively, with the highest proportion in the HR + /HER2- group ($p < 0.01$). Of the cases above, 4211 patients underwent breast-conserving surgery, while 5169 received a mastectomy. Aside from the application of radiotherapy, statistical differences ($p < 0.05$) were observed in the distribution of patient age, race, histological grade, T stage, N stage, and surgery approach among different molecular subtypes. The baseline characteristics of the patients are provided in detail in Table 1. Significant differences were observed in pathological complete response rates among different molecular subtypes after neoadjuvant chemotherapy ($p < 0.01$). The pCR rates for HR + /HER-2 + , HR + /HER-2-, HR-/HER-2 + , and HR-/HER-2- molecular subtypes were 37.89%, 15.49%, 54.88%, and 36.88% (with details in the supplementary materials).

In the univariate analysis, molecular subtype, T stage, N stage, radiation therapy, and surgery approach were related to OS and CSS, while age is only associated with the OS. Multivariate analysis identified molecular subtype as an independent risk factor for OS and CSS in patients (Table 2). Compared to patients in the HR + / HER-2 + positive group, other molecular subtypes of breast cancer exhibited poorer CSS, with the HR + / HER-2- subtype displaying the lowest OS (HR = 2.95, 95%CI:2.16–4.02, $P < 0.05$) and CSS (HR = 3.68, 95%CI: 2.57–5.29, $P < 0.05$). The Kaplan–Meier (KM) curves based on molecular subtypes were presented in Fig. 2.

This study discovered significant prognostic differences across molecular subtypes in patients with breast invasive ductal carcinoma after achieving a pathologic complete response (pCR) through neoadjuvant chemotherapy. HR + /HER-2- group was associated with the poorest outcomes, and patients with HR + / HER-2 + showed the highest OS and CSS ($p < 0.05$). To address potential selection biases highlighted by significant differences in baseline characteristics in our retrospective analysis, we applied propensity score matching for age, race, T stage, N stage, histological

Table 1 Clinicopathological characteristics of different molecular subtypes

Characteristics	All patients *n* = 9380	HR + /HER-2 + *n* = 2721	HR + /HER-2- *n* = 1661	HR-/HER-2 + *n* = 2082	HR-/HER-2- *n* = 2916	*P* value
Age(Mean ± SD)	51.04(± 11.95)	50.91(± 11.90)	49.59(± 11.99)	53.14(± 11.48)	50.49(± 12.10)	< 0.01
≤ 50(%)	4626(49.32)	1370 (50.35)	908 (54.67)	837 (40.20)	1511 (51.82)	
> 50(%)	4754(50.68)	1351 (49.65)	753 (45.33)	1245 (59.80)	1405 (48.18)	
Race,n(%)						< 0.01
Black	1311(13.98)	257 (9.45)	263 (15.83)	227 (10.90)	564 (19.34)	
Others	1192(12.71)	405 (14.88)	180 (10.84)	332 (15.95)	275 (9.43)	
White	6877(73.31)	2059 (75.67)	1218 (73.33)	1523 (73.15)	2077 (71.23)	
T stage,n(%)						
T1	2136(22.77)	636 (23.37)	372 (22.40)	457 (21.95)	671 (23.01)	< 0.01
T2	5329(56.81)	1521 (55.90)	948 (57.07)	1118 (53.70)	1742 (59.74)	
T3	1260(13.43)	383 (14.08)	209 (12.58)	333 (15.99)	335 (11.49)	
T4	655(6.99)	181 (6.65)	132 (7.95)	174 (8.36)	168 (5.76)	
N stage,n(%)						< 0.01
N0	4882(52.05)	1377 (50.61)	745 (44.85)	999 (47.98)	1761 (60.39)	
N1	3716(39.62)	1147 (42.15)	730 (43.95)	902 (43.32)	937 (32.13)	
N2	396(4.22)	102 (3.75)	104 (6.26)	81 (3.89)	109 (3.74)	
N3	386(4.11)	95 (3.49)	82 (4.94)	100 (4.80)	109 (3.74)	
Grade,n(%)						< 0.01
1	160(1.71)	69 (2.54)	55 (3.31)	25 (1.20)	11 (0.38)	
2	2200(23.45)	959 (35.24)	385 (23.18)	526 (25.26)	330 (11.32)	
3	7020(74.84)	1693 (62.22)	1221 (73.51)	1531 (73.54)	2575 (88.30)	
Radiation,n(%)						0.06
No	3530(37.63)	1073 (39.43)	588 (35.40)	783 (37.61)	1086 (37.24)	
Yes	5850(62.37)	1648 (60.57)	1073 (64.60)	1299 (62.39)	1830 (62.76)	
Surgery,n(%)						0.02
Breast conserving	4211(44.89)	1207 (44.36)	720 (43.35)	905 (43.47)	1379 (47.29)	
Mastectomy	5169 (55.11)	1514 (55.64)	941 (56.65)	1177 (56.53)	1537 (52.71)	
Cancer-specific death,n(%)						< 0.01
No	9065(96.64)	2680(98.49)	1557(93.74)	2025(97.26)	2803(96.12)	
Yes	315(3.36)	41(1.51)	104(6.26)	57(2.74)	113(3.88)	
Overall survival,n(%)						< 0.01
No	387(4.13)	59 (2.17)	123(7.41)	72(3.46)	133(4.56)	
Yes	8993(95.87)	2662(97.83)	1538(92.59)	2010(96.54)	2783(95.44)	

grade, radiation therapy, and surgery approach between the HR + /HER-2- and HR + /HER-2 + groups. After propensity score matching, both the HR + /HER2- and HR + /HER2 + groups had 1,647 patients. Following this matching (with details in the supplementary materials), Kaplan–Meier analysis indicated that OS and CSS in HR + /HER-2 + patients were significantly higher than HR + /HER-2- patients ($p < 0.05$) (Fig. 3). Subgroup analysis forest plots revealed that the HR + / HER-2 + group exhibited a higher OS in White, histological grades II and III, T2 stage, N0 and N1 stages, and across all age groups, surgery approach, and radiation therapy subgroups ($p < 0.05$) (Fig. 4).

Discussion

Neoadjuvant chemotherapy is a pivotal component in the management of breast cancer, with its efficacy significantly correlated to the molecular subtype and stage of the disease. It is administered to approximately 17–40% of patients with early-stage breast cancer, aiming for the optimal outcome of a pathological complete response (pCR) [5, 6]. Nonetheless, the pCR rates after neoadjuvant chemotherapy vary across different

Table 2 Univariate and multivariate cox regression analyses of CSS and OS

Characteristics	Cancer-specific survival				Overall survival			
	Univariate		Multivariate		Univariate		Multivariate	
	HR (95%CI)	*P*	HR (95%CI)	*P*	HR (95%CI)	*P*	HR (95%CI)	*P*
Age								
≤ 50	ref		-		ref		ref	
> 50	1.16(0.93–1.45)	0.189	-	0.102	1.43(1.16–1.75)	< 0.01	1.02(1.01–1.03)	< 0.01
Race								
Black	ref		-		ref		-	
Others	0.65(0.41–1.03)	0.067	-		0.69(0.46–1.07)	0.099	-	
White	0.87(0.64–1.17)	0.360	-		0.86(0.72–1.47)	0.761	-	
Subtype								
HR + /HER-2 +	ref		ref		ref		ref	
HR + /HER-2-	3.68(2.57–5.29)	< 0.01	3.52(2.45–5.05)	< 0.01	2.99(2.19–4.09)	< 0.01	2.95(2.16–4.02)	< 0.01
HR-/HER-2 +	1.82(1.22–2.73)	< 0.01	1.78(1.19–2.66)	< 0.01	1.61(1.14–2.27)	< 0.01	1.49(1.06–2.10)	0.024
HR-/HER-2-	2.51(1.75–3.59)	< 0.01	2.91(2.03–4.17)	< 0.01	2.04(1.49–2.77)	< 0.01	2.33(1.71–3.17)	< 0.01
T stage								
T1	ref		ref		ref		ref	
T2	1.30(0.93–1.83)	0.12	1.18(0.84–1.65)	0.345	1.31(0.97–1.77)	0.074	1.22(0.91–1.65)	0.187
T3	1.62(1.08–2.42)	0.02	1.20(0.79–1.81)	0.401	1.62(1.08–2.42)	0.033	1.25(0.86–1.83)	0.239
T4	4.27(2.93–6.22)	< 0.01	2.17(1.45–3.25)	< 0.01	4.06(2.89–5.70)	< 0.01	2.32(1.61–3.35)	< 0.01
N stage								
N0	ref		ref		ref		ref	
N1	2.31(1.75–3.05)	< 0.01	2.04(1.53–2.72)	< 0.01	1.98(1.56–2.51)	< 0.01	1.81(1.41–2.31)	< 0.01
N2	4.32(2.88–6.47)	< 0.01	3.11(2.05–4.74)	< 0.01	3.09(2.11–4.52)	< 0.01	2.29(1.55–3.41)	< 0.01
N3	8.63(6.14–12.13)	< 0.01	6.21(4.31–8.95)	< 0.01	6.40(4.69–8.74)	< 0.01	4.71(3.37–6.58)	< 0.01
Grade								
I	ref				ref			
II	1.65(0.52–5.25)	0.369	-		1.21(0.49–2.99)	0.674	-	
III	1.90(0.61–5.94)	0.269	-		1.40(0.58–3.38)	0.458	-	
Surgery								
Breast conserving	ref		ref		ref		ref	
Mastectomy	1.81(1.42–2.31)	< 0.01	1.44(1.09–1.89)	0.008	1.44(1.17–1.78)	< 0.01	1.26(0.99–1.60)	0.042
Radiotherapy								
No	ref		ref		ref		ref	
Yes	1.71(1.33–2.19)	< 0.01	1.38(1.05–1.81)	0.019	1.54(1.23–1.92)	< 0.01	1.25(0.99–1.59)	0.063

molecular subtypes of breast cancer. Reports suggest that HER-2 + patients have a pCR rate of around 40%, triple-negative breast cancer exhibits a pCR rate of approximately 23%, and HR + /HER-2- breast cancer has a notably low pCR rate of only 9.1% [7–10]. Despite these differences, there is a paucity of research on the prognostic implications post-pCR across these molecular subtypes. Our study, utilizing a comprehensive retrospective analysis of the SEER database, indicates that HR + / HER-2 + patients exhibit the best OS and CSS following pCR achieved through neoadjuvant treatment, outperforming other molecular subtypes. Conversely, the prognosis for HR + /HER-2- patients is significantly poorer.

Nadia Howlader et al. conducted a retrospective analysis through the SEER database on the overall 4-year survival rate of 196,094 female patients with invasive breast cancer from 2010 to 2014. They found that the survival rates for patients with HR + /HER2- and HR + / HER2 + subtypes were similar, at 92.5% versus 90.3% respectively. Moreover, among patients with initial stage IV disease, those with the HR + /HER2 + subtype had a better survival rate compared to those with the HR + / HER2- subtype (45.5% vs 35.9%) [11]. The Kaplan Meier survival curve in our study indicated that patients with invasive ductal carcinoma who received neoadjuvant chemotherapy and achieved the pCR had a higher CSS

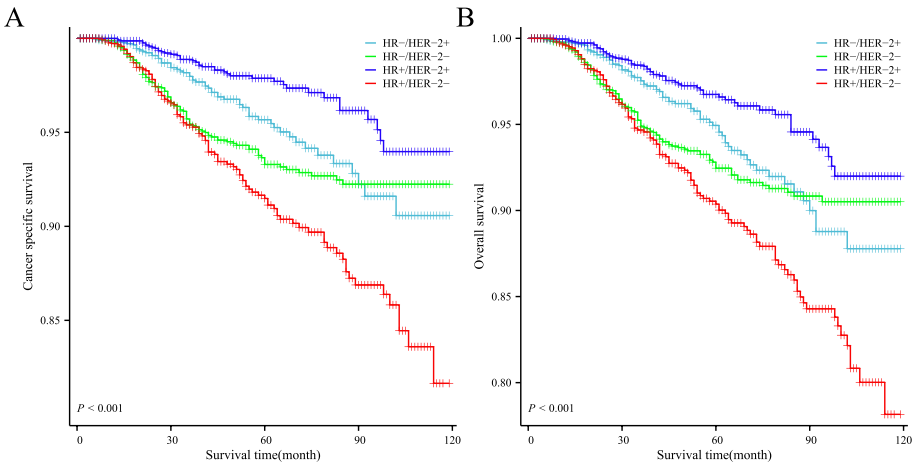

Figure. 2 Kaplan–Meier plots for patient outcomes. **A** Cancer-specific survival for patients in different molecular subtypes ($p < 0.001$). **B** Overall survival for patients in different molecular subtypes ($p < 0.001$)

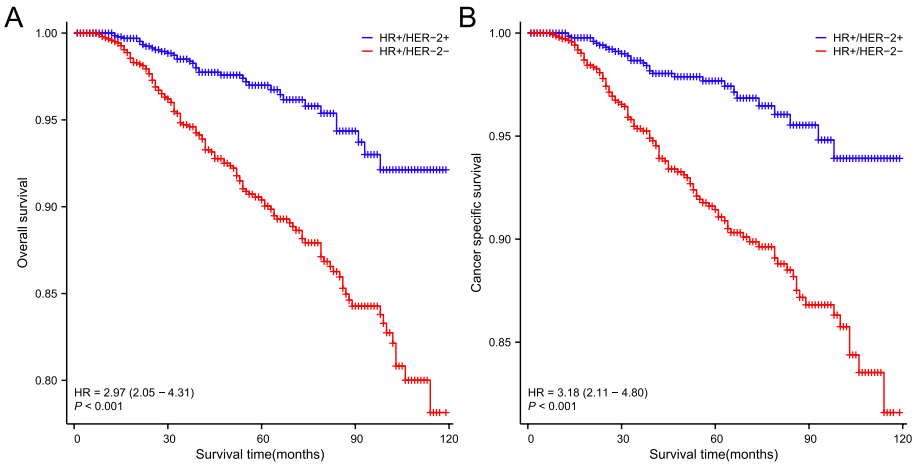

Fig. 3 **A** Overall survival in the HR + /HER-2 + group compared to the HR + /HER-2- group. **B** Cancer-specific survival in the HR + /HER-2 + group compared to the HR + /HER-2- group

rate in the HR + /HER-2 + group. This could be associated with the use of targeted treatment drugs for patients with HER-2 + . In the KRISTINE phase 3 trial, a pathological complete response was achieved by 55.7% in the docetaxel, carboplatin, and trastuzumab plus pertuzumab neoadjuvant therapy group [12]. In the CLEOPATRA clinical trial, 402 patients with HER-2 + metastatic breast cancer treated with Pertuzumab, Trastuzumab, and Docetaxel had a median survival of nearly 5 years (57.1 months), significantly exceeding the early estimated median survival of about 2 years [13]. In addition, other drugs targeting HER-2, such as Lapatinib, Pyrotinib, and T-DM1, have been incorporated into clinical guidelines and practice. These drugs can be combined with endocrine therapy, chemotherapy, or each other, making the treatment options for HR + /HER2 + subtypes more extensive than those for other types of breast cancer. This might explain the higher OS and CSS we observed.

Several studies report that HER-2 + and triple-negative patients have a high neoadjuvant response rate, achieving significant survival benefits after reaching pCR [14–16]. However, HR + /HER-2- early invasive cancer patients show a low response rate to neoadjuvant chemotherapy, and clinicians often prioritize surgery, followed mainly by endocrine therapy postoperatively [17]. Although HR + / HER-2- is the most common type of invasive breast cancer clinically, accounting for 60–70% of all breast cancer classifications [18]. Unlike other subtypes of breast cancer, the recurrence risk of HR + breast cancer extends from 5 years post-diagnosis to at least 20 years, with

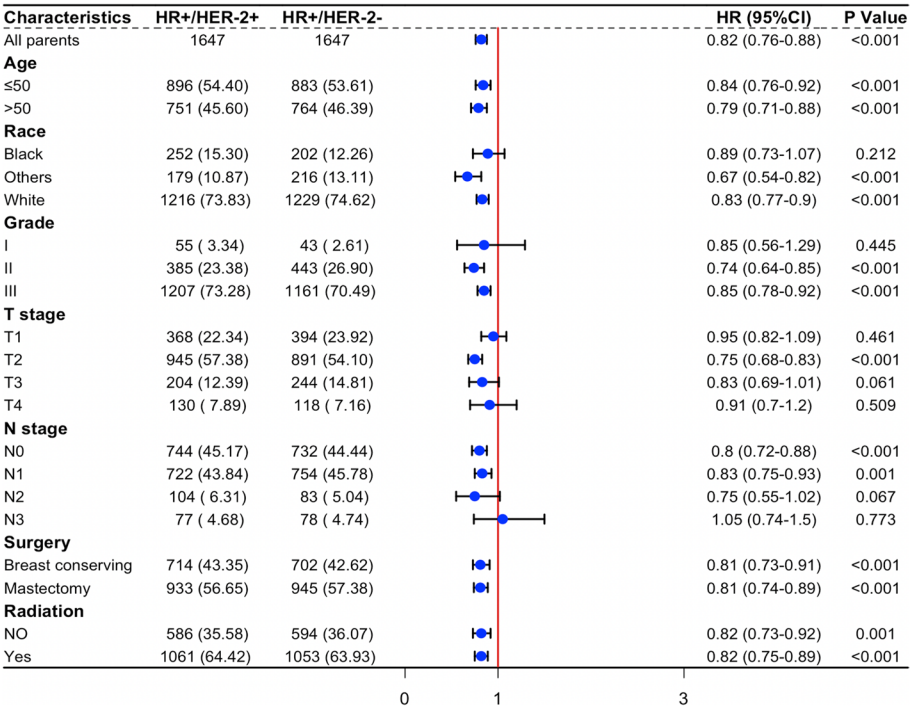

Fig. 4 The forest plot of OS for different subgroups between HR + /HER-2 + and HR + /HER-2- after propensity score matching

some patients potentially relapsing even 30 years after diagnosis [19]. Despite HR + /HER-2- breast cancer having a higher endocrine treatment response rate, the 5-year tumor-specific mortality rate still exceeds 30% in some high-recurrence risk patients [20]. The recurrence and metastasis of HR + /HER-2- breast cancer is closely related to intertumoral heterogeneity and endocrine resistance [21]. To enhance the precision treatment effectiveness for HR + /HER2- breast cancer, Zhi-Ming Shao et al. utilized multi-omics technologies to classify HR + /HER-2- type invasive breast cancer into four subtypes: canonical luminal subtype (SNF1), immunogenic subtype (SNF2), proliferative subtype (SNF3), RTK-driven subtype (SNF4). It was found that among these four subtypes, patients with the RTK-Driven type had the worst prognosis, with endocrine therapy being almost ineffective [22]. This may also result in a subset of HR + / HER-2- patients having a poor prognosis despite achieving pCR through neoadjuvant chemotherapy, followed by standardized surgery and endocrine therapy.

In addition to molecular subtypes, lymph node staging is also an important prognostic risk factor [23, 24]. Approximately 30% of breast cancer patients experience regional lymph node (LN) metastasis, which is associated with early recurrence and poor clinical prognosis. Elevated lymph node staging is frequently correlated with worse prognosis [25, 26]. Similar to previous studies, in the multivariable analysis of tumor-specific survival for invasive ductal carcinoma in this study, the hazard ratio for N3 significantly increased compared to N0 (HR = 6.17, 95%CI:4.28–8.89, $P < 0.05$), this suggested a deterioration in prognosis with increasing N staging. After neoadjuvant chemotherapy, patients whose axillary lymph nodes reached pCR had a better prognosis than those who did not reach pCR. However, there are differences in the pCR rates of axillary lymph nodes among patients with invasive breast cancer of different molecular subtypes. Sanaz Samiei et al. conducted a pooled analysis, encompassing 33 studies and a total of 57,531 patients. The results showed that the pCR rate in axillary lymph nodes was lowest for the HR + /HER-2- subtype of breast cancer, at 16%. For HR + /HER-2 +, HR-/HER-2 +, and HR-/HER-2- subtypes, the axillary lymph node pCR rates were 45%, 57%, and 47% respectively [27]. Rene Flores et al. discovered that, in comparison to other molecular subtypes, patients diagnosed with HR + /HER-2- breast cancer exhibited the greatest risk of their axillary lymph nodes failing to achieve a pathological complete response (pCR) following neoadjuvant chemotherapy (OR = 1.57, CI:1.41–1.74, $p < 0.001$) [28]. Among the four subtypes of invasive ductal carcinoma patients who achieved pathological complete response (pCR) after neoadjuvant chemotherapy, the HR + /HER-2- group had the highest proportion of N2 + N3, reaching

11.2%. Patients with the HR + /HER-2 subtype exhibited higher N staging and lower lymph node response rates to neoadjuvant chemotherapy, which may also be related to the observed lower overcomes.

Surgery approach is also an independent risk factor for OS and CSS. According to univariate analysis, comparing with breast-conserving surgery, total mastectomy had a worse OS(HR = 1.44, CI:1.17–1.78) and CSS (HR = 1.81, CI:1.42–2.31, $p < 0.05$). Yu-Chun Song et al. conducted a retrospective analysis of data from 730 patients who underwent neoadjuvant chemotherapy between 2000 and 2014, finding that patients in both the total mastectomy and breast-conserving surgery groups had similar 5-year rates of locoregional recurrence (LRR), distant metastases (DM), and disease-free survival (DFS). However, the breast-conserving surgery group had a significantly higher 5-year breast CSS (98.9% vs. 90.4%, $p = 0.005$) and OS (98.9% vs. 90.1%, $P = 0.003$) rates [29]. It is well-known that breast cancer patients undergoing mastectomy often present with larger tumors and a higher frequency of lymph node metastases compared to those who opt for breast-conserving surgery. To balance the baseline differences in factors other than the surgical method among breast cancer patients, Sungchan Gwark et al. utilized propensity score matching to evaluate 1641 patients undergoing neoadjuvant chemotherapy. Their findings indicated that breast-conserving surgery combined with radiotherapy leads to superior disease-free survival (DFS, $p < 0.05$), distant metastasis-free survival (DMFS, $p < 0.05$), and overall survival (OS, $p < 0.05$) in comparison to mastectomy [30]. Combining the results of this study with the latest related research, we found that choosing breast-conserving surgery after neoadjuvant chemotherapy offers better benefits in survival prognosis for patients.

This study has certain limitations. It is a database-based retrospective analysis, and the conclusions may be subject to potential unknown biases or confounding factors. There is a lack of data on the application of HER-2 + targeted drugs and endocrine therapy for HR + patients. Additionally, the SEER database has a short record time for neoadjuvant chemotherapy, lacking longer follow-up data. Moreover, there is a lack of external data validation and data on Disease-Free Survival (DFS) and Local Recurrence Rate (LRR), and this may have also affected the results of our systemic treatment analysis.

Conclusions

This study discovered that there are differences in the clinicopathological characteristics of different molecular subtypes of invasive ductal carcinoma of the breast that achieve pCR through neoadjuvant chemotherapy. Patients in the HR + /HER-2- group are typically younger, present with a more advanced lymph node stage, and exhibit the lowest survival rates. In contrast, patients in the HR + /HER-2 + group demonstrate the highest OS and CSS rates. Following the achievement of a pathological complete response (pCR) after neoadjuvant chemotherapy, patients who undergo breast-conserving surgery significantly improved OS and CSS compared to those who undergoing mastectomy.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12957-024-03535-x.

Supplementary Material 1.

Acknowledgements
None.

Authors' contributions
XC and GY participated in study design. LJY and HJH undertook the research and performed the analyses. XC wrote the manuscript. XY contributed for overall editing and visualization. All the authors read and approved the final manuscript.

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Availability of data and materials
In this study data are available from the Surveillance, Epidemiology, and End Results (SEER) database.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Ethical approval was waived by the Ethics Committee of Second Clinical Medical College, Affiliated Fifth People's Hospital of Chengdu University of Traditional Chinese Medicine and The General Hospital of Western Theater Command in view of the retrospective nature of the study and all the procedures being performed were part of the routine care.

Competing interests
The authors declare no competing interests.

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