Supplementary Table 1. Expanded multivariable logistic regression analysis of factors associated with pathological complete response. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for pathological complete response (pCR) derived from a multivariable logistic regression model including homologous recombination deficiency (HRD) status, composite DNA damage response (DDR) score level, clinical stage, age, menopausal status, and Ki67 expression.

Variable	Adjusted OR	95% CI	p value
HRD-positive vs HRD-negative	2.24	0.81–6.80	0.128
DDR level (linear trend)	0.56	0.15–2.00	0.371
DDR level (quadratic component)	2.66	0.91–8.47	0.081
Clinical stage (linear trend: I→III)	0.13	0.01–0.89	0.057
Clinical stage (quadratic component)	0.70	0.15–2.69	0.611
Age (per 10-year increase)	0.74	0.29–1.78	0.517
Postmenopausal vs premenopausal	0.36	0.03–3.37	0.374
Ki67 (linear trend across tertiles)	1.52	0.49–4.99	0.476
Ki67 (quadratic component)	0.81	0.22–2.82	0.743

Analyses were restricted to the 61 patients with complete data for all variables included in the model. HRD status was categorized as HRD-negative (reference) or HRD-positive. The composite DDR score was categorized into low (reference), intermediate, and high groups based on cohort-specific tertiles and modeled as an ordered categorical variable using polynomial contrasts. Clinical stage was modeled as an ordered categorical variable (I, II, III) using the same contrast structure. Age was modeled per 10-year increase. Menopausal status was modeled as premenopausal (reference) versus postmenopausal. Ki67 was categorized into cohort-specific tertiles (low <40%, intermediate 40–69%, high ≥70%). P values are two-sided.

Supplementary Table 2. Univariable Cox proportional hazards models for disease-free and overall survival.

Endpoint	Predictor	Comparison	N	Events	HR (95% CI)	p value	Global p
DFS	Adj_RT	Adj_RT (ref=yes) : no	126	22	0.62 (0.25–1.52)	0.292	
DFS	Adj_syst_treat	Adj_syst_treat (ref=yes) : no	128	22	0.38 (0.17–0.89)	0.026	
DFS	Age10	Age10 (per 1 unit)	128	22	0.92 (0.65–1.29)	0.614	
DFS	BMI	BMI (ref=underweight) : normal	127	22	31271783.80 (0.00–Inf)	0.997	0.192
DFS	BMI	BMI (ref=underweight) : overweight	127	22	16580697.85 (0.00–Inf)	0.997	0.192
DFS	BMI	BMI (ref=underweight) : obese	127	22	55342645.48 (0.00–Inf)	0.997	0.192
DFS	CP_dose_red	CP_dose_red (ref=no) : yes	128	22	2.59 (1.05–6.35)	0.038	
DFS	Center	Center (ref=IRE) : PER	128	22	0.81 (0.28–2.37)	0.704	0.682
DFS	Center	Center (ref=IRE) : SGA	128	22	1.30 (0.49–3.47)	0.601	0.682
DFS	DDR_level	DDR_level (ref=DDR-low) : DDR-intermediate	102	15	2.00 (0.59–6.85)	0.268	0.438
DFS	DDR_level	DDR_level (ref=DDR-low) : DDR-high	102	15	1.04 (0.26–4.16)	0.956	0.438
DFS	EC_DD	EC_DD (ref=yes) : no	119	19	1.42 (0.33–6.15)	0.639	
DFS	EC_dose_red	EC_dose_red (ref=no) : yes	120	20	1.40 (0.53–3.68)	0.500	
DFS	HER2_Ihc_pre	HER2_Ihc_pre (per 1 unit)	128	22	0.97 (0.42–2.20)	0.936	
DFS	HRD_status	HRD_status (ref=HRD-negative) : HRD-positive	80	15	0.46 (0.13–1.64)	0.232	
DFS	HR_pre	HR_pre (ref=negative) : low	128	22	1.13 (0.38–3.34)	0.827	
DFS	Ki67_pre	Ki67_pre (ref=low) : intermediate	128	22	0.76 (0.26–2.18)	0.605	0.709
DFS	Ki67_pre	Ki67_pre (ref=low) : high	128	22	1.18 (0.44–3.15)	0.747	0.709

DFS	Menopause	Menopause (ref=premenopausal) : postmenopausal	128	22	0.69 (0.28–1.70)	0.421	
DFS	cStage	cStage (ref=I) : II	128	22	3.86 (0.51–29.11)	0.190	0.028
DFS	cStage	cStage (ref=I) : III	128	22	11.37 (1.32–97.73)	0.027	0.028
DFS	pCR_binary	pCR_binary (ref=no pCR) : pCR	128	22	0.29 (0.12–0.72)	0.008	
OS	Adj_RT	Adj_RT (ref=yes) : no	126	19	0.64 (0.24–1.69)	0.365	
OS	Adj_syst_treat	Adj_syst_treat (ref=yes) : no	128	19	0.42 (0.17–1.02)	0.056	
OS	Age10	Age10 (per 1 unit)	128	19	0.95 (0.65–1.37)	0.776	
OS	BMI	BMI (ref=underweight) : normal	127	19	32578808.62 (0.00–Inf)	0.998	0.185
OS	BMI	BMI (ref=underweight) : overweight	127	19	14793288.49 (0.00–Inf)	0.998	0.185
OS	BMI	BMI (ref=underweight) : obese	127	19	61927481.20 (0.00–Inf)	0.998	0.185
OS	CP_dose_red	CP_dose_red (ref=no) : yes	128	19	1.94 (0.76–4.94)	0.164	
OS	Center	Center (ref=IRE) : PER	128	19	0.86 (0.29–2.57)	0.791	0.942
OS	Center	Center (ref=IRE) : SGA	128	19	0.83 (0.26–2.62)	0.751	0.942
OS	DDR_level	DDR_level (ref=DDR-low) : DDR-intermediate	102	13	2.54 (0.66–9.83)	0.176	0.272
OS	DDR_level	DDR_level (ref=DDR-low) : DDR-high	102	13	1.07 (0.21–5.29)	0.937	0.272
OS	EC_DD	EC_DD (ref=yes) : no	119	17	1.81 (0.41–7.98)	0.432	
OS	EC_dose_red	EC_dose_red (ref=no) : yes	120	18	1.53 (0.56–4.20)	0.411	
OS	HER2_Ihc_pre	HER2_Ihc_pre (per 1 unit)	128	19	0.94 (0.37–2.36)	0.887	
OS	HRD_status	HRD_status (ref=HRD-negative) : HRD-positive	80	12	0.62 (0.17–2.30)	0.475	
OS	HR_pre	HR_pre (ref=negative) : low	128	19	1.38 (0.46–4.17)	0.565	

OS	Ki67_pre	Ki67_pre (ref=low) : intermediate	128	19	0.75 (0.24–2.38)	0.623	0.686
OS	Ki67_pre	Ki67_pre (ref=low) : high	128	19	1.24 (0.42–3.62)	0.696	0.686
OS	Menopause	Menopause (ref=premenopausal) : postmenopausal	128	19	0.75 (0.28–1.98)	0.557	
OS	cStage	cStage (ref=I) : II	128	19	105860025.15 (0.00–Inf)	0.997	0.005
OS	cStage	cStage (ref=I) : III	128	19	316738258.74 (0.00–Inf)	0.997	0.005
OS	pCR_binary	pCR_binary (ref=no pCR) : pCR	128	19	0.30 (0.12–0.81)	0.017	

DFS defined as time to recurrence (local/regional/distant) or death; OS defined as time to death from any cause; censoring at last follow-up. HRs are from separate univariable Cox models; HR <1 indicates reduced hazard (favorable prognosis). Models reported as: A_base: pCR + age (per 10 years) + clinical stage + center; A_base_strataCenter: pCR + age + clinical stage, stratified by center; B_biomarker: HRD status + DDR level + pCR + age + clinical stage + center (HRD/DDR subset); S_deliverySensitivity: A_base + CP/EC dose reductions + EC dose-density maintenance; E_adjuvantExploratory: A_base + adjuvant radiotherapy + adjuvant systemic therapy

Supplementary Table 3. Multivariable Cox proportional hazards models for disease-free and overall survival.

Endpoint	Model	Model N	Model events	Term	HR (95% CI)	p value
DFS	A_base	128	22	pCR_binarypCR	0.30 (0.12–0.76)	0.011
DFS	A_base	128	22	cStageIII	8.00 (0.90–70.91)	0.062
DFS	A_base	128	22	cStageII	3.09 (0.40–23.76)	0.278
DFS	A_base	128	22	Age10	0.86 (0.61–1.21)	0.378
DFS	A_base	128	22	CenterSGA	1.44 (0.53–3.91)	0.477
DFS	A_base	128	22	CenterPER	0.88 (0.30–2.60)	0.819
DFS	A_base_strataCenter	128	22	pCR_binarypCR	0.30 (0.12–0.77)	0.012

DFS	A_base_strataCenter	128	22	cStageIII	7.89 (0.89–69.54)	0.063
DFS	A_base_strataCenter	128	22	cStageII	2.99 (0.39–22.95)	0.293
DFS	A_base_strataCenter	128	22	Age10	0.86 (0.61–1.22)	0.407
DFS	B_biomarker	61	10	pCR_binarypCR	0.19 (0.03–1.07)	0.059
DFS	B_biomarker	61	10	HRD_statusHRD-positive	0.14 (0.02–1.35)	0.089
DFS	B_biomarker	61	10	Age10	0.54 (0.25–1.16)	0.111
DFS	B_biomarker	61	10	CenterSGA	3.25 (0.58–18.09)	0.179
DFS	B_biomarker	61	10	DDR_levelDDR-high	0.42 (0.03–5.30)	0.502
DFS	B_biomarker	61	10	DDR_levelDDR-intermediate	1.47 (0.25–8.53)	0.669
DFS	B_biomarker	61	10	cStageIII	1093194993.36 (0.00–Inf)	0.999
DFS	B_biomarker	61	10	cStageII	203736939.92 (0.00–Inf)	0.999
DFS	B_biomarker	61	10	CenterPER	0.00 (0.00–Inf)	0.999
DFS	E_adjuvantExploratory	126	22	cStageIII	8.46 (0.91–78.68)	0.061
DFS	E_adjuvantExploratory	126	22	pCR_binarypCR	0.43 (0.14–1.33)	0.144
DFS	E_adjuvantExploratory	126	22	cStageII	3.15 (0.40–24.61)	0.274
DFS	E_adjuvantExploratory	126	22	CenterSGA	1.72 (0.61–4.88)	0.306

DFS	E_adjuvantExploratory	126	22	Adj_syst_treatno	0.58 (0.20–1.66)	0.310
DFS	E_adjuvantExploratory	126	22	Age10	0.86 (0.60–1.23)	0.414
DFS	E_adjuvantExploratory	126	22	Adj_RTno	0.81 (0.31–2.14)	0.674
DFS	E_adjuvantExploratory	126	22	CenterPER	0.89 (0.30–2.64)	0.831
DFS	S_deliverySensitivity	116	19	pCR_binarypCR	0.40 (0.15–1.08)	0.069
DFS	S_deliverySensitivity	116	19	cStageIII	6.64 (0.73–60.07)	0.092
DFS	S_deliverySensitivity	116	19	CP_dose_redyes	2.52 (0.77–8.21)	0.126
DFS	S_deliverySensitivity	116	19	Age10	0.75 (0.49–1.13)	0.167
DFS	S_deliverySensitivity	116	19	EC_DDno	2.85 (0.49–16.65)	0.244
DFS	S_deliverySensitivity	116	19	cStageII	2.37 (0.29–19.05)	0.418
DFS	S_deliverySensitivity	116	19	EC_dose_redyes	1.42 (0.43–4.65)	0.563
DFS	S_deliverySensitivity	116	19	CenterSGA	1.07 (0.33–3.50)	0.914
DFS	S_deliverySensitivity	116	19	CenterPER	0.97 (0.26–3.59)	0.965
OS	A_base	128	19	pCR_binarypCR	0.34 (0.12–0.92)	0.035
OS	A_base	128	19	Age10	0.88 (0.62–1.25)	0.477
OS	A_base	128	19	CenterSGA	0.90 (0.28–2.86)	0.855
OS	A_base	128	19	CenterPER	0.93 (0.31–2.81)	0.896
OS	A_base	128	19	cStageIII	236539329.97 (0.00–Inf)	0.997
OS	A_base	128	19	cStageII	87063997.06 (0.00–Inf)	0.998

OS	A_base_strataCenter	128	19	pCR_binarypCR	0.34 (0.12–0.93)	0.036
OS	A_base_strataCenter	128	19	Age10	0.88 (0.61–1.26)	0.477
OS	A_base_strataCenter	128	19	cStageIII	237800248.86 (0.00–Inf)	0.997
OS	A_base_strataCenter	128	19	cStageII	87365756.95 (0.00–Inf)	0.998
OS	B_biomarker	61	8	HRD_statusHRD-positive	0.17 (0.02–1.62)	0.122
OS	B_biomarker	61	8	Age10	0.58 (0.24–1.39)	0.220
OS	B_biomarker	61	8	pCR_binarypCR	0.33 (0.06–1.96)	0.223
OS	B_biomarker	61	8	DDR_levelDDR-intermediate	2.81 (0.29–27.08)	0.372
OS	B_biomarker	61	8	CenterSGA	2.00 (0.37–10.85)	0.420
OS	B_biomarker	61	8	DDR_levelDDR-high	0.00 (0.00–Inf)	0.999
OS	B_biomarker	61	8	cStageIII	2542754776.43 (0.00–Inf)	0.999
OS	B_biomarker	61	8	cStageII	791653571.19 (0.00–Inf)	0.999
OS	B_biomarker	61	8	CenterPER	0.00 (0.00–Inf)	0.999
OS	E_adjuvantExploratory	126	19	pCR_binarypCR	0.43 (0.13–1.44)	0.173
OS	E_adjuvantExploratory	126	19	Adj_syst_treatno	0.68 (0.22–2.06)	0.497
OS	E_adjuvantExploratory	126	19	Age10	0.90 (0.62–1.29)	0.554

OS	E_adjuvantExploratory	126	19	CenterPER	0.90 (0.29–2.77)	0.859
OS	E_adjuvantExploratory	126	19	Adj_RTno	1.06 (0.37–3.03)	0.909
OS	E_adjuvantExploratory	126	19	CenterSGA	0.96 (0.29–3.17)	0.945
OS	E_adjuvantExploratory	126	19	cStageIII	248353928.75 (0.00–Inf)	0.997
OS	E_adjuvantExploratory	126	19	cStageII	88761638.21 (0.00–Inf)	0.997
OS	S_deliverySensitivity	116	17	pCR_binarypCR	0.40 (0.14–1.16)	0.091
OS	S_deliverySensitivity	116	17	EC_DDno	3.55 (0.57–22.24)	0.176
OS	S_deliverySensitivity	116	17	Age10	0.75 (0.49–1.14)	0.180
OS	S_deliverySensitivity	116	17	CP_dose_redyes	2.12 (0.64–7.06)	0.220
OS	S_deliverySensitivity	116	17	EC_dose_redyes	1.37 (0.41–4.58)	0.610
OS	S_deliverySensitivity	116	17	CenterSGA	0.78 (0.22–2.82)	0.708
OS	S_deliverySensitivity	116	17	CenterPER	0.92 (0.24–3.49)	0.902
OS	S_deliverySensitivity	116	17	cStageIII	252246336.77 (0.00–Inf)	0.998
OS	S_deliverySensitivity	116	17	cStageII	93903103.67 (0.00–Inf)	0.998

DFS defined as time to recurrence (local/regional/distant) or death; OS defined as time to death from any cause; censoring at last follow-up. HRs are from separate univariable Cox models; HR <1 indicates reduced hazard (favorable prognosis).

Supplementary Table 4. Worst-grade toxicity distribution by treatment block (CP and EC).

Treatment block	Adverse event	Completeness (assessed/128)	Grade 0	Grade 1	Grade 2	Grade 3	Grade 4
CP	Leukopenia	106/128 (82.8%)	56 (52.8%)	18 (17.0%)	19 (17.9%)	11 (10.4%)	2 (1.9%)
CP	Neutropenia	106/128 (82.8%)	48 (45.3%)	23 (21.7%)	20 (18.9%)	12 (11.3%)	3 (2.8%)
CP	Thrombocytopenia	100/128 (78.1%)	64 (64.0%)	30 (30.0%)	4 (4.0%)	2 (2.0%)	0 (0.0%)
CP	Anemia	106/128 (82.8%)	20 (18.9%)	53 (50.0%)	31 (29.2%)	2 (1.9%)	0 (0.0%)
CP	Fever	103/128 (80.5%)	97 (94.2%)	6 (5.8%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
CP	Nausea	102/128 (79.7%)	71 (69.6%)	28 (27.5%)	3 (2.9%)	0 (0.0%)	0 (0.0%)
CP	Vomiting	101/128 (78.9%)	97 (96.0%)	4 (4.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
CP	Diarrhea	101/128 (78.9%)	87 (86.1%)	11 (10.9%)	2 (2.0%)	1 (1.0%)	0 (0.0%)
CP	Hypersensitivity reaction	98/128 (76.6%)	95 (96.9%)	3 (3.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
CP	Peripheral neuropathy	100/128 (78.1%)	78 (78.0%)	17 (17.0%)	5 (5.0%)	0 (0.0%)	0 (0.0%)
CP	Mucositis	98/128 (76.6%)	92 (93.9%)	6 (6.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
CP	Skin toxicity	98/128 (76.6%)	94 (95.9%)	2 (2.0%)	2 (2.0%)	0 (0.0%)	0 (0.0%)
CP	Cardiotoxicity	98/128 (76.6%)	98 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
CP	Phlebitis	98/128 (76.6%)	96 (98.0%)	2 (2.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
CP	Transaminase elevation	104/128 (81.2%)	91 (87.5%)	11 (10.6%)	2 (1.9%)	0 (0.0%)	0 (0.0%)

EC	Leukopenia	96/128 (75.0%)	59 (61.5%)	18 (18.8%)	8 (8.3%)	6 (6.2%)	5 (5.2%)
EC	Neutropenia	100/128 (78.1%)	57 (57.0%)	17 (17.0%)	12 (12.0%)	6 (6.0%)	8 (8.0%)
EC	Thrombocytopenia	97/128 (75.8%)	64 (66.0%)	23 (23.7%)	7 (7.2%)	3 (3.1%)	0 (0.0%)
EC	Anemia	101/128 (78.9%)	15 (14.9%)	39 (38.6%)	40 (39.6%)	7 (6.9%)	0 (0.0%)
EC	Fever	102/128 (79.7%)	91 (89.2%)	10 (9.8%)	1 (1.0%)	0 (0.0%)	0 (0.0%)
EC	Nausea	100/128 (78.1%)	76 (76.0%)	20 (20.0%)	3 (3.0%)	1 (1.0%)	0 (0.0%)
EC	Vomiting	99/128 (77.3%)	95 (96.0%)	3 (3.0%)	1 (1.0%)	0 (0.0%)	0 (0.0%)
EC	Diarrhea	94/128 (73.4%)	92 (97.9%)	1 (1.1%)	1 (1.1%)	0 (0.0%)	0 (0.0%)
EC	Hypersensitivity reaction	94/128 (73.4%)	94 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
EC	Peripheral neuropathy	94/128 (73.4%)	91 (96.8%)	2 (2.1%)	1 (1.1%)	0 (0.0%)	0 (0.0%)
EC	Mucositis	98/128 (76.6%)	93 (94.9%)	4 (4.1%)	1 (1.0%)	0 (0.0%)	0 (0.0%)
EC	Skin toxicity	95/128 (74.2%)	93 (97.9%)	0 (0.0%)	1 (1.1%)	1 (1.1%)	0 (0.0%)
EC	Cardiotoxicity	94/128 (73.4%)	94 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
EC	Phlebitis	95/128 (74.2%)	94 (98.9%)	0 (0.0%)	1 (1.1%)	0 (0.0%)	0 (0.0%)
EC	Transaminase elevation	100/128 (78.1%)	94 (94.0%)	6 (6.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

Toxicities were graded according to CTCAE v5.0; the maximum (worst) grade observed across all cycles within each treatment block is shown. Completeness indicates the number of patients with recorded grading for that endpoint (N assessed/128). Grade categories (G0–G4) are presented as n (%) among assessed patients for the specified endpoint and treatment block.