Original Article

Eur J Breast Health 2022; 18(3): 271-278
DOI: 10.4274/ejbh.galenos.2022.2022-2-5

An Overview of the Impact of Body Mass Index on Pathological Complete Response Following Neoadjuvant Chemotherapy in Operable Breast Cancer in a Tertiary Care Centre in South India

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ABSTRACT

Objective: The incidence of female breast cancer in the world is 11.7% with a mortality rate of 6.9%. According to Globocon 2020, breast cancer is the most commonly diagnosed cancer (24.5%) and the leading cause of cancer-related death amongst women worldwide. The purpose of this study was to analyze the impact of Body Mass Index (BMI) on pathological complete response (pCR) rates for operable breast cancer after neoadjuvant chemotherapy (NACT). The primary endpoint was to assess histopathological features of the surgical specimen in response to NACT and to investigate the relationship with pre-chemotherapy BMI taking into account the various molecular subtypes of breast cancer.

Materials and Methods: Patients with biopsy-proven breast carcinoma who underwent surgery after NACT between January 2017 and May 2021 were included. All patients were initially divided into three groups depending on their pre-chemotherapy BMI. With BMI <22.9 as normal or underweight category, BMI of 23-27.4, was taken as overweight category and BMI ≥27.5 as obese category.

Results: The study included 184 patients. Normal weight patients had the highest rate of pCR (75%) and the lowest was seen in the obese category (33.75%). Furthermore, the subtype most likely to achieve pCR was HER2+/ER negative followed by triple negative BC with odds ratios of 3.46 and 2.21, respectively.

Conclusion: This retrospective study established that overweight and obese patients suffering from breast carcinoma had a lessened pCR rate following NACT in comparison with those who were under-/normal weight.

Keywords: Body mass index; breast carcinoma; invasive ductal carcinoma; molecular subtypes of breast carcinoma; neoadjuvant chemotherapy; pathological complete response

Cite this article as: Somashekhar SP, Jaiswal R, Kumar R, Ashok BC, Rakshit S, Rauthan A, Patil P, Yashas N, Karthik HK, Prasad A, Islam H, Ashwin KR. Eur J Breast Health 2022; 18(3): 271-278

Key Points

- The endpoint of the study was to assess histopathological features of the surgical specimen as a response to neoadjuvant chemotherapy and investigate its relation with pre-chemotherapy body mass index with regard to the subtype of breast cancer.
- This study showed that overweight and obese breast cancer patients had a lower pathological clinical response rate following neoadjuvant chemotherapy compared to those with under-/normal weight.
- The pathological clinical response rate was highest in the HER2/neu enriched patients followed by those with the triple-negative subtype of breast cancer.

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Received: 21.02.2022
Accepted: 29.04.2022
Available Online Date: 01.07.2022

Introduction

The incidence of female breast cancer globally is 11.7% with a mortality rate of 6.9% (1). According to Globocon 2020, breast cancer is the most commonly diagnosed cancer (24.5%) and the leading cause of cancer-related death amongst women worldwide (1). Various studies have established the risk associated with obesity and the development of malignancies, such as endometrial, ovarian and breast cancers (2). Obesity is a well-known risk factor for the development of hormone receptor-positive breast cancer in postmenopausal women (3, 4). Furthermore, it is linked with an advanced stage at the time of the breast carcinoma diagnosis along with a higher rate of recurrence risk, post-treatment (5, 6). Obesity is associated with poor outcomes in both premenopausal and postmenopausal breast cancer patients (7). However, the exact mechanism leading to the association between obesity and breast cancer risk and outcome remain obscure. Assessing the connection between obesity and pathological complete response (pCR) after neoadjuvant chemotherapy (NACT) will increase the understanding of the effect of obesity in patients with breast cancer. NACT offers a unique setting to assess whether there may be a link between obesity and response to chemotherapy *in vivo* (8).

Overweight is defined by the World Health Organization (WHO) as a Body Mass Index (BMI) ≥25 and <30 kg/m^2) and obesity as (BMI ≥30 kg/m^2) (9). Nonetheless, the definition of obesity differs with ethnicities because certain populations have a higher percentage of body fat or a preferential visceral fat accumulation. So lower BMI thresholds are recommended for black African, African-Caribbean, and Asian individuals so that overweight in these ethnicities is defined as BMI 23.0 to 27.4 kg/m^2 and obesity as BMI >27.5 kg/m^2 (9), (Table 1).

Various molecular subtypes of breast cancer were defined in accordance with the St. Gallen's surrogate definition of intrinsic subtypes of breast cancer. These are: luminal A [ER + and/or PR+, Ki-67 <14% and human epidermal growth factor receptor 2 (HER2) -]; luminal B (estrogen receptor (ER) + and/or progesterone receptor (PR)+, Ki-67 high and/or HER2+); HER2-positive (ER-, PR- and HER2+); and triple-negative (ER-, PR-, HER2-) (10). Patients are accepted as ER/PR-positive if receptor expression is >1%.

The purpose of this study was to analyze the impact of BMI on pathological complete response (pCR) rates for operable breast cancer after NACT. The primary endpoint was to assess histopathological features of the surgical specimen as a response to NACT and study its relation with pre-chemotherapy BMI, considering various molecular subtypes of breast cancer.

Materials and Methods

After institutional review and ethical board approval, we retrospectively analyzed the medical records of 184 biopsy-proven breast carcinoma patients who had undergone surgery, post neoadjuvant chemotherapy at Manipal Comprehensive Cancer Centre, a tertiary care centre in South India, between January 2017 and May 2021.

All patients were initially divided into three groups depending on their pre-chemotherapy BMI. With BMI <22.9 as normal or underweight category, BMI: 23–27.4, was taken as overweight category and BMI ≥27.5 as obese category (Table 1). These categories were in coherence with WHO standards of BMI classification for Asian populations (9). Various molecular subtypes of breast cancer were defined in accordance with the St. Gallen's surrogate definition of intrinsic subtypes of breast cancer as luminal A, luminal B, HER2-positive and triple-negative, as described above. In our study patients who were hormone receptor-positive and HER-2 positive were classified as HER-2 positive luminal B, whereas those who were HER-2 positive and ER/PR negative were classified as HER-2 enriched. HER-2 positive status was indicated by evidence of protein overexpression on immunohistochemical staining or gene amplification on fluorescence *in sit*u hybridisation (FISH). Immunohistochemical overexpression with a score of 3 was accepted as positive. Borderline expression of score 2 was validated using FISH.

Written informed consent was taken from each patient after explaining the nature of the procedure with its advantages, disadvantages, expected results, and possible re-excision rates. As per our institutional protocol, all patients recruited were those who had received NACT followed by surgery, which was further followed by adjuvant treatment depending upon the final histopathology and nature of surgery. In our institute, we used a chemotherapy regimen of four courses of Anthracycline and cyclophosphamide, followed by four courses of taxanes. (11, 12). Additionally, carboplatin and trastuzumab were added for HER2 positive disease along with taxane in a 3-weekly schedule for six consecutive cycles preoperatively (13, 14). Pertuzumab was not added to patient treatment regimens in our study. The duration of neoadjuvant chemotherapy was 12–14 weeks.

Following NACT, patients were evaluated and planned for breast conservation surgery (BCS) with sentinel lymph node biopsy (SLNB) or mastectomy with sentinel lymph node biopsy (SLNB) with or without axillary lymph node dissection (ALND), depending upon the stage of the tumour at the time of detection and its response to NACT and frozen section report of SLNB. Patients who underwent BCS were then continued for adjuvant radiotherapy. This adjuvant treatment plan was structured in accordance with the recommendations proposed during the tumour board discussions.

A comparison was made for pathological response post NACT, between the various BMI category groups. Moreover, an analysis of the association between BMI and pCR in various subtypes of breast cancer, based on hormone receptors and HER2 status was performed.

pCR was defined according to the Lancet trial of 2014 as ypT0/Tis ypN0, ypT0/Tis, or ypN0 (15).

Statistical Analysis

Data were first summarized by as mean, standard deviation, median, and range for continuous variables and frequency and proportion for categorical variables. A Spearman correlation coefficient was calculated to evaluate the relationship between BMI, age, and body

Table 1. BMI subgroups

Ethnicity	Normal	Overweight	Obese
Asians, Black Africans	<22.9	23–27.4	>27.5
Other population	18–24.9	25–29.9	>30

composition measurements. A univariate logistic regression model was fitted to evaluate the association between clinical characteristics and the probability of pCR and those showing a *p*-value <0.25 were further considered for multivariate analysis. Further, using the forward stepwise method the best method was chosen. For all the logistic regression models, parameter estimates, standard error of estimates, odds ratios, 95% confidence intervals and *p*-values of each factor were computed. Akaike information criterion (AIC) and Residual Deviance of models were compared. All statistical tests were performed using R software (R Foundation). Statistical significance was set at a 95% level of significance ($p<0.05$).

Results

In total the records of 184 patients were retrospectively reviewed. The median age of the whole cohort was 52 years and most of the patients (58%) were postmenopausal. BMI of the overall cohort was 26.19 kg/m^2. All demographic data and data specific to the type and stage of breast cancer for the study population are shown in Table 2. Approximately one fifth of patients were underweight/normal, one third were overweight and the remainder were obese according to BMI categories for Asians.

A total of 176 (95.6%) had infiltrating ductal carcinoma and the remaining eight (4.35%) had lobular carcinoma. Most of the patients had stage II (n = 90; 49.18%), followed by stage III (n = 88; 48.09%) disease. A total of 79 (43.17%) patients had achieved pCR.

A total of 176 patients had a tumour that was infiltrating ductal carcinoma and the rest eight patients had a tumour that was lobular carcinoma (Table 2).

Our study is limited by the fact that there are fewer patients in the low BMI group compared to the overweight and obese groups.

A univariate logistic regression model (Table 3) was conducted for the primary outcome of the pathological stage (pCR and non pCR) with all the variables. The model showed a strong association between BMI categories and type of surgery with the pathological stage ($p<0.01$). The rest of the variables were found to be non-significant ($p>0.05$).

The highest pCR rate was seen in normal-weight patients (75 %) and the lowest in the obese category (33.75%) (Graph 1). The odds ratio of achieving pCR of 0.21 (0.08, 0.52) for overweight and 0.20 (0.08, 0.49) for the obese group in the overall cohort using the underweight/normal patients as reference indicate that the higher the BMI then the lower the chance of achieving pCR (Table 4).

Multivariate analysis was carried out for primary outcome pCR for the variables which had *p*-value ≤0.25 in the univariate analysis. These variables were: menopausal status; BMI; quadrant; type of surgery; and Luminal type. Following further optimization of the model using the stepwise method, the final model was obtained. The final model showed that the variables BMI (category), type of surgery and Luminal type, were associated with the pathological stage (Table 4).

Analysis showed that, based on the odds ratio (OR) value with respect to Luminal A (OR = 1 as reference), the trend of achieving pCR, was in favour of HER2+/ER negative and TNBC with odds ratios of 3.46 (0.92, 14.38) and 2.21 (0.62, 8.58), respectively. These were found to be independent factors affecting pCR (Table 3).

Analysis also revealed that patients undergoing MRM and BCS + ALND were less likely to achieve pCR, with an OR of 0.54 (0.25, 1.11) and 0.18 (0.05, 0.54) compared to patients who underwent BCS + SLNB in our center (OR = 1 as reference).

The final model was found to be superior to the preliminary multivariate model with AIC 222.03 *versus* 225.46. The residual deviance was found to be 204.03 (degree of freedom = 172) and lack of fit insignificant (*p*-value = 0.051). Hosmer and Lemeshow goodness of fit (GOF) test *p*-value = 0.3327. Hence the final model is a good fit and can be considered over the preliminary multivariate model.

Discussion and Conclusion

The impact of high BMI on breast malignancy patients undergoing NACT is a topic of uncertainty and controversy. Therefore, to develop an improved perspective in this topic, we investigated the influence of BMI on pathological response rates after NACT, in operable carcinomas of the breast. The results showed that overweight and

Table 2. Demographic and baseline characteristics of study population (n = 184)

Variables	BMI classification n (%)			
	Underweight/normal BMI <22.9 kg/m^2	Overweight BMI: 23–27.4 kg/m^2	Obese BMI ≥ 27.5 kg/m^2	Overall cohort n (%)
No of patients	40 (21.86)	63 (34.43)	80 (43.72)	184 (100)
Age (years)				
Median (min, max) mean	53.00 (29.00, 71.00) 51.41±12.53	52.00 (26.00, 72.00) 51.48±11.54	52 (29.00, 84.00) 51.99±11.30	52.00 (26.00, 84.00) 51.41±11.65
Menopausal, n (%)				
Pre	17 (42.5)	26 (41.27)	33 (41.25)	76 (41.53)
Post	23 (57.5)	37 (58.73)	47 (58.75)	107 (58.47)
BMI	21.36 (19.14, 22.31) IQR (20.57, 22.21)	24.91 (22.52, 27.34) IQR (42.00, 25.73)	31.01 (27.55, 48.98) IQR (29.28, 33.32)	26.14 (19.14, 48.98) IQR (23.33, 30.12) 27.22±5.12

Table 2. continued

Variables	BMI classification n (%)			
	Underweight/normal BMI <22.9 kg/m²	Overweight BMI: 23–27.4 kg/m²	Obese BMI ≥ 27.5 kg/m²	Overall cohort n (%)
Stage, n (%)				
I	1 (2.50)	1 (1.59)	0	2 (1.09)
II	24 (60.00)	33 (52.38)	33 (41.25)	90 (49.18)
III	15 (37.50)	27 (42.86)	45 (56.25)	88 (48.09)
IV	1 (2.86)	1 (1.59)	2 (2.50)	4 (2.19)
Quadrant, n (%)				
UO	23 (57.50)	47 (74.60)	53 (66.25)	124 (67.76)
LO	7 (17.50)	6 (9.52)	15 (18.75)	28 (15.30)
UI	1 (2.86)	8 (12.70)	5 (6.25)	14 (7.65)
LI	5 (12.50)	1 (1.59)	4 (5.00)	10 (5.47)
Central	4 (10.00)	1 (1.59)	3 (3.75)	8 (4.37)
Side, n (%)				
Right	23 (57.50)	34 (53.96)	37 (46.25)	95 (51.91)
Left	17 (42.50)	29 (46.03)	43 (53.75)	89 (48.63)
Type				
IDC	37 (92.50)	62 (98.41)	76 (95.00)	176 (96.18)
Lobular	3 (7.50)	1 (1.59)	4 (5.00)	8 (4.37)
Luminal, n (%)				
A	3 (7.50)	6 (9.52)	9 (11.25)	18 (9.84)
B	18 (45.00)	23 (36.51)	37 (46.25)	78 (42.63)
TNBC	10 (25.00)	22 (34.92)	19 (23.75)	52 (28.42)
HER 2+/ER NEG	9 (22.50)	8 (12.70)	12 (15.00)	29 (15.85)
HER2+/ER POS	0	4 (6.3)	3 (3.75)	7 (3.83)
Type surgery, n (%)				
BCS + SLNB	19 (47.50)	32 (50.79)	31 (38.75)	82 (44.81)
MRM	19 (47.50)	20 (31.75)	32 (40.00)	72 (39.34)
BCS + ALND	2 (5.00)	9 (14.29)	17 (21.25)	28 (15.30)
Grade, n (%)				
2	29 (68.57)	43 (72.06)	51 (62.96)	124 (67.39)
3	11 (31.43)	20 (27.94)	29 (37.04)	60 (32.61)
Pathological stage, n (%)				
No pCR	10 (25.00)	41 (65.08)	53 (66.25)	104 (56.83)
pCR	30 (75.00)	22 (34.92)	27 (33.75)	79 (43.17)
SLNB, n (%)				
Negative	10 (25.00)	39 (61.91)	53 (66.25)	144 (78.69)
Positive	30 (75.00)	22 (34.92)	27 (33.75)	38 (20.77)

UO: upper outer quadrant; LO: lower outer quadrant; UI: upper inner quadrant; UO: upper outer quadrant; TNBC: triple negative breast cancer; BCS: breast conservation surgery; IDC: infiltrating ductal carcinoma; IQR: interquartile range; BMI: Body Mass Index; IDC: invasive ductal carcinoma; BCS: breast conservation surgery; SLNB: sentinel lymph node biopsy; MRM: modified radical mastectomy; ALND: axillary lymph node dissection; pCR: pathological complete response; HER2: human epidermal growth factor receptor 2; ER: estrogen receptor; TNBC: triple-negative breast cancer; NEG: negative; POS: positive; min: minimum; max: maximum; n: number

obese breast cancer patients were less likely to achieve a pCR to NACT which was consistent with a meta-analysis carried out by Wang et al. (16) in 2021.

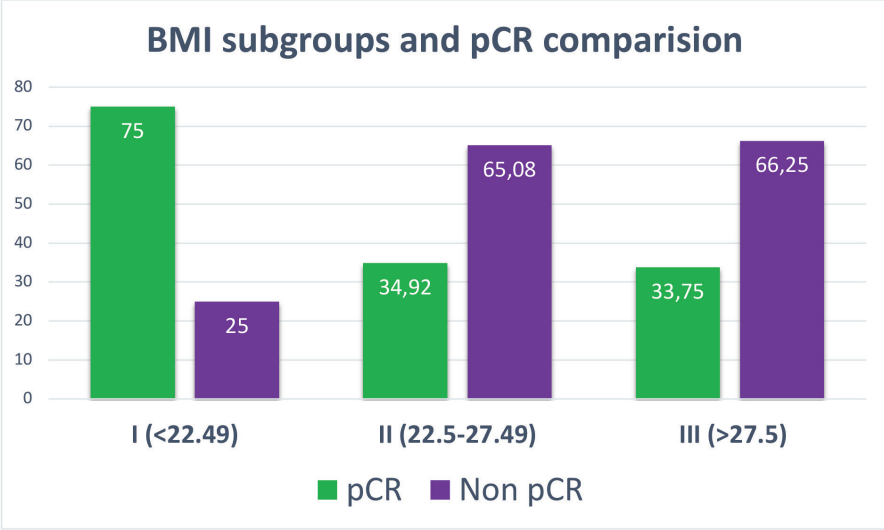
Additionally, we attempted to investigate the relationship between BMI and various subtypes of breast cancer, based on hormone receptors and HER2 status. A study by Warner et al. (17), explored this concept, and there was a significant inverse association between BMI and pCR in ER+/HER2+ patients (p-trend = 0.01) whereas in contrast, in ER–/HER2+ patients pCR rates were higher in overweight (71.3%; 62/87), obese women (60.7%; 74/122) and underweight women (83.3%; 10/12) women compared to normal-weight women (54.4%; 49/90),

Table 3. Univariate models

Variables		Estimate ± SD	OR (95%CI)	*p*-value
Age		-0.002±0.01	1.00 (0.97, 1.02)	**0.861**
Menopausal	**Pre**	Reference	1	
	Post	0.37±0.31	1.45 (0.80, 2.65)	0.2272
BMI	Underweight/normal <22.9	Reference	1	
	Overweight = 23–27.4	-1.67±0.45	0.19 (0.08, 0.44)	**0.0002**
	Obese ≥27.5	-1.77±0.44	0.17 (0.07, 0.39)	**4.58e-05**
Stage	I	Reference	1	
	II	-16.48±1696.73	$6.98x10^{-8}$ (NA, $3.01x10^{108}$)	0.992
	III	-17.23±1696.73	$3.31x10^{-8}$ (NA, $1.40x10^{108}$)	0.992
	IV	-33.13±2399.54	$4.08x10^{-15}$ (NA, $1.32x10^{105}$)	0.989
Quadrant	UO	Reference	1	
	LO	0.12 ±0.44	1.12 (0.47, 2.63)	0.11
	UI	-0.16±0.59	0.85 (0.25, 2.61)	
	LI	2.62±1.07	13.78 (2.48, 258.03)	
	Central	0.94±0.75	2.55 (0.60, 12.89)	
Side	Right	Reference	1	
	Left	0.61±0.30	1.85 (1.02, 3.36)	0.04263
Type	IDC	Reference	1	
	Lobular	-16.38±848.37	$7.68x10^{-08}$ (NA, $1.19x10^{24}$)	0.985
Ki-67		2.08e-05±8.27e-05	1.00002 (0.99986, 1.0002)	0.8015
Luminal	A	Reference	1	
	B	0.22±0.55	1.25 (0.44, 3.92)	0.16
	TNBC	0.65±0.57	1.92 (0.64, 6.26)	
	HER 2+/ER NEG	1.28 ±0.64	3.60 (1.07, 1.33)	
	HER2+/ER POS	-15.87 ±906.94	$1.28x10^{-07}$ ($2.46x10^{-152}$,$1.63 x10^{07}$)	
Type of surgery	BCS + SLNB	Reference	1	
	MRM	2.10±0.65	8.14 (2.58, 36.10)	<0.0001
	BCS + ALND	4.80±0.77	121.13 (30.88, 662.81)	
Grade	2	1	Reference	
	3	-0.11±0.32	0.90 (0.48, 1.68)	0.740
SLNB	0	Reference	1	
	1	-18.84±994.69	$6.57x10^{-09}$ ($9.28x10^{-150}$, $3.52x10^{10}$)	0.985

Significant values are shown in bold.

UO: upper outer quadrant; LO: lower outer quadrant; UI: upper inner quadrant; UO: upper outer quadrant; TNBC: triple negative breast cancer; BCS: breast conservation surgery; SLNB: sentinel lymph node biopsy; IDC: infiltrating ductal carcinoma; BMI: body mass Index; IDC: invasive ductal carcinoma; BCS: breast conservation surgery; SLNB: sentinel lymph node biopsy; MRM: modified radical mastectomy; ALND: axillary lymph node dissection; pCR: pathological complete response; HER2: human epidermal growth factor receptor 2; ER: estrogen receptor; NEG: negative; POS: positive; min: minimum; max: maximum; SD: standard deviation; OR: odds ratio; CI: confidence interval; n: number



Graph 1. Comparison of BMI categories and pCR rates in breast carcinoma post NACT

I: Normal BMI, II: Overweight, III: Obese, pCR is in percentage; BMI: Body Mass Index; pathological complete response

Table 4. Multivariate analysis

Variables OR (95%CI)		Initial model		Final model	
		p-value	OR (95%CI)	*p*-value	
Menopausal	Pre	1		-	
	Post	1.25 (0.60, 2.61)	0.55202	-	0.55202
BMI	Underweight/normal <22.9	1		1	
	Overweight = 23-27.4	0.25 (0.09, 0.67)	**0.00672**	0.21 (0.08, 0.52)	**0.001139**
	Obese BMI ≥ 27.5	0.22 (0.08, 0.55)	**0.00152**	0.20 (0.08, 0.49)	**0.00152**
Quadrant	UO	1		-	-
	LO	1.16 (0.43, 3.12)	0.76784	-	-
	UI	0.54 (0.14, 1.95)	0.35870	-	-
	LI	5.91 (0.93, 116.01)	0.11158	-	-
	Central	2.55 (0.44, 20.52)	0.31780	-	-
Luminal	A	1		1	
	B	1.35 (0.42, 4.72)	0.6189	1.35 (0.43, 4.63)	0.6158
	TNBC	2.21 (0.62, 8.58)	0.23316	2.21 (0.62, 8.58)	0.233871
	HER 2+/ER NEG	2.98 (0.77, 12.65)	0.12298	3.46 (0.92, 14.38)	**0.07449**
	HER2+/ER POS	$1.64x10^{-07}$ ($2.75x10^{-152}$, $5.97x10^{06}$)	0.98561	$1.87x10^{-07}$ ($1.22x10^{-142}$, $4.01x10^{07}$)	0.985842
Type of surgery	BCS + SLNB	1		1	
	MRM	0.47 (0.21, 1.01)	**0.057**	0.54 (0.25, 1.11)	**0.0978**
	BCS + ALND	0.18 (0.05, 0.57)	**0.0061**	0.18 (0.05, 0.54)	**0.0046**

Significant values are shown in bold.

UO: upper outer quadrant; LO: lower outer quadrant; UI: upper inner quadrant; UO: upper outer quadrant; TNBC: triple negative breast cancer; BCS: breast conservation surgery; SLNB: sentinel lymph node biopsy; ALND: axillary lymph node dissection; BMI: body mass Index; IDC: invasive ductal carcinoma; BCS: breast conservation surgery; SLNB: sentinel lymph node biopsy; MRM: modified radical mastectomy; ALND: axillary lymph node dissection; pCR: pathological complete response; HER2: human epidermal growth factor receptor 2; ER: estrogen receptor; TNBC: triple-negative breast cancer; NEG: negative; POS: positive; min: minimum; max: maximum; SD: standard deviation; OR: odds ratio; CI: confidence interval; n: number

resulting in a non-significant positive association between BMI and pCR (p-trend = 0.82) for that subtype in their study (17). In our study, the highest pCR rate was seen in Normal-weight patients (75%) and the lowest was found in the obese category (33.75%). Also, in our cohort the trend of achieving pCR, was in favour of HER2+/ER negative and TNBC compared to the other molecular subtypes.

Despite the molecular mechanisms being unclear, there have been hypotheses concerning the relationship between raised BMI and worsened breast cancer outcomes. It has been noted that a higher level of adipose tissue contributes to an elevation in estrogen production, thus leading to significant levels of circulating estrogen (18). Besides, it is seen that obese individuals have a higher level of insulin-like growth factor (IGF) and raised insulin resistance. This could activate the tumour cell survival pathways (19, 20). Studies have proven that patients having high insulin levels have been associated with higher breast malignancy incidence and, importantly, mortality (21). Another contributing pathological process may be low-grade chronic inflammation which is initiated and exaggerated by hypoxia in adipose tissues of obese patients (22). This is associated with an increased level of adipocytokines, such as interleukin 1β (IL-1β), IL-6, IL-8, leptin, and vascular endothelial growth factor (VEGF)(20). The low-grade chronic inflammation in obese adipose tissue is activated and maintained by the nuclear factor kappa B (NF-κB) pathway (23). Chronic NF-κB activation in obese adipose tissue maintains a micro-environment that also leads to stimulation of breast cancer cell proliferation, invasion, angiogenesis, and metastasis (24).

It has been reported that the overall pCR rate varied widely between 9.6% and 40.3% in numerous studies in a meta-analysis of 18,702 women with biopsy-proven breast cancer who had received NACT (16).

Breast cancer is a heterogeneous disease, and each St. Gallen subtype has different mechanisms of molecular carcinogenesis. Our study shows that, by considering BMI as a variable, different subtypes demonstrate variable responses to NACT. Our data suggest that maximum pCR is seen in HER2 positive patients, followed by triple-negative subtype and lastly the hormone receptor-positive sub-type. The study by Warner et al. (17) found significantly worse BMI related pCR in ER-positive/HER2 positive subtype.

Our study is limited by the fact that there are fewer patients in the low BMI group compared to the overweight and obese groups. So, there is a need for further, larger studies with similar sized subgroups and uniform neoadjuvant regimes to prove correlation.

In conclusion, this retrospective study established that overweight and obese South Asian patients suffering from breast carcinoma had a lower pCR rate following NACT in comparison with those who were under-/normal weight. Crucially, this holds true even for Asian populations, wherein obesity is defined by BMI >27.5. Taking BMI as a variable, various subtypes of breast malignancies exhibited differing responses to NACT.

It is notable that a high rate of pCR was detected in HER2+/ER negative patients, then the patients with triple-negative sub-type followed by the hormone receptor-positive sub-types (HER2+/ER positive, Luminal A and Luminal B). Studies should continue to investigate the mechanisms related to lower pCR rates, particularly in relation to patients with breast cancer who are overweight or obese, especially given the increasing trends for overweight in national populations globally.

Also, the need for further studies with comparable size subgroups and larger cohorts and uniform neoadjuvant regimes to prove co-relations, which was the limitation of our study.

Ethics Committee Approval: This original study was exempted by the ethics committee of our institution.

Informed Consent: Written informed consent was obtained from the patient for publication of this original study and accompanying images and tables.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: S.P.S., R.J., B.C.A., K.R.A., R.K., A.R., S.R.; Concept: S.P.S., R.J., K.R.A.; Design: S.P.S., R.J., K.R.A., R.K., H.I.; Data Collection and/or Processing: S.P.S., R.J., H.K.K., A.P., N.Y.; Analysis and/or Interpretation: S.P.S., R.J., R.K., K.R.A., N.Y.; Literature Searching: S.P.S., R.J., A.P., P.P.; Writing: S.P.S., R.J., R.K., K.R.A., H.I., H.K.K.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declare that this study received no financial disclosure.

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