RESEARCH ARTICLE

Immunoexpression of P63 and SOX2 in triple-negative breast cancers, Indonesia [version 1; referees: 1 approved with reservations]

Reno K Kamarlis¹,², Muhammad ND Lubis³, Bethy S Hernowo⁴, Harapan Harapan ⁵, Azmi S Kar⁶

¹Department of Pathology Anatomy, Dr. Zainoel Abidin General Hospital, Banda Aceh, Indonesia
²Department of Pathology Anatomy, School of Medicine, Syiah Kuala University, Banda Aceh, Indonesia
³Department of Pathology Anatomy, Medical Faculty, Sumatera Utara University, Medan, Indonesia
⁴Department of Pathology Anatomy, Medical Faculty, Padjajaran University, Bandung, Indonesia
⁵Medical Research Unit, School of Medicine, Syiah Kuala University, Banda Aceh, Indonesia
⁶Department of Internal Medicine, Medical Faculty, Sumatera Utara University, Medan, Indonesia

Abstract

Background: Using immunohistochemical stains to target specific breast cancer markers has become indispensable for evaluation of small diagnostic tissue specimens, and therefore novel marker cocktails for specific breast cancers are required. This study was conducted to assess the immunoexpression of P63 and SOX2 in triple negative breast cancer (TNBC), and to evaluate the predictive diagnostic value of these markers for specific types of TNBC.

Methods: Histological slides and paraffin blocks of TNBC cases were collected from Dr. Hasan Sadikin Hospital, Bandung, Indonesia from 5-years period (2011-2015). Each histological slide was subjected to immunohistochemical staining for P63 (nucleus and cytoplasm) and SOX2 (nucleus), with specific primer antibodies. Immunoexpression of P63 and SOX2 was evaluated using immunoreactivity scoring. Associations between P63 and SOX2 immunoexpression and TNBC types were assessed using Mann Whitney tests. In addition, the predictive diagnostic values of these markers were assessed. Results: Forty TNBC histological slides were included, and 23 (57.5%) were Basal-like type TNBC and 17 (42.5%) were Non basal-like type TNBC. Immunoexpression of P63 nucleus and SOX2 was not different between types of TNBC. However, immunoexpression of P63 in the cytoplasm in Basal-like type TNBC was significantly higher than in Non basal-like type TNBC ($p = 0.021$). Predictor diagnostic value analysis suggested that immunoexpression of P63 in cytoplasm had 56.5% sensitivity and 70.6% specificity for diagnosing Basal-like type TNBC, with area under curve of 0.64.

Conclusions: Immunoexpression of P63 in the cytoplasm has a relatively weak diagnostic value to discriminate Basal-like and Non basal-like types of TNBC.
Corresponding authors: Reno K Kamarlis (reno.sppa@yahoo.com), Harapan Harapan (harapan@unsyiah.ac.id)

Author roles: Kamarlis RK: Conceptualization, Data Curation, Formal Analysis, Funding Acquisition, Methodology, Resources, Validation, Visualization; Lubis MN: Conceptualization, Data Curation, Investigation, Methodology, Supervision, Validation; Hernowo BS: Conceptualization, Data Curation, Funding Acquisition, Investigation, Methodology, Resources, Supervision, Validation; Harapan H: Conceptualization, Data Curation, Formal Analysis, Validation, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; Kar AS: Conceptualization, Data Curation, Funding Acquisition, Resources, Supervision, Validation

Competing interests: No competing interests were disclosed.

How to cite this article: Kamarlis RK, Lubis MN, Hernowo BS et al. Immunoexpression of P63 and SOX2 in triple-negative breast cancers, Indonesia [version 1; referees: 1 approved with reservations] F1000Research 2017, 6:1780 (doi: 10.12688/f1000research.12671.1)

Copyright: © 2017 Kamarlis RK et al. This is an open access article distributed under the terms of the Creative Commons Attribution Licence, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. Data associated with the article are available under the terms of the Creative Commons Zero "No rights reserved" data waiver (CC0 1.0 Public domain dedication).

Grant information: The author(s) declared that no grants were involved in supporting this work.

Introduction
Breast cancer, accounting for 25% of all cancer cases and 15% of all cancer deaths among females, is the most frequently diagnosed cancer among female worldwide. In 2012, it was estimated that there were 1.7 million breast cancer cases with more than half million deaths. Between 1980s and 1990s, the incidence of breast cancer increased significantly, approximately by 30% in developed countries and currently it has been also rising in many developing countries. In Asia, 639,824 breast cancer cases and 228,926 deaths were recorded in 2012, from which 48,998 cases and 19,750 deaths occurred in Indonesia.

Advanced screening and diagnostic methods for breast cancer such as mammograms, ultrasound, magnetic resonance imaging and fine-needle aspiration, have allowed for detection of small lesions at the early stage. Identifying breast cancer at the early stage will increase the potential for curative treatment and therefore increases the survival rate. However, smaller lesions are more challenging to diagnose. Therefore, it is essential to use an advanced immunohistochemical approach for evaluation of smaller tissue specimens that target more specific markers.

A previous study using a MCF7 breast cancer cell line to produce MCF7-derived tumour xenografts found that P63 and SOX2 immunostainings were two potential markers for breast cancer. P63, involved in cellular differentiation, is a homolog of tumour protein P53 and in normal breast ducts and lobules it is expressed frequently in the nuclei of myoepithelial cells. Mutation of the p53 gene results in a very high risk of breast cancer. A study revealed that the total percentage of P63-positive cells was related to marked nuclear pleomorphism and the intensity of P63 staining was associated with syncytial growth pattern in triple-negative breast cancer (TNBC). In addition, data also reveals that p63 gene expression in breast cancer could be used as a specific marker of metaplastic carcinoma, and P63 immunohistochemical staining could improve diagnostic accuracy of breast cancer even in small tissue specimens.

SOX2 is a transcription factor belonging to the SOX family and functions as an activator or suppressor of gene transcription. Data shows that SOX2 promotes cellular proliferation of breast tissue and regulates self-renewal in cancer stem cells. The scientific evidence reveals that SOX2 acts as an oncogene in epithelial cancers and in the breast, a study found that silencing of sox2 gene was associated with reduction of the size of the cancer stem cells and restoration of tamoxifen sensitivity. All together, these data indicate that P63 and SOX2 have pivotal role in breast cancer and therefore are potential to be used as specific biomarkers. This study was conducted to assess the immunoreactivity of P63 and SOX2 in TNBC cases in order to provide insight regarding their potential diagnostic value (single or in combination) to differentiate TNBC types.

Methods
Study setting and histological slides
A cross-sectional study to assess the immunoreexpression of P63 and SOX2 in TNBC cases (negative expression of estrogen and progesterone receptors and c-erbB2) was conducted. Histological slides of TNBC and their paraffin blocks, tested between the 1st of January 2011 and 31st of December 2015, were collected from the Pathology Anatomy Laboratory, Dr. Hasan Sadikin Hospital, Bandung, Indonesia. Each histological slide was examined by two certified pathologists. To classify the type of TNBC morphology, between Basal-like type TNBC and Non basal-like type TNBC, cytokeratin 5/6 (CK 5/6) immunohistochemical staining was carried out on all TNBC histological slides. Concurrently, the immunoreexpression of P63 and SOX2 was measured using immunohistochemical stains with specific primer antibodies. The protocol of this study was approved by the Health Research Ethical committee of Sumatera Utara University (approval 103/KOMET/FK USU/2015) and the usage of histological specimens was approved by the Pathology Anatomy Laboratory of Dr. Hasan Sadikin Hospital (LB.02.01/229/239/X/2015).

Immunohistochemistry
Forty archival paraffin blocks from TNBC cases were subjected to immunohistochemical staining to assess the immunoreexpression of CK 5/6, P63 and SOX2. Briefly, 4 µm sections of each paraffin block were prepared using standard procedure. Immunohistochemical staining was conducted using primary antibodies as follows: anti-CK5/6 monoclonal antibody (Biocare Medical, Concord, CA, USA), anti-P63 monoclonal antibody (Biocare Medical, Concord, CA, USA) and anti-SOX2 monoclonal antibody (Abcam, Cambridge, UK). Starr Trek Universal HRP Detection (Biocare Medical, Concord, CA, USA) was used as second antibody. A chromogen 3,3’-diaminobenzidine (DAB) (Biocare Medical, Concord, CA, USA) was used to develop the colour. For each experiment, appropriate controls were used.

Immunoreexpression of CK 5/6 was interpreted as positive or negative, in which positive CK 5/6 indicates Basal-like type TNBC while negative CK 5/6 indicates Non basal-like type TNBC. Immunoreexpression of P63 and SOX2 was evaluated using an immunoreactivity scoring system that had been published elsewhere with modification. Staining intensity was scored as follows: 1 (no staining), 2 (weak staining), 3 (moderate staining) and 4 (strong staining). The percentage of positively stained tumour cells was assessed as a proportion of the total number of tumour cells present in the section as follows: 1 (<20%), 2 (20–50%), 3 (>50–80%) and 4 (>80%).

Immunoreactivity score was calculated by multiplying staining intensity and the percentage of positivity, and the score therefore ranged from 1 to 16. The immunoreactive score was then divided into low (≤ 5), moderate (6 – 10) and high (≥11 – 16). Immunoreexpression of P63 was measured both in cytoplasm and nucleus while SOX2 immunoreexpression was measured in nucleus only.

Statistical analysis
Normality of the data was assessed using the Shapiro-Wilk test and therefore the analysis tests chosen based on the normality of the data. The correlations between immunoreexpression of P63 (cytoplasm and nucleus) and SOX2 were assessed using
Pearson correlation and Spearman correlation, respectively. The associations of P63 and SOX2 immunoreactivity and type of TNBC were assessed using Mann Whitney test. The predictive diagnostic values of P63 cytoplasm for diagnosing Basal-like type TNBC were estimated using several immunoreactivity score cut-off points. Receiver operating characteristic curve (ROC) was plotted and area under the ROC curves (AUC) was estimated. For all analyses, estimates were considered statistically significant for two-tailed values of \( p < 0.05 \). All analyses were conducted using Statistical Package for the Social Sciences software (SPSS for Windows, Version 16, Chicago, IL).

**Results**

**Clinicopathology and classification of TNBC**

The histopathology of the TNBC samples used in this study is described in Table 1. Approximately 45% of the samples were classified as metaplastic carcinomas. In addition, immunohistochemical staining for CK 5/6 revealed that 23 (57.5%) of samples were Basal-like type TNBC and while 17 (42.5%) samples were Non basal-like type TNBC.

**Immunoreactivity score of P63 and SOX2**

Immunoreactivity of P63 and SOX2 in samples, categorized by immunoreactivity score, are presented in Table 2. For both types of TNBC (basal and non basal-like type), all immunoreactivity scores for P63 in the nucleus were classified as low grade, while 11 (27.5%) and 7 (17.5%) samples were classified as moderate and high grade, respectively for the P63 in the cytoplasm. The immunoreactivity grade for SOX2 was similar to P63 in the cytoplasm, and therefore correlation analyses were conducted.

**Correlation between immunoreexpression of P63 and SOX2**

There was a strong negative correlation between immunoreexpression of P63 in the cytoplasm and immunoreexpression of SOX2 in the nucleus in metaplastic carcinoma (a sub-type of TNBC basal-like type) (r = -0.73, \( p = 0.013 \)) (Table 3). In addition, linear regression showed a relatively strong correlation between P63 cytoplasm and SOX2 immunoreexpression in Non basal-like type TNBC, and no significant correlation between P63 nucleus and SOX2 immunoreexpression either in Basal-like type or Non basal-like type of TNBC.

**Immunoreexpression of P63 and SOX2 in Basal-like and Non basal-like type of TNBC**

Immunoreexpression of P63 cytoplasm, P63 nucleus and SOX2 in Basal-like and Non Basal-like TNBC is shown in Table 4. The data indicates that the immunoreexpression of P63 cytoplasm in Basal-like type TNBC was significantly higher compared to Non basal-like type TNBC (\( p = 0.021 \)). Immunoreexpression of P63 nucleus and SOX2 was not different between Basal-like and Non basal-like types of TNBC, with \( p \)-values of \( p = 0.27 \) and \( p = 0.17 \), respectively.

**Predictor diagnostic value of P63 in the cytoplasm for diagnosing Basal like type TNBC**

As mentioned above, immunoreexpression of P63 in the cytoplasm was the only marker that was significantly different between TNBC types. Therefore, immunoreactivity score of P63 cytoplasm was further analysed to determine its ability to predict Basal-like type TNBC. Table 5 shows the predictive values of P63 in the

---

**Table 1. Histopathology types of TNBC samples used in this study (N=40).**

<table>
<thead>
<tr>
<th>Type of histopathology</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metaplastic carcinoma, spindle cells component</td>
<td>10 (25.0)</td>
</tr>
<tr>
<td>Metaplastic carcinoma, producing mucin</td>
<td>3 (7.5)</td>
</tr>
<tr>
<td>Metaplastic carcinoma, liposarcoma component</td>
<td>2 (5.0)</td>
</tr>
<tr>
<td>Metaplastic carcinoma, squamous cell</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Metaplastic carcinoma, matrix hyaline</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Medullary carcinoma</td>
<td>13 (32.5)</td>
</tr>
<tr>
<td>Micropapillary carcinoma</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Invasive ductal carcinoma grade 3</td>
<td>6 (15.0)</td>
</tr>
<tr>
<td>Invasive lobular carcinoma grade 3</td>
<td>2 (5.0)</td>
</tr>
<tr>
<td>Invasive ductal carcinoma + invasive lobular carcinoma (mixed)</td>
<td>1 (2.5)</td>
</tr>
</tbody>
</table>

**Table 2. Immunoreactivity score of P63 and SOX2 in TNBC.**

<table>
<thead>
<tr>
<th>Grade</th>
<th>P63 cytoplasm, n (%)</th>
<th>P63 nucleus, n (%)</th>
<th>SOX2, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (≤ 5)</td>
<td>22 (55.0)</td>
<td>40 (100.0)</td>
<td>19 (47.5)</td>
</tr>
<tr>
<td>Moderate (≥ 6 – 10)</td>
<td>11 (27.5)</td>
<td>0 (0.0)</td>
<td>12 (30.0)</td>
</tr>
<tr>
<td>High (≥11 – 16)</td>
<td>7 (17.5)</td>
<td>0 (0.0)</td>
<td>9 (22.5)</td>
</tr>
</tbody>
</table>

**Table 3. Correlation between immunoreexpression of P63 cytoplasm and SOX2 in Basal-like type TNBC.**

<table>
<thead>
<tr>
<th>TNBC basal-like type</th>
<th>n</th>
<th>P63 Mean (±SD)</th>
<th>SOX2 Mean (±SD)</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invasive ductal carcinoma</td>
<td>2</td>
<td>5.50 (3.54)</td>
<td>5.00 (5.66)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Invasive ductal carcinoma and invasive lobular carcinoma</td>
<td>1</td>
<td>16.00 (0.00)</td>
<td>9.00 (0.00)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Invasive lobular carcinoma</td>
<td>1</td>
<td>8.00 (0.00)</td>
<td>1.00 (0.00)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Invasive micropapillary carcinoma</td>
<td>1</td>
<td>12.00 (0.00)</td>
<td>16.00 (0.00)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Medullary carcinoma</td>
<td>6</td>
<td>5.50 (4.76)</td>
<td>8.00 (5.48)</td>
<td>0.64</td>
<td>0.172</td>
</tr>
<tr>
<td>Metaplastic carcinoma</td>
<td>12</td>
<td>6.67 (4.68)</td>
<td>6.00 (3.77)</td>
<td>-0.73</td>
<td>0.013*</td>
</tr>
</tbody>
</table>

* Significant at 0.05
cytoplasm for determining Basal-like type TNBC, using seven immunoreactivity score cut-off values from 3 to 9. It shows that P63 has relatively weak diagnostic value in diagnosing Basal-like type TNBC. The highest sensitivity was achieved at immunoreactivity score 3, while specificity was increasing with a higher immunoreactivity score.

Using the average score of P63 cytoplasm immunoexpression for Basal-like type TNBC in this study, 5.6 or 6, the sensitivity and specificity of P63 cytoplasm immunoreactivity score to predict Basal-like type TNBC was 56.5% and 72.6%, respectively with area under curve 0.64. The receiver operating curve of predictive diagnostic value of P63 cytoplasm for determining Basal-like type TNBC is plotted in Figure 1.

Table 4. Immunoexpression of P63 and SOX2 in Basal-like type TNBC and Non basal-like type TNBC.

<table>
<thead>
<tr>
<th>Marker</th>
<th>TNBC type</th>
<th>n</th>
<th>Immunoreactivity score Mean (±SD)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basal-like</td>
<td>23</td>
<td>6.96 (4.73)</td>
<td>0.021*</td>
</tr>
<tr>
<td>P63 cytoplasm</td>
<td>Non basal-like</td>
<td>17</td>
<td>3.76 (4.16)</td>
<td></td>
</tr>
<tr>
<td>P63 nucleus</td>
<td>Basal-like</td>
<td>23</td>
<td>1.22 (0.52)</td>
<td>0.273</td>
</tr>
<tr>
<td></td>
<td>Non basal-like</td>
<td>17</td>
<td>1.06 (0.24)</td>
<td></td>
</tr>
<tr>
<td>SOX2</td>
<td>Basal-like</td>
<td>23</td>
<td>6.78 (4.69)</td>
<td>0.172</td>
</tr>
<tr>
<td></td>
<td>Non basal-like</td>
<td>17</td>
<td>4.82 (3.61)</td>
<td></td>
</tr>
</tbody>
</table>

*Significant at 0.05

Table 5. Predictor diagnostic value of P63 in the cytoplasm for diagnosing Basal-like type TNBC.

<table>
<thead>
<tr>
<th>Diagnostic test</th>
<th>Cut-off of P63 cytoplasm immunoreactivity score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Sensitivity (%)</td>
<td></td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>78.3</td>
</tr>
<tr>
<td>Positive predictive value (%)</td>
<td>72.0</td>
</tr>
<tr>
<td>Negative predictive value (%)</td>
<td>66.7</td>
</tr>
<tr>
<td>Positive likelihood ratio (%)</td>
<td>190.1</td>
</tr>
<tr>
<td>Negative likelihood ratio (%)</td>
<td>37.0</td>
</tr>
<tr>
<td>Accuracy (%)</td>
<td>70.0</td>
</tr>
</tbody>
</table>

Figure 1. Receiver operating curve of P63 cytoplasm immunoexpression for determining TNBC basal-like type.
Discussion

To the best of our knowledge, this is the first study conducted to assess the immunoreexpression of P63 and SOX2 in TNBC cases in Indonesia. Some studies have been conducted to assess the predictive values of P63 as specific marker for breast cancer\(^1,2\). In addition, the idea of utilization of a cocktail of specific markers has been proposed previously to provide higher sensitivity and specificity for diagnosing specific breast cancers\(^3,12,22\).

However, none of the previous studies had been conducted to assess the diagnostic value of immunoreexpression of P63 and SOX2 in combination. This study, at the beginning, sought to assess predictive value of combination both of those markers for specific type of TNBC. However, we found that there was no difference in immunoreexpression of SOX2 between Basal-like type TNBC and Non basal-like type TNBC. Nevertheless, we found that immunoreexpression of P63 cytoplasm, but not P63 nucleus, was higher in Basal-like type TNBC compared to Non basal-like type TNBC.

P63 is highly expressed in embryonic ectoderm and in the nuclei of basal regenerative cell of many epithelial tissues\(^3\). P63 is expressed selectively in basal mammary epithelial cells and its expression is increased during mammary gland maturation\(^3\). P63 has been proposed as a breast cancer marker for a long time, but with conflicting results. A study demonstrated that immunoreexpression of P63 was associated with breast cancers, for example the metaplastic carcinoma type of breast cancer\(^1\), but there was no difference in immunoreexpression of P63 between medullary breast carcinomas and atypical medullary breast carcinomas of TNBC\(^2\). In our study, we found that the sensitivity and specificity of P63 cytoplasm immunoreexpression to diagnose Basal-like type TNBC was 56.5% and 72.6%, respectively, with area under curve of 0.64. This sensitivity and specificity seems higher compared to a previous study, with 14% and 94%, respectively in determining a Basal-like type in infiltrative ductal carcinomas (TNBC)\(^1\). All together, these data indicate a weak predictive value of P63 immunoreexpression as marker for Basal-like type TNBC. However, a study found that P63 is a specific marker for metaplastic carcinomas of the breast (a sub-type of Basal-like type TNBC)\(^1\). In our study, we could not assess the predictive value of P63 cytoplasm immunoreexpression for determining metaplastic carcinomas, due to the small sample size (see Table 3).

We found that SOX2 immunoreexpression grade was classified as moderate and high grade in 55% of TNBC cases (Table 2), and it has been indicated previously that SOX2 has strong roles in promoting breast cancers\(^17\). However, there was no different in immunoreexpression between Basal-like type TNBC and Non basal-like type TNBC. This result indicates that SOX2 expression is not different amongst TNBC types. This finding was in line with a previous study that indicated that SOX2 was expressed across different breast cancer subtypes\(^26\). A study found that SOX2 antibody in the sera was is higher in patients with breast cancer compared to healthy women and therefore it could be used to discriminate between breast cancer patients and healthy controls\(^27\). In addition, a meta-analysis found that SOX2 expression was associated with tumor size, histological grade, the aggressiveness and lymph node metastasis in TNBC patients\(^28\). All together, these results indicate that there was a possibility SOX2 expression could be used for diagnosing breast cancers, but there was no difference in expression amongst breast cancer types, and therefore it could not be used as specific marker for differentiating TNBC types.

There are some limitations to this study. The sample size was relatively small, and therefore some analyses could not be conducted. In addition, the diagnostic specimens were collected from different procedures such as from biopsy, mastectomy or lumpectomy, and this might influence the immunoreexpression of the markers.

Conclusions

Immunoreexpression of P63 cytoplasm is higher among Basal-like type TNBC compared to Non basal-like type TNBC. However, the predictive diagnostic value of P63 immunoreexpression in the cytoplasm for Basal-like type TNBC is relatively low, with 56.5% sensitivity and 72.6% specificity.

Data availability

Dataset 1: Immunoreexpression and immunoreactivity scores of P63, SOX2 and CK 5/6 in the forty specimens that were analysed. DOI, 10.5256/f1000research.12671.d179131

Competing interests

No competing interests were disclosed.

Grant information

The author(s) declared that no grants were involved in supporting this work.

References


Open Peer Review

Introduction:

Do not explain the epidemiology of breast cancer too long, but explain more detail about TNBC and its subtypes (Basal-like and non basal-like), such as differences in histological type, behaviour, prognosis, treatment etc. So, the role of p63 and SOX2 on TNBC becomes clearer.

Method:

Statistical analysis predictive diagnostic value of cytoplasmic p63 expression of basal-like and non basal-like TNBC, as far as I know there should be also negative p63 expression. Therefore I suggest to ask a qualified statistician.

Discussion:

Explain the importance of negative correlation between p63 expression and metaplastic carcinoma. Compare with previous studies.

Conclusion:

Mention also other important results of this study such as:
- The frequency of non basal-like is higher than basal-like.
- The most common histological type of TNBC is metaplastic carcinoma.
- Negative correlation between p63 expression and metaplastic carcinoma
- SOX2 expression in TNBC, even there is no statistically significant

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?
I cannot comment. A qualified statistician is required.

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
Partly

**Competing Interests:** No competing interests were disclosed.

**Referee Expertise:** I am a pathologist with major interest in breast cancer

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.