GBP5 expression associates with survival in triple negative breast cancer.

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We mined published microarray data (1) to understand the most significant gene expression differences in the tumors of triple negative breast cancer patients based on survival at time of analysis: dead or alive. The inflammasome component and guanylate-binding protein GBP5 emerged as among the most significant differences, transcriptome-wide, when comparing the primary tumors of triple negative breast cancer patients dead or alive. Importantly, GBP5 expression was significantly correlated with overall survival in basal subtype breast cancer, a molecular subtype sharing significant overlap with triple negative breast cancer. GBP5 may be of relevance as a biomarker or as a molecule of interest in understanding the etiology or progression of triple negative breast cancer.

Keywords: triple negative breast cancer, TNBC, systems biology of breast cancer, targeted therapeutics in breast cancer, GBP5, guanylate binding protein 5.

Triple negative breast cancer is defined by lack of expression of the receptors for the hormones progesterone and estrogen (PR negative and ER negative), as well as for the human epidermal growth factor receptor 2 (HER2 negative) (2, 3). Though not completely identical, triple negative breast cancer shares significant overlap with the basal or basal-like molecular subtype of human breast cancer (3). TNBC is more frequently diagnosed in women of African descent (black women) for reasons not understood, and their disease course is similarly more aggressive than in white women with triple negative breast cancer (2, 3). To understand the transcriptional biology of triple negative breast cancer in an unbiased fashion and at the systems level, we mined published microarray data paired with patient survival data (1), performing comparative transcriptome analysis based on survival at time of data collection: dead or alive. We present here a finding from the preliminary results of this analysis.

Methods

We used dataset GSE142102 (1) for this differential gene expression analysis in conjunction with GEO2R. GSE142102 was generated using Affymetrix Human Gene 2.1 ST Array technology; in this analysis, we used data from $n=87$ tumors from TNBC patients that were dead at time of analysis and $n=123$ tumors from TNBC patients that were alive at time of analysis. The Benjamini and Hochberg method of p -value adjustment was used for ranking of differential expression but raw p -values were used to assess statistical significance of global differential expression. Log-transformation of data was auto-detected, and the NCBI generated category of platform annotation was used. A statistical test was performed to evaluate whether GBP5 expression was significantly different between the primary tumors of TNBC patients that were dead or alive using a two-tailed t -test. For Kaplan-Meier survival analysis, we used the Kaplan-Meier plotter tool (4) for correlation of GBP5 mRNA expression levels with overall survival (OS) in $n=278$ patients with basal subtype cancer.

Results

We performed comparative transcriptome analysis using published microarray data (1) to understand in an unbiased fashion the most significant gene expression differences in the primary tumors of patients with triple negative breast cancer based on survival outcomes.

GBP5 is differentially expressed in triple negative breast cancer and positively correlates with survival.

When comparing primary tumors of 87 patients with triple negative breast cancer, alive at time of data collection and 123 TNBC patients, dead at time of data collection, we identified the guanylate-binding protein 5 *GBP5* as among the most significant transcriptional differences based on survival in human triple negative breast cancer. When ranking each of the transcripts whose expression was measured by microarray based on significance of difference in expression between the tumors of patients dead and alive, GBP5 ranked 224 out of 53617 total transcripts, equivalent to 99.6% differential expression (Chart 1). GBP5 differential expression in the tumors of patients based on survival outcomes was statistically significant (Figure 1; $p=0.00552917$).

GBP5 expression correlates with overall survival in basal subtype human breast cancer.

We referenced a bioinformatics tool containing Kaplan-Meier survival data of human breast cancer patients to understand more thoroughly whether a relationship existed between GBP5 primary tumor expression and patient survival in human breast cancer. We found that GBP5 expression was positively and significantly correlated with overall survival in patients with basal or basal-like human breast cancer, a breast cancer molecular subtype which shares significant overlap with triple negative breast cancer (Figure 2; log rank p -value: $1.6e-05$ for overall survival, hazard ratio: 0.34 (0.21-0.57) (Fig. 2)). GBP5 mRNA levels were a positive prognostic indicator in basal subtype breast cancer patients. Median OS was, on average, markedly shorter for basal subtype patients with low tumor expression of GBP5 as compared to basal subtype patients with high tumor expression of GBP5.

GBP5 is expressed at significantly higher levels in the breast tumors of TNBC patients when comparing based on survival.

We obtained exact mRNA expression levels for GBP5 from breast tumors of TNBC patients dead and alive to understand the magnitude and direction of GBP5 expression change based on survival outcomes. GBP5 was expressed at higher levels in tumors of TNBC patients alive as compared to that of TNBC patients dead (Figure 1). Increased expression of GBP5 in primary breast tumors was statistically significant (Figure 1: $p=0.0036$). GBP5 was expressed at -0.21 ± 0.81 arbitrary units (AU) in the primary tumors of TNBC patients alive, while it was expressed at 0.17 ± 1.09 AU in the primary tumors of the TNBC patients dead.

Thus, we found through unbiased comparative transcriptome analysis that GBP5 was among the genes whose expression was most significantly different in the primary tumors of triple negative breast cancer patients alive when compared to that of TNBC patients dead, that GBP5 was expressed at significantly higher levels in the primary tumors of TNBC patients alive as compared to TNBC patients dead, and that GBP5 expression was positively correlated with overall survival in the basal or basal-like molecular subtype.

Discussion

It is not understood why women of African descent (black women) are diagnosed with triple negative breast cancer more frequently than white women, and why this disease is more aggressive in black women. GBP5 may be of relevance as a biomarker in identifying patients who are more likely to survive, perhaps as part of a panel of genes used for prognostic stratification, and the molecule itself may be important to the biology of triple negative breast cancer etiology or more likely its progression. GBP5 is a component of the NLRP3 inflammasome for ligands that are pathogenic or soluble but not crystalline (5); we recently described NLRC3 (NOD3) as another target gene identified as differentially expressed in triple negative breast cancer when comparing tumor transcriptomes based on survival (6), with higher expression in the tumors of TNBC patients alive, and with higher expression correlating with superior overall survival in patients with basal subtype human breast cancer. GBP5 may function as a retroviral restriction factor by interfering with the processing of the viral envelope glycoprotein, for HIV-1 and other retroviruses but not for the vesicular stomatitis virus glycoprotein (VSV-G) (7). Blind systems-level analyses, like this, can help shed light on the fundamental molecular characteristics of a disease whose racial propensities demand further explanation.

References

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Rank: 224
Probe ID: 16689400
p-value: 0.00552917
t: -2.7744708
B: -3.5
Gene: GBP5
Gene name: guanylate binding protein 5

Chart 1: GBP5 is differentially expressed at the transcriptome-level when comparing the primary tumors of TNBC patients dead and alive.

Rank of differential expression, probe ID, *p*-value of global differential expression, *t*, a moderated *t*-statistic, *B*, the log-odds of differential expression between the groups compared, gene and gene name are listed in this chart.

Figure 1: GBP5 is expressed at significantly higher levels in the primary tumors of TNBC patients alive as compared to the primary tumors of TNBC patients dead.

The mRNA expression level of GBP5 in the primary tumors of TNBC patients dead (left) and in primary tumors of TNBC patients alive (right) is graphically depicted with the result of a statistical test evaluating significance of difference in GBP5 expression between the primary tumors of TNBC patients dead and alive, a *p*-value, is *p*=0.0036.

Figure 2: GBP5 expression correlates with overall survival in basal subtype human breast cancer.

Depicted in this Kaplan-Meier plot is the probability of overall survival (OS) for $n=278$ breast cancer patients of basal subtype, based on low or high expression of GBP5 in patient primary tumors. The log rank p-value denoting statistical significance of difference in recurrence-free survival when comparing the two groups, as well as hazard ratio for this comparison is listed above. Listed below is the number of patients at risk (number of patients alive) per interval, after stratification based on GBP5 expression; in the first interval, number at risk is number of patients alive; in each subsequent interval, number at risk is the number at risk less those who have expired or are censored.