Over-expression of voltage dependent anion channel 1 in human endometrial cancer.

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Gynecologic cancers including cancers of the endometrium are a clinical problem¹⁻⁴. We mined published microarray data^{5,6} to discover genes associated with endometrial cancers by comparing transcriptomes of the normal endometrium and endometrial tumors from humans. We identified voltage dependent anion channel 1, encoded by VDAC1, as among the most differentially expressed genes, transcriptome-wide, in cancers of the endometrium. VDAC1 was expressed at significantly higher levels in endometrial tumor tissues as compared to the endometrium. Importantly, in human endometrial cancer, primary tumor expression of VDAC1 was correlated with overall survival in white patients with high mutational burden. VDAC1 may be a molecule of interest in understanding the etiology and/or progression of human endometrial cancer.

Keywords: endometrial cancer, gynecologic cancers, endometrium, VDAC1, voltage dependent anion channel 1, systems biology of endometrial cancer, targeted therapeutics in endometrial cancer.

Endometrial cancer is the most common gynecologic cancer in the developed world¹. Over the last three decades, the incidence of endometrial cancer has increased 21%⁴ and the death rate has increased 100%³. We harnessed the power of independently published microarray datasets^{5,6} to determine in an unbiased fashion and at the systems-level genes most differentially expressed in endometrial tumors. We report here the differential and increased expression of the voltage dependent anion channel 1 (VDAC1) in human endometrial cancer.

Methods

We utilized datasets GSE63678⁵ and GSE17025⁶ for this global differential gene expression analysis of human endometrial cancer in conjunction with GEO2R. GSE63678 was generated using Affymetrix Human Genome U133A 2.0 Array technology with $n=5$ control endometrial tissues (including $n=4$ uterine myomas and $n=1$ benign cyst) and $n=7$ endometrial cancers (including $n=2$ endometrial adenocarcinomas, $n=3$ mixed endometrioid adenocarcinomas, and $n=2$ adenocarcinomas with squamous differentiation); analysis was performed using platform GPL571. GSE17025 was generated using Affymetrix Human Genome U133 Plus 2.0 Array technology with $n=5$ normal endometrial tissues (inactive endometrium) and $n=91$ endometrial cancers; analysis was performed using platform GPL570. 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 VDAC1 gene expression was significantly different between control endometrial tissue and endometrial tumor tissue in humans using a two-tailed t-test. For Kaplan-Meier survival analysis, we used the Kaplan-Meier plotter tool⁷ for correlation of VDAC1 mRNA expression levels with overall survival in $n=543$ endometrial cancer patients.

Results

We harnessed the power of blind comparative transcriptome analysis using published microarray data^{5,6} to discover in an unbiased fashion genes associated with endometrial cancer in humans.

VDAC1 is differentially expressed in endometrial cancer.

We identified voltage dependent anion channel 1, encoded by VDAC1, as among the genes most differentially expressed in cancers of the endometrium when compared to benign endometrial tissues (Chart 1). When sorting each of the genes expressed in endometrial tumor tissue based on significance of change in expression as compared to benign endometrial tissue, VDAC1 ranked 10 out of 22273 transcripts, equating to 99.96% differential expression (Chart 1). Differential expression of VDAC1 in human endometrial cancers was statistically significant (Chart 1; $p=8.04E-06$).

We queried a second microarray data to validate differential expression of VDAC1 in endometrial cancer. Again, we observed differential expression of VDAC1 when comparing endometrial tumor tissue to benign endometrial tissue (Chart 2). When sorting each of the genes expressed in endometrial tumor tissue based on significance of change in expression as compared to benign endometrial tissue, VDAC1 ranked 431 out of 54675 transcripts, equating to 99.2% differential expression (Chart 2). Differential expression of VDAC1 in human endometrial cancers trended towards statistical significance (Chart 2; $p=9.03E-06$).

VDAC1 is expressed at significantly higher levels in endometrial cancers as compared to benign endometrial tissue.

We obtained exact mRNA expression levels for VDAC1 in endometrial tumor tissues and from benign endometrial tissue to evaluate direction and statistical significance of change in expression of VDAC1 in human endometrial cancer. VDAC1 was expressed at higher levels in endometrial tissue as compared to normal endometrial tissue, and this difference was statistically significant (Figure 1; $p=0.0003$). We calculated a mean fold change of 1.13 in VDAC1 mRNA levels in human endometrial cancer, as VDAC1 was expressed at 9.92 ± 0.37 arbitrary units (A.U.) in control endometrial tissue but at 11.21 ± 0.25 A.U. in endometrial tumor tissue.

VDAC1 expression is correlated with patient survival outcomes in endometrial cancer.

We performed Kaplan-Meier survival analysis to evaluate correlation between VDAC1 primary tumor expression and survival outcomes in 543 patients with endometrial cancer. We observed a correlation between primary tumor expression of VDAC1 and overall survival in white endometrial cancer patients with high mutational burden (Figure 2). White patients with high mutational burden whose primary tumors expressed low levels of VDAC1 possessed, on average, markedly shorter OS as compared to white patients with high mutational burden whose tumors expressed high levels of VDAC1 (Figure 2). This difference in OS based on VDAC1 tumor expression in patients with endometrial cancer trended towards statistical significance (Figure 2, Chart 3; logrank p -value: 0.096; hazard ratio: 0.36 (0.11-1.26)). VDAC1 primary endometrial tumor expression was not correlated with recurrence-free survival in white patients with low mutational burden (Figure 2, Chart 3; logrank p -value: 0.13; hazard ratio: 1.92 (0.81-4.52)), nor in black patients with high ((Figure 2, Chart 3; logrank p -value: 0.75; hazard ratio: 0.7 (0.08-6.35)) or low mutational burden (Figure 2, Chart 3; logrank p -value: 0.51; hazard ratio: 0.58 (0.12-2.92)).

Thus, by mining published microarray data^{5,6} in an unbiased and systematic fashion, we identified voltage dependent anion channel 1, encoded by VDAC1, as among the genes whose expression was most different, transcriptome-wide, in the endometrial tumor tissue of patients with endometrial cancer when compared to benign endometrial tissue; we observed significantly increased expression of VDAC1 in endometrial tumor tissue as compared to benign endometrial

1 tissue. Further, we found a correlation between VDAC1 expression and patient survival
2 outcomes in human endometrial cancer, as overall survival was superior in patients whose tumors
3 expressed higher levels of VDAC1 as compared to patients whose tumors expressed lower levels
4 of VDAC1, in white patients with high mutational burden, but not in white patients with low
mutational burden, but not in black patients with high or low mutational burden.

5 **Discussion**

6 We provided evidence here that voltage dependent anion channel 1 is among the genes
7 most differentially expressed in human endometrial cancer, that mRNA for VDAC1 is present at
8 significantly increased quantity in endometrial tumor tissue as compared to benign endometrium,
9 and that VDAC1 primary tumor expression is correlated with overall survival in white
10 endometrial cancer patients with high mutational burden. These data suggest VDAC1 may be of
11 importance to fundamental biological processes that underlie the initiation, progression or
12 maintenance of human endometrial cancer.
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Rank: 10
Probe ID: 212038_s_at
p-value: 8.04E-06
t: -7.3634343
B: 3.94346
Gene: VDAC1
Gene name: voltage dependent anion channel 1

Chart 1: VDAC1 is differentially expressed in endometrial cancer when comparing primary endometrial tumors to benign endometrial tissue.

The rank of global differential expression, probe/transcript ID, the *p*-value with respect to differential expression transcriptome-wide, *t*, a moderated *t*-statistic, *B*, the log-odds of differential expression between the groups compared, the gene and gene name are listed in this chart.

Rank: 431
probe ID: 217140_s_at
p-value: 9.03E-06
t: -4.6839335
B: 3.35515
Gene: VDAC1
Gene name: voltage dependent anion channel 1

Chart 2: VDAC1 is differentially expressed in endometrial cancer when comparing primary endometrial tumors to benign endometrial tissue.

The rank of global differential expression, probe/transcript ID, the *p*-value with respect to differential expression transcriptome-wide, *t*, a moderated *t*-statistic, *B*, the log-odds of differential expression between the groups compared, the gene and gene name are listed in this chart.

Figure 1: VDAC1 is expressed at significantly higher levels in the endometrial tumors of patients with endometrial cancer when compared to benign endometrium.

The mRNA expression level of VDAC1 in benign endometrial tissue (left) and in primary tumors of the endometrium (right) is graphically depicted; the result of a statistical test evaluating significance of difference in VDAC1 expression between benign endometrial tissue and primary tumors of the endometrial tissue is $p=0.0003$.

Figure 2: Correlation between VDAC1 primary tumor expression and overall survival in endometrial cancer, in white patients with high mutational burden.

Depicted in this Kaplan-Meier plot is the probability of overall survival for $n=543$ total endometrial cancer patients stratified into two groups, based on low or high expression of VDAC1 in patient primary tumors, in black patients with high mutational burden (top left), black patients with low mutational burden (top right), white patients with high mutational burden (bottom left), and white patients with low mutational burden (bottom right). The log rank p -value denoting statistical significance of difference in overall 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 VDAC1 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.