

**METHOD FOR PREDICTING RESPONSE TO BREAST CANCER
THERAPEUTIC AGENTS AND METHOD OF TREATMENT OF BREAST
CANCER**

Cross-Reference to Related Applications

[0001] This application claims the benefit of the following U.S. Provisional Applications, the entire disclosures of which are incorporated herein by reference: No. 62/091,195, filed December 12, 2014; No. 62/142,504, filed April 3, 2015; and No. 62/167,110, filed May 27, 2015.

Sequence Listing

[0002] The instant application contains a Sequence Listing which has been submitted in ASCII format via EFS-Web and is hereby incorporated by reference in its entirety. Said ASCII copy, created on 12/04/2015, is named 212181_0001_00_WO_SeqListing_ST25 and is 262,467 bytes in size.

Field of the Invention

[0003] The field relates to breast cancer therapy.

Background of the Invention

[0004] Breast cancer is considered a genetically heterogeneous and biologically diverse disease. The long-recognized clinical and phenotypic differences have been shown to correlate with differences in gene expression. Previous studies of breast tumors have identified five distinct subtypes of breast carcinomas that are associated with different clinical outcomes: luminal A (estrogen receptor (ER)+); luminal B (ER+); HER2 overexpressing; normal breast-like; and basal-like. *See, Perou et al. Nature*, 406(6797):747-52 (2000); Sorlie *et al. PNAS*, 98(19):10869-74 (2001).

[0005] Analysis of breast cancer biopsy and surgical specimens typically includes an assessment of nuclear and cell surface receptors (ER, PgR, and HER2), gene amplification of HER2 (if HER2 analysis by immunohistochemistry(IHC) is not definitive), and other prognostic tests such as microvessel invasion and proliferation markers. Endocrine therapies that target ER signaling pathways for ER+ disease and HER2-targeted therapies for HER2+ disease play a critical role in the treatment of most patients with breast cancer. However, little progress has been made in identifying

effective targeted therapies for patients whose disease lacks these receptors, i.e., the so-called “triple negative” breast cancers or “TNBC”, and nonselective cytotoxic chemotherapy remains the primary therapeutic option.

[0006] The androgen receptor (AR) is the most commonly expressed nuclear hormone receptor in breast cancer, though its functional role in initiating or driving malignancy is not yet well understood. In a study of 3093 breast cancers, AR expression (10% or more nuclear staining by IHC) was observed in 77% of invasive breast tumors and across all molecular phenotypes (Collins *et al.*, *Mod Pathol* 2011; 24(7):924-931). However, androgen receptor levels are not routinely assessed, since they have not been shown to predict responses to currently used therapies.

[0007] The use of AR inhibitors has been proposed as part of a therapeutic regimen for the treatment of breast cancer. See, e.g., Garay and Park, *Am. J. Cancer Res.* 2012; 2(4):434-445. Interest has been generated recently in the treatment of TNBC. Lack of expression of all three of estrogen receptor, progesterone receptor and HER2 predicts non-response to available endocrine (tamoxifen, aromatase inhibitors) and anti-HER2 (trastuzumab) targeted therapies. From 10 to 35% of such TNBC tumors express androgen receptor (Ogawa *et al.*, *Int J. Clin. Oncol.* 2008;13:431435). AR-targeted therapies may prove to be a valuable treatment for a large proportion of breast cancers, including triple negative cancers.

[0008] Despite the interest in androgen receptor signaling inhibition as a modality for the treatment of breast cancer, and in the treatment of TNBC in particular, there remains a need for predicting whether the individual patient will be responsive in advance of therapy. A test to predict the likelihood of whether or not a particular patient will respond to a therapy that inhibits androgen receptor signaling, and TNBC patients in particular, would be a valuable tool in planning patient treatment.

Summary of the Invention

[0009] In one embodiment, provided is a method of screening a treatment for triple negative breast cancer comprising the use of an androgen receptor inhibitor, the method comprising assaying a biological sample obtained from a subject to determine whether the biological sample obtained from the subject is classified as basal-like subtype or another

subtype. If the biological sample is classified as other than a basal-like subtype, the breast cancer treatment comprising an androgen receptor inhibitor is more likely to be effective than if the sample were classified as basal-like subtype.

[0010] Also provided is a method of screening for the likelihood of the effectiveness of a treatment for triple negative breast cancer comprising an androgen receptor inhibitor, in a subject in need of such treatment. The method comprises:

assaying a biological sample obtained from the subject to determine whether the biological sample is classified as a basal-like subtype or another subtype; and

wherein if the biological sample is classified as other than a basal-like subtype, the breast cancer treatment comprising an androgen receptor inhibitor is more likely to be effective than if the sample were classified as basal-like subtype.

[0011] Also provided is a method of classifying a biological sample from a subject as an indicator of the likelihood of the effectiveness of a treatment of the patient for triple negative breast cancer, said treatment comprising an androgen receptor inhibitor, the method comprising:

assaying a biological sample obtained from the subject to determine whether the biological sample is classified as a basal-like subtype or another subtype; and

wherein the biological sample classified as other than basal-like subtype indicates that the breast cancer treatment comprising an androgen receptor inhibitor is more likely to be effective than if the sample were classified as basal-like subtype.

[0012] In certain embodiments of the screening and classifying methods (collectively “the aforementioned methods”), assaying the biological sample to determine whether the biological sample is classified as a basal-like subtype or another subtype is performed by detecting the expression of the set of intrinsic genes listed in Table 1.

[0013] In certain embodiments of the aforementioned methods, the Basal Centroid classifier score of the sample is determined from the expression of the set of intrinsic genes listed in Table 1.

[0014] In one embodiment of the aforementioned methods, if the Basal Centroid classifier score is less than or equal to 0.9, the breast cancer treatment comprising an

androgen receptor inhibitor is determined to be likely more effective in treating the subject than if the Basal Centroid classifier score is greater than 0.9. In another embodiment, if the Basal Centroid classifier score is less than or equal to 0.6, the breast cancer treatment comprising an androgen receptor inhibitor is determined to be likely more effective in treating the subject than if the Basal Centroid classifier score is greater than 0.6. In another embodiment, if the Basal Centroid classifier score is in the range from 0.2 to 0.8, the breast cancer treatment comprising an androgen receptor inhibitor is likely to be effective in treating the subject. In another embodiment, if the Basal Centroid classifier score is in the range from 0.4 to 0.7, the breast cancer treatment comprising an androgen receptor inhibitor is likely to be effective in treating the subject.

[0015] In certain embodiments of the aforementioned methods, the Basal Centroid classifier score and the Luminal A Centroid classifier score of the sample are determined from the expression of the set of intrinsic genes listed in Table 1. The methods further comprises calculating a Weighted Basal and Luminal A classifier score from the Basal Centroid classifier score and the Luminal A Centroid classifier score according to the following equation:

$$\text{Weighted Basal and Luminal A classifier score} = -0.25(\text{Basal Centroid classifier score}) + 0.27(\text{Luminal A Centroid classifier score})$$

wherein if the Weighted Basal and Luminal A classifier score is greater than -0.3, the breast cancer treatment comprising an androgen receptor inhibitor is more likely to be effective in the subject than if the Weighted Basal and Luminal A classifier score is less than or equal to

-0.3. In another embodiment, if the Weighted Basal and Luminal A classifier score is greater than -0.2, the breast cancer treatment comprising an androgen receptor inhibitor is more likely to be effective in the subject than if the Weighted Basal and Luminal A classifier score is less than or equal to -0.2. In another embodiment, if the Weighted Basal and Luminal A classifier score is greater than -0.25, the breast cancer treatment comprising an androgen receptor inhibitor is more likely to be effective in the subject than if the Weighted Basal and Luminal A classifier score is less than or equal to -0.25.

[0016] In some embodiments, the equation for determining the Weighted Basal and Luminal A classifier score takes the form:

$$\text{Weighted Basal and Luminal A classifier score} = \\ -0.2468275(\text{Basal Centroid classifier score}) + 0.2667110(\text{Luminal A Centroid classifier score})$$

[0017] In certain embodiments of the aforementioned methods, the breast cancer is characterized by the presence of androgen receptor-positive tumor cells.

[0018] In certain embodiments of the aforementioned methods, the biological sample is selected from the group consisting of a cell, tissue and bodily fluid. In certain embodiments, the body fluid is selected from the group consisting of blood, lymph, urine, saliva, fluid from ductal lavage and nipple aspirate. In some embodiments, the tissue is obtained from a biopsy.

[0019] In any of the aforementioned methods, an assay to determine the androgen receptor status of the cells of the sample, *i.e.* AR-positive vs. AR-negative, may be carried out.

[0020] Also provided is a method of treating triple negative breast cancer in a subject, said subject having a breast cancer comprising breast cancer cells that have been classified as other than basal-like subtype, said method comprising administering a breast cancer treatment to the subject comprising an androgen receptor inhibitor, thereby treating the triple negative breast cancer in the subject.

[0021] In one embodiment of the treatment method, the breast cancer cells of the subject are characterized by a Basal Centroid classifier score of less than or equal to 0.9, determined from the expression by said cells of the set of intrinsic genes listed in Table 1. In another embodiment of the treatment method, the breast cancer cells of the subject are characterized by a Basal Centroid classifier score of less than or equal to 0.6. In another embodiment of the treatment method, the breast cancer cells of the subject are characterized by a Basal Centroid classifier score in the range from 0.2 to 0.8. In another embodiment of the treatment method, the breast cancer cells of the subject are characterized by a Basal Centroid classifier score in the range from 0.4 to 0.7.

[0022] In another embodiment of the treatment method, the breast cancer cells of the subject are characterized by Weighted Basal and Luminal A classifier score greater than -0.3. In another embodiment of the treatment method, the breast cancer cells of the subject are characterized by a Weighted Basal and Luminal A classifier score greater than -0.2.

In another embodiment of the treatment method, the breast cancer cells of the subject are characterized by a Weighted Basal and Luminal A classifier score greater than -0.25.

[0023] Also provided is a triple negative breast cancer treatment comprising an androgen receptor inhibitor for use in the treatment of a triple negative breast cancer in a subject in need thereof, wherein said method of treatment comprises: (a) assaying a biological sample from the subject to determine whether the biological sample is classified as basal-like subtype or another subtype; and (b) administering said triple negative breast cancer treatment to the subject if the biological sample is classified as other than basal-like subtype.

[0024] Also provided is a therapeutic agent for triple negative breast cancer therapy or treatment for use in a subject in need thereof, wherein said agent is an androgen receptor inhibitor, comprising: (a) assaying a biological sample from the subject to determine whether the biological sample is classified as basal-like subtype or another subtype; and (b) administering said agent to the subject if the biological sample is classified as other than basal-like subtype.

[0025] Also provided is an androgen receptor inhibitor for use in the treatment of a triple negative breast cancer in a subject wherein a biological sample from the subject has been assayed to determine whether sample is classified as basal-like subtype or another subtype.

[0026] Also provided is a method of treating triple negative breast cancer in a subject in need of such treatment comprising: (a) assaying the biological sample to determine whether the biological sample is classified as a basal-like subtype or another subtype; and (b) if the biological sample is classified as other than a basal-like subtype, administering a breast cancer treatment to the subject comprising an androgen receptor inhibitor, thereby treating the breast cancer in the subject.

[0027] In certain embodiments of the aforementioned methods of treatment, treatments and androgen receptor inhibitors for use in treatment, assaying the biological sample to determine whether the biological sample is classified as a basal-like subtype or another subtype is performed by detecting the expression of the intrinsic genes listed in Table 1.

[0028] In certain embodiments of the aforementioned methods of treatment, treatments and androgen receptor inhibitors for use in treatment, assaying the biological sample comprises determining the Basal Centroid classifier score of the sample from the expression of the set of intrinsic genes listed in Table 1, wherein the breast cancer treatment is administered if the Basal Centroid classifier score is less than or equal to 0.9. In one embodiment, the breast cancer treatment is administered if the Basal Centroid classifier score is less than or equal to 0.6. In one embodiment, the breast cancer treatment is administered if the Basal Centroid classifier score is in the range from 0.2 to 0.8. In another embodiment, the breast cancer treatment is administered if the Basal Centroid classifier score is in the range from 0.4 to 0.7.

[0029] In certain embodiments of the aforementioned methods of treatment, treatments and androgen receptor inhibitors for use in treatment, assaying the biological sample comprises determining the Basal Centroid classifier score and the Luminal A Centroid classifier score of the sample from the expression of the set of intrinsic genes listed in Table 1, and calculating a Weighted Basal and Luminal A classifier score, wherein the breast cancer treatment is administered to the subject if the Weighted Basal and Luminal A classifier score greater than -0.3. In one embodiment, the breast cancer treatment is administered if the Weighted Basal and Luminal A classifier score is greater than -0.2. In another embodiment, the breast cancer treatment is administered if the Weighted Basal and Luminal A classifier score is greater than -0.25.

[0030] In certain embodiments of the aforementioned methods of treatment, treatments and androgen receptor inhibitors for use in treatment, the breast cancer of the subject is further characterized by the presence of androgen receptor-positive tumor cells.

[0031] In embodiments of the aforementioned methods of treatment, treatments and androgen receptor inhibitors for use in treatment, the androgen receptor inhibitor is selected from the group consisting of enzalutamide, bicalutamide, flutamide, nilutamide, ARN509, ketoconazole, abiraterone acetate, VN/124-1 (TOK-001), orteronel (TAK-700), finasteride, galeterone, cyproterone acetate, andarine and combinations thereof. The list of androgen receptor inhibitor is exemplary and not meant to be limiting.

[0032] In certain embodiments, the androgen receptor inhibitor is enzalutamide. In once such embodiment, enzalutamide is orally administered once daily at a dose of 160

mg. In some embodiments, enzalutamide is administered as a single capsule comprising 160 mg enzalutamide. In other embodiments, enzalutamide is administered as four capsules, each capsule comprising 40 mg enzalutamide.

[0033] In embodiments of the aforementioned methods of treatment, treatments and androgen receptor inhibitors for use in treatment, the breast cancer treatment comprising an androgen receptor inhibitor further comprises one or more other anti-cancer agents that is not an androgen receptor inhibitor. Such other anti-cancer agents that are not androgen receptor inhibitors may be selected from the group consisting of cyclophosphamide, fluorouracil, 5-fluorouracil, methotrexate, thiotepa, carboplatin, cisplatin, taxanes, paclitaxel, protein-bound paclitaxel, docetaxel, vinorelbine, tamoxifen, raloxifene, toremifene, fulvestrant, gemcitabine, irinotecan, ixabepilone, temozolamide, topotecan, vincristine, vinblastine, eribulin, mutamycin, capecitabine, capecitabine, anastrozole, exemestane, letrozole, leuprolide, abarelix, buserlin, goserelin, megestrol acetate, risedronate, pamidronate, ibandronate, alendronate, denosumab, zoledronate, trastuzumab, tykerb or bevacizumab, and combinations thereof. The list of other anti-cancer agents is exemplary and not meant to be limiting.

[0034] In one embodiment, the non-AR inhibitor anticancer agent is paclitaxel. In another embodiment, the AR inhibitor is enzalutamide and the non-AR inhibitor anticancer agent is paclitaxel.

[0035] In certain embodiments, the treatment method comprises a step of testing the subject to determine whether the subject has a breast cancer comprising breast cancer cells that are other than basal-like subtype.

[0036] In certain embodiments, the treatment method comprises a step of testing the subject to determine the Basal Centroid classifier score of breast cancer cells of the subject.

[0037] In certain embodiments, the treatment method comprises a step of testing the subject to determine the Weighted Basal and Luminal A classifier score of breast cancer cells of the subject.

[0038] In some embodiments of the aforementioned methods of treatment, treatments and androgen receptor inhibitors for use in treatment, the subject has received zero or one

rounds of prior treatment with an anti-cancer agent, other than an androgen receptor inhibitor, for treatment of triple negative breast cancer.

[0039] In embodiments of the aforementioned screening methods, classifying methods, treatment methods, treatments, and androgen receptor inhibitors for use in treatment, the biological sample may be selected from the group consisting of a cell, tissue and bodily fluid. In certain embodiments, the body fluid is selected from the group consisting of blood, lymph, urine, saliva, fluid from ductal lavage and nipple aspirate. In some embodiments, the tissue is obtained from a biopsy.

[0040] In any of the aforementioned screening methods, classifying methods, treatment methods, treatments, and androgen receptor inhibitors for use in treatment, an assay to determine the androgen receptor status of the cells of the sample, *i.e.* AR-positive vs. AR-negative, may be carried out.

[0041] As envisioned in the present invention with respect to the disclosed compositions of matter and methods, in one aspect the embodiments of the invention comprise the components and/or steps disclosed herein. In another aspect, the embodiments of the invention consist essentially of the components and/or steps disclosed herein. In yet another aspect, the embodiments of the invention consist of the components and/or steps disclosed herein.

Definitions

[0042] The articles “a” and “an” are used herein to refer to one or to more than one (*i.e.* to at least one) of the grammatical object of the article. By way of example, “an element” means one element or more than one elements.

[0043] “About” will be understood by persons of ordinary skill in the art and will vary to some extent depending on the context in which it is used. As used herein, “about” is meant to encompass variations of $\pm 20\%$ or $\pm 10\%$, more preferably $\pm 5\%$, even more preferably $\pm 1\%$, and still more preferably $\pm 0.1\%$.

[0044] “Androgen receptor inhibitor” means a compound or molecule that directly or indirectly inhibits the androgen receptor (AR) signaling pathway. In one embodiment, direct inhibitors of the AR receptor include enzalutamide, bicalutamide (Casodex),

flutamide, nilutamide, ARN509 and the like. In another embodiment, indirect inhibitors of AR include Cyp 17 inhibitors such as ketoconazole, abiraterone acetate, VN/124-1 (TOK-001), orteronel (TAK-700) and the like. In another embodiment, AR inhibitors include finasteride, galeterone, cyproterone acetate, and andarine, and the like.

[0045] By "detecting expression" is intended determining the quantity or presence of an RNA transcript or its expression product of an *intrinsic gene*.

[0046] By "inhibit" or other forms of inhibit means to hinder or restrain a particular characteristic. It is understood that this is typically in relation to some standard or expected value, in other words it is relative, but that it is not always necessary for the standard or relative value.

[0047] As used throughout, by a "subject" is meant an individual, typically a mammal or fowl. Mammals can include, for example, domesticated animals (e.g., cat or dog), livestock (e.g., cattle, horses, pigs, sheep, goats, etc.), laboratory animals (e.g., mouse, rabbit, rat, guinea pig, etc.) and primates. Preferably, the mammal is a human being.

[0048] "Triple negative breast cancer" or "TNBC" refers to any breast cancer that does not express the genes for estrogen receptor (ER), progesterone receptor (PR) and Her2/neu. The term includes primary epithelial TNBCs, as well as TNBC that involved with other tumors. The cancer can include a triple negative carcinoma of the breast, ductal carcinoma of the breast, lobular carcinoma of the breast, undifferentiated carcinoma of the breast, cystosarcoma phyllodes of the breast, angiosarcoma of the breast, and primary lymphoma of the breast. TNBC can also include any stage of triple negative breast cancer, and can include breast neoplasms having histologic and ultrastructural heterogeneity (e.g., mixed cell types).

[0049] "A TNBC treatment comprising androgen receptor inhibitor" is a TNBC *treatment that includes administration of an androgen receptor inhibitor*. The treatment may include other anti-cancer or chemotherapeutic agents.

[0050] A subject "in need of" treatment for TNBC is a subject having TNBC or presenting with one or more symptoms of TNBC, or a subject having an increased risk of developing TNBC relative to the population at large. Preferably, a subject "in need" of treatment for TNBC is a subject who is afflicted with TNBC.

[0051] As used herein, "therapeutically effective amount" or "therapeutically effective dose" refers to an agent, compound, material, or composition containing a compound that is at least sufficient to produce a therapeutic effect. An effective amount is the quantity of a therapeutic agent necessary for preventing, curing, ameliorating, arresting or partially arresting a symptom of a disease or disorder.

[0052] "Treating" or "treatment" does not mean a complete cure. It means that the symptoms of the underlying disease are reduced, and/or that one or more of the underlying cellular, physiological, or biochemical causes or mechanisms causing the symptoms are reduced. It is understood that reduced, as used in this context, means relative to the state of the disease, including the molecular state of the disease, not just the physiological state of the disease.

Description of the Figures

[0053] Fig. 1 is a graph of the results from some of the patients enrolled into either the prescreening or screening period of a clinical trial evaluating enzalutamide in patients whose TNBC also expressed AR. "Diagnostic -" represents patients having the Basal-like subtype, as determined by PAM50 gene breast cancer subtype classification. "Diagnostic +" represents the patients with Her2, LumA, LumB or Normal subtypes. Patients were scored as "Responder" or "Non-Responder" to the enzalutamide therapy according to the criteria set forth in Example 1.

[0054] Figs. 2A and 2B are graphs of results of the same TNBC clinical trial in which patient gene expression classifier scores for the Basal-like subtype were correlated with patient response. A threshold cut-off of 0.2 for the patient Basal Centroid classifier score was applied. "Diagnostic +" represents patients whose samples met the indicated prognostic signature comprising the indicated threshold cut-off. "Diagnostic -" represents patients whose samples did not meet the indicated threshold cut-off. Patients were scored as "Responder" or "Non-Responder" to the enzalutamide therapy according to the criteria set forth in Example 1.

[0055] Figs. 3A and 3B are graphs of results of the same TNBC clinical trial in which patient gene expression classifier scores for the Basal-like subtype were correlated with patient response. A threshold cut-off of 0.3 for the patient Basal Centroid classifier score

was applied. “Diagnostic +” represents patients whose samples met the indicated prognostic signature comprising the indicated threshold cut-off. “Diagnostic -” represents patients whose samples did not meet the indicated threshold cut-off. Patients were scored as “Responder” or “Non-Responder” to the enzalutamide therapy according to the criteria set forth in Example 1.

[0056] Figs. 4A and 4B are graphs of results of the same TNBC clinical trial in which patient gene expression classifier scores for the Basal-like subtype were correlated with patient response. A threshold cut-off of 0.4 for the patient Basal Centroid classifier score was applied. “Diagnostic +” represents patients whose samples met the indicated prognostic signature comprising the indicated threshold cut-off. “Diagnostic -” represents patients whose samples did not meet the indicated threshold cut-off. Patients were scored as “Responder” or “Non-Responder” to the enzalutamide therapy according to the criteria set forth in Example 1.

[0057] Figs. 5A and 5B are graphs of results of the same TNBC clinical trial in which patient gene expression classifier scores for the Basal-like subtype were correlated with patient response. A threshold cut-off of 0.5 for the patient Basal Centroid classifier score was applied. “Diagnostic +” represents patients whose samples met the indicated prognostic signature comprising the indicated threshold cut-off. “Diagnostic -” represents patients whose samples did not meet the indicated threshold cut-off. Patients were scored as “Responder” or “Non-Responder” to the enzalutamide therapy according to the criteria set forth in Example 1.

[0058] Figs. 6A and 6B are graphs of results of the same TNBC clinical trial in which patient gene expression classifier scores for the Basal-like subtype were correlated with patient response. A threshold cut-off of 0.6 for the patient Basal Centroid classifier score was applied. “Diagnostic +” represents patients whose samples met the indicated prognostic signature comprising the indicated threshold cut-off. “Diagnostic -” represents patients whose samples did not meet the indicated threshold cut-off. Patients were scored as “Responder” or “Non-Responder” to the enzalutamide therapy according to the criteria set forth in Example 1.

[0059] Figs. 7A and 7B are graphs of results of the same TNBC clinical trial in which patient gene expression classifier scores for the Basal-like subtype were correlated with

patient response. A threshold cut-off of 0.65 for the patient Basal Centroid classifier score was applied. "Diagnostic +" represents patients whose samples met the indicated prognostic signature comprising the indicated threshold cut-off. "Diagnostic -" represents patients whose samples did not meet the indicated threshold cut-off. Patients were scored as "Responder" or "Non-Responder" to the enzalutamide therapy according to the criteria set forth in Example 1.

[0060] Figs. 8A and 8B are graphs of results of the same TNBC clinical trial in which patient gene expression classifier scores for the Basal-like subtype were correlated with patient response. A threshold cut-off of 0.7 for the patient Basal Centroid classifier score was applied. "Diagnostic +" represents patients whose samples met the indicated prognostic signature comprising the indicated threshold cut-off. "Diagnostic -" represents patients whose samples did not meet the indicated threshold cut-off. Patients were scored as "Responder" or "Non-Responder" to the enzalutamide therapy according to the criteria set forth in Example 1.

[0061] Figs. 9A and 9B are graphs of results of the same TNBC clinical trial in which patient gene expression classifier scores for the Basal-like subtype were correlated with patient response. A threshold cut-off of 0.8 for the patient Basal Centroid classifier score was applied. "Diagnostic +" represents patients whose samples met the indicated prognostic signature comprising the indicated threshold cut-off. "Diagnostic -" represents patients whose samples did not meet the indicated threshold cut-off. Patients were scored as "Responder" or "Non-Responder" to the enzalutamide therapy according to the criteria set forth in Example 1.

[0062] Figs. 10A and 10B are graphs of results of the same TNBC clinical trial in which patient gene expression classifier scores for the Basal-like subtype were correlated with patient response. A threshold cut-off of 0.9 for the patient Basal Centroid classifier score was applied. "Diagnostic +" represents patients whose samples met the indicated prognostic signature comprising the indicated threshold cut-off. "Diagnostic -" represents patients whose samples did not meet the indicated threshold cut-off. Patients were scored as "Responder" or "Non-Responder" to the enzalutamide therapy according to the criteria set forth in Example 1.

[0063] Fig. 11 comprises a representation of the response to enzalutamide of various patient subgroups treated with enzalutamide in the clinical trial. Response is shown in terms of Clinical Benefit Rate at ≥ 24 weeks (CBR24). The subgroups include Intent-To-Treat (ITT) patients; Evaluable Patients; patients with breast tumor tissue which was AR staining $\geq 10\%$ (IHC AR $\geq 10\%$); patients whose breast tumor tissue was classified as a non-Basal like subtype by the PAM50 subtype classifier (PAM50 non-basal); patients whose tumors were classified as Basal-like subtype (PAM50 basal); and patient samples analyzed by applying the indicated cut-offs of <0.6 , ≥ 0.6 , <0.7 , ≥ 0.7 , <0.75 and ≥ 0.75 , from patient Basal Centroid classifier scores. "DX -" signifies patients whose samples did not meet the indicated threshold cut-off. "DX +" signifies patients whose samples did meet the indicated threshold cut-off. Also shown in in Fig 11 are data for the combined criteria IHC AR $\geq 10\%$ and DX+ <0.6 .

[0064] Fig. 12 is a further representation of the response to enzalutamide of various patient subgroups treated with enzalutamide in the clinical trial. Response is shown in terms of Clinical Benefit Rate at ≥ 24 weeks (CBR24). The subgroups include Intent-To-Treat (ITT) patients; Evaluable Patients; patients with breast tumor tissue which was AR staining $\geq 10\%$ (IHC AR $\geq 10\%$); and patients in which the enzalutamide therapy is administered as the first (1st line) or second (2nd line) of therapy. The subgroups further include a subgroup of patient samples analyzed by applying a <0.6 cut-off to Basal Centroid classifier scores ("Novel DX+"), and a subgroup comprising samples from 1st and 2nd line therapy, applying the <0.6 cut-off to Basal Centroid classifier scores.

[0065] Fig. 13 is a Kaplan-Meier plot showing median progression-free survival (MPS) of patients treated with enzalutamide as a function of time. The curves correspond to patients that were identified as meeting the novel prognostic signature condition of a Basal Centroid classifier score of <0.6 ("Novel DX Pos") versus patients who did not meet the definition ("Novel DX Neg").

[0066] Figs. 14A-14D comprise the results of patient responses in the clinical trial of the drug enzalutamide for the treatment of TNBC. Gene expression analysis was carried out on patient breast tumor samples using PAM50 intrinsic gene set of Table 1. The Spearman rank correlation to the Basal-like gene expression centroid was evaluated for each sample and assigned as the "Basal Centroid classifier score". The Spearman rank

correlation to the Luminal A gene expression centroid was evaluated for each sample and assigned as the “Luminal A classifier score”. A Weighted Basal and Luminal A classifier score of the patient samples was determined from the following formula:

$$\text{Weighted Basal and Luminal A classifier score} = -0.2468275(\text{Basal Centroid classifier score}) + 0.2667110(\text{Luminal A Centroid classifier score}).$$

The enzalutamide response/non-response data was analyzed using Weighted Basal and Luminal A classifier score cut-offs of >-0.2 (Fig. 14A), >-0.25 (Fig. 14B), >-0.3 (Fig. 14C) and >-0.35 (Fig. 14D). The data is set forth in Figure 14A-14D. In each figure, “Diagnostic +” represents patients whose samples met the indicated prognostic signature comprising the indicated threshold cut-off. “Diagnostic -” represents patients whose samples did not meet the indicated threshold cut-off. Patients were scored as “Responder” or “Non-Responder” to the enzalutamide therapy according to the criteria set forth in Example 1.

[0067] Fig. 15 comprises a representation of the response to enzalutamide of various patient subgroups treated with enzalutamide in the clinical trial. Response is shown in terms of Clinical Benefit Rate at ≥ 24 weeks (CBR24). The subgroups include Intent-To-Treat (ITT) patients; Evaluable Patients; patients whose breast tumor tissue was classified as a non-Basal like subtype by the PAM50 subtype classifier (PAM50 non-basal); patients whose tumors were classified as Basal-like subtype (PAM50 basal); and patients whose breast tumor tissue samples were analyzed to by applying the indicated cut-offs of >-0.2 , >-0.25 , >-0.3 , and >-0.35 to the Weighted Basal and Luminal A classifier score. “PR-AR DX -” signifies patients whose samples did not meet the indicated threshold cut-off. “PR-AR DX +” signifies patients whose samples did meet the indicated threshold cut-off. Also shown are response data (applying a Weighted Basal and Luminal A classifier score cut-off of >-0.25) for samples from patients in the study receiving enzalutamide therapy after having received from zero to one prior therapies for treatment of TNBC with a drug other than an androgen receptor inhibitor (“and 0-1 prior therapy”) or after having received two or more prior therapies for treatment of TNBC with a drug other than an androgen receptor inhibitor (“and ≥ 2 prior therapies”).

[0068] Fig. 16 is a Kaplan-Meier plot showing progression-free survival of patients treated with enzalutamide as a function of time to 56 weeks. The curves correspond to patients that were identified as meeting the signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.2 ("PR-AR DX+: > -0.2", top curve) versus a classifier score of less than or equal to -0.2 ("PR-AR DX-: ≤ -0.2", bottom curve).

[0069] Fig. 17 is a Kaplan-Meier plot showing progression-free survival of patients treated with enzalutamide as a function of time to 56 weeks. The curves correspond to patients that were identified as meeting the signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.25 ("PR-AR DX+: > -0.25", top curve) versus a classifier score of less than or equal to -0.25 ("PR-AR DX-: ≤ -0.25", bottom curve).

[0070] Fig. 18 is a Kaplan-Meier plot showing progression-free survival of patients treated with enzalutamide as a function of time to 56 weeks. The curves correspond to patients that were identified as meeting the signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.3 ("PR-AR DX+: > -0.3", top curve) versus a classifier score of less than or equal to -0.30 ("PR-AR DX-: ≤ -0.3", bottom curve).

[0071] Fig. 19 is a Kaplan-Meier plot showing progression-free survival of patients treated with enzalutamide as a function of time to 56 weeks. The curves correspond to patients that were identified as meeting the signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.35 ("PR-AR DX+: > -0.35", top curve) versus a classifier score of less than or equal to -0.35 ("PR-AR DX-: ≤ -0.35", bottom curve).

[0072] Fig. 20 is a Kaplan-Meier plot showing progression-free survival of patients treated with enzalutamide after receiving from zero to one prior therapies for treatment of TNBC with a drug other than an androgen receptor inhibitor. The curves correspond to patients that were identified as meeting the signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.25 ("PR-AR DX+: > -0.25", top curve) versus a classifier score of less than or equal to -0.25 ("PR-AR DX-: ≤ -0.25", bottom curve).

[0073] Figs. 21A and 21B comprise graphs of the effect of the novel prognostic signature utilizing a Weighted Basal and Luminal A classifier score cut-off of >-0.25 as a predictor of response to AR inhibitor therapy in patients receiving zero or one (0-1 Prior Lines) or two or more (2+ Prior Lines) prior therapies for treatment of TNBC with a drug other than an androgen receptor inhibitor. The 56 patients of Fig. 21B were identified as meeting the signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.25 . The 62 study patients identified by a classifier score of less than or equal to -0.25 are identified in Fig. 21A. Each bar in the figures represents a single patient. Patient bars marked with a triangle ("Active") are active in the study. Patient bars marked with a star signify complete response (CR) or partial response (PR).

[0074] Figs. 22A and 22B comprise Kaplan-Meier plots respectively showing median progression-free survival (Fig. 22A) (mPFS) and overall survival (mOS) of patients treated with enzalutamide as a function of time. The curves correspond to patients that were identified as meeting the signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.25 ("PR-AR DX+", top curves) versus a classifier score of less than or equal to -0.25 ("PR-AR DX-", bottom curves). Fig. 22A: mPFS = 16.1 weeks for patients meeting signature condition; mPFS = 8.1 weeks for patients not meeting signature condition. Fig. 22B: mOS = NYR (not yet reached) at 84 weeks for patients meeting signature condition; mOS = 32.1 weeks for patients not meeting signature condition.

[0075] Fig. 23 is a Kaplan-Meier plot showing progression-free survival of patients treated with enzalutamide after receiving from zero to one prior therapies for treatment of TNBC with a drug other than an androgen receptor inhibitor. The curves correspond to patients that were identified as meeting the signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.25 ("PR-AR DX+: > -0.25 ", top curve) versus a classifier score of less than or equal to -0.25 ("PR-AR DX-: ≤ -0.25 ", bottom curve). The data represents a continuation of the study of Fig. 20, taken beyond the 56 week interval of Fig. 20 to 64 weeks in Fig. 23. In Fig. 23, mPFS = 40.4 weeks for patients meeting signature condition; mPFS = 8.9 weeks for patients not meeting signature condition. "NYR" means "not yet reached" in the statement of the 95%

confidence interval (CI) for the data represented by patients meeting the signature condition in Fig. 23.

[0076] Figs. 24A, 24B and 24C show the viability of TNBC cell lines BT549, MDA-MB-436 and MDA-MB-453, respectively, when treated with the indicated concentrations of enzalutamide (Enza), paclitaxel (PTX) or combinations thereof. Mean values are presented for each cell line (n=5).

[0077] Figs. 25A and 25B show the growth of tumors induced in NOD-SCID mice transplanted with cells of the TNBC cell line MDA-MB-453 following (i) oral gavage (PO) with enzalutamide (Enza) at 3 mg/kg/day (n=10), (ii) paclitaxel (PTX) at 6 mg/kg QMWF (IP) (n=7), or (iii) the combination of (i) and (ii) (n=10). Tumor volume was measured on the days indicated in Fig. 25A. Data points in Fig. 25A represent the average tumor volume for each group, and error bars reflect the SEM of the data. Tumor weights in Fig. 25B were determined at day 35.

Detailed Description of the Invention

[0078] The present invention provides a method of treating TNBC in subjects afflicted with TNBC in which breast cancer cells of the TNBC-afflicted subject are characterized by a score derived from the expression by those cells of a certain set of intrinsic genes described more particularly below. The present invention also provides a method of assessing whether a TNBC treatment comprising an AR inhibitor is recommended (will likely be effective) for administration as a course of therapy for a patient afflicted with TNBC. Thus, the present invention provides in one embodiment a method of evaluating a treatment for triple negative breast cancer comprising the use of an androgen receptor inhibitor, the method comprising assaying a biological sample obtained from a subject to determine whether the biological sample obtained from the subject is classified as basal-like subtype or another subtype. If the biological sample is classified as other than a basal-like subtype, the breast cancer treatment comprising an androgen receptor inhibitor is more likely to be effective than if the sample were classified as basal-like subtype. Thus, the present invention provides in one embodiment a method of treating triple negative breast cancer in a subject having a cancer comprising breast cancer cells that have been previously classified as other than basal-like subtype. The method comprises

administering a breast cancer treatment to the subject comprising an androgen receptor inhibitor, thereby treating the triple negative breast cancer in the subject.

[0079] The present invention further provides a method of treating TNBC by determining whether a TNBC patient should receive a treatment including AR inhibitor therapy, and then administering the optimal AR inhibitor treatment to the patient based on that determination. While the studies referenced herein were conducted on patient samples comprising tumor tissue staining positive by immunohistochemistry (IHC) for the AR receptor, the scope of the present invention is not so limited to the treatment and prognosis of AR(+) TNBC.

[0080] Studies of breast tumors based upon intrinsic gene analysis have identified five distinct subtypes of breast carcinomas: Luminal A (LumA), Luminal B (LumB), HER2-enriched (Her-2-E), Basal-like, and Normal-like (Perou et al. *Nature*, 406(6797):747-52 (2000); Sorlie et al. *PNAS*, 98(19):10869-74 (2001)). The HER2-enriched subtype may be referred to herein by “HER2”, it being understood that the latter also means the HER2-enriched subtype. The Basal-like subtype may be referred to herein as “Basal”, it being understood that the latter also means the Basal-like subtype. A breast cancer sample or cell is thus “classified” by assigning the cell or sample to an aforementioned subtype. A breast cancer sample or cell can also be considered “classified” in negative terms, i.e., a cell or sample may be classified as “non-Basal” or “other than Basal” upon determination that the cell or sample is of the LumA, LumB, HER2, or Normal-like sub-type.

[0081] We have unexpectedly found that the presence of the basal-like subtype is indicative of a likelihood of clinical non-response in TNBC to treatment with an AR inhibitor. We have found that a Basal Centroid classifier score of less than or equal to 0.9 is indicative of a likelihood of clinical response to an AR inhibitor. We have also unexpectedly found that an empirically determined weighted score based upon Basal-like and Luminal A subtype analysis conducted on biological samples from TNBC patients is indicative of a likelihood of clinical response to treatment with an AR inhibitor. Thus, in one embodiment, an assay is thus performed on a biological sample from a patient suffering from TNBC to determine the breast cancer subtype. In another embodiment, an assay is performed on a biological sample from a patient suffering from TNBC to

determine the Basal Centroid classifier score, or both the Basal Centroid classifier score and the Luminal A classifier score.

[0082] The assay for determining whether the biological sample is classified as a subtype other than a basal-like subtype can comprise an assay for determining the presence of a basal-like subtype; a negative result indicates a non-basal subtype. Any assay capable of identifying the presence of a basal-like subtype may be utilized for this purpose. With approximately 70–90% of triple-negative carcinomas revealed to be basal-like breast carcinomas (Bertucci *et al.*, *Int. J. Cancer* 2008, 123, 236–240; Wang *et al.*, *Eur. J. Clin. Invest.* 2008, 38, 438–446), the triple negative phenotype has been used as a surrogate for the basal-like subtype. However, studies have shown that triple-negative and basal-like breast tumors are not synonymous. *See, e.g.*, Choo and Nielsen, *Cancers* 2010, 2, 1040-1065. Thus, care must be exercised in selecting an assay for identifying the basal-like subtype.

[0083] Recently, an assay for basal-like subtype has been announced that relies on the following profile which has been found to be characteristic of the basal-like subtype: ER negative, HER2 negative, and cytokeratin 5/6 and/or HER1 positive. A panel of four antibodies (ER, HER1, HER2, and cytokeratin 5/6) has thus been proposed as an immunohistochemical profile for identifying breast basal-like tumors (Nielsen *et al.*, *Clinical Cancer Research* 2014; 10:5367-5374).

[0084] The Basal-like and Luminal A subtype analysis is performed by means of a gene expression assay which utilizes expression of intrinsic genes as classifier genes for breast cancer classification. Intrinsic genes, as described in Perou *et al.* (2000) *Nature* 406:747-752, are statistically selected to have low variation in expression between biological sample replicates from the same individual and high variation in expression across samples from different individuals. The present invention utilizes the PAM50 gene expression assay (Parker *et al. J Clin Oncol.*, 27(8):1160-7 (2009) and U.S. Patent Application Publication No. 2011/0145176, both incorporated herein, by reference, in their entireties). The PAM50 gene expression assay can be used to identify intrinsic subtypes of breast cancer (Luminal A, Luminal B, HER2-enriched, Basal-like, and Normal-like) from standard biological samples, such as formalin fixed paraffin embedded tumor tissue. The PAM50 gene expression classifier is a supervised, centroid-based

prediction method to classify breast cancers into one of the five aforesaid molecular subtypes using a 50-gene intrinsic gene signature.

[0085] As described in Parker *et al.* and in U.S. Patent Application Publication No. 2011/0145176, as well as in U.S. Patent application Publication No. 2013/0004482, the PAM50 gene expression assay method utilizes a supervised algorithm to classify subject samples according to breast cancer intrinsic subtype. This algorithm, referred to herein as the "PAM50 classification model" or "PAM50 classifier" is based on the gene expression profile of a defined subset of 50 intrinsic genes that has been identified for classifying breast cancer intrinsic subtypes. The subset of genes, along with primers specific for their detection, is provided in Table 1 of U.S. Patent Application Publication No. 2013/0004482 and reproduced below as Table 1 of this disclosure. Select sequences of the same 50 intrinsic genes are set forth in Table 2 below. The entire disclosure of Publication No. 2013/0004482, is incorporated herein by reference.

[0086] The detection and estimation of the expression of the set of 50 subtype predictor genes of Table 1 is performed by any suitable means.

[0087] The PAM50 gene expression classifier operates by using a supervised prediction algorithm developed based on the profiles of objectively-selected prototype samples for "training" the algorithm. The samples are selected and subtyped using an expanded intrinsic gene set according to the methods disclosed in U.S. Patent Publication No. 2009/0299640, the entire disclosure of which is incorporated herein by reference. After stratifying the training samples according to subtype, a centroid-based prediction algorithm is used to construct centroids for each molecular subtype based on the expression profile of the intrinsic gene set described in Table 1. The centroid is the average gene expression for each gene in each subtype (or "class") divided by the within-class standard deviation for that gene. Nearest centroid classification takes the gene expression profile of a new sample, and compares it to each of these class centroids. Subtype prediction is done by calculating the Spearman's rank correlation of each test case to the five centroids of the PAM50 subtypes, and assigning a sample to a subtype based on the nearest centroid.

[0088] According to one embodiment, which does not necessarily involve assigning the patient sample to a PAM50 subtype, the Spearman rank correlation to the basal-like

gene expression centroid is determined. The Spearman rank correlation between the sample and the basal-like centroid is assigned as the “Basal Centroid classifier score”. The Spearman rank correlation to the Luminal A gene expression centroid is determined. The Spearman rank correlation between the sample and the Luminal A centroid is assigned as the “Luminal A Centroid classifier score”. Methods for utilizing the PAM50-based signature to provide a Basal Centroid classifier score and a Luminal A Centroid classifier score are known to those skilled in the art. See, for example, U.S. Patent Application Publication No. 2009/0299640; Parker et al., *J Clin. Oncol.*, 27(8):1160-7 (2009); U.S. Patent Application Publication No. 2011/0145176. Also see, for example, Prat et al., *British Journal of Cancer*, (2014) **111**, 1532–1541, incorporated herein by reference.

[0089] We have found, as demonstrated by the clinical trial of TNBC patients treated with the AR inhibitor enzalutamide, that a Basal Centroid classifier score of less than or equal to 0.9 is indicative of a likelihood of clinical response to an AR inhibitor. In some embodiments, a Basal Centroid classifier scores of less than or equal to 0.9, from 0.2 to 0.8, from 0.4 to 0.7 are used to predict the likelihood of clinical response to an AR inhibitor. In one embodiment, a Basal Centroid classifier score of less than or equal to 0.6 is used to predict the likelihood of clinical response to an AR inhibitor.

[0090] We have further found that the Basal Centroid classifier score and Luminal A Centroid classifier score, when combined subject to certain empirically defined weighting factors, provides a score (“Weighted Basal and Luminal A classifier score”) that can be used to further predict responsiveness to androgen receptor inhibitor therapy in an individual TNBC patient. The Weighted Basal and Luminal A classifier score is determined from the following equation:

$$\begin{aligned} \text{Weighted Basal and Luminal A classifier score} = \\ -0.25(\text{Basal Centroid classifier score}) + 0.27(\text{Luminal A Centroid classifier score}). \end{aligned}$$

[0091] In some embodiments, the equation for determining the Weighted Basal and Luminal A classifier score takes the form:

$$\begin{aligned} \text{Weighted Basal and Luminal A classifier score} = \\ -0.2468275(\text{Basal Centroid classifier score}) + 0.2667110(\text{Luminal A Centroid classifier score}). \end{aligned}$$

[0092] As demonstrated by the clinical trial of TNBC patients treated with the AR inhibitor enzalutamide, if the Weighted Basal and Luminal A classifier score is greater than

-0.3, the patient is identified as one likely responsive to AR inhibitor therapy.

Alternatively, if the Weighted Basal and Luminal A classifier score is greater than -0.2, the patient may also be identified as one likely responsive to AR inhibitor therapy.

Increased accuracy is obtained by selecting -0.25 as the cut-off for predicting responsiveness to AR inhibitor therapy. Thus, in a preferred embodiment, if the Weighted Basal and Luminal A classifier score is greater than -0.25, the patient is identified as one likely responsive to AR inhibitor therapy. If the TNBC patient is identified through determination of the Weighted Basal and Luminal A classifier score as one who is likely responsive to AR inhibitor therapy for TNBC, an appropriate AR inhibitor therapy may then be administered to treat the TNBC condition in the patient.

[0093] The utility of the Weighted Basal and Luminal A classifier score for predicting patient response to AR inhibitor therapy is illustrated in Figs. 14A-14D and Fig. 15. The figures comprise a representation of the response to enzalutamide of various TNBC patient subgroups treated with enzalutamide in the clinical trial. Patient responsiveness to enzalutamide therapy was correlated with Weighted Basal and Luminal A classifier score, applying a series of cut-offs of >-0.2 (Fig. 14A), >-0.25 (Fig. 14B), >-0.3 (Fig. 14C), and >-0.35 (Fig. 14D) to the Weighted Basal and Luminal A classifier score. "Diagnostic -" in Figs. 14A-D and "PR-AR DX -" in Fig. 15 signify patients whose samples did not meet the indicated Weighted Basal and Luminal A classifier score threshold cut-off.

"Diagnostic +" in Figs. 14A-14D and "PR-AR DX +" in Fig. 15 signify patients whose samples did meet the indicated threshold cut-off. As is apparent from a consideration of the data, a Weighted Basal and Luminal A classifier score of greater than -0.25 provided the highest level of accuracy in predicting TNBC patient responsiveness to enzalutamide therapy, with the criteria of greater than -0.2, or greater than -0.3, also providing acceptable results.

[0094] The correlation between patient response and Weighted Basal and Luminal A classifier score is further illustrated in the Kaplan-Meier plot of Figs. 16-19, showing progression-free survival of TNBC patients treated with enzalutamide, as a function of

time to 56 weeks. The curves in Fig. 16 correspond to patients that were identified as meeting the signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.2 ("PR-AR DX+: > -0.2", top curve) versus a classifier score of less than or equal to -0.2 ("PR-AR DX-: ≤ -0.2", bottom curve). Figs. 17, 18 and 19 are similar to Fig. 16, where the signature conditions of greater than -0.25 (Fig. 17), greater than -0.3 (Fig. 18) and greater than -0.35 (Fig. 19) were imposed. It may be appreciated that the magnitude of the vertical separation between the respective curves on each individual plot is a measure of the accuracy of correlation between patient Weighted Basal and Luminal A classifier score and progression-free survival. On this basis, it may be further appreciated from a comparison of Figs. 16-19 that applying the criterion of a Weighted Basal and Luminal A classifier score greater than -0.25 (Fig. 17) provides the most accuracy in correlating Weighted Basal and Luminal A classifier score to TNBC patient responsiveness to enzalutamide therapy, with the criteria of greater than -0.2 (Fig. 16) or greater than -0.3 (Fig. 18) also provided acceptable results.

[0095] It was also found that the novel Weighted Basal and Luminal A classifier score as a predictor of responsiveness to AR inhibitor therapy for TNBC achieves even greater accuracy in patients who have either received no prior TNBC therapy, or have received no more than one round of prior TNBC therapy. As may be appreciated from a comparison of Fig. 20 and Fig. 17, imposing the criterion of a Weighted Basal and Luminal A classifier score of greater than -0.25 in the zero to 1 prior therapy patient group (Fig. 20), versus the larger group of all trial patients (Fig. 17), resulted in increased accuracy in identifying patients responsive to enzalutamide therapy, as evidenced by the greater vertical separation between the curves in Fig. 20, versus the vertical separation of the curves in Fig. 17. The trend is further observed in Fig. 23, in which the progression-free survival time in the study subjects of Fig. 20 is shown beyond the 56 weeks in Fig. 20, to 64 weeks in Fig. 23.

[0096] This result is also illustrated in Figs. 21A and 21B, showing the extent of time on treatment without progression of disease (progression-free survival) for 56 patients that were identified as meeting the signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.25 (Fig. 21B) versus 62 patients identified by a classifier score of less than or equal to -0.25 (Fig. 21A). Each bar represents a patient.

Patients received either zero or one prior TNBC therapy before enzalutamide treatment (0-1 Prior Lines) with a drug other than an androgen receptor inhibitor, or two or more prior therapies (2+ Prior Lines) with a drug other than an androgen receptor inhibitor. Patient bars marked with a triangle ("Active") are active in the study. Patient bars marked with a star signify complete response (CR) or partial response (PR). The best time on treatment without disease progression is apparent in responder patients who received one or no prior lines of therapy (Fig. 21B).

[0097] The correlation between patient response and Weighted Basal and Luminal A classifier score is further illustrated in the Kaplan-Meier plots of Figs. 22A and 22B, comparing the endpoints of median progression-free survival (mPFS) (Fig. 22A) and median overall survival (mOS) (Fig. 22B) of study patients. The curves in Figs. 22A and 22B correspond to patients that were identified as meeting the signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.25 ("PR-AR DX+", top curves) versus a classifier score of less than or equal to -0.25 ("PR-AR DX-", bottom curves). The results thus show that the Weighted Basal and Luminal A classifier of greater than -0.25 score correlates with overall survival, in addition to progression-free survival. The patients not meeting the prognostic signature condition were characterized by a median progression-free survival of 8.1 weeks and median overall survival of 32.1 weeks. In contrast, patients meeting the prognostic signature condition were characterized by a median progression-free survival of 16.1 weeks and median overall survival not yet reached (mOS NYR) at 84 weeks.

Gene Expression Detection

[0098] As the first step in determining the Basal Centroid Classifier Score or Weighted Basal and Luminal A classifier score of a TNBC patient, gene expression detection of the genes of the intrinsic gene set of Table 1 is carried out on patient samples by any method for determining the quantity or presence of an RNA transcript or its expression product of an intrinsic gene. Such methods are described in U.S. Patent Application Publication Nos. 2009/0299640 and 2013/0004482, incorporated herein by reference. They include, for example means, methods based on hybridization analysis of polynucleotides, methods based on sequencing of polynucleotides,

immunohistochemistry methods, and proteomics-based methods. The methods generally detect expression products (e.g., mRNA) of the intrinsic genes listed in Table 1.

[0099] RNA sequencing as a method for assaying gene expression may be utilized in one embodiment. The assay for gene expression of the intrinsic gene set can also be performed by other technologies used to evaluate gene expression/quantification, including but not limited to real-time PCR, microarrays, microfluidic gene expression, and targeted gene sequencing. Such methods include, for example, hybridization analysis of polynucleotides, methods based on sequencing of polynucleotides, immunohistochemistry methods, and proteomics-based methods. PCR-based methods, such as reverse transcription PCR (RT-PCR) (Weis *et al.*, *TIG* 8:263-64, 1992), and array-based methods such as microarray (Schena *et al.*, *Science* 270:467-70, 1995) may be used.

[00100] General methods for RNA extraction are well known in the art and are disclosed in standard textbooks of molecular biology, including Ausubel *et al.*, ed., *Current Protocols in Molecular Biology*, John Wiley & Sons, New York 1987-1999. Methods for RNA extraction from paraffin embedded tissues are disclosed, for example, in Rupp and Locker, *Lab Invest.* 56:A67, (1987); and De Andres *et al.*, *Biotechniques* 18:42-44, (1995). Isolated RNA can be used in hybridization or amplification assays that include, but are not limited to, PCR analyses and probe arrays. Intrinsic gene expression product level determination in a sample may also involve nucleic acid amplification, for example, by RT-PCR (U.S. Pat. No. 4,683,202), ligase chain reaction, self-sustained sequence replication, transcriptional amplification, rolling circle replication, and other methods utilizing nucleic acid amplification method, followed by the detection of the amplified molecules using techniques well known to those of skill in the art.

[00101] Microarrays may be used for expression profiling. Each array includes a reproducible pattern of capture probes attached to a solid support. Labeled RNA or DNA is hybridized to complementary probes on the array and then detected by laser scanning. Hybridization intensities for each probe on the array are determined and converted to a quantitative value representing relative gene expression levels. See, for example, U.S. Pat. Nos. 6,040,138, 5,800,992 and 6,020,135, 6,033,860, and 6,344,316. High-density

oligonucleotide arrays are particularly useful for determining the gene expression profile for a large number of RNAs in a sample.

[00102] Total RNA for analysis of the intrinsic gene set may be isolated from a biological sample, such as a tumor. If the source of RNA is a primary tumor, RNA (e.g., mRNA) can be extracted, for example, from frozen or archived paraffin-embedded and fixed (e.g., formalin-fixed) tissue samples (e.g., pathologist-guided tissue core samples).

Gene Analysis and Data Processing

[00103] Patient sample gene expression data from the intrinsic gene set may be pre-processed by known techniques to achieve sequence data alignment, data normalization and mean centering of data, for example. Methods of normalization include, for example, (i) global normalization that uses all genes on the array; (ii) housekeeping genes normalization that uses constantly expressed housekeeping/invariant genes; and (iii) internal controls normalization that uses known amount of exogenous control genes added during hybridization (Quackenbush *Nat. Genet.* 32 (Suppl.), 496-501 (2002)). Gene count estimates can also be normalized to a fixed quartile, such as a fixed upper quartile. The resulting normalized gene expression estimates may then be adjusted such that the median expression value of each gene is equivalent to the median of a known subset, such as a gene subset from TNBC patients.

[00104] According to one embodiment, patient sample expression data for processing by the PAM50 classifier is first pre-processed by alignment and data centering techniques. RNA-sequence data is first aligned to Human (*Homo sapiens*) genome sequence hg19 (<https://genome.ucsc.edu/cgi-bin/hgGateway?db=hg19>) (http://www.ncbi.nlm.nih.gov/assembly/GCF_000001405.25/) using, for example, MapSplice (*Nucleic Acids Res.* 2010 Oct;38(18):e178. doi: 10.1093/nar/gkq622). Gene and isoform level counts may be estimated, for example, using RNA-Seq by Expectation-Maximization (RSEM) (<http://deweylab.biostat.wisc.edu/rsem/>). Gene count estimates are normalized to a fixed upper quartile. The resulting normalized gene expression estimates may then be adjusted such that the median expression value of each gene is equivalent to the median of the triple negative subset of the TCGA RNA-seq data reported in “Comprehensive Molecular Portraits of Human Breast Tumors”, *The Cancer*

Genome Atlas Network, Nature 490, 61-70 (October 4, 2012)

(<http://www.nature.com/nature/journal/v490/n7418/full/nature11412.html>).

[00105] Following pre-processing, the patient sample expression data from the PAM50 gene array is processed according to the known techniques for processing intrinsic gene set data. Complete instructions for processing of patient sample gene expression data from the PAM50 intrinsic gene set is described in detail in at least the following, and will not be detailed herein except by way of summary: Parker et al. *J Clin Oncol.*, 27(8):1160-7 (2009); U.S. Patent Application Publication No. 2011/0145176; and U.S. Patent Application Publication No. 2013/0004482. (U.S. Patent Application Publication No. 2013/0004482 describes the application of the PAM50 classifier for screening breast cancer subjects' possible responsiveness to anthracycline therapy relying on, *inter alia*, classification of the patient tumor into the HER2 subtype by the PAM50 classifier.) The Spearman rank correlation to the basal-like gene expression centroid is determined. The Spearman rank correlation between the sample and the basal-like centroid is assigned as the Basal Centroid classifier score. The Spearman rank correlation to the Luminal A gene expression centroid is determined. The Spearman rank correlation between the sample and the Luminal A centroid is assigned as the Luminal A Centroid classifier score. The Basal Centroid classifier score and Luminal A Centroid classifier score so determined are then inserted into the equation,

$$\begin{aligned} \text{Weighted Basal and Luminal A classifier score} = \\ -0.25(\text{Basal Centroid classifier score}) + 0.27(\text{Luminal A Centroid classifier score}) \end{aligned}$$

to provide the Weighted Basal and Luminal A classifier score for the patient sample.

Samples

[00106] Samples for analysis of intrinsic subtype classification may comprise a biological sample comprising a cancer cell or tissue, such as a breast tissue sample or a primary breast tumor tissue sample. In some embodiments, the biological sample comprises breast tissue or cells. By "biological sample" is intended any sampling of cells, tissues, or bodily fluids in which expression of an intrinsic gene can be detected. Examples of such biological samples include, but are not limited to, biopsies and smears. Bodily fluids useful in the present disclosure include blood, lymph, urine, saliva, nipple aspirates, fluid from ductal lavage, gynecological fluids, or any other bodily secretion or

derivative thereof. Blood can include whole blood, plasma, serum, or any derivative of blood. In some embodiments, the biological sample includes breast cells, and may particularly comprise breast tissue from a biopsy, such as a breast tumor tissue sample. Biological samples may be obtained from a subject by a variety of techniques including, for example, by scraping or swabbing an area, by using a needle to aspirate cells or bodily fluids, or by removing a tissue sample (i.e., biopsy). Methods for collecting various biological samples are well known in the art. In some embodiments, a breast tissue sample is obtained by, for example, fine needle aspiration biopsy, core needle biopsy, or excisional biopsy. In another embodiment, fluid is obtained by ductal lavage. A thin catheter is inserted into the natural opening of the milk duct. A saline solution is then infused through the catheter to rinse the duct, which loosens cells from the duct lining. The solution containing the loosened cells is withdrawn through the catheter and biopsied. Fixative and staining solutions may be applied to the cells or tissues for preserving the specimen and for facilitating examination. In one embodiment, the biological sample is a formalin-fixed, paraffin-embedded breast tissue sample, particularly a primary breast tumor sample. In various embodiments, the tissue sample is obtained from a pathologist-guided tissue core sample.

Therapeutic Agents

[00107] Androgen receptor inhibitors directly or indirectly inhibit the androgen receptor (AR) signaling pathway. In one embodiment, direct inhibitors of the AR receptor include enzalutamide, bicalutamide (Casodex), flutamide, nilutamide, ARN509, and the like. In another embodiment, indirect inhibitors of AR include Cyp 17 inhibitors such as ketoconazole, abiraterone acetate, VN/124-1 (TOK-001), orteronel (TAK-700) and the like. In another embodiment, AR inhibitors include finasteride, galeterone, cyproterone acetate, and andarine, and the like. The antigen receptor inhibitor may result in complete or partial inhibition of the biological activity of the androgen receptor.

[00108] In a preferred embodiment, the AR inhibitor is enzalutamide (Xtandi®), which has the systematic (IUPAC) name 4-(3-(4-cyano-3-(trifluoromethyl)phenyl)-5,5-dimethyl-4-oxo-2-thioxoimidazolidin-1-yl)-2-fluoro-N-methylbenzamide, directly binds the androgen receptor (AR) and has three sites of activity. It inhibits binding of

androgens to AR, inhibits nuclear translocation of AR, and inhibits AR-mediated DNA binding.

[00109] In certain embodiments, the breast cancer treatment comprising an androgen receptor inhibitor further comprises one or more other anti-cancer agents that is not an androgen receptor inhibitor. Such non-AR inhibitor anticancer agents that may also be administered to patients in conjunction with AR inhibitor therapy include, for example, cyclophosphamide, fluorouracil (or 5-fluorouracil or 5-FU), methotrexate, thiotepa, carboplatin, cisplatin, taxanes, paclitaxel, protein-bound paclitaxel, docetaxel, vinorelbine, tamoxifen, raloxifene, toremifene, fulvestrant, gemcitabine, irinotecan, ixabepilone, temozolamide, topotecan, vincristine, vinblastine, eribulin, mutamycin, capecitabine, capecitabine, anastrozole, exemestane, letrozole, leuprolide, abarelix, buserlin, goserelin, megestrol acetate, risedronate, pamidronate, ibandronate, alendronate, denosumab, zoledronate, trastuzumab, tykerb or bevacizumab, or combinations thereof.

[00110] In one embodiment, the non-AR inhibitor anticancer agent is paclitaxel. In one embodiment, the AR inhibitor is enzalutamide and the non-AR inhibitor anticancer agent is paclitaxel. As described hereinafter, it has been found that the combination of enzalutamide and paclitaxel results in enhanced cytotoxicity in tumor cells that are positive for the prognostic marker consisting of a Weighted Basal and Luminal A classifier score of greater than -0.25.

[00111] A therapeutically effective amount of one or more AR inhibitors is administered to the subject according to the present invention, to treat TNBC utilizing dosing and treatment regimens that are typically employed when administering AR inhibitors in the treatment of cancer. The AR inhibitor can be administered in the breast cancer treatments described herein, by the routes by which such agents are typically administered. A representative regimen for one such AR inhibitor, enzalutamide, is 160 mg/day orally, once daily. The dosage form may comprise, for example, a capsule. The daily dose may be administered, for example, in the form of a capsule comprising 160 mg enzalutamide. In another embodiment, four capsules, each comprising 40 mg enzalutamide, are administered. Lower or higher doses may be utilized. The non-AR inhibitor agents are administered according to well-known dosages and treatment regimens for such agents as used in the treatment of breast cancer.

Table 1 – PAM50 Intrinsic Gene List

Gene	Genbank Accession No.	Forward Primer	SEQ ID NO:	Reverse Primer	SEQ ID NO:
ACTR3B	NM_020445 NM_001040135	AAAGATTCCTG GGACCTGA	1	TGGGGCAGTTCT GTATTACTTC	51
ANLN	NM_018685	ACAGCCACTTTC AGAAGCAAG	2	CGATGGTTTTGT ACAAGATTCTC	52
BAG1	NM_004323	CTGGAAGAGTT GAATAAAGAGC	3	GCAAATCCTTGG GCAGA	53
BCL2	NM_000633	TACCTGAACCG GCACCTG	4	GCCGTACAGTTC CACAAAGG	54
BIRC5	NM_001012271	GCACAAAGCCA TTCTAAGTC	5	GACGCTTCCTAT CACTCTATTC	55
BKVRA	BX647539	GCTGGCTGAGC AGAAAG	6	TTCCTCCATCAA GAGTTCAACA	56
CCNB1	NM_031966	CTTTCGCCTGAG CCTATTT	7	GGGCACATCCAG ATGTTT	57
CCNE1	BC035498	GGCCAAAATCG ACAGGAC	8	GGGTCTGCACAG ACTGCAT	58
CDC20	BG256659	CTGTCTGAGTGC CGTGGAT	9	TCCTTGTAATGG GGAGACCA	59
CDC6	NM_001254	GTAAATCACCTT CTGAGCCT	10	ACTTGGGATATG TGAATAAGACC	60
CDCA1	NM_031423	GGAGGCGGAAG AAACCAG	11	GGGGAAAGACA AAGTTTCCA	61
CDH3	BC041846	GACAAGGAGAA TCAAAAGATCA GC	12	ACTGTCTGGGTC CATGGCTA	62
CENPF	NM_016343	GTGGCAGCAGA TCACAA	13	GGATTTTCGTGGT GGGTTC	63

CEP55	AB091343	CCTCACGAATT GCTGAACTT	14	CCACAGTCTGTG ATAAACGG	64
CXXC5	BC006428	CATGAAATAGT GCATAGTTTGCC	15	CCATCAACATTC TCTTTATGAACG	65
EGFR	NM_005228	ACACAGAATCT ATACCCACCAG AGT	16	ATCAACTCCCAA ACGGTCAC	66
ERBB2	NM_001005862	GCTGGCTCTCAC ACTGATAG	17	GCCCTTACACAT CGGAGAAC	67
ESR1	NM_001122742	GCAGGGAGAGG AGTTTGT	18	GACTTCAGGGTG CTGGAC	68
EXO1	NM_130398	CCCATCCATGTG AGGAAGTATAA	19	TGTGAAGCCAGC AATATGTATC	69
FGFR4	AB209631	CTTCTTGGACCT TGCGC	20	TATTGGGAGGCA GGAGGTTTA	70
FOXA1	NM_004496	GCTACTACGCA GACACG	21	CTGAGTTCATGT TGCTGACC	71
FOXC1	NM_001453	GATGTTTCGAGT CACAGAGG	22	GACAGCTACTAT TCCCGTT	72
GPR160	AJ249248	TTCGGCTGGAA GGAACC	23	TATGTGAGTAAG CTCGGAGAC	73
GRB7	NM_005310	CGTGGCAGATG TGAACGA	24	AGTGGGCATCCC GTAGA	74
HSPC150 (UBE2T)	NM_014176	GGAGATCCGTC AACTCCAAA	25	AGTGGACATGCG AGTGGAG	75
KIF2C	NM_006845	TGGGTCGTGTC AGGAAAC	26	CACCGCTGGAAA CTGAAC	76
KNTC2	NM_006101	CGCAGTCATCC AGAGATGTG	27	CGTGCACATCCA TGACCTT	77
KRT14	BC042437	ACTCAGTACAA GAAAGAACCG	28	GAGGAGATGACC TTGCC	78
KRT17	AK095281	GTTGGACCAGT CAACATCTCTG	29	GCCATAGCCACT GCCACT	79

KRT5	M21389	TGTGGCTCATTA GGCAAC	30	CTTCGACTGGAC TCTGT	80
MAPT	NM_001123066	GACTCCAAGCG CGAAAAC	31	CAGACATGTTGG TATTGCACATT	81
MDM2	M92424	CCAACAAAATA TTCATGGTTCTT G	32	AGGCGATCCTGG GAAATTAT	82
MELK	NM_014791	CCAGTAGCATT GTCCGAG	33	CCCATTTGTCTG TCTTCAC	83
MIA	BG765502	GTCTCTGGTAAT GCACACT	34	CTGATGGTTGAG GCTGTT	84
MK167	NM_002417	GTGGAATGCCT GCTGACC	35	CGCACTCCAGCA CCTAGAC	85
MLPH	NM_024101	AGGGGTGCCCT CTGAGAT	36	TCACAGGGTCAA ACTTCCAGT	86
MMP11	NM_005940	CGAGATCGCCA AGATGTT	37	GATGGTAGAGTT CCAGTGATT	87
MYBL2	BX647151	AGGCGAACACA CAACGTC	38	TCTGGTCACGCA GGGCAA	88
MYC	NM_002467	AGCCTCGAACA ATTGAAGA	39	ACACAGATGATG GAGATGTC	89
NAT1	BC013732	ATCGACTGTGT AAACAAC TAGA GAAGA	40	AGTAGCTACATC TCCAGGTTCTCT G	90
ORC6L	NM_014321	TTTAAGAGGGC AATGGAAGG	41	CGGATTTTATCA ACGATGCAG	91
PGR	NM_000926	TGCCGCAGAAC TCACTTG	42	CATTTGCCGTCC TTCATCG	92
PHGDH	AK093306	CCTCAGATGAT GCCTATCCA	43	GCAGGTCAAAAC TCTCAAAG	93
PTTG1	BE904476	CAGCAAGCGAT GGCATAGT	44	AGCGGGCTTCTG TAATCTGA	94
RRM2	AK123010	AATGCCACCGA	45	GCCTCAGATTTC	95

		AGCCTC		AACTCGT	
SFRP1	BC036503	TCGAACTGAAG GCTATTTACGA G	46	CTGCTGAGAATC AAAGTGGGA	96
SLC39A6	NM_012319	GTCGAAGCCGC AATTAGG	47	GGAACAAACTGC TCTGCCA	97
TMEM45B	AK098106	CAAACGTGTGT TCTGGAAGG	48	ACAGCTCTTTAG CATTTGTGGA	98
TYMS	BQ056428	TGCCCTGTATGA TGTCAGGA	49	GGGACTATCAAT GTTGGGTTCTC	99
UBE2C	BC032677	GTGAGGGGTGT CAGCTCAGT	50	CACACAGTTCAC TGCTCCACA	100

Table 2 – PAM50 Intrinsic Gene Sequences

Gene	Genbank Accession No.	SEQ ID NO:	Gene	Genbank Accession No.	SEQ ID NO:
ACTR3B	NM_020445	101	KIF2C	NM_006845	127
	NM_001040135	102			
ANLN	NM_018685	103	KNTC2	NM_006101	128
BAG1	NM_004323	104	KRT14	BC042437	129
BCL2	NM_000633	105	KRT17	AK095281	130
BIRC5	NM_001012271	106	KRT5	M21389	131
BKVRA	BX647539	107	MAPT	NM_001123066	132
CCNB1	NM_031966	108	MDM2	M92424	133
CCNE1	BC035498	109	MELK	NM_014791	134
CDC20	BG256659	110	MIA	BG765502	135
CDC6	NM_001254	111	MK167	NM_002417	136
CDCA1	NM_031423	112	MLPH	NM_024101	137
CDH3	BC041846	113	MMP11	NM_005940	138
CENPF	NM_016343	114	MYBL2	BX647151	139
CEP55	AB091343	115	MYC	NM_002467	140
CXXC5	BC006428	116	NAT1	BC013732	141
EGFR	NM_005228	117	ORC6L	NM_014321	142
ERBB2	NM_001005862	118	PGR	NM_000926	143
ESR1	NM_001122742	119	PHGDH	AK093306	144
EXO1	NM_130398	120	PTTG1	BE904476	145
FGFR4	AB209631	121	RRM2	AK123010	146
FOXA1	NM_004496	122	SFRP1	BC036503	147

FOXC1	NM_001453	123	SLC39A6	NM_012319	148
GPR160	AJ249248	124	TMEM45B	AK098106	149
GRB7	NM_005310	125	TYMS	BQ056428	150
HSPC150 (UBE2T)	NM_014176	126	UBE2C	BC032677	151

[00112] The practice of the invention is illustrated by the following non-limiting examples.

Examples

Example 1

Clinical Study Protocol

[00113] A clinical trial was conducted to determine clinical benefit of enzalutamide treatment in patients whose tumors are androgen receptor-positive (AR+) and triple-negative. In this study, AR+ is defined as any nuclear AR staining by immunohistochemistry (IHC) and TNBC is defined as < 1% staining by IHC for estrogen receptor (ER) and progesterone receptor (PgR), 0 or 1+ by IHC for human epidermal growth factor receptor 2 (HER2), or negative for HER2 amplification by *in situ* hybridization (ISH) for 2+ IHC disease. AR staining was carried out by IHC with two different antibodies each of which were individually optimized on breast cancer tissue. Enzalutamide (160 mg/day) was administered as four 40 mg soft gelatin capsules orally once daily with or without food. Patients received enzalutamide until disease progression per Response Evaluation Criteria in Solid Tumors version 1.1 (RECIST 1.1) was documented unless treatment was discontinued due to other reasons specified in the trial protocol. The study periods included prescreening (patients could sign consent to submit to tissue for testing for AR expression at any time in their disease course); screening (28 days before first dose of study drug); treatment (day 1 through discontinuation); safety follow-up (approximately 30 days after the last dose of study drug or before initiation of a new antitumor treatment, whichever occurs first); and long-term follow-up (assessment of subsequent breast cancer therapies and survival status every 3 to 6 months after treatment discontinuation). Objective response — complete response (CR) or partial response (PR) — was determined by investigators according to the RECIST 1.1.

[00114] The trial was a Simon 2-stage study where a minimum benefit was required in a pre-defined patient population prior to expanding the study to a larger size. In Stage 1, 42 patients enrolled into the study to obtain the pre-defined 26 Evaluable patients. The requisite clinical benefit to proceed to Stage 2 was observed in Stage 1 and an additional 76 patients were enrolled for a total of 118 patients overall. Patients who received prior

treatment with an androgen receptor signaling inhibitor, who had central nervous system (CNS) metastases were excluded; there was no limit to number of prior therapies, and patients with patients measurable disease or bone-only nonmeasurable disease were eligible. Clinical Benefit Rate at 16 weeks (CBR16) was defined as the proportion of Evaluable Patients with a best response of complete remission (CR), partial response (PR) or stable disease (SD) $\geq$ 16 weeks (CBR16). The Clinical Benefit Rate at $\geq$ 24 weeks (CBR16) was also assessed.

[00115] In Stage 1, 42 patients were enrolled to get 26 Evaluable Patients (n=26). Evaluable patients were those who had both AR staining in $\geq$ 10% of tumor and at least 1 post-baseline tumor assessment. The Intent-To-Treat (ITT) population (n=42 in Stage 1) was defined as all enrolled patients who had centrally assessed AR+ TNBC and received at least 1 dose of study drug. Twenty-six (62%) of 42 ITT patients were Evaluable, while 16 of 42 were not Evaluable. Of the 16 not meeting the criteria for Evaluable, 10 had AR expression below 10%; 6 had AR expression $\geq$ 10% but did not have a post-baseline assessment (2 were discovered to have CNS metastases shortly after study entry and were withdrawn from treatment prior to having a post-baseline tumor assessment). More than 50% of the patients received enzalutamide as their first or second line of therapy, while $>$ 30% had $\geq$ 3 prior regimens before receiving enzalutamide.

Intrinsic Gene Expression Analysis

[00116] Human breast tumors from TNBC patients were obtained from the aforementioned clinical study of enzalutamide, an AR antagonist. The patient breast cancer tissue was stained for AR expression. The patient staining was graded by a pathologist on both the staining intensity (3+, 2+ and 1+) as well as the percentage of tumor cells stained as given in the standard operating procedure. AR staining was evaluated both in the nucleus and cytoplasm.

[00117] RNA-seq data utilized in this study were pre-processed as follows. The RNA-seq data was aligned to Human (Homo sapiens) genome sequence hg19 from the Human Genome Browser – hg19 Assembly created by the Genome Bioinformatics Group of UC Santa Cruz (<https://genome.ucsc.edu/cgi-bin/hgGateway?db=hg19>) (http://www.ncbi.nlm.nih.gov/assembly/GCF_000001405.25/) using MapSplice (Nucleic Acids Res. 2010 Oct;38(18):e178. doi: 10.1093/nar/gkq622). Gene and isoform level

counts were estimated using RNA-Seq by Expectation-Maximization (RSEM) (<http://deweylab.biostat.wisc.edu/rsem/>). Gene count estimates were normalized to a fixed upper quartile. The resulting normalized gene expression estimates were adjusted such that the median expression value of each gene was equivalent to the median of the triple negative subset of the TCGA RNA-seq data reported in “Comprehensive Molecular Portraits of Human Breast Tumors”, The Cancer Genome Atlas Network, *Nature* 490, 61-70 (October 4, 2012) (<http://www.nature.com/nature/journal/v490/n7418/full/nature11412.html>).

[00118] Intrinsic subtype classification was performed into the LumA, LumB, Basal, HER2 and Normal groups using the PAM50 classification model as described in Parker et al. *J Clin Oncol.*, 27(8):1160-7 (2009). The intrinsic subtype classification was carried out on genomic data obtained from RNA sequencing of RNA obtained from formalin fixed, paraffin embedded tissue collected from subjects' breast tumors. The data was pre-processed as indicated above. Subtype classification was performed on a “Training and Test” set and a further “Validation” set. The Training and Test set consisted of 122 patient samples out of which 42 patients were from the pre-screened population but not enrolled in the study and 80 patients samples were from the enrolled population in the clinical study. The Validation set consisted of 55 patient samples which had 15 patients from the pre-screened population not enrolled on the study and 40 samples from the enrolled population.

[00119] The data was analyzed according to the known methods for analyzing PAM50 intrinsic gene set data, as described by Parker *et al. et al.*, *supra*. Essentially, the detection and estimation of the expression of the set of 50 subtype predictor genes of Table 1 from patient tumor samples was carried out. The expression profile of the set of 50 subtype predictor genes by the described method that provides Basal-like, HER2, LumA, LumB and Normal subtype classifications was analyzed. The Spearman correlation was calculated for each sample and PAM50 centroid. These values were used as continuous estimates of distance or similarity of a sample to each centroid. The subtype of each sample was assigned as the closest (largest positive correlation) centroid. The underlying measures of correlation to each subtype were used to classify a sample as one of 4 tumor subtypes (Basal-like, HER2, LumA and LumB) or Normal-like.

[00120] Further, the Spearman rank correlation to the Basal-like gene expression centroid was evaluated. The Spearman rank correlation between the sample and the Basal-like centroid was assigned as the “Basal Centroid classifier score”. The Spearman rank correlation to the Luminal A gene expression centroid was evaluated. The Spearman rank correlation between the sample and the Luminal A centroid was assigned as the “Luminal A classifier score”.

[00121] In the enrolled patients (Intent-To-Treat (ITT) population, Basal-like subtype generally correlated with non-response to enzalutamide therapy, while existence of one of the other subtypes generally correlated with response to enzalutamide therapy. See Fig. 1, wherein “Diagnostic -” represents the Basal-like subtype patients and “Diagnostic +” represents the patients with Her2, LumA, LumB or Normal subtypes. Thus, a PAM50 gene expression classifier result indicating a non-Basal-like tumor type is a marker for predicting responsiveness to enzalutamide therapy in TNBC.

Example 2

The results of the clinical study of Example 1 were further analyzed utilizing the patient Basal Centroid classifier scores. The therapeutic response data was evaluated imposing a series of threshold cut-offs on the Basal Centroid classifier score. The enzalutamide response/non-response data was analyzed using Basal Centroid classifier score cut-offs of 0.2, 0.3, 0.4, 0.5, 0.6, 0.65, 0.7, 0.8 and 0.9. The data is set forth in Figures 2A/B through 10A/B. In each figure, “Diagnostic +” represents patients whose samples met the indicated prognostic signature comprising the indicted threshold cut-off. “Diagnostic -” represents patients whose samples did not meet the indicated threshold cut-off.

Fig.	2A/B	3A/B	4A/B	5A/B	6A/B	7A/B	8A/B	9A/B	10A/B
Basal Centroid classifier score	0.2	0.3	0.4	0.5	0.6	0.65	0.7	0.8	0.9

[00122] As shown in Figures 2A/B - 10A/B, a target Basal Centroid classifier score of 0.6 or less for defining Dx+ and Dx- patients best correlated with response to enzalutamide therapy, while defining the Dx+ and Dx- based upon scores from 0.2 to 0.9 enriched the predictive value somewhat less. Thus, defining the population of responders

and non-responders upon a Basal Centroid classifier cutoff score that is in the range of 0.2-0.9 is a further basis for predicting responsiveness to enzalutamide therapy in TNBC, with a sample's Basal Centroid classifier score of 0.6 or less being a preferred embodiment for a marker to predict responsiveness. As shown in Figure 6A, defining Dx+ and Dx- pursuant to a relative Basal Centroid classifier score of 0.6 resulted in a prediction that yielded a large Diagnostic + population with most responders in the Diagnostic + population and high non-responders in the Diagnostic – population.

Example 3

[00123] The results of the clinical study of Example 1 are further analyzed and summarized in Fig. 11, showing the response of various patient subgroups to enzalutamide therapy in terms of Clinical Benefit Rate at ≥ 24 weeks (CBR24). The subgroups include all Intent-To-Treat (ITT) patients; Evaluable Patients; patients with breast tumor tissue which was AR staining $\geq 10\%$ (IHC AR $\geq 10\%$); patients whose breast tumor tissue was classified as a non-Basal like subtype by the PAM50 subtype classifier (PAM50 non-basal); patients whose tumors were classified as Basal like subtype (PAM50 basal); and patient samples analyzed by applying the indicated cut-offs of <0.6 , ≥ 0.6 , <0.7 , ≥ 0.7 , <0.75 , ≥ 0.75 to the Basal Centroid classifier score. "DX -" signifies patients whose samples did not meet the indicated threshold cut-off. "DX +" signifies patients whose samples did meet the indicated threshold cut-off. Also shown in in Fig 11 are data for the samples satisfying the combined criteria IHC AR $\geq 10\%$ and DX+ <0.6 , that is the sample met the criteria of (i) staining for AR of more than 10% and (ii) a PAM50 gene expression Basal Centroid classifier score of 0.6 or less.

Example 4

[00124] The results of the clinical study of Example 1 are further analyzed and summarized in Fig. 12, showing the response of various patient subgroups to enzalutamide therapy in terms of Clinical Benefit Rate at ≥ 24 weeks (CBR24). The subgroups include all Intent-To-Treat (ITT) patients; Evaluable Patients; patients with breast tumor tissue which was AR staining $\geq 10\%$ (IHC AR $\geq 10\%$); and patients in which the enzalutamide therapy is the sole (1st line) or second (2nd line) of therapy. The subgroups further include subgroup of patient samples analyzed by applying a <0.6 Basal

Centroid classifier score cut-off (“Novel DX+,”), and a subgroup comprising samples from 1st and 2nd line therapy, applying the <0.6 cut-off. A CBR of 42% using the prognostic Basal Centroid classifier score of <0.6 (and 60% when used in a group comprising both 1st line and 2nd line patients) exceeds typical benchmarks for predicting responsiveness to therapy in TNBC and is on a par with the predictive ability of models used to predict response to hormonal agent therapy in ER+/PgR+ breast cancer.

Example 5

[00125] The effect of the novel prognostic signature utilizing a Basal Centroid classifier score of <0.6 as a predictor of response to AR inhibitor therapy is further illustrated in Fig. 13 with respect to patient progression-free survival time to 56 weeks. The results demonstrate a prolonged progression-free survival in patients that were identified as meeting the novel prognostic signature condition of a Basal Centroid classifier score of <0.6 (“Novel DX Pos”) versus patients having a ≥ 0.6 distance score (“Novel DX Neg”).

Example 6

[00126] The results of the clinical study of Example 1 were further analyzed utilizing the patient Basal Centroid classifier and Luminal A classifier scores. The classifier scores and response data were analyzed. As a result of analysis, a Weighted Basal and Luminal A classifier score was empirically devised that predicted responsiveness to androgen receptor inhibitor therapy in the clinical trial. The Weighted Basal and Luminal A classifier score of patient samples was determined from the following formula:

$$\text{Weighted Basal and Luminal A classifier score} = -0.2468275(\text{Basal Centroid classifier score}) + 0.2667110(\text{Luminal A Centroid classifier score}).$$

[00127] The therapeutic response data was then evaluated imposing a series of threshold cut-offs on the Weighted Basal and Luminal A classifier score. Specifically, the enzalutamide response/non-response data was analyzed using Weighted Basal and Luminal A classifier score cut-offs of greater than -0.2, greater than -0.25, greater than -0.3 and greater than -0.35. The data is set forth in Figs. 14A (> -0.2), 14B (> -0.25), 14C (> -0.3), and 14D (> -0.35). In each figure, “Diagnostic +” represents patients whose samples met the indicated prognostic signature comprising the indicated threshold cut-off.

“Diagnostic -” represents patients whose samples did not meet the indicated threshold cut-off.

[00128] As shown in Figures 14A-14D, selecting a criterion of a Weighted Basal and Luminal A classifier of greater than x , with x in the range of -0.2 to -0.3, best correlated with response to enzalutamide therapy, with the criterion of a score of greater than -0.25 being optimal. Thus, defining the population of responders and non-responders based upon a Weighted Basal and Luminal A classifier score that is greater than -0.2, or greater than -0.3 is a basis for predicting responsiveness to enzalutamide therapy in TNBC, with a Weighted Basal and Luminal A classifier score of greater than -0.25 being a preferred embodiment of a criterion for predicting responsiveness.

Example 7

[00129] The results of the clinical study of Example 1 are further analyzed and summarized in Fig. 15, showing the response of various patient subgroups to enzalutamide therapy in terms of Clinical Benefit Rate at ≥ 24 weeks (CBR24). The subgroups include all Intent-To-Treat (ITT) patients; Evaluable Patients; patients whose breast tumor tissue samples were analyzed by applying the indicated cut-offs of >-0.2 , >-0.25 , >-0.3 , and >-0.35 , to the Weighted Basal and Luminal A classifier score. “PR-AR DX -” signifies patients whose samples did not meet the indicated threshold cut-off. “PR-AR DX +” signifies patients whose samples did meet the indicated threshold cut-off. Thus, for example, “PR-AR DX + >-0.25 ” indicates the patients whose samples met the criterion of a Weighted Basal and Luminal A classifier score greater than -0.25.

[00130] Also shown in in Fig. 15 are data for samples from patients in the study receiving enzalutamide therapy (i) after having received from zero to one prior therapies for treatment of TNBC with a drug other than an androgen receptor inhibitor (“and 0-1 prior therapy”) or (ii) after having received two or more prior therapies for treatment of TNBC with a drug other than an androgen receptor inhibitor (“and ≥ 2 prior therapies”). A Weighted Basal and Luminal A classifier score cut-off of >-0.25 was applied to these patient samples.

Example 8

[00131] The effect of the novel prognostic signature utilizing a Weighted Basal and Luminal A classifier score cut-off of >-0.2 as a predictor of response to AR inhibitor therapy is further illustrated in Fig. 16 with respect to patient progression-free survival time to 56 weeks. The results demonstrate a prolonged progression-free survival in patients that were identified as meeting the prognostic signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.2 ("PR-AR DX+: > -0.2 ", top curve) versus a classifier score of less than or equal to -0.2 ("PR-AR DX-: ≤ -0.2 ", bottom curve).

Example 9

[00132] The effect of the novel prognostic signature utilizing a Weighted Basal and Luminal A classifier score cut-off of >-0.25 as a predictor of response to AR inhibitor therapy is further illustrated in Fig. 17 with respect to patient progression-free survival time to 56 weeks. The results demonstrate a prolonged progression-free survival in patients that were identified as meeting the prognostic signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.25 ("PR-AR DX+: > -0.25 ", top curve) versus less than or equal to -0.25 ("PR-AR DX-: ≤ -0.25 ", bottom curve).

Example 10

[00133] The effect of the novel prognostic signature utilizing a Weighted Basal and Luminal A classifier score cut-off of >-0.3 as a predictor of response to AR inhibitor therapy is further illustrated in Fig. 18 with respect to patient progression-free survival time to 56 weeks. The results demonstrate a prolonged progression-free survival in patients that were identified as meeting the prognostic signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.3 ("PR-AR DX+: > -0.3 ", top curve) versus a classifier score of less than or equal to -0.3 ("PR-AR DX-: ≤ -0.3 ", bottom curve).

Example 11

[00134] The effect of the novel prognostic signature utilizing a Weighted Basal and Luminal A classifier score cut-off of >-0.35 as a predictor of response to AR inhibitor therapy is further illustrated in Fig. 19 with respect to patient progression-free survival

time to 56 weeks. The results demonstrate a prolonged progression-free survival in patients that were identified as meeting the prognostic signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.35 ("PR-AR DX+: > -0.35", top curve) versus less than or equal to -0.35 ("PR-AR DX-: <= -0.35", bottom curve).

Example 12

[00135] The effect of the novel prognostic signature utilizing a Weighted Basal and Luminal A classifier score cut-off of >-0.25 as a predictor of response to AR inhibitor therapy is further illustrated in Fig. 20 with respect to patient progression-free survival time to 56 weeks, in patients receiving from zero to one prior therapies for treatment of TNBC with a drug other than an androgen receptor inhibitor. The results demonstrate a prolonged progression-free survival in patients that were identified as meeting the prognostic signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.25 ("PR-AR DX+: > -0.25", top curve) versus less than or equal to -0.25 ("PR-AR DX-: <= -0.25", bottom curve). It may be appreciated from a comparison of Figs. 17 and 20, that the -0.25 cut-off was able to identify a longer duration of progression-free survival that characterized the zero to 1 prior therapy group (Fig. 20) versus the shorter duration of progression-free survival that characterized the population of all study patients (Fig. 17).

[00136] The effect of the novel prognostic signature utilizing a Weighted Basal and Luminal A classifier score cut-off of >-0.25 as a predictor of response to AR inhibitor therapy in patients receiving from zero to one prior therapies for treatment of TNBC with a drug other than an androgen receptor inhibitor is further shown in Fig. 23. Fig. 23 is similar to Fig. 20, except that the progression-free survival time in the study is determined beyond the 56 weeks in Fig. 20 to 64 weeks in Fig. 23.

Example 13

[00137] The effect of the novel prognostic signature utilizing a Weighted Basal and Luminal A classifier score cut-off of >-0.25 as a predictor of response to AR inhibitor therapy is further illustrated in Figs. 21A and 21B, with respect to time on treatment without progression of patients receiving zero or one (0-1 Prior Lines), or two or more (2+ Prior Lines), prior therapies for treatment of TNBC with a drug other than an

androgen receptor inhibitor. The 56 patients that were identified as meeting the signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.25 are represented in Fig. 21B. The 62 study patients identified by a classifier score of less than or equal to -0.25 are identified in Fig. 21A. Each bar in the figures represents a single patient. The best time on treatment without disease progression is apparent in responder patients who received one or no prior lines of therapy (Fig. 21B). Patient bars marked with a triangle (“Active”) are active on study. Patient bars marked with a star signify complete response (CR) or partial response (PR).

Example 14

[00138] The effect of the novel prognostic signature utilizing a Weighted Basal and Luminal A classifier score cut-off of >-0.25 as a predictor of response to AR inhibitor therapy is further illustrated in Figs. 22A and 22B with respect to patient progression-free survival time to 64 weeks (Fig. 22A) and overall survival to 84 weeks (Fig. 22B). The results of Fig. 22A demonstrate a prolonged progression-free survival in patients that were identified as meeting the prognostic signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.25 (“PR-AR DX+: >-0.25 ”, top curve) versus less than or equal to -0.25 (“PR-AR DX-: ≤ -0.25 ”, bottom curve). The results of Fig. 22B demonstrate a prolonged overall survival in patients that were identified as meeting the prognostic signature condition of a Weighted Basal and Luminal A classifier score of greater than -0.25 (“PR-AR DX+: >-0.25 ”, top curve) versus less than or equal to -0.25 (“PR-AR DX-: ≤ -0.25 ”, bottom curve). The patients not meeting the prognostic signature condition were characterized by a median progression-free survival of 8.1 weeks and median overall survival of 32.1 weeks. In contrast, patients meeting the prognostic signature condition were characterized by a median progression-free survival of 16.1 weeks and median overall survival not yet reached at 84 weeks.

Example 15

[00139] A Phase II clinical trial of the androgen receptor antagonist bicalutamide has been reported. Ayca *et al.*, “Phase II Trial of Bicalutamide in Patients with Androgen Receptor Positive, Hormone Receptor Negative Metastatic Breast Cancer”, *Clin Cancer Res* 19: 5505-5512 (October 1, 2013). The trial was designed to study the effect of

bicalutamide in treating metastatic breast cancer that is AR-positive, estrogen receptor (ER)-negative, and progesterone receptor (PgR)-negative.

[00140] Briefly, as described by Ayca *et al.*, tumors from 452 patients with ER-negative/PgR-negative advanced breast cancer were tested centrally for AR by immunohistochemistry (IHC) (> 10% nuclear staining considered positive). *See Ayca et al.*, p. 5506 for additional eligibility criteria. If either the primary or a metastatic site was positive, patients were eligible to receive the AR antagonist bicalutamide at a dose of 150 mg daily. Twenty-eight patients were treated on study. Bicalutamide 150 mg was administered orally on a continuous daily schedule. Patients were treated until disease progression or unacceptable adverse events. A maximum of 2 dose reductions for grade ≥ 3 toxicity were allowed (100 and 50 mg). A maximum of 2 weeks was permitted for treatment delays due to toxicity. Two patients who initiated bicalutamide were removed from study, leaving 26 study participants with AR(+) ER/PgR(-) metastatic breast cancer. Five patients had stable disease >6 months (number of cycles completed: 6, 8, 10+, 13, 57+) as their best response on treatment. There were no confirmed complete or partial responses yielding a clinical benefit rate of 19% (95% CI, 7%–39%) in the target population (n = 26). In an intention-to-treat analysis, a CBR of 18% (95% CI, 6%–37%) was observed. *See Ayca et al.*, p. 5507.

[00141] Twenty-one of the 26 bicalutamide-treated study patients were determined to also be HER-2 negative, *i.e.*, twenty-one patients had breast cancers that were triple negative (Her-2(-), ER (-) and PgR(-)). Following the study, patient tumor samples from the twenty-one TNBC patients that received bicalutamide therapy were subjected to intrinsic subtype classification into the Luminal A, Luminal B, Basal-like, HER2-enriched and Normal-like groups using the PAM50 classification model. Each subtype score for each sample is listed in Table 3. Also set forth in Table 3 is the Weighted Basal and Luminal A classifier score of each sample. Based on the results obtained in Example 6 from the clinical trial of the AR-receptor antagonist enzalutamide, a greater than -0.25 Weighted Basal and Luminal A classifier score (“PR-AR DX + > -0.25”) indicates that such patients are more likely to respond to the bicalutamide treatment than patients with a Weighted Basal and Luminal A classifier score of less than or equal to -0.25. Eight patients satisfied this criterion, and are designated in Table 3 as having a likely positive

("POS") prognosis on bicalutamide treatment. Each of the 21 patient samples displayed a confidence level of 1, except for sample No. 16, which had a confidence level of 0.99.

Table 3

No.	Basal Score	Her2 Score	LumA Score	LumB Score	Normal Score	Weighted Basal/LumA Score	Prognosis
1	0.542569	-0.02857	-0.59846	0.242161	-0.25186	-0.29354	NEG
2	0.405618	-0.17714	-0.11635	-0.30343	0.296423	-0.13115	POS
3	0.509628	0.038367	-0.3915	-0.20711	0.059208	-0.23021	POS
4	0.753469	0.003025	-0.59088	-0.28912	0.055078	-0.34357	NEG
5	0.766146	-0.00543	-0.69729	-0.08581	-0.07851	-0.37508	NEG
6	0.638896	-0.34665	-0.22439	-0.54103	0.447779	-0.21755	POS
7	0.75078	0.112509	-0.7188	-0.01945	-0.11001	-0.37702	NEG
8	0.795342	0.039808	-0.66511	-0.22968	0.052293	-0.37371	NEG
9	0.793421	-0.06708	-0.59818	-0.372	0.158127	-0.35538	NEG
10	0.699496	-0.23275	-0.43616	-0.26617	0.192221	-0.28898	NEG
11	0.634478	-0.15333	-0.33906	-0.49273	0.304298	-0.24704	POS
12	0.729556	-0.15188	-0.48984	-0.35529	0.206531	-0.31072	NEG
13	0.72110	0.01522	-0.66387	-0.074	-0.03558	-0.35505	NEG

	4	2					
14	0.74741 9	-0.26098	-0.42406	-0.40687	0.25541 4	-0.29758	NEG
15	0.70208 9	-0.04	-0.53719	-0.25522	0.09541 4	-0.31657	NEG
16	0.16110 4	-0.10146	-0.01647	-0.29834	0.38372 1	-0.04416	POS
17	0.57147 7	-0.12826	-0.27549	-0.34146	0.26002 4	-0.21453	POS
18	0.39918 4	-0.03741	-0.21268	-0.22113	0.09070 8	-0.15525	POS
19	0.62208 9	-0.18588	-0.31313	-0.58329	0.43174 1	-0.23706	POS
20	0.75279 7	-0.13546	-0.55064	-0.40072	0.16100 8	-0.33267	NEG
21	0.73656 7	-0.1346	-0.58339	-0.24216	0.08273 7	-0.3374	NEG

Example 16

[00142] The following study demonstrates the enhanced antitumor effect of the combination of enzalutamide plus paclitaxel in cells positive for the prognostic marker of a Weighted Basal and Luminal A classifier score greater than -0.25.

[00143] Triple negative breast cancer cell lines BT549, MDA-MB-436, MDA-MB-453 were selected for study. Messenger RNA datasets for the cell lines were down-loaded from the Cancer Cell Line Encyclopedia (CCLE) database. The Weighted Basal and Luminal A classifier score for each cell line was determined from the downloaded datasets. Applying a Weighted Basal and Luminal A classifier score of >-0.25 as a prognostic marker for responsiveness to AR inhibitor therapy, it was determined that MDA-MB-453, but not BT549 and MDA-MB-436, satisfied this criterion.

[00144] Cells were maintained in 10% FBS supplemented growth media. Viability assays were performed in 10% FBS, and measured by CellTiter-Glo reagent according to

the manufacturer's protocol (Promega). To determine molecular effects of enzalutamide alone or in combination with paclitaxel on androgen receptor signaling, cells (BT549, MDA-MB-436 or MDA-MB-453) were seeded on day one in 10% FBS. The cells were treated with enzalutamide or paclitaxel or the combination in 2% charcoal-stripped serum and were stimulated with 10nM DHT for 4 hours. Cell fractionation was isolated for cytosolic and nuclear fractions. Protein expression levels were determined using a Western blotting method. The IC₅₀ for enzalutamide or paclitaxel for each cell line is shown in Table 4. Mean values are presented for each cell line (n= 3). The prognostic marker-positive MDA-MB-453 cells exhibited greater sensitivity to enzalutamide compared to the prognostic marker-negative BT549 and MDA-MB-463 cells.

Table 4

Cell Line	Enzalutamide IC ₅₀ (μM)	Paclitaxel IC ₅₀ (nM)
BT549	57.0	2.8
MDA-MB-436	73.0	6.7
MDA-MB-453	22.7	20.7

[00145] Viability of the cells was measured in the presence of the concentrations of enzalutamide (Enza) and paclitaxel (PTX) in Figs. 24A-C. Mean values are presented for each cell line (n=5). In the prognostic marker-positive MDA-MB-453 cell line, the combination of enzalutamide plus paclitaxel resulted in enhanced cytotoxicity. See Fig. 24C.

Example 17

[00146] To generate a mouse xenograft model, 5- to 6-week-old female NOD-SCID mice were injected orthotopically into the mammary gland with 6.0×10^6 MDA-MB-453 cells. DHT (10.5 mg in a 60-day release pellet) or control pellets were implanted into animals. When tumor size reached $\sim 100 \text{ mm}^3$, mice were treated by (i) oral gavage (PO) with enzalutamide ("Enza") at 3 mg/kg/day (n=10), (ii) paclitaxel ("PTX") at 6 mg/kg QMWF (IP) (n=7), or (iii) the combination of (i) and (ii) (n=10). A control group of mice (n=8) was treated with vehicle (0.5% Methocel solution). Tumor size was measured by caliper. Tumor weights were determined at day 35. The results are shown in Fig. 25A

(tumor volume vs. time) and Fig. 25B (tumor weight). Data points in Fig. 25A represent the average tumor volume for each group, and error bars reflect the SEM of the data. The student T-Test was used to calculate p values: Fig. 25A: control v. enzalutamide, 0.007; control v. paclitaxel, 0.0007; enzalutamide vs. enzalutamide plus paclitaxel, 0.074; paclitaxel vs. enzalutamide plus paclitaxel, 0.013. Fig. 25B: control v. enzalutamide, 0.001; control v. paclitaxel, 0.0001; enzalutamide vs. enzalutamide plus paclitaxel, 0.08; paclitaxel vs. enzalutamide plus paclitaxel, 0.017. The data demonstrates that the combination of enzalutamide plus paclitaxel results in enhanced antitumor effect compared to either drug alone.

[00147] Representative tumors from each treated group were selected to perform immunohistochemistry against AR, Ki67 or p-AKT. Immunohistochemistry staining for Ki67 or AKT phosphorylation was significantly reduced in the enzalutamide plus paclitaxel tumors compared to the enzalutamide or paclitaxel single treated group (data not shown).

[00148] The disclosures of each and every patent, patent application, and publication cited herein are hereby incorporated herein by reference in their entirety. One skilled in the art will readily appreciate that the present invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. While the invention has been disclosed with reference to specific embodiments, it is apparent that other embodiments and variations of this invention may be devised by others skilled in the art without departing from the true spirit and scope used in the practice of the invention. The appended claims are intended to be construed to include all such embodiments and equivalent variations.

Claims

1. A method of screening a treatment for triple negative breast cancer comprising the use of an androgen receptor inhibitor, the method comprising assaying a biological sample obtained from a subject to determine whether the biological sample obtained from the subject is classified as basal-like subtype or another subtype.

2. The method according to claim 1, wherein assaying the biological sample to determine whether the biological sample is classified as a basal-like subtype or another subtype is performed by detecting the expression of the set of intrinsic genes listed in Table 1.

3. The method according to claim 2, comprising:

(a) determining the Basal Centroid classifier score of the sample from the expression of the set of intrinsic genes listed in Table 1;

(b) determining the Luminal A Centroid classifier score of the sample from the expression of the set of intrinsic genes listed in Table 1; and

(c) calculating a Weighted Basal and Luminal A classifier score from the Basal Centroid classifier score and the Luminal A Centroid classifier score according to the following equation:

$$\text{Weighted Basal and Luminal A classifier score} = -0.25(\text{Basal Centroid classifier score}) + 0.27(\text{Luminal A Centroid classifier score})$$

wherein if the Weighted Basal and Luminal A classifier score is greater than -0.3, the breast cancer treatment comprising an androgen receptor inhibitor is more likely to be effective in the subject than if the Weighted Basal and Luminal A classifier score is less than or equal to -0.3.

4. The method according to claim 3, wherein if the Weighted Basal and Luminal A classifier score is greater than -0.2, the breast cancer treatment comprising an androgen receptor inhibitor is more likely to be effective in the subject than if the Weighted Basal and Luminal A classifier score is less than or equal to -0.2.

5. The method according to claim 4, wherein if the Weighted Basal and Luminal A classifier score is greater than -0.25, the breast cancer treatment comprising an androgen receptor inhibitor is more likely to be effective in the subject than if the Weighted Basal and Luminal A classifier score is less than or equal to -0.25.

6. The method according to claim 2, comprising determining the Basal Centroid classifier score of the sample from the expression of the set of intrinsic genes listed in Table 1, wherein if the Basal Centroid classifier score is less than or equal to 0.9, the breast cancer treatment comprising an androgen receptor inhibitor is likely to be more effective in treating the subject than if the Basal Centroid classifier score is greater than 0.9.

7. The method according to claim 6, wherein if the Basal Centroid classifier score is less than or equal to 0.6, the breast cancer treatment comprising an androgen receptor inhibitor is likely to be effective in treating the subject.

8. The method according to claim 6, wherein if the Basal Centroid classifier score is in the range from 0.2 to 0.8, the breast cancer treatment comprising an androgen receptor inhibitor is likely to be effective in treating the subject.

9. The method according to claim 8, wherein if the Basal Centroid classifier score is in the range from 0.4 to 0.7, the breast cancer treatment comprising an androgen receptor inhibitor is likely to be effective in treating the subject.

10. The method according to any of claims 1 to 9, wherein the breast cancer of the subject is characterized by the presence of androgen receptor-positive tumor cells.

11. The method according to any of claims 1 to 10, wherein the biological sample is selected from the group consisting of a cell, tissue and bodily fluid.

12. The method according to claim 11, wherein the biological sample comprises breast tissue or cells.
13. The method according to claim 11, wherein the tissue is obtained from a biopsy.
14. The method according to claim 11, wherein the bodily fluid is selected from the group consisting of blood, lymph, urine, saliva, fluid from ductal lavage, and nipple aspirate.
15. An androgen receptor inhibitor for use in the treatment of a triple negative breast cancer in a subject wherein a biological sample from the subject has been assayed to determine whether the sample is classified as basal-like subtype or another subtype.
16. The use of an inhibitor according to claim 15, wherein assaying the biological sample to determine whether the biological sample is classified as a basal-like subtype or another subtype is performed by detecting the expression of the intrinsic genes listed in Table 1.
17. The use of an inhibitor according to claim 16, comprising determining the Basal Centroid classifier score and the Luminal A Centroid classifier score of the sample from the expression of the set of intrinsic genes listed in Table 1 and calculating a Weighted Basal and Luminal A classifier score from the Basal Centroid classifier score and the Luminal A Centroid classifier score according to the following equation:
- $$\text{Weighted Basal and Luminal A classifier score} = -0.25(\text{Basal Centroid classifier score}) + 0.27(\text{Luminal A Centroid classifier score})$$
- wherein the breast cancer treatment is administered to the subject if the Weighted Basal and Luminal A classifier score greater than -0.3.
18. The use of an inhibitor according to claim 17, wherein the breast cancer treatment is administered if the Weighted Basal and Luminal A classifier score is greater than -0.2.

19. The use of an inhibitor according to claim 18, wherein the breast cancer treatment is administered if the Weighted Basal and Luminal A classifier score is greater than -0.25.

20. The use of an inhibitor according to claim 16, comprising determining the Basal Centroid classifier score of the sample from the expression of the set of intrinsic genes listed in Table 1, wherein the breast cancer treatment is administered if the Basal Centroid classifier score is less than or equal to 0.9.

21. The use of an inhibitor according to claim 20, wherein the breast cancer treatment is administered if the Basal Centroid classifier score is less than or equal to 0.6.

22. The use of an inhibitor according to claim 20, wherein the breast cancer treatment is administered if the Basal Centroid classifier score is in the range from 0.2 to 0.8.

23. The use of an inhibitor according to claim 22, wherein the breast cancer treatment is administered if the Basal Centroid classifier score is in the range from 0.4 to 0.7.

24. The use of an inhibitor according to any of claims 15 to 23, wherein the breast cancer of the subject is characterized by the presence of androgen receptor-positive tumor cells.

25. The use of an inhibitor according to any of claims 15 to 24, wherein the androgen receptor inhibitor is selected from the group consisting of enzalutamide, bicalutamide, flutamide, nilutamide, ARN509, ketoconazole, abiraterone acetate, VN/124-1 (TOK-001), orteronel (TAK-700), finasteride, galeterone, cyproterone acetate, andarine and combinations thereof.

26. The use of an inhibitor according to claim 25, wherein the androgen receptor inhibitor is enzalutamide.

27. The use of an inhibitor according to claim 26, wherein the enzalutamide is orally administered once daily at a dose of 160 mg.

28. The use of an inhibitor according to claim 27, wherein the enzalutamide is administered as a single capsule comprising 160 mg enzalutamide.

29. The use of an inhibitor according to claim 27, wherein the enzalutamide is administered as four capsules, each capsule comprising 40 mg enzalutamide.

30. The use of an inhibitor according to any of claims 15 to 29, wherein the breast cancer treatment comprising an androgen receptor inhibitor further comprises one or more other anti-cancer agents that is not an androgen receptor inhibitor.

31. The use of an inhibitor according to claim 30, wherein the one or more other anti-cancer agent that is not an androgen receptor inhibitor is selected from the group consisting of cyclophosphamide, fluorouracil, 5-fluorouracil, methotrexate, thiotepa, carboplatin, cisplatin, taxanes, paclitaxel, protein-bound paclitaxel, docetaxel, vinorelbine, tamoxifen, raloxifene, toremifene, fulvestrant, gemcitabine, irinotecan, ixabepilone, temozolamide, topotecan, vincristine, vinblastine, eribulin, mutamycin, capecitabine, capecitabine, anastrozole, exemestane, letrozole, leuprolide, abarelix, buserlin, goserelin, megestrol acetate, risidronate, pamidronate, ibandronate, alendronate, denosumab, zoledronate, trastuzumab, tykerb or bevacizumab, and combinations thereof.

32. The use according to claim 31 wherein the other anti-cancer agent that is not an androgen receptor inhibitor is paclitaxel.

33. The use of an inhibitor according to any of claims 15 to 32, wherein the biological sample is selected from the group consisting of a cell, tissue and bodily fluid.

34. The use of an inhibitor according to claim 33, wherein the biological sample comprises breast tissue or cells.

35. The use of an inhibitor according to claim 33, wherein the tissue is obtained from a biopsy.

36. The use of an inhibitor according to claim 33, wherein the bodily fluid is selected from the group consisting of blood, lymph, urine, saliva, fluid from ductal lavage, and nipple aspirate.

37. A method of treating triple negative breast cancer in a subject, said subject having a breast cancer comprising breast cancer cells that have been classified as other than basal-like subtype, said method comprising administering a breast cancer treatment to the subject comprising an androgen receptor inhibitor, thereby treating the triple negative breast cancer in the subject.

38. The method according to claim 37, wherein the breast cancer cells of the subject are characterized by a Weighted Basal and Luminal A classifier score greater than -0.3 according to the formula:

$$\text{Weighted Basal and Luminal A classifier score} = \\ -0.25(\text{Basal Centroid classifier score}) + 0.27(\text{Luminal A Centroid classifier score})$$

wherein said Basal Centroid classifier score and said Luminal A Centroid classifier score are determined for the breast cancer cells of the subject from the expression by said cells of the set of intrinsic genes listed in Table 1.

39. The method according to claim 38, wherein the breast cancer cells of the subject are characterized by a Weighted Basal and Luminal A classifier score greater than -0.2.

40. The method according to claim 39, wherein the breast cancer cells of the subject are characterized by a Weighted Basal and Luminal A classifier score greater than -0.25.

41. The method according to claim 37, wherein the breast cancer cells of the subject are characterized by a Basal Centroid classifier score of less than or equal to 0.9, determined from the expression by said cells of the set of intrinsic genes listed in Table 1.

42. The method according to claim 41, wherein the breast cancer cells of the subject are characterized by a Basal Centroid classifier score of less than or equal to 0.6.

43. The method according to claim 41, wherein the breast cancer cells of the subject are characterized by a Basal Centroid classifier score is in the range from 0.2 to 0.8.

44. The method according to claim 43, wherein the breast cancer cells of the subject are characterized by a Basal Centroid classifier score is in the range from 0.4 to 0.7.

45. The method according to any of claims 37 to 44, wherein the breast cancer of the subject is characterized by the presence of androgen receptor-positive tumor cells.

46. The method according to any of claims 37 to 45, wherein the androgen receptor inhibitor is selected from the group consisting of enzalutamide, bicalutamide, flutamide, nilutamide, ARN509, ketoconazole, abiraterone acetate, VN/124-1 (TOK-001), orteronel (TAK-700), finasteride, galeterone, cyproterone acetate, andarine and combinations thereof.

47. The method according to claim 46, wherein the androgen receptor inhibitor is enzalutamide.

48. The method according to claim 47, wherein the enzalutamide is orally administered once daily at a dose of 160 mg.

49. The method according to claim 48, wherein the enzalutamide is administered as a single capsule comprising 160 mg enzalutamide.

50. The method according to claim 48, wherein the enzalutamide is administered as four capsules, each capsule comprising 40 mg enzalutamide.

51. The method according to any of claims 37 to 50, wherein the breast cancer treatment comprising an androgen receptor inhibitor further comprises one or more other anti-cancer agents that is not an androgen receptor inhibitor.

52. The method according to claim 51, wherein the other anti-cancer agent that is not an androgen receptor inhibitor is selected from the group consisting of cyclophosphamide, fluorouracil, 5-fluorouracil, methotrexate, thiotepa, carboplatin, cisplatin, taxanes, paclitaxel, protein-bound paclitaxel, docetaxel, vinorelbine, tamoxifen, raloxifene, toremifene, fulvestrant, gemcitabine, irinotecan, ixabepilone, temozolamide, topotecan, vincristine, vinblastine, eribulin, mutamycin, capecitabine, capecitabine,

anastrozole, exemestane, letrozole, leuprolide, abarelix, buserlin, goserelin, megestrol acetate, risedronate, pamidronate, ibandronate, alendronate, denosumab, zoledronate, trastuzumab, tykerb or bevacizumab, and combinations thereof.

53. The method according to claim 52 wherein the other anti-cancer agent that is not an androgen receptor inhibitor is paclitaxel.

54. The method according to claim 37, further comprising a step of testing the subject to determine whether the subject has a breast cancer comprising breast cancer cells that are other than basal-like subtype.

55. The method according to any of claims 38 to 40, further comprising a step of testing the subject to determine the Weighted Basal and Luminal A classifier score of breast cancer cells of the subject.

56. The method according to any of claims 41 to 44, further comprising a step of testing the subject to determine the Basal Centroid classifier score of breast cancer cells of the subject.

57. The method according to claim 40, wherein the subject has received zero or one rounds of prior treatment with an anti-cancer agent, other than an androgen receptor inhibitor, for treatment of triple negative breast cancer.

58. A method of treating triple negative breast cancer in a subject in need of such treatment comprising:

- (a) providing a biological sample from the subject;
- (b) assaying the biological sample to determine whether the biological sample is classified as a basal-like subtype or another subtype; and
- (c) if the biological sample is classified as other than a basal-like subtype, administering a breast cancer treatment to the subject comprising an androgen receptor inhibitor, thereby treating the breast cancer in the subject.

59. The method of claim 58, wherein assaying the biological sample to determine whether the biological sample is classified as a basal-like subtype or another subtype is performed by detecting the expression of the intrinsic genes listed in Table 1.

60. The method according to claim 59, comprising:

(a) determining the Basal Centroid classifier score and the Luminal A Centroid classifier score of the sample from the expression of the set of intrinsic genes listed in Table 1; and

(b) calculating a Weighted Basal and Luminal A classifier score from the Basal Centroid classifier score and the Luminal A Centroid classifier score according to the following equation:

$$\begin{aligned} \text{Weighted Basal and Luminal A classifier score} = \\ -0.25(\text{Basal Centroid classifier score}) + 0.27(\text{Luminal A Centroid classifier score}) \end{aligned}$$

; and

wherein the breast cancer treatment is administered to the subject if the Weighted Basal and Luminal A classifier score is greater than -0.3,

61. The method according to claim 60, wherein the breast cancer treatment is administered if the Weighted Basal and Luminal A classifier score is greater than -0.2.

62. The method according to claim 61 wherein the breast cancer treatment is administered if the Weighted Basal and Luminal A classifier score is greater than -0.25.

63. The method according to claim 59, comprising determining the Basal Centroid classifier score of the sample from the expression of the set of intrinsic genes listed in Table 1, wherein the breast cancer treatment is administered if the Basal Centroid classifier score is less than or equal to 0.9.

64. The method according to claim 63 wherein the breast cancer treatment is administered if the Basal Centroid classifier score is less than or equal to 0.6.

65. The method according to claim 63, wherein a breast cancer treatment is administered to the subject if the Basal Centroid classifier score is in the range from 0.2 to 0.8.

66. The method according to claim 65, wherein a breast cancer treatment is administered to the subject if the Basal Centroid classifier score is in the range from 0.4 to 0.7.

67. The method according to any of claims 58 to 66, wherein the breast cancer of the subject is characterized by the presence of androgen receptor-positive tumor cells.

68. The method according to any of claims 58 to 67, wherein the androgen receptor inhibitor is selected from the group consisting of enzalutamide, bicalutamide, flutamide, nilutamide, ARN509, ketoconazole, abiraterone acetate, VN/124-1 (TOK-001), orteronel (TAK-700), finasteride, galeterone, cyproterone acetate, andarine and combinations thereof.

69. The method according to claim 68, wherein the androgen receptor inhibitor is enzalutamide.

70. The method according to claim 69, wherein the enzalutamide is orally administered once daily at a dose of 160 mg.

71. The method according to claim 70, wherein the enzalutamide is administered as a single capsule comprising 160 mg enzalutamide.

72. The method according to claim 70, wherein the enzalutamide is administered as four capsules, each capsule comprising 40 mg enzalutamide.

73. The method according to any of claims 58 to 72, wherein the breast cancer treatment comprising an androgen receptor inhibitor further comprises one or more other anti-cancer agents that is not an androgen receptor inhibitor.

74. The method according to claim 73, wherein the other anti-cancer agent that is not an androgen receptor inhibitor is selected from the group consisting of cyclophosphamide, fluorouracil, 5-fluorouracil, methotrexate, thiotepa, carboplatin,

cisplatin, taxanes, paclitaxel, protein-bound paclitaxel, docetaxel, vinorelbine, tamoxifen, raloxifene, toremifene, fulvestrant, gemcitabine, irinotecan, ixabepilone, temozolamide, topotecan, vincristine, vinblastine, eribulin, mutamycin, capecitabine, capecitabine, anastrozole, exemestane, letrozole, leuprolide, abarelix, buserlin, goserelin, megestrol acetate, risedronate, pamidronate, ibandronate, alendronate, denosumab, zoledronate, trastuzumab, tykerb or bevacizumab, and combinations thereof.

75. The method according to claim 74 wherein the other anti-cancer agent that is not an androgen receptor inhibitor is paclitaxel.

76. The method according to any of claims 58 to 75, wherein the biological sample is selected from the group consisting of a cell, tissue and bodily fluid.

77. The method according to claim 76, wherein the biological sample comprises breast tissue or cells.

78. The method of claim 77, wherein the tissue is obtained from a biopsy.

79. The method of claim 77, wherein the bodily fluid is selected from the group consisting of blood, lymph, urine, saliva, fluid from ductal lavage, and nipple aspirate.

80. The method according to claim 62, wherein the subject has received zero or one rounds of prior treatment with an anti-cancer agent, other than an androgen receptor inhibitor, for treatment of triple negative breast cancer.