

Side effects and imaging
correlates

Targeted cancer therapies

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Abiraterone

- Trade name: Arimidex
 - “rozole”: aromatase inhibitors, imidazole-triazole derivatives
- Target
 - Aromatase: Hormonal therapy
- Indications
 - Breast cancer (HR+)
- ***Side effects with possible imaging correlates:***
 - Ischemic cardiovascular events
 - Decreased bone mineral density
- Other side effects
 - Hypercholestermia
- Associated with pseudoprogression?
 - No
- Special considerations:
 - Risk of Abiraterone-induced ischemic cardiovascular events is reportedly higher in women with pre-existing ischemic heart disease

Ado-trastuzumab

- Trade name: Kacyla
 - “-tu+zumab”: humanized monoclonal antibody with a tumor target
- Target
 - Her2 (ERBB2/neu): Cytotoxic (immunoconjugate)
- Indications
 - Breast cancer
- ***Side effects with possible imaging correlates:***
 - Hepatotoxicity (asymptomatic, transient transaminitis and nodular regenerative hyperpalsia)
 - Left ventricular dysfunction
 - Pulmonary toxicity
 - Embryo-fetal toxicity
 - Hemorrhage (CNS, respiratory, gastrointestinal)
- Other side effects
 - Infusion related reactions
 - Thrombocytopenia
 - Peripheral neuropathy
- Associated with pseudoprogression?
 - Yes

Afatinib

- •Trade name: Gilotrif
 - “tin+nib”: small molecule
- •Target
 - EGFR (HER1/ERBB1), HER2 (ERBB2/neu): Growth Inhibitor
- Indications
 - Non-small cell lung cancer
- ***Side effects with possible imaging correlates:***
 - Interstitial lung disease
 - Hepatotoxicity
 - Embryofetal toxicity
- Other side effects
 - Diarrhea
 - Bullous/Exfoliative skin disorders
- Associated with pseudoprogression?
 - Some documented cases

Aldesleukin

- Trade name: Proleukin
 - “-leukin”: IL-2
- Target
 - IL-2 Signaling pathway: Immunotherapy
- Indications
 - Renal cell carcinoma
 - Melanoma
- ***Side effects with possible imaging correlates:***
 - Exacerbation of pre-existing autoimmune disease (Crohn’s, Scleroderma, thyroiditis, inflammatory arthritis, glomerulonephritis)
 - Cholecystitis
 - Cerebral vasculitis
 - CNS effects (single or multiple cortical lesions of MRI and evidence of demyelination)
- Other side effects
 - Dermatologic toxicity (Steven Johnson syndrome, Bullous pemphigoid)
 - Occulo-bulbar myasthenia gravis
- Associated with pseudoprogression?
 - No
- Special considerations
 - All patients should have thorough evaluation and treatment of CNS metastases and have a negative scan, prior to receiving Proleukin therapy

Alectinib

- Trade name: Alecensa
 - “-tin+nib”: small molecule tyrosine kinase inhibitor
- Target
 - ALK: Growth Inhibitor
- Indications
 - Non-small cell lung cancer (with ALK fusion)
- ***Side effects with possible imaging correlates:***
 - Hepatotoxicity
 - Interstitial lung disease and pneumonitis
 - Embryo-fetal toxicity
- Other side effects
 - Bradycardia
 - Severe myalgia and CPK elevation
- Associated with pseudoprogression?
 - Yes

Alemtuzumab

- Trade name: Campath
 - “-mab” humanized monoclonal antibody with a tumor target
- Target
 - CD52: Cytotoxic/Immunotherapy
- Indications
 - B-cell chronic lymphocytic leukemia
- ***Side effects with possible imaging correlates:***
 - None documented
- Other side effects
 - Cytopenia
 - Immunosuppression requiring laboratory monitoring (CBC, CD4 count)
- Associated with pseudoprogression?
 - No

Anastrozole

- Trade name: Arimidex
 - “rozole”: aromatase inhibitors, imidazole-triazole derivatives
- Target
 - Aromatase: Hormonal therapy
- Indications
 - Breast cancer (HR+)
- ***Side effects with possible imaging correlates:***
 - Ischemic cardiovascular events
 - Decreased bone mineral density
- Other side effects
 - Hypercholesterolemia
- Associated with pseudoprogression?
 - No
- Special considerations:
 - Risk of medication-induced ischemic cardiovascular events is reportedly higher in women with pre-existing ischemic heart disease

Atezolizumab

- Trade name: Keytruda
 - “zumab” humanized monoclonal antibody
- Target
 - PD-L1: Immunotherapy checkpoint inhibitor
- Indications
 - Urothelial cell carcinoma
 - Non-small cell lung cancer
- ***Side effects with possible imaging correlates:***
 - Immune-related pneumonitis
 - Immune-related hepatitis
 - Immune related colitis
 - Immune related endocrinopathies (hypothyroidism, hyperthyroidism, pancreatitis)
 - Immune related meningitis and encephalitis
 - Embryo-fetal toxicity
- Other side effects
 - Infusion-related reactions
 - Motor and sensory neuropathy
 - Adrenal insufficiency
- Associated with pseudoprogression?
 - Yes

Avelumab

- Trade name: Bavencio
 - “umab: fully human monoclonal antibody
- Target
 - PD-L1: Immunotherapy checkpoint inhibitor
- Indications
 - Merkel cell carcinoma
- ***Side effects with possible imaging correlates:***
 - Immune-related pneumonitis
 - Hepatitis
 - Colitis
 - Nephritis
 - Embryo-fetal toxicity
- Other side effects
 - Infusion-related reactions
 - Renal impairment
- Associated with pseudoprogression?
 - Yes

Axitinib

- Trade name: Inlyta
 - “-tin+nib”: small molecule tyrosine kinase inhibitor
- Target
 - VEGFR1/2/3: Angiogenesis Inhibitor
- Indications
 - Renal cell carcinoma
- ***Side effects with possible imaging correlates:***
 - Arterial and venous thromboembolic events
 - Hemorrhage
 - Cardiac failure
 - Gastrointestinal perforation and fistula formation
 - Posterior reversible enhancement syndrome (PRES)
 - Hepatotoxicity
- Other side effects
 - Hypertension and hypertensive crisis
 - Renal dysfunction, proteinuria
- Associated with pseudoprogression?
 - No

Belinostat

- Trade name: Beleodaq
 - “-ino-stat”: histone deacetylase inhibitor
- •Target
 - HDAC: cytotoxic
- Indications
 - Peripheral T-cell lymphoma
- ***Side effects with possible imaging correlates:***
 - Hepatotoxicity
 - Embryo-fetal toxicity
 - Gastrointestinal toxicity
- Other side effects
 - Tumor lysis syndrome
 - Infections
- •Associated with pseudoprogression?
 - No

Bevacizumab

- Trade name: Avastin
 - “ci+zumab”: humanized monoclonal antibody with a circulatory target
- Target
 - VEGF: Angiogenesis inhibitor
- Indications
 - Colorectal cancer, Breast Cancer, Glioblastoma, Non-small cell lung cancer
 - Renal cell carcinoma, Ovarian cancer
- ***Side effects with possible imaging correlates:***
 - Gastrointestinal perforation and fistula formation
 - Non-gastrointestinal fistula formation
 - Arterial and venous thromboembolic events
 - Posterior reversible enhancement syndrome (PRES)
 - Embryo-fetal toxicity
- Other side effects
 - Wound healing complications
 - Hypertension
 - Renal dysfunction and proteinuria
- Associated with pseudoprogression?
 - Yes

Bicalutamide

- Trade name: Casodex
 - Small molecule: androgen receptor inhibitor
- Target
 - Androgen receptor: Growth inhibitor (hormone therapy)
- Indications
 - Metastatic prostate cancer
- ***Side effects with possible imaging correlates:***
 - Hepatitis
 - Gynecomastia and breast pain
- Other side effects
 - Hyperglycemia
- Associated with pseudoprogression?
 - Yes
- Special considerations:
 - Diabetic patients may develop loss of glycemic control

Blinatumomab

- Trade name: Blincyto
 - “-tu(m)+omab”: mouse monoclonal antibody with tumor target
- Target
 - CD19: Cytotoxic/immunotherapy
- Indications
 - Acute Lymphoblastic Leukemia
- ***Side effects with possible imaging correlates:***
 - Hepatitis
 - Pancreatitis
 - Leukoencephalopathy
- Other side effects:
 - Cytokine release syndrome
 - Tumor Lysis Syndrome
 - Neutropenia
- Associated with pseudoprogression?
 - No
- Special considerations:
 - Risk of serious adverse reactions in pediatric patients due to benzyl alcohol preservative (“gasping syndrome” – CNS depression, metabolic acidosis and gasping respirations)

Bortezomab

- Trade name: Velcade
 - “-zomib”: small molecule proteasome inhibitor
- Target:
 - Proteasome: Cytotoxic
- Indications:
 - Multiple myeloma
 - Mantle cell lymphoma
- ***Side effects with possible imaging correlates:***
 - New or worsening congestive heart failure
 - Pneumonitis
 - Posterior reversible enhancement syndrome
 - Hepatitis
- Other side effects:
 - Peripheral neuropathy
 - Gastrointestinal upset (nausea, diarrhea)
 - Hypotension
 - Thrombocytopenia and neutropenia
- Associated with pseudoprogression?
 - No

Bosutinib

- Trade name: Bosulif
 - “-tin+nib”: small molecule tyrosine kinase inhibitor
- Target
 - BCR-ABL: Growth inhibitor
- Indications
 - Chronic myelogenous leukemia (Philadelphia chromosome positive)
- ***Side effects with possible imaging correlates:***
 - Hepatitis
 - Embryo-fetal toxicity
 - Fluid retention
- Other side effects
 - Myelosuppression
 - Renal toxicity
- Associated with pseudoprogression?
 - No

Brentuximab vedotin

- Trade name: Adcetris
 - “-tu+ximab”: chimceric human-animal monoclonal antibody with a tumor target
- Target:
 - CD30: Cytotoxic
- Indications:
 - Hodgkin lymphoma
 - Anaplastic large cell lymphoma
- ***Side effects with possible imaging correlates:***
 - Hepatitis
 - Progressive multifocal leukoencephalopathy
 - Embyro-fetal toxicity
- Other side effects:
 - Peripheral neuropathy
 - Anaphylaxis and infusion reactions
 - Tumor lysis syndrome
- Associated with pseudoprogression?
 - Yes

Brigatinib

- Trade name: Alunbrig
 - “-ib”: small molecule tyrosine kinase inhibitor
- Target:
 - ALK: Growth inhibitor
- Indications:
 - Non-small cell lung cancer
- ***Side effects with possible imaging correlates:***
 - Interstitial lung disease
 - Pneumonitis
 - Pancreatitis
 - Embryo-fetal toxicity
- Other side effects:
 - Myelosuppression
 - Hypertension
 - Bradycardia
 - Visual disturbances
- Associated with pseudoprogression?
 - No

Cabozantinib

- Trade name: Cabometyx
 - “-tin+ib”: small molecular tyrosine kinase inhibitor
- Target
 - MET, VEGFR-1, -2 and -3, AXL, RET, ROS1, TYRO3, MER, KIT, TRKB, FLT-3, and TIE-2d: Angiogenesis inhibitor/Growth inhibitor
- Indications:
 - Renal cell carcinoma
- ***Side effects with possible imaging correlates:***
 - Gastrointestinal perforations and fistulas
 - Posterior reversible leukoencephalopathy syndrome (PRES)
 - Hemorrhage
 - Thrombotic events
 - Embryo-fetal toxicity
- Other side effects
 - Hypertension and hypertensive crisis
- Associated with pseudoprogression?
 - No

Carlfizomib

- **Trade name:** Kyprolis
- **Target:**
 - -Poteasome: Cytotoxic
- **Indications:**
 - Multiple myleoma
- ***Side effects with possible imaging correlates***
 - Cardiac toxicity (acute or exacarbation of heart failure, restrictive cardiomyopathy, myocardial ischemia and infarction)
 - Pneumonitis and interstitial lung disease
 - Pulmonary hypertension
 - Hepatitis
 - Venous thromboembolism
 - Posterior reversible leukoencephalopathy syndrome (PRES)
- **Other side effects:**
 - Hypertension and hypertensive crisis
 - Acute renal failure
 - Tumor lysis syndrome
- **Associated with pseudoprogression?**
 - No
- **Special considerations:**
 - Increased risk of fatal and serious toxicity when combined with Melphalan and Prednisone in newly diagnosed transplant-eligible patients

Ceritinib

- Trade name: Zykadia
 - “-tin+ib”: small molecular tyrosine kinase inhibitor
- Target
 - ALK: Growth inhibitor
- Indications
 - Non-small cell lung cancer (with ALK fusion)
 - Multiple myeloma
- ***Side effects with possible imaging correlates:***
 - Hepatotoxicity
 - Pneumonitis and interstitial lung disease
 - Pancreatitis
 - Embryo-fetal toxicity
- Other side effects
 - Gastrointestinal effects (nausea, vomiting, diarrhea)
 - Hyperglycemia
 - Hypertension and hypertensive crisis
- Associated with pseudoprogression?
 - Unclear

Cetuximab

- Trade name: Erbitux
 - “-tu-ximab”: chimeric human-animal monoclonal antibody with a tumor target
- Target:
 - EGFR (HER1/ERBB1): Cytotoxic/Growth inhibitor
- Indications
 - Non-small cell lung cancer (with ALK fusion)
 - Colorectal cancer (EGFR expressing, K-ras mutatio negative)
 - Squamous cell carcinoma of head and neck
- ***Side effects with possible imaging correlates:***
 - Pulmonary toxicity
- Other side effects
 - Gastrointestinal effects (nausea, vomiting, diarrhea)
 - Cardiopulmonary arrest
 - Dermatologic pathology (acnieform rash, dry skin and fissuring)
- Associated with pseudoprogression?
 - No

Cobemetinib

- Trade name: Cotellic
 - “-tin+ib”: small molecular tyrosine kinase inhibitor
- Target
 - MEK: Cytotoxic/Growth inhibitor
- Indications
 - Melanoma (with BRAF V600E and V600K mutation)
- ***Side effects with possible imaging correlates:***
 - Hepatotoxicity
 - New primary malignancies (cutaneous and non-cutaneous)
 - Cardiomyopathy
 - Serous retinopathy
 - Retinal vein occlusion
 - Embryo-fetal toxicity
- Other side effects
 - Dermatologic toxicity and photosensitivity
 - Rhamdomyolysis
- Associated with pseudoprogression?
 - No

Crizotinib

- Trade name: Xalkori
 - “-tin+ib”: small molecular tyrosine kinase inhibitor
- Target
 - ALK, MET, ROS1: Growth inhibitor
- Indications
 - Non-small cell lung cancer (with ALK fusion or ROS1 gene alteration)
- ***Side effects with possible imaging correlates:***
 - Hepatotoxicity
 - Pneumonitis and interstitial lung disease
 - Embryofetal toxicity
- Other side effects
 - Severe visual loss
 - Bradycardia
- Associated with pseudoprogression?
 - Yes

Daratumumab

- Trade name: Darzalex
 - “-tu(m)+umab”: fully human monoclonal antibody with a tumor target
- Target
 - CD38: cytotoxic
- Indications
 - Multiple myeloma
- ***Side effects with possible imaging correlates:***
 - None known
- Other side effects
 - Infusion reactions
 - Neutropenia
 - Thrombocytopenia
- Associated with pseudoprogression?
 - No

Debrafinib

- Trade name: Tafenlar
 - “-ib”: small molecular tyrosine kinase inhibitor
- Target
 - BRAF: Growth inhibitor
- Indications
 - Melanoma (with BRAF V600E mutation)
 - Non-small cell lung cancer (with BRAF V500E mutation)
- ***Side effects with possible imaging correlates:***
 - Associated with new cutaneous and non-cutaneous primary malignancies (melanoma, SCC, keratocanthomas)
 - Cardiomyopathy
 - Embryo-fetal toxicity
- Other side effects
 - Gastrointestinal upset: nausea, vomiting, diarrhea
 - Dermatologic toxicity
 - Hyperglycemia
 - Glucose-6-phosphate deficiency
- Associated with pseudoprogression?
 - No
- Special considerations
 - Tumor promotion can occur in BRAF wild-type tumors (paradoxical activation of MAP-kinase signaling and increased cell proliferation)

Decatinib

- Trade name: Sprycel
 - “-tin+ib”: small molecular tyrosine kinase inhibitor
- Target
 - ABL: Growth inhibitor
- Indications
 - Non-small cell lung cancer (with ALK fusion)
 - Multiple myeloma
 - Chronic myelogenous leukemia (Philadelphia chromosome positive)
 - Acute lymphoblastic leukemia (Philadelphia chromosome positive)
- ***Side effects with possible imaging correlates:***
 - Pulmonary artery hypertension
 - Embryofetal toxicity
- Other side effects
 - Fluid retention
 - Tumor lysis syndrome
 - Severe dermatologic reactions
- Associated with pseudoprogression?
 - No

Denileukin Difitox

- Trade name: Ontak
 - “leukin”: IL-2
- Target
 - CD25: Cytotoxic
- Indications
 - Cutaneous T-cell Lymphoma (expressing CD25 component of IL-2)
- ***Side effects with possible imaging correlates:***
 - Capillary leak syndrome
- Other side effects
 - Infusion reactions
 - Visual loss (acuity, color)
- Associated with pseudoprogression?
 - No

Denosumab

- Trade name: Xgeva/Prolia
 - “-os+umab”: human monoclonal antibody targeting bone
- Target:
 - RANKL
- Indications:
 - Cutaneous T-cell Lymphoma (expressing CD25 component of IL-2)
 - Giant cell bone tumor
 - Osteoporosis
 - Hypercalcemia of malignancy refractory to bisphosphonate therapy
- ***Side effects with possible imaging correlates:***
 - Osteonecrosis of the jaw
 - Atypical subtrochanteric and diaphyseal femoral fracture
 - Embryo-fetal toxicity
- Other side effects:
 - Hypersensitivity reactions (anaphylaxis)
 - Hypocalcemia
- Associated with pseudoprogression?
 - No

Denituximab

- Trade name: Unituxin
 - “-tu+ximab”: chimeric human-animal monoclonal antibody with a tumor target
- Target
 - GD2: Cytotoxic
- Indications
 - Pediatric neuroblastoma
- ***Side effects with possible imaging correlates:***
 - Capillary leak syndrome
 - Transverse myelitis
 - Urinary retention
 - Embryo-Fetal Toxicity
 - Capillary leak syndrome
- Other side effects
 - Infusion reactions
 - Bone marrow suppression
 - Atypical hemolytic-uremic syndrome
- Associated with pseudoprogression?
 - No

Durvalumab

- Trade name: Imfinzi
 - “-umab”: fully human monoclonal antibody
- Target
 - PD-L1: Immunotherapy checkpoint inhibitor
- Indications
 - Urothelial carcinoma
- ***Side effects with possible imaging correlates:***
 - Capillary leak syndrome
 - Pneumonitis
 - Hepatitis
 - Colitis
 - Endocrinopathies (thyroiditis, hypophysitis/hypopituitarism)
- Other side effects
 - Endocrinopathies (Adrenal insufficiency, Type 1 diabetes mellitus)
 - Infusion reactions
- Associated with pseudoprogression?
 - Yes

Elotuzumab

- Trade name: Empliciti
 - “-tu+zumab”: humanized monoclonal antibody with a tumor target
- Target
 - CD25: Cytotoxic
 - SLAMF7 (CS1/CD319/CRACC): Cytotoxic/Immunotherapy
- Indications
 - Multiple myeloma
- ***Side effects with possible imaging correlates:***
 - Hepatotoxicity
 - New primary malignancy (hematologic, solid, skin tumors)
- Other side effects
 - Infusion reactions
- Associated with pseudoprogression?
 - No
- Special considerations:
 - New primary malignancies occurred at higher rates with patients treated with combination of Elotuzumab, Lenalidomide, and Dexamethasone)

Enzalutamide

- Trade name: Xtandi
 - Androgen receptor inhibitor
- Target
 - Androgen receptor: Growth inhibitor (Hormonal therapy)/Cytotoxic
- Indications
 - Prostate cancer
- ***Side effects with possible imaging correlates:***
 - Posterior reversible leukoencephalopathy syndrome (PRES)
- Other side effects
 - Seizure
- Associated with pseudoprogression?
 - No

Erlotinib

- Trade name: Tarceva
 - “-tin+ib”: small molecular tyrosine kinase inhibitor
- Target:
 - EGFR (HER1/ERBB1): Growth inhibitor
- Indications
 - Non-small cell lung cancer
 - Pancreatic cancer
- ***Side effects with possible imaging correlates:***
 - Interstitial lung disease
 - Hepatotoxicity
 - Cerebrovascular complications
 - Gastrointestinal perforation
 - Embryo-Fetal toxicity
- Other side effects
 - Renal failure
 - Dermatologic toxicity (Bullous and exfoliative skin disorders)
- Associated with pseudoprogression?
 - Yes
- Special considerations
 - Risk of hemorrhage in patients taking Erlotinib and Warfarin

Everolimus

- Trade name: Afinitor
 - “-rol+imus”: antineoplastic, Rapamycin derivative
- Target:
 - mTOR: Angiogenesis inhibitor/Growth inhibitor
- Indications
 - Cutaneous T-cell Lymphoma (expressing CD25 component of IL-2)
 - Pancreatic, Gastrointestinal or Lung origin neuroendocrine tumor
 - Renal cell carcinoma
 - Subependymal giant cell tumor associated with tuberous sclerosis
 - Breast cancer (HR+, HER2-)
- ***Side effects with possible imaging correlates:***
 - Pneumonitis
 - Embryo-Fetal toxicity
- Other side effects
 - Hepatic impairment
 - Renal failure
- Associated with pseudoprogression?
 - Yes
- Special considerations:
 - Anigoedema with concomitant use of ACE inhibitors
 - Drug-drug interactions (due to CYP3A4 mutations)

Exemestane

- Trade name: Aromasin
 - “-mestane”: aromatase inhibitors
- Target:
 - Aromatase: Growth inhibitor (Hormone therapy)
- Indications:
 - Breast cancer
- ***Side effects with possible imaging correlates:***
 - Capillary leak syndrome
 - Reduction in bone mineral density
 - Embryo-Fetal toxicity
- Other side effects:
 - Infusion reactions
 - Laboratory abnormalities (lymphocytopenia, elevates AST, ALT, alkaline phosphatase, bilirubin, creatinine, GGT)
- Associated with pseudoprogression?
 - No

Fulvestrant

- Trade name: Faslodex
 - “estr”: estrogen receptor antagonist
- Target
 - Estrogen receptor: Growth inhibitor (Hormone therapy)
- Indications
 - Breast Cancer (HR+)
- ***Side effects with possible imaging correlates:***
 - Embryo-fetal toxicity
 - Hemorrhage
- Other side effects
 - Hepatic impairment
 - Peripheral neuropathy and neuralgia
- Associated with pseudoprogression?
 - No

Gefitinib

- Trade name: Iressa
 - “-tin+ib”: small molecular tyrosine kinase inhibitor
- Target:
 - EGFR (HER1/ERBB1): Cytotoxic/Growth inhibitor
- Indications:
 - Non-small cell lung cancer
- ***Side effects with possible imaging correlates:***
 - Hepatotoxicity
 - Interstitial lung disease
 - Gastrointestinal perforation
 - Embryo-Fetal toxicity
- Other side effects
 - Persistent diarrhea
 - Bullous and exfoliative disorders
- Associated with pseudoprogression?
 - No

Ibritumumab Tiuxetan

- Trade name: Zevalin
 - “-omab”: mouse monoclonal antibody
- Target
 - CD20: Cytotoxic (Immunoconjugate)
- Indications
 - Follicular B cell Non-Hodgkin lymphoma
- ***Side effects with possible imaging correlates:***
 - Embryo-fetal toxicity
 - Risk of developing other malignancies (myelodysplastic syndrome, leukemia)
- Other side effects
 - Infusion reactions
 - Cytopenia
 - Mucocutaneous reactions (erythema multiforme, Steven-Johnson syndrome, dermatitis)
- Associated with pseudoprogression?
 - No

Ibrutinib

- Trade name: Imbruvica
 - “-tin+ib”: small molecular tyrosine kinase inhibitor
- Target
 - BTK: Growth inhibitor
- Indications
 - Mantle cell lymphoma
 - Chronic lymphocytic leukemia
 - Small lymphocytic lymphoma
 - Waldenstrom’s macroglobulinemia
 - Marginal zone lymphoma
- ***Side effects with possible imaging correlates:***
 - Embryo-fetal toxicity
 - Secondary primary malignancies (non-melanoma skin cancer)
 - Hemorrhage
- Other side effects
 - Cytopenia
 - Hypertension
 - Tumor lysis syndrome
- Associated with pseudoprogression?
 - Yes

Idelalisib

- Trade name: Zydelig
 - “-ib”: small molecular kinase inhibitor
- Target
 - PI3K δ : Cytotoxic/Growth inhibitor
- Indications
 - Follicular B cell Non-Hodgkin lymphoma
 - Chronic lymphocytic leukemia
 - Small lymphocytic lymphoma
- ***Side effects with possible imaging correlates:***
 - Embryo-fetal toxicity
 - Hepatotoxicity
 - Colitis
 - Pneumonitis
 - Gastrointestinal perforation
- Other side effects
 - Infusion reactions
 - Neutropenia and severe infections
 - Severe cutaneous reactions (Steven-Johnson syndrome, toxic epidermal necrolysis)
- Associated with pseudoprogression?
 - No

Imatinib

- Trade name: Gleevac
 - “tin+mib”: small molecular tyrosine kinase inhibitor
- Target
 - KIT, PDGFR, BCR-ABL, c-kit
- Indications
 - Philadelphia chromosome positive ALL and CML
 - Myelodysplastic/Myeloproliferative diseases
 - Aggressive systemic mastocytosis
 - Chronic eosinophilic syndrome
 - GI stromal tumor (KIT+)
 - Dermatofibrosarcoma protuberans
- ***Side effects with possible imaging correlates:***
 - Fluid retention and edema (pleural effusion, pericardial effusion, pulmonary edema, ascites)
 - Severe congestive heart failure and left ventricular dysfunction
 - Gastrointestinal perforation
 - Embryo-fetal toxicity
- Other side effects
 - Infusion reactions
 - Hematologic toxicity (anemia, neutropenia, thrombocytopenia)
 - Toxicity from long-term use (cardiac, liver, kidney)
- Associated with pseudoprogression?
 - Yes

Inotuzumab ozogamicin

- Trade name: Besponsa
 - “-zumab”: humanized monoclonal antibody
- Target
 - CD22: Cytotoxic (Immunoconjugate)
- Indications
 - Acute lymphoblastic leukemia (B-cell precursor)
- ***Side effects with possible imaging correlates:***
 - Hepatotoxicity
 - Hepatic veno-occlusive disease (sinusoidal-obstruction syndrome)
 - Embryo-Fetal toxicity
- Other side effects
 - Infusion reactions
 - Increased risk of post-transplant non-relapse mortality
- Associated with pseudoprogression?
 - No

Ipilimumab

- Trade name: Yervoy
 - “-li(m)+umab”: fully human monoclonal antibody with an immune system target
- Target
 - CTLA4: Immunotherapy (Checkpoint inhibitor)
- Indications
 - Melanoma
- ***Side effects with possible imaging correlates:***
 - Immune mediated enterocolitis (including intestinal perforation)
 - Immune mediated hepatitis
 - Immune mediated endocrinopathies (hypo-or-hyperthyroidism)
 - Other immune mediated reactions (nephritis, pneumonitis, meningitis, pericarditis, uveitis, iritis)
- Other side effects
 - Immune mediated endocrinopathies (adrenal insufficiency, hypogonadism, Cushing’s syndrome)
 - Immune mediated neuropathies (Guillain Barre, peripheral neuropathy, myasthenia gravis)
- Associated with pseudoprogression?
 - Yes

Ixazomib

- Trade name: Ninlaro
 - “-zomib”: small molecular proteasome inhibitor
- Target
 - Proteasome: Cytotoxic
- Indications
 - Multiple myeloma
- ***Side effects with possible imaging correlates:***
 - Hepatotoxicity
 - Embryo-fetal toxicity
- Other side effects
 - Thrombocytopenia
 - Gastrointestinal toxicities (diarrhea, constipation, nausea, vomiting)
 - Peripheral edema
 - Cutaneous reactions
- Associated with pseudoprogression?
 - No

Lanreotide

- Trade name: Somatulin
 - “-tide”: antineoplastic
- Target
 - Somatostatin receptor: Hormone therapy
- Indications
 - Acromegaly
 - Gastroenteropancreatic neuroendocrine tumors (GEP-NETs)
- ***Side effects with possible imaging correlates:***
 - Cholelithiasis and gallbladder sludge (decreased gallbladder motility)
- Other side effects
 - Hypoglycemia and hyperglycemia
 - Hypothyroidism
 - Cardiovascular (hypertension, sinus bradycardia)
- Associated with pseudoprogression?
 - No

Lepatinib

- Trade name: Tykerb
 - “-tin+ib”: small molecule tyrosine kinase inhibitor
- Target
 - HER2 (ERBB2/neu), EGFR (HER1/ERBB1): Growth inhibitor
- Indications
 - Breast cancer (HER2+)
- ***Side effects with possible imaging correlates:***
 - Decreased left ventricular ejection fraction
 - Hepatotoxicity
 - Interstitial lung disease and pneumonitis
 - Embryo-fetal toxicity
- Other side effects
 - Severe cutaneous reactions (Steven-Johnson syndrome, toxic epidermal necrolysis)
- Associated with pseudoprogression?
 - No

Lenvatinib

- Trade name: Lenvima
 - “-tin+ib”: small molecule tyrosine kinase inhibitor
- Target
 - VEGFR1/2/3, FGFR1/2/3/4, PDGFR α , KIT, RET: Angiogenesis/Growth inhibitor
- Indications
 - Renal cell carcinoma
 - Thyroid cancer
- ***Side effects with possible imaging correlates:***
 - Cardiac dysfunction (decreased right and left ventricular dysfunction, cardiac failure, pulmonary edema)
 - Arterial thromboembolic events
 - Hepatotoxicity
 - Gastrointestinal perforation and fistula formation
 - Posterior reversible leukoencephalopathy syndrome
 - Embryo-fetal toxicity
 - Hemorrhagic events
- Other side effects
 - Hypertension
 - Hypocalcemia
 - Impaired thyroid function
- Associated with pseudoprogression?
 - Yes

Letrozole

- Trade name: Femara
 - “-rozole”: aromatase inhibitor
- Target
 - Aromatase: Growth inhibitor (Hormone therapy)
- Indications
 - Breast cancer
- ***Side effects with possible imaging correlates:***
 - Decreased bone mineral density
 - Hepatic impairment
- Other side effects
 - Thrombocytopenia
 - Hypercholesterolemia
- Associated with pseudoprogression?
 - No

Midostaurin

- Trade name: Rydapt
 - Small molecular tyrosine kinase inhibitor
- Target
 - FLT3: Angiogenesis inhibitor/Growth inhibitor/Cytotoxic
- Indications
 - Acute myeloid leukaemia (FLT3+)
 - Aggressive systemic mastocytosis
 - Systemic mastocytosis with associated neoplasm (SM-AHM)
 - Mast cell leukemia
- ***Side effects with possible imaging correlates:***
 - Embryo-fetal toxicity
 - Interstitial lung disease and pneumonitis
- Other side effects
 - None
- Associated with pseudoprogression?
 - No

Necitumumab

- Trade name: Portrazza
 - “-tu+umab”: fully human monoclonal antibody with a tumor target
- Target
 - EGFR (HER1/ERBB1): Angiogenesis inhibitor/Cytotoxic
- Indications
 - Squamous non-small cell lung cancer
- ***Side effects with possible imaging correlates:***
 - Venous and arterial thromboembolic events
 - Embryo-fetal toxicity
 - Cardiopulmonary arrest
- Other side effects
 - Infusion reactions
 - Dermatologic toxicity (rash, dermatitis)
- Associated with pseudoprogression?
 - No

Neratinib

- Trade name: Nerlynx
 - “-tin+ib”: small molecule tyrosine kinase inhibitor
- Target
 - EGFR, HER2, HER4
- Indications
 - Breast cancer (HER2+)
- ***Side effects with possible imaging correlates:***
 - Hepatotoxicity
 - Embryo-fetal toxicity
- Other side effects
 - Gastrointestinal effects (diarrhea)
- Associated with pseudoprogression?
 - No

Nilotinib

- Trade name: Tasigna
 - “-tin+ib”: small molecule tyrosine kinase inhibitor
- Target
 - ABL: Growth inhibitor
- Indications
 - Chronic myelogenous leukemia (Philadelphia chromosome positive)
- ***Side effects with possible imaging correlates:***
 - Cardiac and arterial vascular occlusive events
 - Pancreatitis and elevates serum lipase
 - Hepatic impairment
 - Fluid retention (pleural effusion, pericardial effusion, ascites)
- Other side effects
 - Myelosuppression
 - QT prolongation
- Associated with pseudoprogression?
 - No

Niraparib

- Trade name: Zejula
 - “-ib”: poly (ADP-ribose) polymerase (PARP) inhibitor
- Target
 - PARP: Cytotoxic
- Indications
 - Ovarian cancer
 - Fallopian tube cancer
 - Peritoneal cancer
- ***Side effects with possible imaging correlates:***
 - Embryo-fetal toxicity
 - Development of acute myeloid leukemia/myelodysplastic syndrome
- Other side effects
 - Cardiovascular events (hypertension and hypertensive crisis)
 - Bone marrow suppression
- Associated with pseudoprogression?
 - No

Nivolumab

- Trade name: Opdivo
 - “-umab”: fully human monoclonal antibody
- Target
 - PD-1: Immunotherapy (Checkpoint inhibitor)
- Indications
 - Head and neck squamous cell carcinoma, Hodgkin lymphoma, Melanoma, Non-small cell lung cancer, Renal cell carcinoma and urothelial cell carcinoma
- ***Side effects with possible imaging correlates:***
 - Immune mediated pneumonitis, colitis, hepatitis, nephritis
 - Immune mediated endocrinopathies (hypophysitis, pancreatitis)
 - Other Immune-Mediated Adverse Reactions (uveitis, iritis, pancreatitis, facial and abducens nerve paresis, demyelination,, autoimmune neuropathy, Guillain-Barré syndrome, systemic inflammatory response syndrome, gastritis, duodenitis, sarcoidosis, histiocytic necrotizing lymphadenitis (Kikuchi lymphadenitis), myositis, myocarditis, vasculitis, and myasthenic syndrome)
 - Embryo-fetal toxicity
- Other side effects
 - Other immune mediated reactions: hyperthyroidism, hypothyroidism, type 1 diabetes mellitus, adrenal insufficiency, hypopituitarism, polymyalgia rheumatica, systemic inflammatory response syndrome, rhabdomyolysis
- Associated with pseudoprogression?
 - Yes

Obinutuzumab

- Trade name: Gazyva
 - “-zumab”: humanized monoclonal antibody
- Target
 - CD20: Cytotoxic
- Indications
 - Chronic lymphocytic leukemia
 - Follicular lymphoma
- ***Side effects with possible imaging correlates:***
 - Progressive multifocal leukoencephalopathy
- Other side effects
 - Hepatitis B re-activation
 - Tumor lysis syndrome
 - Infusion reactions
 - Neutropenia and infections
- Associated with pseudoprogression?
 - No

Ofatumumab

- Trade name: Arzerra
 - “-umab”: fully human monoclonal antibody
- Target
 - CD20: Cytotoxic
- Indications
 - Chronic lymphocytic leukemia
- ***Side effects with possible imaging correlates:***
 - Progressive multifocal leukoencephalopathy
- Other side effects
 - Hepatitis B re-activation
 - Tumor lysis syndrome
 - Cytopenia
- Associated with pseudoprogression?
 - No

Olaparib

- Trade name: Lynparza
 - “-ib”: small molecule poly(ADP-ribose) polymerase (PARP) inhibitor
- Target
 - PARP: Cytotoxic Growth Inhibitor
- Indications
 - Ovarian cancer (BRCA mutation)
 - Fallopian tube epithelial cancer
 - Primary peritoneal epithelial cancer
- ***Side effects with possible imaging correlates:***
 - Embryo-fetal toxicity
 - Pneumonitis
 - Development of acute myeloid leukemia/myelodysplastic syndrome
- Other side effects
 - None
- Associated with pseudoprogression?
 - No

Olaratumab

- Trade name: Lartruvo
 - “-tu(m)+umab”: fully human monoclonal antibody with a tumor target
- Target
 - PDGFRa: Growth inhibitor
- Indications
 - Soft tissue sarcoma
- ***Side effects with possible imaging correlates:***
 - Embryo-fetal toxicity
- Other side effects
 - Infusion reactions
- Associated with pseudoprogression?
 - No

Osimertinib

- Trade name: Tagrisso
 - “-ttin+ib”: small molecule tyrosine kinase inhibitor
- Target
 - EGFR: Growth inhibitor
- Indications
 - Non-small cell lung cancer (with EGFR T790M mutation)
- ***Side effects with possible imaging correlates:***
 - Interstitial lung disease and pneumonitis
 - Cardiomyopathy
 - Embryo-fetal toxicity
- Other side effects
 - QT prolongation
 - Keratitis
- Associated with pseudoprogression?
 - No
- Special considerations:
 - Higher incidence of ILD following use of Osimertinib in patients who had undergone immediate prior Rivolumab therapy

Palbociclib

- Trade name: Ibrance
 - “-ib”: small molecule tyrosine kinase inhibitor
- Target
 - CDK4, CDK6: Growth inhibitor
- Indications
 - Breast cancer (HR+, HER2-)
- ***Side effects with possible imaging correlates:***
 - Embryo-fetal toxicity
- Other side effects
 - Neutropenia
- Associated with pseudoprogression?
 - No

Panitumumab

- Trade name: Vectibix
 - “-tu(m)+umab”: fully human monoclonal antibody with a tumor target
- Target
 - EGFR (HER1/ERBB!): Cytotoxic/Growth inhibitor
- Indications
 - Metastatic colorectal cancer (KRAS wild type)
- ***Side effects with possible imaging correlates:***
 - Pulmonary fibrosis/Interstitial lung disease
 - Embryo-fetal toxicity
- Other side effects
 - Electrolyte abnormalities
 - Acute renal failure
 - Photosensitivity
 - Dermatologic toxicity
 - Infusion reactions
- Associated with pseudoprogression?
- Special considerations:
 - Increased tumor progression and increased mortality with RAS-mutant metastatic colorectal cancer
 - Increased toxicity with combination of Panitumumab and Bevacizumab

Panobinostat

- Trade name: Farydak
 - “-ino+stat”: histone deacetylase inhibitor
- Target
 - HDAC: Cytotoxic
- Indications
 - Multiple myeloma (refractory to two prior regimens, including Bortezomib and an immunomodulatory agent)
- ***Side effects with possible imaging correlates:***
 - Hepatotoxicity
 - Embryo-fetal toxicity
 - Cardiac toxicity (cardiac ischemic events)
- Other side effects
 - Hemorrhage
 - Myelosuppression and infections
 - Gastrointestinal effects (diarrhea)
- Associated with pseudoprogression?
 - No

Pazopanib

- Trade name: Vortrient
 - “-an+ib”: small molecule angiogenesis inhibitor
- Target
 - VEGF/1/2/3, PDGFR, FGFR1/3, Kit, Lck, C-Fms
- Indications
 - Renal cell carcinoma
 - Soft tissue sarcoma (in patients who received prior chemotherapy)
- ***Side effects with possible imaging correlates:***
 - Hepatotoxicity and hepatic impairment
 - Cardiac dysfunction (congestive heart failure, decreased left ventricular ejection fraction)
 - Arterial and venous thromboembolic events
 - Interstitial lung disease and pneumonitis
 - Gastrointestinal perforation and fistula formation
 - Posterior reversible leukoencephalopathy
 - Embryo-fetal toxicity
- Other side effects
 - QT prolongation and Torsades de Pointes
 - Thrombotic microangiopathy (TTP and HUS)
- Associated with pseudoprogression?
 - No

Pembrolizumab

- Trade name: Keytruda
 - “-zumab”: humanized monoclonal antibody
- Target
 - PD-1: Immunotherapy (Checkpoint inhibitor)
- Indications
 - Melanoma
 - Non-small cell lung cancer (PD-L1+)
 - Classic Hodgkin lymphoma
 - Squamous cell carcinoma of head and neck
- ***Side effects with possible imaging correlates:***
 - Immune mediated pneumonitis, hepatitis, nephritis, myocarditis, myelitis and endocrinopathies (hypophysitis, thyroiditis, pancreatitis)
 - Other immune mediated reactions: Guillan-Barre syndrome, vasculitis, partial seizures with inflammatory foci in the brain parenchyma
 - Embryo-fetal toxicity
- Other side effects
 - Immune mediated dermatitis, bullous pemphigoid, myasthenia gravis, hemolytic anemia and renal dysfunction
 - Infusion reactions
- Associated with pseudoprogression?
 - Yes

Pertuzumab

- Trade name: Perjeta
 - “-tu+zumab”: humanized monoclonal antibody with a tumor target
- Target
 - HER2 (ERBB2/neu): Cytotoxic/Growth inhibitor
- Indications
 - Breast cancer (HER2+)
- ***Side effects with possible imaging correlates:***
 - Cardiac dysfunction (decreased left ventricular ejection fraction)
 - Embryo-fetal toxicity
- Other side effects
 - Infusion reactions
 - Hypersensitivity reactions and anaphylaxis
- Associated with pseudoprogression?
 - No

Ponatinib

- Trade name: Iclusig
 - “-tin+ib”: small molecule tyrosine kinase inhibitor
- Target
 - ABL, T3151 mutant ABL, PDGFR, EPH, Src, Kit, Ret, TIE2, FGFR1-3, FLT3, VEGFR2: Growth inhibitor
- Indications
 - Chronic myelogenous leukemia
 - Acute lymphoblastic leukemia (Philadelphia chromosome positive)
- ***Side effects with possible imaging correlates:***
 - Arterial occlusive events (acute myocardial infarction, stroke, stenosis of large intracranial vessels)
 - Peripheral vascular disease
 - Venous thromboembolism
 - Cardiac failure
 - Hepatotoxicity
 - Pancreatitis
 - Posterior reversible leukoencephalopathy
 - Gastrointestinal perforation
 - Fluid retention (peripheral edema, pleural effusion, pericardial effusion)
 - Embryo-fetal toxicity
- Other side effects
 - Myelosuppression
 - Tumor lysis syndrome
- Associated with pseudoprogression?
 - No

Ramucirumab

- Trade name: Cyramza
 - “-mab”: monoclonal antibody VEGFR antagonist
- Target
 - VEGFR2: Angiogenesis inhibitor
- Indications
 - Metastatic colon cancer
 - Gastric cancer and Gastroesophageal junction (GEJ) cancer
 - Non-small cell lung cancer
- ***Side effects with possible imaging correlates:***
 - Arterial thromboembolic events
 - Gastrointestinal perforation
 - Posterior reversible leukoencephalopathy (PRES)
 - Embryo-fetal toxicity
 - Hemorrhage
- Other side effects
 - Nephrotic syndrome
 - Thyroid dysfunction
 - Clinical deterioration in patients with Child-Pugh B or C cirrhosis
- Associated with pseudoprogression?
 - No

Regorafenib

- Trade name: Stivarga
 - “-ib”: small molecule kinase inhibitor
- Target
 - RET, VEGFR1/2/3, KIT, PDGFR-alpha, PDGFR-beta, FGFR1/2, TIE2, DDR2, TrkA, Eph2A, RAF-1, BRAF, BRAF V600E, SAPK2, PTK5, Abl and CSF1R: Angiogenesis inhibitor/Growth inhibitor
- Indications
 - Colorectal cancer
 - Gastrointestinal stromal tumors
 - Hepatocellular carcinoma
- ***Side effects with possible imaging correlates:***
 - Hepatotoxicity
 - Gastrointestinal perforation or fistula formation
 - Cardiac ischemia and infarction
 - Posterior reversible leukoencephalopathy (PRES)
 - Embryo-fetal toxicity
- Other side effects
 - Infections
 - Hemorrhage
 - Dermatologic toxicity
- Associated with pseudoprogression?
 - No

Ribociclib

- Trade name: Kisqali
 - “-ib”: small molecule kinase inhibitor
- Target
 - CDK4, CDK6: Growth inhibitor
- Indications
 - Breast cancer (HR+, HER2-)
- ***Side effects with possible imaging correlates:***
 - Embryo-fetal toxicity
 - Hepatobiliary toxicity
- Other side effects
 - Neutropenia
 - QT prolongation
- Associated with pseudoprogression?
 - No

Rituximab

- Trade name: Rituxan, Mabthera
 - “-tu+ximab”: chimeric human-animal monoclonal antibody with a tumor target
- Target
 - CD20: Cytotoxic
- Indications
 - Non-Hodgkin lymphoma
 - Rheumatoid arthritis
 - Granulomatosis with polyangiitis
 - Chronic lymphocytic leukemia
- ***Side effects with possible imaging correlates:***
 - Bowel obstruction and perforation
 - Progressive multifocal leukoencephalopathy
- Other side effects
 - Mucocutaneous reactions (Paraneoplastic pemphigus, Steven-Johnson syndrome, vesiculobullous dermatitis, lichenoid toxic epidermal necrolysis)
 - Reactivation of Hepatitis B virus
 - Tumor lysis syndrome
 - Infusion reactions
- Associated with pseudoprogression?
 - Yes

Romidepsin

- Trade name: Istodax
 - Small molecule histone deacetylase inhibitor
- Target
 - HDAC: Cytotoxic
- Indications
 - Cutaneous T-cell lymphoma
 - Peripheral T-cell lymphoma
- ***Side effects with possible imaging correlates:***
 - Embryo-fetal toxicity
- Other side effects
 - Myelosuppression
 - Infections
 - Tumor lysis syndrome
- Associated with pseudoprogression?
 - No

Rucaparib

- Trade name: Rubraca
 - “-ib”: Poly (ADP-ribose) polymerase (PARP) inhibitor
- Target
 - PARP: Cytotoxic
- Indications
 - Ovarian cancer (with BRCA mutation)
- ***Side effects with possible imaging correlates:***
 - Development of acute myeloid leukemia/myelodysplastic syndrome
 - Embryo-fetal toxicity
- Other side effects
 - None
- Associated with pseudoprogression?
 - No

Ruxolitinib

- Trade name: Jakafi
 - “-tin+ib”: small molecule tyrosine kinase inhibitor
- Target
 - JAK1/2: Growth inhibitor
- Indications
 - Myelofibrosis
 - Polycythemia vera
- ***Side effects with possible imaging correlates:***
 - Development of non-melanoma skin cancer (Basal cell, Squamous cell, and Merkel cell carcinoma)
- Other side effects
 - Anemia, thrombocytopenia and neutropenia
 - Infection
 - Lipid elevation
- Associated with pseudoprogression?
 - No

Siltuximab

- Trade name: Sylvant
 - “-tu+ximab”: chimeric human-animal monoclonal antibody with a tumor target
- Target
 - IL-6: Immunotherapy
- Indications
 - Multicentric Castelman’s disease
- ***Side effects with possible imaging correlates:***
 - Gastrointestinal perforation
- Other side effects
 - Infusion reactions and hypersensitivity reactions
 - Associated with concurrent active severe infections
- Associated with pseudoprogression?
 - No

Sipuleucel-T

- Trade name: Provenge
 - Autologous cellular immunotherapy
- Target
 - PAP-GM-CSF: Immunotherapy (Cancer vaccine)
- Indications
 - Prostate cancer
- ***Side effects with possible imaging correlates:***
 - None
- Other side effects
 - Infusion reactions
- Associated with pseudoprogression?
 - Yes

Sonidegib

- Trade name: Odomzo
 - “-ib”: small molecule Hedgehog pathway inhibitor
- Target
 - Smoothed: Growth inhibitor
- Indications
 - Basal cell carcinoma
- ***Side effects with possible imaging correlates:***
 - Embryo-fetal toxicity
- Other side effects
 - Musculoskeletal pain
- Associated with pseudoprogression?
 - No

Sorafenib

- Trade name: Nexavar
 - “-ib”: small molecule kinase inhibitor
- Target
 - c-CRAF, BRAF, mutant BRAF, KIT, FLT-3, RET, RET/PTC, VEGFR-1/2/3, and PDGFR- β : Cytotoxic/Angiogenesis/Growth inhibitor
- Indications
 - Hepatocellular carcinoma
 - Renal cell carcinoma
 - Thyroid carcinoma
- ***Side effects with possible imaging correlates:***
 - Cardiac ischemia and/or infarction
 - Gastrointestinal perforation
 - Hepatitis
 - Embryo-fetal toxicity
 - Hemorrhage
- Other side effects
 - Hypertension
 - Dermatologic toxicity (hand-foot skin rash)
- Associated with pseudoprogression?
 - Some documented cases
- Special considerations:
 - Increased risk of hemorrhage when Sorafenib is taken in combination with Warfarin

Sunitinib

- Trade name: Sutent
 - “-ib”: small molecule kinase inhibitor
- Target
 - PDGFR α/β , VEGFR1/2/3, KIT, FLT3, CSF-1R, RET: Angiogenesis inhibitor/Growth inhibitor
- Indications
 - Gastrointestinal stromal tumor (GIST)
 - Progressive, well-differentiated pancreatic neuroendocrine tumor (pNET)
- ***Side effects with possible imaging correlates:***
 - Hepatotoxicity
 - Cardiovascular events (heart failure, cardiomyopathy, myocardial ischemia or infarction)
 - Osteonecrosis of the jaw
 - Hemorrhagic events (GI, respiratory, urinary tract, brain)
 - Embryo-fetal toxicity
- Other side effects
 - Tumor lysis syndrome
 - QT prolongation and Torsades de Pointes
 - Adrenal insufficiency, hypoglycemia, thyroid dysfunction
 - Dermatologic toxicity (Steven-Johnson syndrome, toxic epidermal necrolysis, erythema multiforme)
- Associated with pseudoprogression?
 - Yes
- Special considerations?
 - Discontinue Sunitinib in the event of new onset congestive heart failure

Tamoxifen

- Trade name: Nolvadex, Soltamox
 - Small molecule antiestrogen
- Target
 - Estrogen receptor: Growth inhibitor (Hormone therapy)
- Indications
 - Breast Cancer (DCIS)
- ***Side effects with possible imaging correlates:***
 - Increased incidence of endometrial cancer and uterine sarcoma
 - Endometrial hyperplasia, polyps, uterine fibroids, ovarian cysts
 - Thromboembolic effects (DVT and pulmonary embolism)
 - Increased incidence of liver cancer, elevated liver enzymes, cholestasis, hepatitis, hepatic necrosis
 - Embryo-fetal toxicity
 - Ocular side effects (retinal vein thrombosis and retinopathy)
- Other side effects
 - Menstrual irregularities, amenorrhea
- Associated with pseudoprogression?
 - No

Toremifene

- Trade name: Fareston
 - “-ifene”: antiestrogen, derivative of Clomiphene and Tamoxifen
- Target
 - Estrogen receptor: Growth inhibitor (Hormone therapy)
- Indications
 - Breast cancer (ER+)
- ***Side effects with possible imaging correlates:***
 - Hepatotoxicity
 - Tumor flare
 - Embryofetal toxicity
 - Risk of uterine malignancy
 - Thromboembolic events (DVT and pulmonary embolism)
- Other side effects
 - Hypercalcemia
 - Prolonged QT interval
- Associated with pseudoprogression?
 - Maybe; documented cases of tumor flare

Tositumomab

- Trade name: Bexxar
 - “-omab”: mouse monoclonal antibody
- Target
 - CD20: Cytotoxic (Immunoconjugate)
- Indications
 - Non-Hodgkin lymphoma
- ***Side effects with possible imaging correlates:***
 - Development of secondary malignancies (myelodysplastic syndrome or acute leukemia)
 - Embryo-fetal toxicity
- Other side effects
 - Serious allergic reactions including anaphylaxis
 - Severe cytopenias (prolonged thrombocytopenia in 70% of patients)
 - Hypothyroidism
- Associated with pseudoprogression?
 - No

Trametinib

- Trade name: Mekinist
 - “-tib+ib” small molecule tyrosine kinase inhibitor
- Target
 - Mek1/2: Growth inhibitor
- Indications
 - Melanoma (with BRAF V600 mutation)
- ***Side effects with possible imaging correlates:***
 - Associated with new primary malignancies (basal cell, squamous cell, melanoma, non-cutaneous malignancies)
 - Venous thromboembolism (DVT and pulmonary embolism)
 - Cardiomyopathy (cardiac failure)
 - Ocular toxicity (retinal vein occlusion and retinal detachment)
 - Interstitial lung disease and pneumonitis
 - Embryo-fetal toxicity
- Other side effects
 - Serious febrile reactions
 - Hyperglycemia
 - Dermatologic toxicity
- Associated with pseudoprogression?
 - No

Trastuzumab

- Trade name: Herceptin
 - “-tu+zumab” humanized monoclonal antibody with a tumor target
- Target
 - HER2 (ERBB2/neu): Cytotoxic
- Indications
 - Breast cancer (HER2+)
 - Gastroesophageal junction (GEJ) cancer (HER2+)
- ***Side effects with possible imaging correlates:***
 - Cardiomyopathy (ventricular dysfunction, asymptomatic decline in left ventricular ejection fraction, cardiac death)
 - Embryo-fetal toxicity
 - Pulmonary toxicity (pneumonitis/ARDS, interstitial lung disease, pleural effusion, non-cardiogenic pulmonary edema)
- Other side effects
 - Exacerbation of chemotherapy induced neutropenia
 - Hypertension
- Associated with pseudoprogression?
 - Yes

Vandetanib

- Trade name: Caprelsa
 - “-an+ib” anigogenesis inhibitor
- Target
 - EGFR, RET, VEGFR, BRK, TIE2, EPH receptors, Src: Angiogenesis inhibitor/Growth inhibitor
- Indications
 - Medullary thyroid cancer
- ***Side effects with possible imaging correlates:***
 - Interstitial lung disease
 - Ischemic cerebrovascular events
 - Cardiac failure
 - Posterior reversible leukoencephalopathy (PRES)
 - Hepatic impairment
 - Embryo-fetal toxicity
- Other side effects
 - Renal impairment
 - QT prolongation and Torsades de Pointes
- Associated with pseudoprogression?
 - No

Vemurafenib

- Trade name: Zelboraf
 - “-ib”: small molecule kinase inhibitor
- Target
 - BRAF V600E, wild-type BRAF, CRAF, ARAF, SRMS, ACK1, MAP4K5, and FGFR: Growth inhibitor
- Indications
 - Melanoma (with BRAF V600E mutation)
- ***Side effects with possible imaging correlates:***
 - Associated with new primary malignancies (cutaneous SCC, melanoma, keratocanthoma, non-cutaneous SCC of the head and neck)
 - Tumor progression in BRAF wild-type melanoma
 - Hepatotoxicity
 - Embryo-fetal toxicity
 - Uveitis
- Other side effects
 - Renal failure
 - Dermatologic toxicity (Steven-Johnson syndrome, toxic epidermal necrolysis)
- Associated with pseudoprogression?
 - No

Venetoclax

- Trade name: Venxlexta
 - Small molecule kinase inhibitor
- Target
 - BCL2: Cytotoxic
- Indications
 - Chronic lymphocytic leukemia (with 17p deletion)
- ***Side effects with possible imaging correlates:***
 - Embryo-fetal toxicity
- Other side effects
 - Tumor lysis syndrome
 - Neutropenia
- Associated with pseudoprogression?
 - No

Vismodegib

- Trade name: Erivedge
 - “-ib”: small molecule Hedgehog pathway inhibitor
- Target
 - Smoothed: Growth inhibitor
- Indications
 - Basal cell carcinoma
- ***Side effects with possible imaging correlates:***
 - Premature fusion of the epiphyses
 - Embryo-fetal toxicity
- Other side effects
 - Renal failure
 - Dermatologic toxicity (Steven-Johnson syndrome, toxic epidermal necrolysis)
- Associated with pseudoprogression?
 - No

Vorinostat

- Trade name: Zolinza
 - “-ino+stat”: histone deacetylase inhibitor
- Target
 - HDAC1/2/3/6: Cytotoxic/Growth inhibitor
- Indications
 - Cutaneous T-cell lymphoma
- ***Side effects with possible imaging correlates:***
 - Thromboembolism
 - Embryo-fetal toxicity
- Other side effects
 - Myelosuppression
 - Gastrointestinal effects (diarrhea, nausea, vomiting)
 - Hyperglycemia
- Associated with pseudoprogression?
 - No

Ziv-Aflibercept

- Trade name: Zaltrap
 - “-ber+cept”: receptor molecule
- Target
 - PDGF, VEGFA/B: Angiogenesis inhibitor
- Indications
 - Colorectal cancer
- ***Side effects with possible imaging correlates:***
 - Hemorrhage
 - Gastrointestinal perforation and fistula formation
 - Posterior reversible leukencephalopathy syndrome (PRES)
 - Arterial thromboembolic events
- Other side effects
 - Neutropenia
 - Gastrointestinal effects (diarrhea and dehydration)
- Associated with pseudoprogression?
 - No

Side effects by large groups

- VEGF
- EGFR
- mTOR
- Checkpoint Inhibitors (CTLA-4, PD-1)

VEGF

- Common side effects:
 - Rash / Impaired wound healing (16-51%)
 - Cardiac impairment (3-13%)
 - Cytopenia (8-18%)
 - Hemorrhage/Thrombosis (15-33%; neuro, GI, etc.)
 - Hypothyroidism (36%)
- Life threatening side effects:
 - Bowel perforation (1.5%)
 - PRES (1%)
 - Tumor necrosis leading to massive hemorrhage (<1%)
 - Liver failure (1%)

EGFR Inhibitors

- Common side effects:
 - Skin toxicity (80-95%)
 - GI toxicity (1-28%)
 - Hypomagnesemia (35-100%; can cause cardiomyopathy or neuromuscular effects)
 - ILD (2%)

Checkpoint Inhibitors

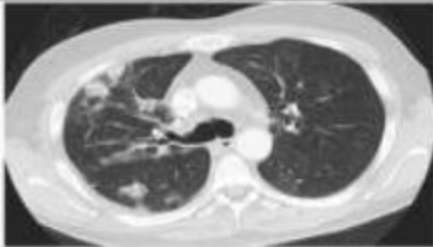


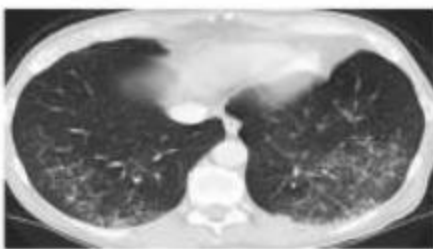
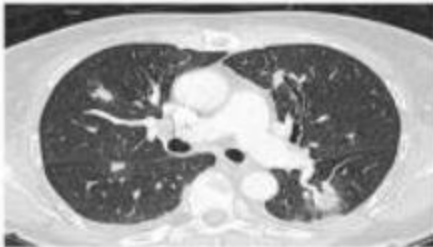
- Common side effects (typically within 12 weeks):
 - Skin disorders (41%; cellulitis)
 - Diarrhea/Colitis (31%); treat with steroids
 - Liver failure (<10%; hepatomegaly, periportal edema, lymphadenopathy)
 - Pneumonitis (<10%)
 - Endocrine disorders (5%; hypopituitarism, hypophysitis, hypothyroidism, pancreatitis)
 - Sarcoidosis (<1%)
- Rare but deadly side effects (<1%):
 - Bowel perforation
 - Guillain-Barre syndrome
 - Multi-organ failure / peritonitis

mTOR inhibitors

- Common side effects:
 - Wound-healing disorder (11-35%; think wound dehiscence, incisional hernia, lymphocele)
 - Pneumonitis (1-7%)
 - Enteritis/Colitis (1%)

Pneumonitis

Note: These pneumonitis cases look very abnormal – they can even appear like A-I aspergillosis.

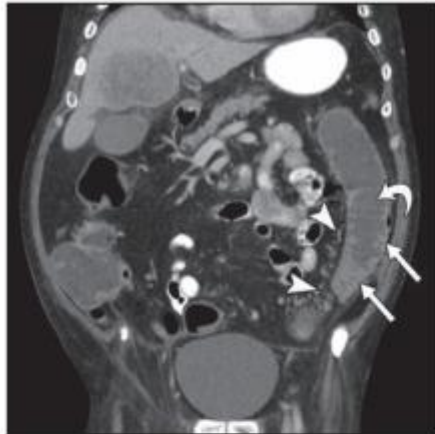
Radiologic Subtypes	Representative Image	Description
Cryptogenic organizing pneumonia-like (n = 5, 19%)		Discrete patchy or confluent consolidation with or without air bronchograms Predominantly peripheral or subpleural distribution
Ground glass opacities (n = 10, 37%)		Discrete focal areas of increased attenuation Preserved bronchovascular markings
Interstitial (n = 6, 22%)		Increased interstitial markings, interlobular septal thickening Peribronchovascular infiltration, subpleural reticulation Honeycomb pattern in severe patient cases
Hypersensitivity (n = 2, 7%)		Centrilobular nodules Bronchiolitis-like appearance Tree-in-bud micronodularity
Pneumonitis not otherwise specified (n = 4, 15%)		Mixture of nodular and other subtypes Not clearly fitting into other subtype classifications

Sarcoid-like reaction

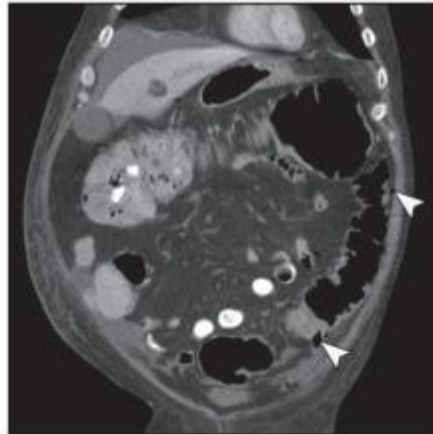
- Predominantly hilar lymphadenopathy, but other lymphadenopathy or lung changes can be seen



Colitis



A

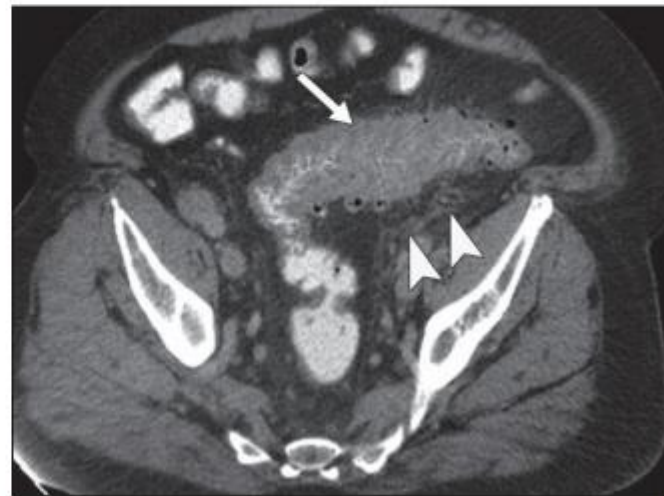


B

Fig. 2—72-year-old woman with watery diarrhea during ipilimumab treatment.
A, Coronal contrast-enhanced CT image shows diffuse colitis pattern with mild diffuse bowel wall thickening (*straight arrows*), mesenteric vessel engorgement (*arrowheads*), and fluid-filled colonic distention (*curved arrow*).
B, CT performed 1 month later shows progressive colonic distention and multifocal sites of perforation (*arrowheads*).



A



B

Skin Toxicities