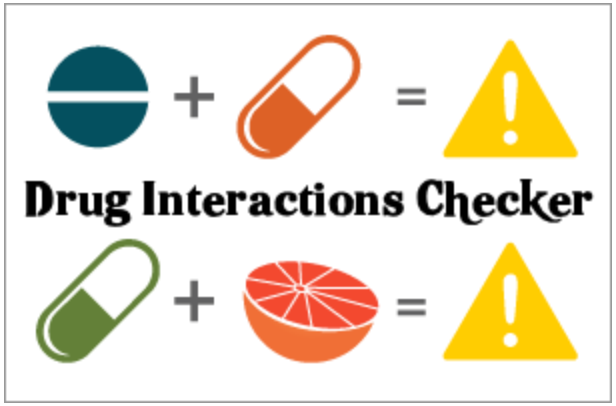
Drug Caused Side Effects and Disorders
ACOI Review Course - Las Vegas

FR Darrow, DO, MACOI
Burrell College of Osteopathic Medicine

Drug Caused Side Effects and Disorders

Usually due to drug:

1. Direct toxic effects
2. Interactions
   a. Cytochrome P 450 enzyme system
   b. Transporter P-glycoprotein transmembrane efflux pumps*
   c. Pharmacodynamic interactions



***** Located in intestine, blood-brain barrier, kidneys, liver, etc.

Drug Side Effects – Abnormal Labs

Hypoglycemia

Alcohol

ASA

Antidysrrhythmics (disopyramide, etc.)

ACE inhibitors* (*especially when taking antidiabetic drugs)*

Pentamidine

Quinine

Sulfonylureas (especially with renal and liver diseases. Also *when combined with Sulfonamides***, *eg. protein binding displacement)*

Tramadol

Hyperglycemia

Antipsychotics (ie. olanzapine, etc.)

BCP

Diuretics

Glucocorticoids

HAART

Niacin

NRTIs (eg. Stavudine)

Pentamidine

Phenytoin

Protease inhibitors (eg. retonavir boosted)

Statins (atorva, rosuva and simva the worst)

Sympathomimetics

Tacrolimus (Prograf)

** Increase insulin sensitivity **mycins, floxacins, metronidazole – all CYP inhibitors.*

Drug Side Effects – Abnormal Labs

- Hyperuricemia

Aspirin
Cytotoxics(Leukemias and lymphomas)
Diuretics
Fructose (soft drinks)
Hyperalimentation
Niacin

- Hypercalcemia

Lithium
Milk alkali syndrome
Thiazides
Vitamin A and D
Aluminum toxicity in RF
TPN

- Thyroid Function Test

Amiodarone (induces thyroid autoantibodies, as does interferon, interleukin and G-CSF)
Androgens
Barbiturates
Estrogens or antiestrogens
Glucocorticoids
Iodides
Lithium
Propranolol
Phenytoin
Salicylates
Sulfonamides

- Hyperphosphatemia

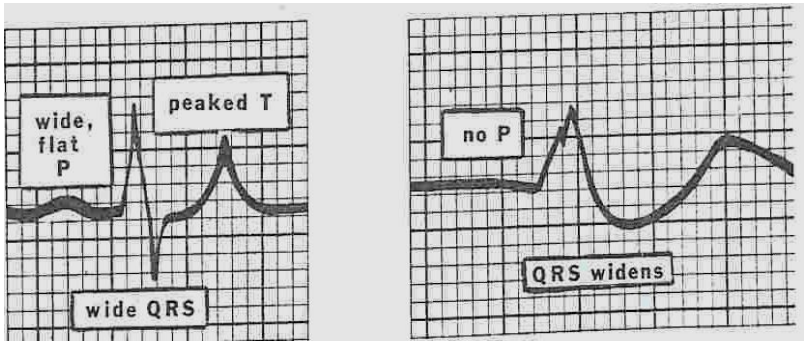
Phosphate enemas (Osmoprep, etc.)

Drug Side Effects – Abnormal Labs

Hyperkalemia

ACE inhibitors
Amiloride
Azole antifungals
Beta blockers
Cyclosporine (Neoral)(K Channel Syndrome)
Cytotoxic Agents
Digitalis
Eplerenone(Inspra)
Heparin (inhibits aldosterone production)
Lithium

NSAIDs
Packed RBCs
Penicillin G potassium
Succinylsholine
Spironolactone*
Triampterine
Trimethoprim/sulfamethoxazole*
Tacrolimus(Prograf)



*trimethoprin (amiloride effects) is often given to patients on spironolactone or ACE inhibitors producing sudden death

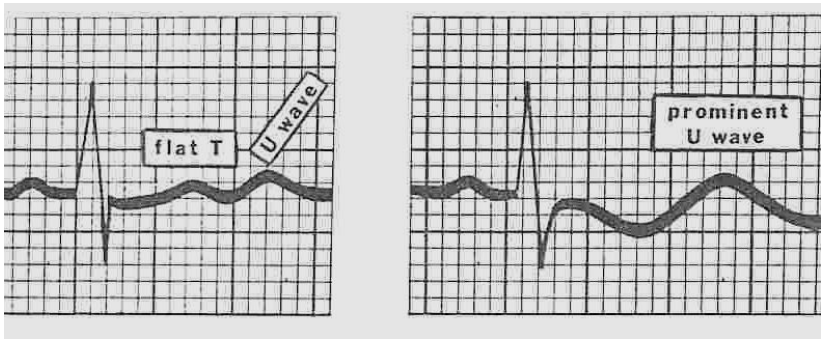
Drug Side Effects – Abnormal labs

Hypokalemia

Ampho B
Beta agonist
Corticosteroids
Diuretics
Gentamycin (defective proximal tubular K+ resorption)
Insulin
Laxative abuse
Mineralocorticoids
Penicillins (poorly resorbable anion)

Hypomagnesemia

PPIs (omeprazole)
Diuretics (watch for muscle cramps and polyuria*)



*due to associated hypocalcemia and hypokalemia.

Drug Side Effects - Abnormal Labs

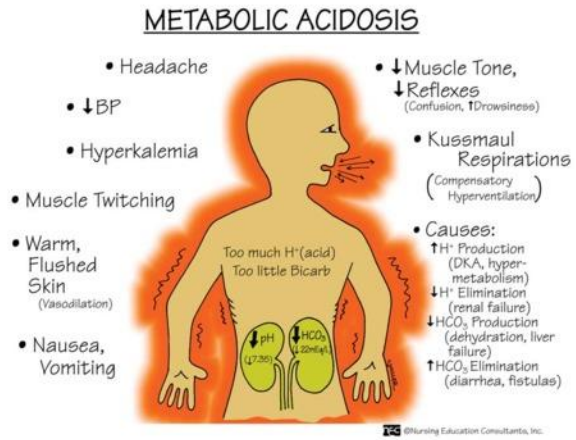
Metabolic Acidosis (AGA or RTA)

Acetazolamide (Type II RTA)
Amiloride (Type IV RTA)
Ampho B (Type I RTA)
Ethylene glycol*
Linezolid* (avoid with serotonergics)
Metformin*
Methyl alcohol*
NRTIs (lamivudine, emtricitabine)*
Paraldehyde*
Propafol Infusion Syndrome*
Propylene glycol* (found in lorazepam infusions)

*= AGA. Zyvox, Glucophage and HAART produce lactic acidosis. **Euglycemic DKA

Metabolic Acidosis (continued)

Pyroglutamic acidosis* (from acetomenaphen)
Salicylates*
SGLT2** (canagliflozin - *DKA*)
Spironolactone (Type IV RTA)
Tenofovir (Type II RTA)
Toluene (Type II RTA)
Topiramate (Type II RTA)
Zonisamide (Type II RTA)

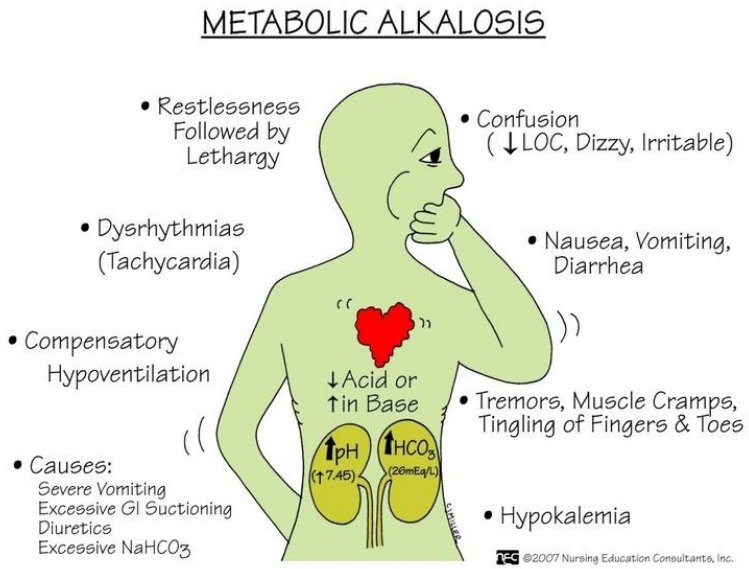


Drug Side Effects - Abnormal Labs

Metabolic alkalosis

Corticosteroids (as seen in primary aldosteronism with unresponsiveness to Cl administration and urine Cl > 20 mEq/L).

Diuretics (as seen in secondary aldosteronism with Cl responsiveness and urine Cl < 20 mEq/L).



Drug Side Effects – Abnormal Labs

Hyperlipidemia

Alcohol
Anabolic steroids(oral)
Beta blockers
Corticosteroids
Cyclosporine
Estrogens
HAART
Isoretinoins

NNRTIs (Efavirenz)
NRTIs (Stavudine)
Protease inhibitors (Ritonavir boosted)
Thiazides
Tricyclics (Metabolic syndrome)

Drug Side Effects – Abnormal Labs

Hyponatremia (with Urine Na+ over 20 mEq/L)

SIADH (increased production)

1. Antidepressants (eg. SSRIs and tricyclics)
2. Antineoplastics (eg. cyclophosphamide* and vincristine*)
3. Carbamazepine*
4. MDMA (Ecstasy)
5. Neuroleptics (eg. Haloperidal and fluphenazine)

SIADH (potentiated action)*

1. Amiodarone
2. NSAIDS
3. Somatostatin

Other salt wasting

1. ACE inhibitors
2. Aminoglycosides
3. Diuretics

Hypernatremia

Demeclocycline

False positive ANAs

Etanercept(Enbrel)
(TNF receptor blocker)
Inflixamab(Remicade)
(monoclonal antibody)

Drug Side Effects – Signs and Symptoms

- Insomnia
  - Alcohol
  - Antibiotics (Acyclovir, Retrovirals)
  - Anticholinergics
  - Antihypertensives (Altace)
  - Beta blockers (atenolol)
  - Caffeine
  - Hormones
  - Methylxanthines
  - MAOIs
  - Phenytoin
  - Psychostimulants
  - SSRIs
  - Withdrawal from opoids

- Fatigue (Flu-like)
  - Beta Blockers
  - HAART
  - Interferon
  - Tyrosine Kinase Inhibitors (Nexavar, Sutent)
  - Zoledronic acid

Drug Side Effects – Signs and Symptoms

- Headaches
  - Ergotamine withdrawal
  - HAARTs
  - Hydralazine
  - Indomethacin
  - Nitrates
  - NNRTIs (eg. Nevirapine-Viramune)
  - Metronidazole
  - NRTIs (eg. Lamivudine-Epivir)
  - PIs (eg. Amprenavir-Agenerase)
  - Quinolones

- Cough
  - ACE inhibitors
  - Asthma provokers (ASA, Beta blockers, NSAIDS, etc.)

Dizziness
- ACE inhibitors
- Beta Blockers
- Calcium Channel Blockers
- Diuretics
- Gabapentin
- Memantine (Namenda)
- Metronidazole
- Nitrates
- Oxycarbazepine (Trileptal)
- Phenothiazines
- Pregabalin (Lyrica)
- Topiramate (Topamax)
- Tricyclics

Drug Side Effects – Signs and Symptoms

- Gingival hyperplasia
  - Ca channel blockers
  - Cyclosporine
  - Phenytoin

- Dry Mouth
  - Anticholinergics
  - Antihistamines
  - Clonidine
  - Levodopa
  - Tricyclics

- Taste disturbance
  - Captopril
  - Griseofulvin
  - Metronidazole
  - Penicillamine
  - Lithium
  - Rifampin

- Salivary gland swelling
  - Bretylium
  - Clonidine
  - Iodides

- Lymphadenopathy
  - Phenytoin
    (Pseudolymphoma)
  - Primidone

Drug Side Effects – Signs and Symptoms

- Fever
  - Aminosalicyclic acid
  - Ampho B
  - Anticonvulsants
  - Antihistamines
  - Anesthetics
  - Antiretrovirals
  - Neuroleptics
  - NNRTIs (Efavirenz- Sustiva)
  - NRTIs (Abacavir*- Ziagen)
  - NSAIDS
  - Penicillins
  - PIs (Atazanavir-Reyataz)
  - Rifamycins
  - Sulfonamides

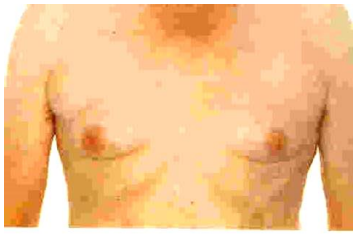
- Hyperpyrexia
  - Antipsychotics (NMS)
  - SSRIs (Serotonin Syn**)
  - Succinylcholine (MH)

- Weight Gain
  - Dronabinol (Marinol)
  - Megestrol (Megase)
  - Mirtazapine (Remeron)
- Weight Loss
  - Diethylproprion
  - Exenitide
  - Metformin
  - Phentermine
  - Sibutramine
  - Topiramate
  - Zonisamide

*HLA-B*5701 – Hypersensitivity syndrome-includes rash, N and V, abd pain, lethargy, etc.
**Also see with linezolid

Drug Side Effects – Signs and Symptoms

- Gynecomastia and Galactorrhea
  - Alcohol
  - Alkylating agents (Busulfan, etc.)
  - Amiodarone
  - Amphetamines
  - Anabolic steroids
  - Antigonadals (Flutamide, etc.)
  - Antipsychotics (including Risperidone)
  - Ca Channel blockers
  - Cimetidine and Ranitidine
  - Digitalis
  - Estrogens
  - Griseofulvin



- HAARTs (PIs)
- Hydroxyzine
- INH
- Meprobamate
- Metoclopramide
- Mirtazapine (Remeron)
- Omeprazole
- Opoids
- Phenytoin
- Spironolactone
- SSRIs
- THC
- Tricyclics
- Verapamil

Most of the above drugs cause the response by dopamine blockade thus increasing prolactin secretion.

Drug Side Effects – Signs and Symptoms

- Nausea and vomiting

  Alcohol
  Antiarrhythmics
  Anticonvulsants
  Calcium channel blockers
  Cholinesterase inhibitors (Donepezil-Aricept, Galantamine-Razadyne, etc)
  Colchicine
  Diabetic meds (Exenatide, Metformin, etc.)
  Digoxin *(Macrolides decrease DRPs*)*
  Estrogen
  Ferrous sulfate
  HAARTs
  Levodopa, etc.
  NNRTIs
  NRTIs
  NSAIDs
  OCPs
  Opiates
  PIs
  Potassium
  Tetracycline

** DRP = Digoxin Reduction Products (normally gut bacteria metabolize digitalis to less active dihydrometabolites). This is another drug interaction!!*

Drug Side Effects – Signs and Symptoms

- Diarrhea

Antimetabolites (5-FU)
Antibiotics (C. diff)
Colchicine
Digoxin
Lactulose
Mg antacids
PIs(Ritonavir boosted)
Targeted agents
(erlotinib, sorafenib)
PPIs (C difficile – worse when combined with steroids, Campylobacter)
Tegaserod (Zelnorm)

Drug Side Effects – Signs and Symptoms

- Impotence
  - Alcohol
  - Antidepressants (SSRIs)
  - Antihistamines
  - Beta blockers
  - Carbamazepine
  - Clonidine
  - Diuretics
  - Ketoconazole
  - Leuprolide
  - Lithium
  - Metoclopramide
  - Opoids
  - Paroxetine(DNA fragmentation)
  - Phenothiazines
  - Sedatives
  - Stimulants (cocaine etc.)
  - THC

Constipation
- Aluminum antacids
- Anticholinergics
- Antihistamines
- Calcium carbonate
- Calcium channel blockers
- Cholestyramine
- Clonidine
- Diuretics
- Ferrous sulfate
- NSAIDs
- Opiates
- Phenothiazines
- Sulcrafate
- Tricyclics

Drug Side Effects - Skin

- Erythema multiforme

  Barbiturates
  Carbamazepine (Asians with HLA B*1502)
  Codeine
  Fluoroquinolones
  HAARTs (Viramune)
  NSAIDs
  Penacillamine
  Penicillins
  Phenytoin
  Salicylates
  Sulfonamides
  Tetracycline
  Thiazides

- Porphyria Cutanea Tarda

  NSAIDs, especially Naproxen
  Tetracyclines
  Voriconazole

Drug Side Effects - Skin

- Photodermatitis

Amiodarone
BCP
Chlordiazepoxide
Diuretics
Grisofulvin
NSAIDs
Phenothiazines
Quinine
Simeprevir
Sulfonamides
Sulfonyureas
Sulindac
Tetracycline

Amiodarone

Thiazide

- Toxic Epidermal Necrolysis

Acetaminophen
Allopurinal (Asians with HLA-B*5801)
Barbituates
Dapsone (Asians with HLA-B* 13:01)
HAARTs
Iodides
Lamotrigine (Lamictal)
NSAIDs
Penicillins
Phenytoin (Asians with HLA- B*1502)
Sulfonamides

Skin necrosis

Warfarin (C and S)
Heparin (PF4)

DRESS

- Antiepileptics
- Allopurinol
- Sulfonamides
- Various antibiotics
- Psychotropics (benzos, buproprion, mirtazapine, amitriptyline)

Journal of Family Medicine and Primary Care

Hand-foot syndrome

(palmoplantar erythrodysesthesia)

Multikinase inhibitors

(sorafenib and other chemotherapy agents)

Medical Journal of Australia

Drug Side Effects - Skin

- Pemphigus/oid
  Captopril
  Penacillamine
  DDP4

- Linear IgA Bullous Dermatosis – produces tense “sausage Shaped” bullae
  Vancomycin

Drug Side Effects - Skin

<u>Allergic contact dermatitis</u>
(including photosensitivity):

Propylene glycol (skin products)

Benzophenones (sunscreens, etc)

Lanolin

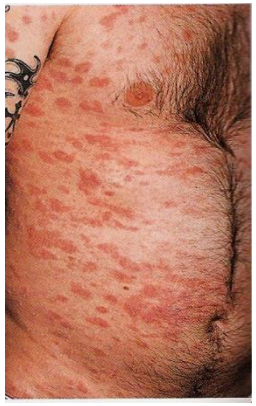
Drug Side Effects - Skin

- Hyperpigmentation
  - Amiodarone
  - Antineoplastics
  - BCPs
  - Bleomycin (nails)
  - Busulfan
  - Chloroquine
  - Corticotropin
  - Cyclophosphamide (nails)
  - Doxorubicin (nails)
  - Fluoroacil (nails)
  - Heavy metals (Gold, etc.)
  - Hydroxyurea (nails)
  - Imipramine
  - Melphalan (nails)
  - Minocycline
  - Methimazole and PTU
  - Niacin
  - Nitrosureas (nails)
  - Phenothiazines
  - Topical tretinoin
  - Zidovudine (nails)

Drug Side Effects - Skin

Fixed Drug Eruption

- Analgesics
- Antibiotics(Tetracyclines, Trimeth-Sulfo, etc.)
- Antihistamines
- Antiparasitics
- Barbituates
- CV drugs
- Heavy metals
- NSAIDs (Ibuprofen, Naproxen)
- Phenolphthalein (in laxatives)



Keratoacanthomas

- Protein kinase inhibitors – sorafenib, etc

Discoid and Subacute SLE

- thiazides
- Calcium channel blockers
- ACEIn
- TNFIn
- Terbinafine

Pityriasis rosea

- ACE inhibitors
- Metronidazole

Drug Side Effects - Skin

- Exfoliative dermatitis
  - Allopurinol
  - Antibiotics (ampicillin and trimeth-sulfo)
  - Barbituates
  - Carbamazepine
  - Gold salts
  - INH
  - Phenytoin
  - Sulfonamides (thiazides, furosemide, and sulfonylureas)

Tegretol

- Erythema Nodosum
  - BCP
  - Penicillins
  - Sulfonamides
  - Phenytoin

- Angioedema including abdominal pain
  - ACE Inhibitors
  - ARBs
  - DPP-IV

- Acute urticaria
  - Penicillins
  - NSAIDs
  - Opiates
  - Salicylates (HLA-DRB1*1302)
  - Sulfonamides

Drug Side Effects Miscellaneous

- Anaphylaxis and anaphylactoid reactions:

Antibiotics: Penicillin, etc.

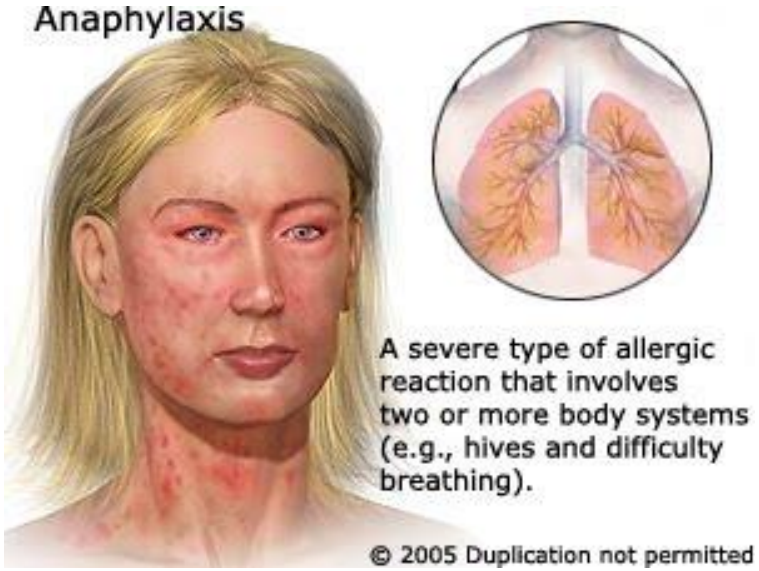
Analgesics: ASA, NSAIDS

Anesthetic agents

Omalizumab

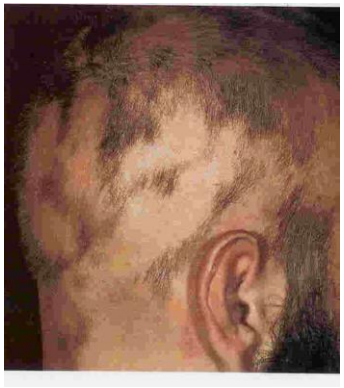
Opoids

Radiocontrast



Drug Side Effects - Skin

- Alopecia
  - Allopurinol
  - Amphetamines
  - Anticoagulants
  - Antimitotic agents
  - Antithyroid drugs
  - ASA
  - BCPs
  - Gentamicin
  - Indomethacin
  - Levodopa
  - Propanolol
  - Retinoids



- Lichen planus-like eruptions
  - Antihypertensives (ACE inhibitors)
  - Bismuth
  - Carbamazepine
  - Diuretics (HCTZ, etc.)
  - Dapsone
  - Ethambutol
  - Gold
  - Hydroxychloroquine
  - NSAIDs
  - Penicillamine
  - Phenothiazines
  - Propranolol
  - Quinine
  - Statins
  - Sildenafil
  - Streptomycin
  - Sulfonylureas
  - Tetracyclines

Drug Side Effects - CNS

Depression
- Alcohol
- Anticholinesterase drugs
- Amphetamine withdrawal
- Beta blockers
- Clonidine
- Cimetidine
- Digitalis
- Efavirenz (Sustiva)
- Levodopa
- Glucocorticoids
- Metronidazole
- Opiates
- Oral contractives
- Sedatives (Benzodiazepines)

Dementia
- PPIs?

Suicide (Serotonin)
- Antidepressants (SSRIs)
- AEDs
- DDAVP (Desmopressin)
- Efavirenz (Sustiva)
- Quetiapine (Seroquel)
- Varenicline (Chantix)

Drug Side Effects-CNS

Stroke

- buspirone
- cocaine
- COX-2 inhibitors*
- diazoxide
- epogen
- etanercept
- ginkgo
- imatinib
- OCs
- PPIs (reduce NO synthase/endothelial dys)
- Warfarin**

*increased mortality post stroke. **higher rate of IC bleeding than dabigatran.

Drug Side Effects CNS

Delirum (confusion)

Acyclovir*

Amantadine

Analgesics

Antibiotics

Anticholinergics

Antidepressants

Azole antifungals

Beta Blockers

Digoxin

Drug withdrawal (ETOH, narcotics, sedatives)

Glucocorticoids

H2 blockers** - cimetidine, rantidine, etc.

INH

Levodopa

Linezolid

Metronidazole (encephalopathy which simulates MS)

Memantine (Namenda)

Narcotics

NNRTIs (eg. efavirenz)

Penicillin

Phenothiazine

Quinolones

Salicylates (chronic use)

Statins

Stimulants (overdose)

Tricyclics

*neurotoxicity includes myoclonus, seizures, coma, and death.
**need dose reduction with renal insufficiency

Drug Side Effects – CNS

Extrapyramidal effects
- Antipsychotics
- BCP
- Metoclopramide
- Phenothiazines
- Tricyclics

Seizures
- Alcohol withdrawal
- Amphetamines
- Benzonatate (Tessalon)
- Imipenem
- INH
- Lidocaine

Seizures (continued)
- Lithium
- Oral Contraceptives
- Penicillins
- Phenothiazines
- Physostigmine
- Quinolones (esp with NSAIDS)
- SSRIs (Serotonin Syndrome)
- Tricyclics
- Vincristine

Drug Side Effects – CNS

Pseudotumor Cerebri

- Amiodarone
- BCP
- Glucocorticoids (usually withdrawal)
- Tetracycline
- Vitamin A

Tremors

- Caffeine
- Lithium
- SSRIs
- Sympathomimetics
- Theophylline
- Thyroid hormone
- Tricyclics
- Valproic acid

Aseptic Meningitis

- AEDs (Gabapentin, levetiracetam, topirmate, lamotrignine)
- Trimethoprin/sulfamethoxazole

Drug Side Effects – CNS

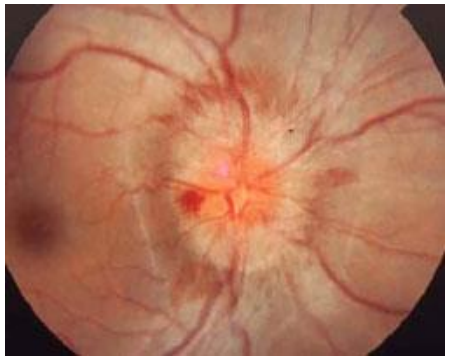
- Peripheral Neuropathy
  - Alcohol
  - Amiodarone
  - Amitriptyline
  - Ampho B
  - Arsenic
  - Chlorambucil
  - Cholorquine
  - Cisplatin
  - Colchicine
  - Dapsone
  - Demeclocycline
  - Disopyramide
  - Ergotamine
  - Ethambutol
  - Fluoroquinolones

- Gold
- Hydralazine
- Indomethacin
- Imipramine
- INH
- Metformin*
- Metronidazole
- Nitrofurantoin
- NRTIs (Stavodine-Zerit, Didanosine-Videx)
- Penicillamine
- Phenytoin
- Strepyomycin
- Sulfonamides
- Tricyclics
- Vincristine

*B12 deficiency

Drug Side Effects - CNS

Optic Neuritis



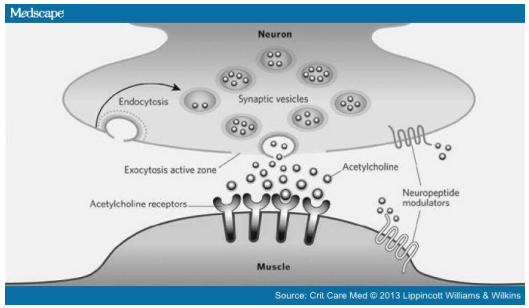
Aminosalacylic acid
Chloramphenicol
Ethambutal
INH
Penicillamine
Phenothiazines
Hydroxychloroquine
Streptomycin
Quinine

Deafness

Aminoglycosides
ASA
Chlorquine
Cisplatin
Erythromycin
Ethacrynic acid
Furosemide
Nortriptyline
Quinine

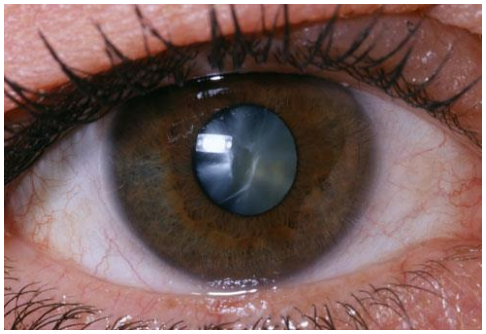
Neuromuscular blockade potentiated by:

Aminoglycosides
Caines
Corticoids
Gallamine
Lithium
Phenothiazines
Phenytoin
Propranolol
Succinylcholine*
Tetracycline
Thyroid hormone



*genetic polymorphism in drug metabolism determines the rate of metabolism, ie. persons with a defect in pseudocholinesterase activity will have prolonged apnea from succinylcholine.

Drug Side Effects - Eye



Cataracts

Busulfan

Chlorambucil

Glucocorticoids

Phenothiazines

Statins

SSRIs (esp. fluvoxamine)

Retinal detachment

Fluoroquinolones*?

Color vision alteration

Barbiturates

Digitalis

Thiazides

Sildenafil (Viagra)

Streptomycin

Sulfonamides

Voriconazole (black and white)

Optic neuropathy

Hydroxychloroquine

Amiodarone – corneal deposits

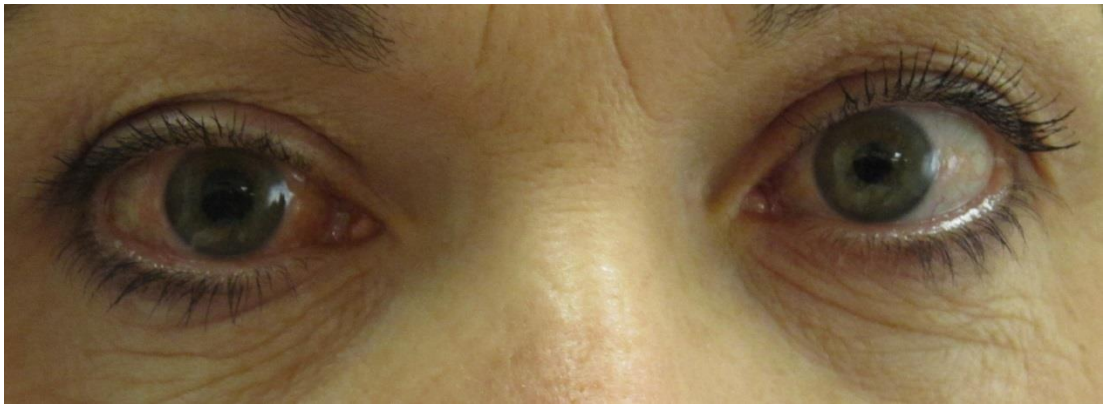
*Also aortic aneurysms. 2015 meta-analysis says no!

Drug Side Effects - Eye

Glaucoma

anticholinergic or sympathomimetic dilating drops, tricyclic antidepressants, monoamine oxidase inhibitors, antihistamines, antiparkinsonian drugs, antipsychotic medications, and antispasmolytic agents.

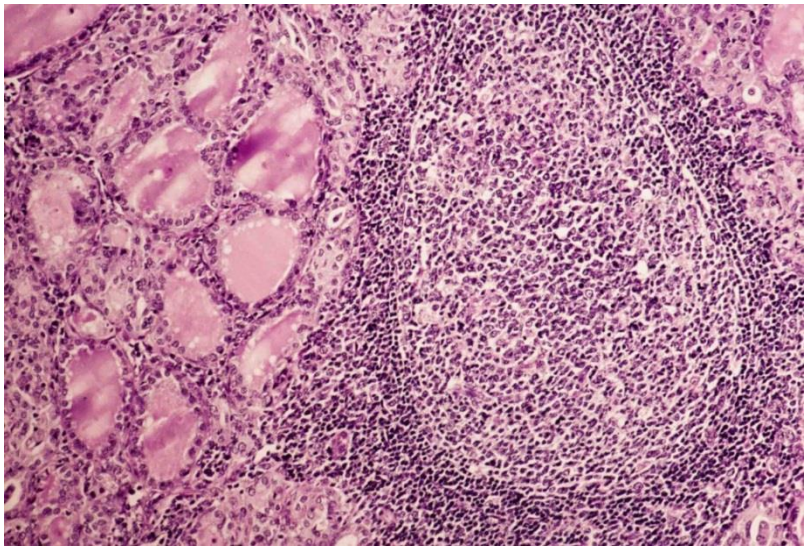
Topiramate



Drug Side Effects - Thyroid

Thyroiditis:

- Amiodarone
- Interferon
- Interleukin
- Lithium
- TK inhibitors



Hashimoto's

Drug Side Effects - Heart

Angina exacerbation and MI

Alpha blockers

Anticholinergics (ie, Ipratropium)

Beta Blockers

Calcium

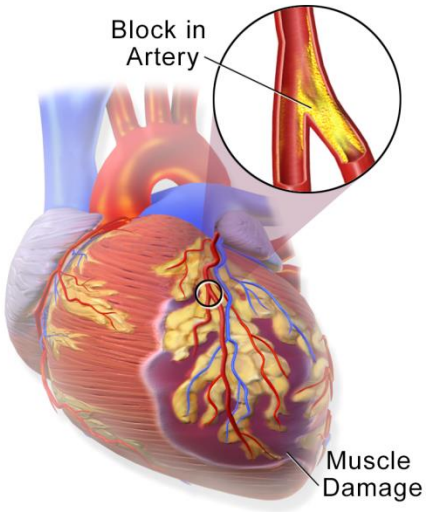
Clarithromycin*

Ergotamine

Erythropoietin

Hydralazine

Vasopressin



Heart Attack

Minoxidil

Nifedipine

NRTIs (ie Videx, Ziagen)

PPIs (nitric oxide)

sulfonylureas (use glimepiride or gliclizide – appear safer).

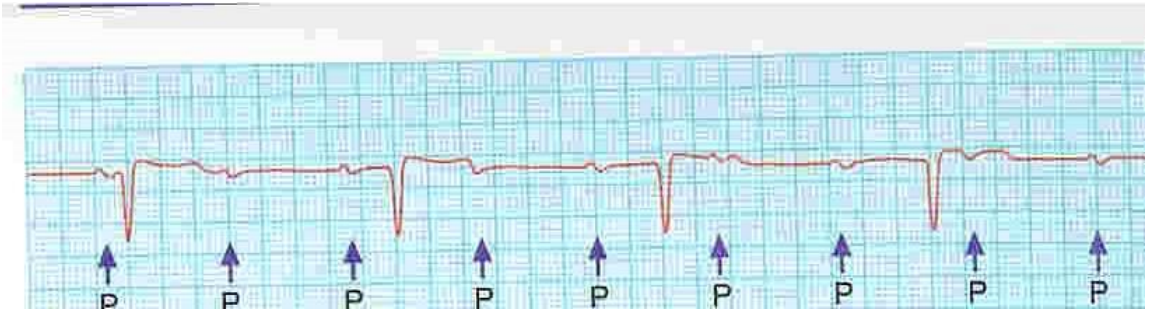
Sumatriptan

Thyroxine

Zoledronic acid (men)

*Unlike azithromycin and erythromycin that seem to prolong the QT, clarithromycin may activate macrophages, leading to an inflammatory cascade, with plaque rupture .

Drug Side Effects - Heart



Heart Block

- Amiodarone and Dronedarone
- Anticholinesterases (Donepezil, Galantamine Rivastigmine)
- Beta Blockers
- Calcium Channel Blockers
- Digitalis

Drug Side Effects - Heart

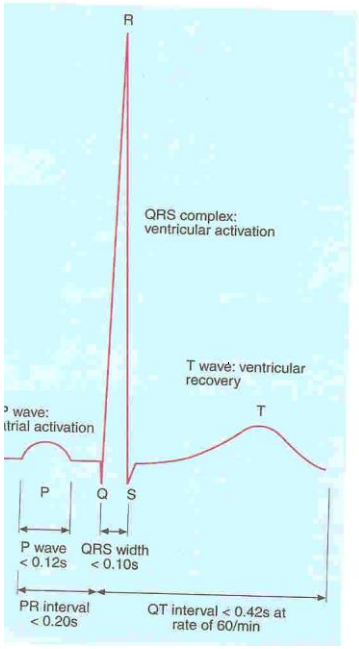
Atrial fibrillation

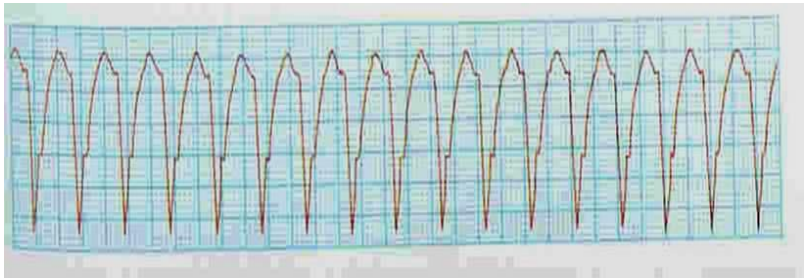
- Amphetamines
- Alcohol
- Bisphosphonates
- Caffeine
- Cocaine
- Thyroid medicines
- Zoledronic acid (women)

Drug Side Effects - Heart

Drugs prolonging the QTc interval:

- Amiodarone and Drone.
- Class 1a antidysrrhythmics
- Antibiotics (Erythromycin, Azithromycin, Levofloxacin)
- Antimigrainous drugs (Sumatriptan, etc.)
- Antipsychotics (eg Quetiapine)
- Cocaine
- Ibutilide
- Methadone
- Ondansetron (Zofran)
- Phenothiazines
- Quinolones
- Sotalol
- SSRIs (citalopram)
- Tricyclics
- Ziprasidone (Geodon)





Drug Side Effects - Heart

Hypertension

Amphetamines
Cocaine
BCP
Calcineuron inhibitors (Cyclosporine, Tacrolimus)
Clonidine withdrawal
Erythropoietin
Glucorticoids
Licorice
NSAIDS
Sibutramine
Sympathomimetics
TKI (Sorafenib, Sunitinib, Nintedanib)

Hypotension

Alpha blockers
Ca channel blockers
Diuretics
Levodopa
Morphine
Nitrates
Phenothiazines
Propofol
Tamsulosin – especially new starts
Tizanidine (Zanaflex)

Drug Side Effects - Heart

Edema/CHF

Beta blockers

Biologics (anti-TNF agents)

Ca antagonist

DPP-4 inhibs

Estrogens

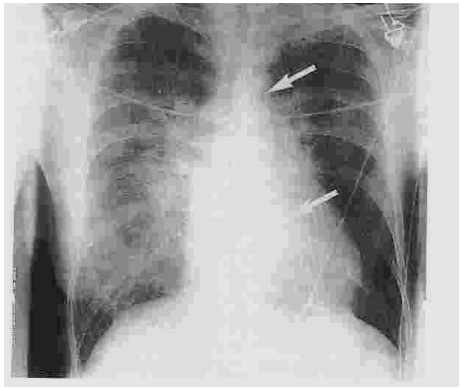
Indomethacin

Minoxidil

NSAIDS → AF

Steroids

Thiazolinediones



Cardiomyopathy

Adriamycin

Chloroquine

Cocaine

Doxorubicin

Emetine

HER-2 targeting drug (Trastuzumab-Herceptin)

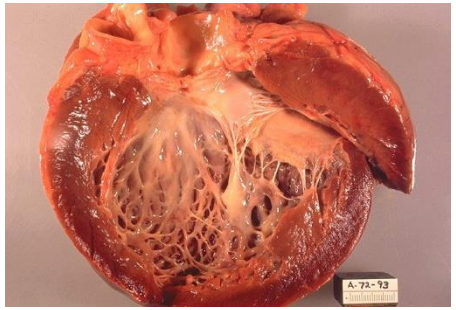
Lithium

Phenothiazines

Sulfonamides

Sympathomimetics

Mitoxantrone



Pericarditis

Hydralazine

Methysergide

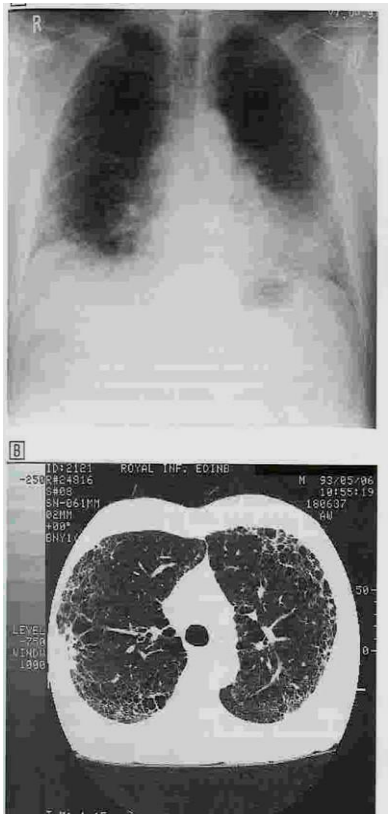
Minoxidil

Penicillins

Drug Side Effects - Lungs

- Pulmonary infiltrates

Acetaminophen*
Acyclovir
Amiodarone
Ampicillin*
Amitriptyline
Azothiaprine
BCNU
Bleomycin
Busulfan
Cocaine*
Cyclophosphamine
Gold
Methysergide
Mitomycin C



MTX*
Nitrofurantoin*
Nitrosoureas
Penacillamine*
Phenytoin*
Procarbazine
Ranitidine*
Sulfonamides*
Tryptophan*

* = with eosinophilia

Drug Side Effects - Lungs

- ARDS

ASA

Barbituates

Chlordiazepoxide

Cocaine

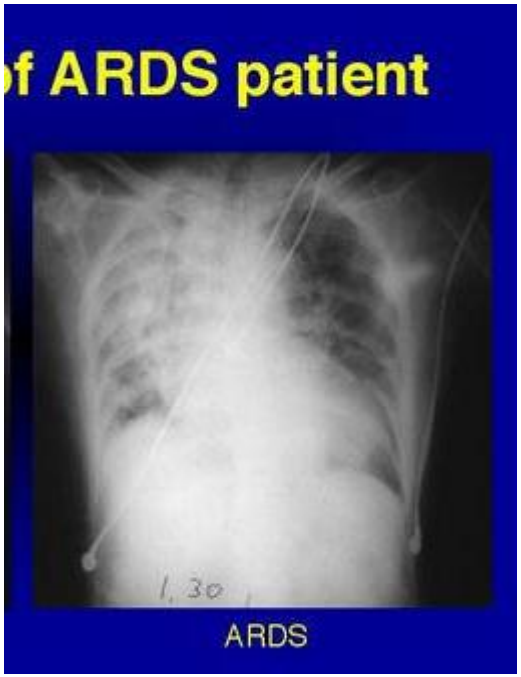
Contrast media

Ethchlorvynal

Heroin

Methadone

Propoxyphene



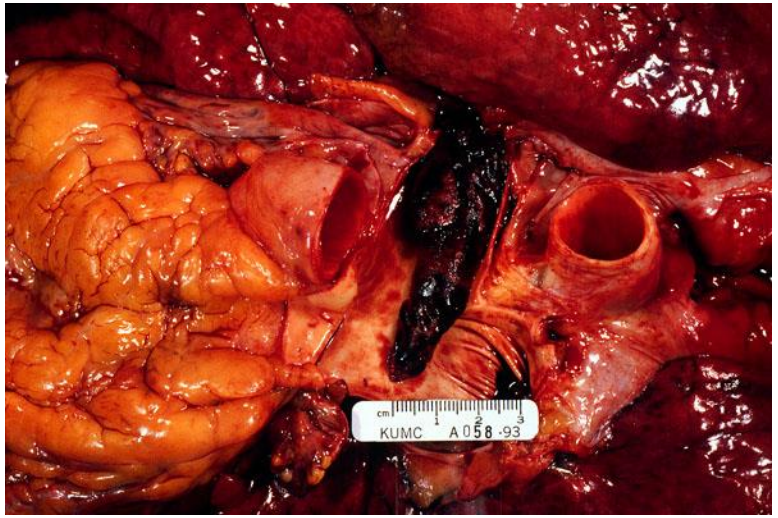
- Respiratory Failure
  - Aminoglycosides
  - Succinylcholine
  - Gallamine
  - Dimethyltubocurarine
  - CNS depressants (ETOH, Sedatives, Tricyclics, O2, etc.)

- Pulmonary vasculitis (Pulmonary–Renal Syndrome)
  - Allopurinol
  - Hydralazine
  - Penacillamine
  - PTU
  - Sulfasalazine

Drug Side Effects - Lung

Thromboembolism

- Chemotherapeutic
  - cytotoxic drugs
- Erythropoiesis Drugs
- Heparin (HIT)
- IV immunoglobulins
- NSAIDs* – especially COX-2 inhibitors by inhibiting prostacyclines and stimulating thromboxane release
- Ocs
- Raloxifene
- Tamoxifen



*especially marked in AF patients on anticoagulants

Drug Side Effects - Blood

Leukocytosis

Glucocorticoids

Lithium

Neutropenia/Agranulocytosis

Acetaminophen

Antithyroid drugs

Captopril

Cephalosporins

Cimetidine

Chloramphenicol

Clozapine (Clozaril)

Colchicine (Dysplastic WBCs with vacuolization)

Cytoxins

Gold salts

Indomethacin

Levamisole (cocaine)

Methamizole

Penicillins

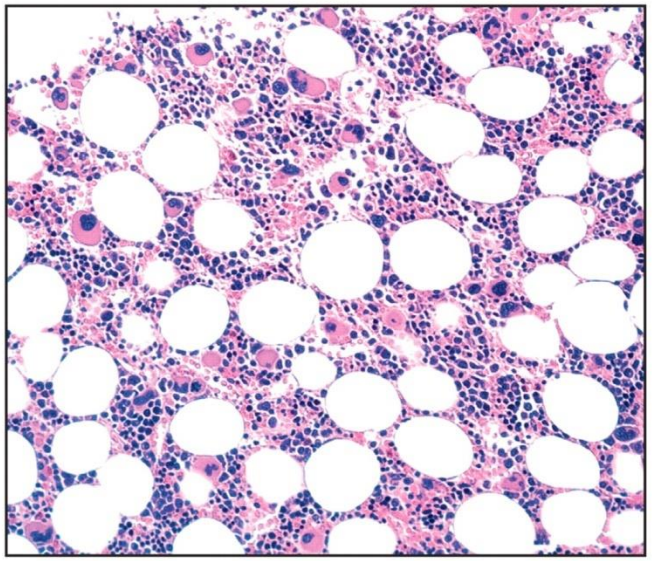
Phenothiazines

Phenytoin

PTU

Sulfonamides

Tricyclics



Drug Side Effects - Blood

- Thrombocytopenia (usually presenting as purpura)
  - Aspirin
  - Barbituates
  - Bleomycin
  - Carbamazepine
  - Carbenicillin
  - Cephalosporins
  - Cimetidine
  - Cyclosporine
  - Desipramine
  - Diuretics
  - Estrogens
  - Furosemide
  - Gold salts
  - Heparin
  - Heroin
  - Indomethacin
  - INH
  - Moxalactam
  - Nitrofurantoin
  - NSAIDs
  - Penicillins
  - Quinine
  - Rifampin
  - Sulfonamides
  - Sulfonylureas
  - Sulindac
  - Ticarcillin
  - Ticlopidine
  - Valproaic acid

Drug Side Effects - Blood

Megaloblastic Anemia

Boceprevir, Telaprevir

BCP

H2 blockers (B12)

MTX

Metformin (B12)

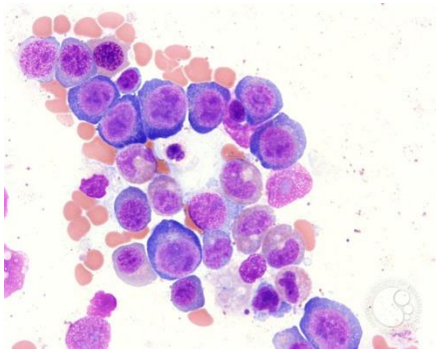
Phenytoin

Primidone

Protein pump inhibitors (B12)

Triamterene

Trimethoprim



Pancytopenia

Carbamazepine

Chloramphenical

Cytotoxics

Gold salts

Phenytoin

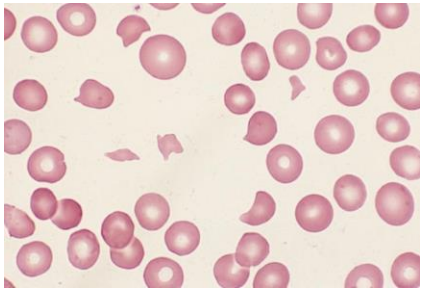
Sulfonamide

Zidovidine (Retrovir)

Drug Side Effects - Blood

Hemolytic Anemia

- Aminosalicyclic acid
- Cephalosporons
- Chlorpromazine
- Dapsone
- INH
- Levodopa
- melphalan
- Penicillin
- PIs (Indinavir-Crixivan)
- Rifampin
- Sulfonamides



Hemolytic Anemia (G6PD)

- Antimalarials
- ASA
- Dapsone
- Nitrofurantoin
- Quinine
- Sulfonamides

Methemoglobinemia

- Dapsone

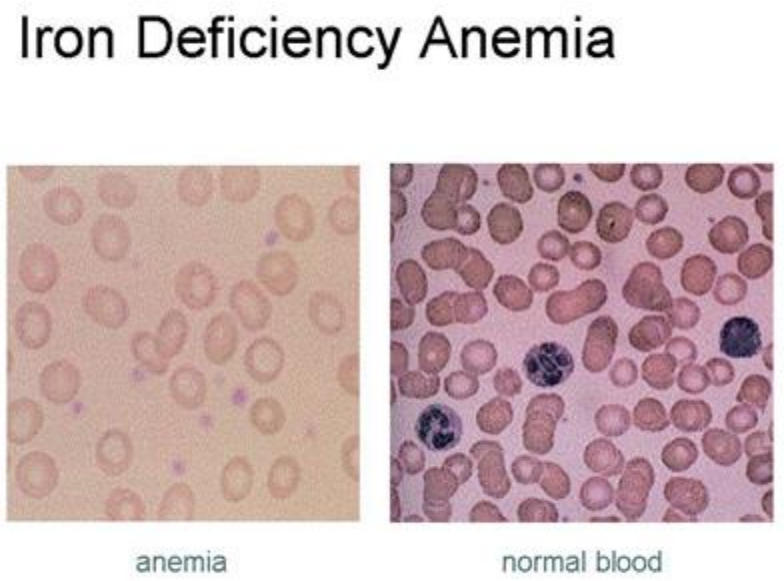
Iron deficiency anemia (often due to GI bleeding)

ASA

Bisphosphanates
(esophageal cancer)

Glucocorticoids

NSAIDs, esp with PPIs



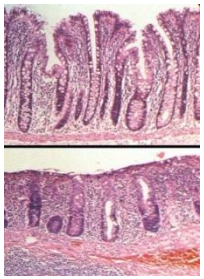
Drug Side Effects – GI Tract

- Pancreatitis

ACE inhibitors
Alpha interferon
Asparaginase
Azathiaprine
BCPs
Calcium
Cyclosporine
DDP4
Didanoside (Videx-DDI)
Ethanol
Ethacrynic acid
Exenitide?
Furosemide
Glucocorticoids
H2 blockers
6-MP
Opiates

Pancreatitis (continued)

NSAIDs
Octreotide
Pentamidine
Propofol (Diprovan)
Ritonavir (Norvir)
Salicylates
Sulfonamides
Tetracyclines
Thiazides
Valproic acid
Vinca alkaloids
Zalcitabine (Hivid)



Drug side effects - GI

Peptic ulcer

ASA

Bisphosphanates (esophageal cancer)

Glucocorticoids

NSAIDs, esp with SSRIs

Small intestional ulcers

NSAIDs with PPIs

NSAIDs with SSRIs

Colitis

Isotretinoin (UC)

Sertraline/Zoloft (microscopic)

Colitis (continued)

NSAIDS (collagenous and exacerbation of UC)

Tocilizumab - lower GI perf

Diarrhea (*C.dif*)

Antidepressants (Fluoxitine, Mirtazapine, Nortriptyline, Trazadone)

Cephalosporins

Clindamycin

Fluoroquinolones

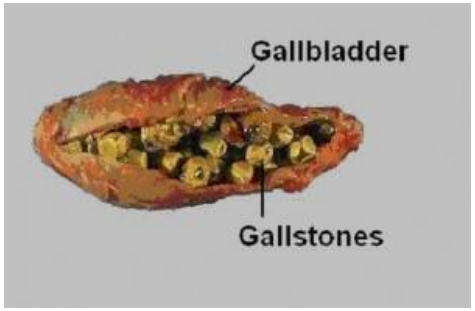
Bleeding

Dabigatran, etc.

Drug Side Effects – Liver

- Cholestatic jaundice
  - Ampicillin
  - Androgens
  - BCP
  - Erythromycin
  - Gold salts
  - Methimazole
  - Nitrofurantoin
  - Phenothiazine

- Gallstones
  - Clofibrate
  - Octreotide
  - Ceftriaxone

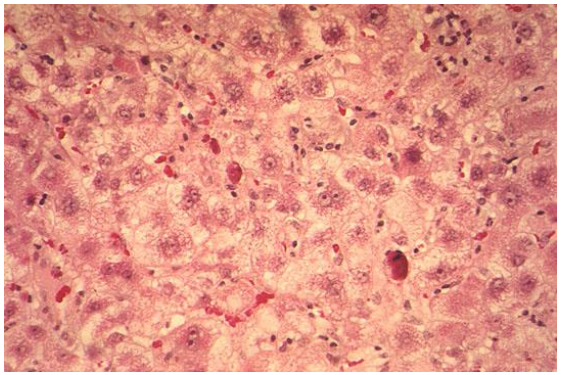


- Steatosis
  - Alcohol
  - Amiodarone
  - Corticosteroids
  - Diltiazem
  - Irinotecan (Camptosar)
  - MTX
  - Oxaliplatin (Eloxatin)
  - NRTIs (Lamivudine-Epivir, Zidovudine-Retrovir)
  - PIs
  - Tamoxifen
  - Tetracyclines
  - Valproic acid

Drug Side Effects - Liver

- Diffuse Hepatocellular Damage

Acetaminophen
Allopurinol
Amiodarone and Dronedarone
Amoxicillin/clavulanate
ASA
Carbamazepine
Cyclophosphamide
Dantrolene
Diclofenac
Ectasy
Erythromycin
Flutamide
Glyburide
HAART
HMG co-reductase inhibitors
INH
Ketoconazole
Lamotrigine(Lamictal)
Leflumonide
Methimizole
Mercaptopurine



- MTX
- NSAIDs
- Niacin
- Nitrofurantoin
- Nifedipine
- Oxacillin
- Phenytoin and other seizure drugs
- Pirfenidone
- Plant alkaloids
- Prophoxyphene
- PTU
- Rifampin
- Ritonavir
- Salicylate
- Sulfonamide
- Tetracycline
- Troglitazone
- Valproic acid
- Vitamin A
- Zidovudine (Retrovir)

Drug Side Effects - Kidney

Renal Concentrating Defects

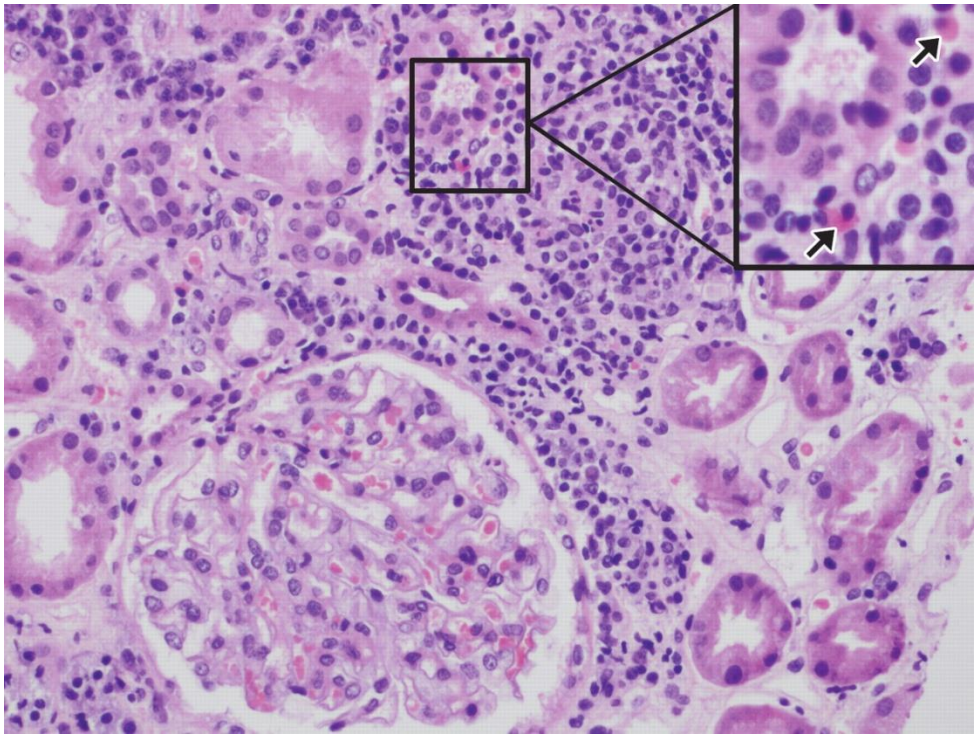
- Demeclocycline
- Lithium
- Vitamin D

Interstitial nephritis

- Allopurinol
- Cephalosporins
- Ciprofloxacin
- Diuretics
- Furesomide
- Methicillin
- Penicillin
- Phenytoin
- PPIs
- NSAIDs

Interstitial nephritis (continued)

- Rifampin
- Sulfonamides
- Thiazides



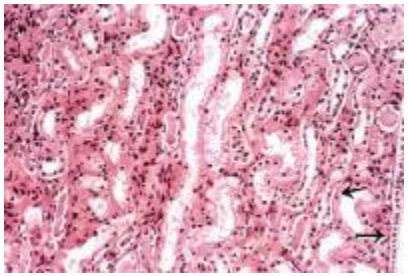
Drug Side Effects – Kidney & GU

Renal Tubular Necrosis

Acyclovir
Aminoglycosides
Ampho B
Atypical antipsychotics
Bowel preps (Visicol, Osmoprep-Phosphates)
Calciuim channel blockers*
Cephalosporins
Cisplatin (RTA IV)
Cyclosporine (RTA IV)
Fluroquinplones

RTN (continued)

Heavy metals
Radioiodinated contrast (more so if on Metformin, NSAIDs or ACE inhibitors)
Statins
Sulfonamides
Synthetic cannabinoids
Tenofovir(Viread) (RTA II)
Tetracyclines
Vancomycin



*if combined with enzyme inhibitors CYP 450 3A4, especially Clarithromycin

Drug Side Effects – Kidney & GU

Kidney stones (crystaluria)

- Triamterene
- Protease inhibitors – atazanavir
- Cipro, acyclovir, amoxicillin, sulfadiazine, cefepine

Nephrotic Syndrome

- Captopril
- Gold salts
- Penacillamine
- Probenecid

Priaprism

- Trazodone

Hypogonadism

- Intrathecal opoids
- Methadone

Vaginal carcinoma

- Diethylstillbestrol

Progressive renal failure

- erythropoiesis stimulating agents

Hemorrhagic Cystitis

- Cyclophosphamide

Drug Side Effects – Muscle and Bone

Fractures (and Osteonecrosis)
- Biphosphonates - jaw osteonecrosis and atypical femoral fractures
- SGLT2*
- Thiazolidinediones
- Vitamin D deficiency and excess - keep 25(OH) D level at 20 – 30 ng/mL
- Sulfonylureas?

Tendonitis and Rupture
- Fluroquinolones (may also produce retinal detachment?)
- Steroids

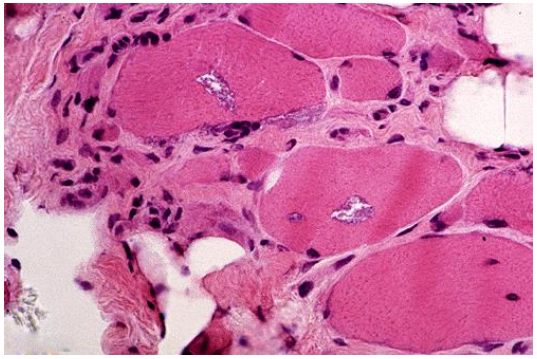
Osteoporosis
- Aluminum
- Anticonvulsants
- Glucocorticoids
- Heparin
- PPIs – also implicated in C diff, pneumonia, hypomagnesemia and osteoporosis , and B12 malabsorption
- Tenofovir (Viread)
- Thiazolinediones

*decreased PTH and vit D

Drug Side Effects – Muscle

Myopathy/Myalgia/Myositis

Alcohol
Aminocaproic acid
Ampho B
Bretylium
BCP
Emetine
Gemfibrozil
Chloroquine
Colchicine
Glucocorticoids
Penicillamine
Statins
Tryptophan
Zidovudine



Rhabdomyolysis

Statins especially with amiodarone* azole antifungals, calcium channel blockers*, cyclosporine, gemfibrozil, macrolides, danazol, and HIV and HCV protease inhibitors[#] – "No Mevacor or Zocor with HAART"

*Simvastatin to be avoided with all above and should not exceed 10 mg dose with amiodarone or CCBs.

[#]Atorvastatin should be restricted with some p[rotease inhibitors and dose limited with others.

Drug Side Effects – Collagen Vascular

- Systemic or Cutaneous Vasculitis
  - Allopurinol
  - Antibiotics
  - Aspirin
  - Cimetidine
  - Furosemide
  - Gold
  - Hydralazine (HLA-DRw4)
  - Indomethacin
  - Leukotriene receptor antagonist (Zafirlukast-Accolate)
  - NSAIDs
  - Penacillamine
  - Penicillins
  - Phenytoin
  - PTU
  - Sulfasalazine
  - Sulfonamides
  - Thiazides

- SLE

Beta blockers*
Captopril*
Carbamazepine*
Cimetidine*
Chlorpromazine
d-penicillamine
HCTZ*
Hydralazine
INH
Levodopa*
Lithium*
Lisinopril*
Nitrofurantoin*
Phenytoin
Procainamide
Sulfasalazine*
Sulfonamides*

*= probable association

Drug Side Effects – Polyarthritis

- Arthralgia (severe)

DPP-IV inhibitors (gliptins)

Thiazides (uric acid)

Drug Side Effects Miscellaneous

Cancer

Amiodarone?

ARBs

Ca channel blockers (ductal and lobular breast cancer)

Chemothearpy (ie. cytoxan)

Erythropoiesis Stimulating Agents

Thiazolinediones (bladder)

Tyrosine kinase inhibitors

TNF inhibitors (melanoma)

Metabolic syndrome (weight gain)

Tricyclics

Psychotropics (amitriptyline, olanzepine, lithium,etc.)

Infections (Fungal)

Anti-IL6 (ie. Tocilizumab-Actemra)

TNF blockers(ie. Adilimumab/ Humira)

Increased carotid artery intima-media thickness

Ezetimibe

Increased mortality

Acetaminophen (GI, renal, and CV events

Tigecycline

Secondary AML

Mitoxantrone

The bottom line: Anticonvulsants, Atypical Antibiotics (dicloxicillin, griseofulvin, nafcillin, rifampin and rifabutin), and St John's Wort, are enzyme inducers and therefore reduce the parent drug.

Most everything else, especially *Amiodarone, Azole Antifungals, Conivaptin, Cyclosporine, Fluvoxamine(Luvox), Grapefruit Juice*, Macrolide Antibiotics, non-hydropyridine calcium channel blockers, Protease Inhibitors*, and Sulfamethoxazole will act as enzyme inhibitors and raise the parent drug and its effects.

One must remember that some drug, ie clopidogrel and, tamoxifen need the CYP 450 for conversion to an active metabolite. In these cases the enzyme inducers will reduce the levels of the parent drug, but actually increase their effect through the increased metabolite. On the contrary and as an example, tamoxifen which needs to be converted to endoxifen, will lose its effects when given with the CYP2D6 inhibitiors paroxetine, fluoxetine, or bupropion.

*possibly also cranberry juice

Drug – Drug Interactions

- Wafarin – Effect reduced by "*enzyme inducers"* of CYP 2C9:

1. AEDs (Barbituates, Carbamazepine, Oxycarbazepine, Phenytoin, Primidone,etc.)
2. Atypical Antibiotics (Dicloxacillin, Griseofulvin, Nafcillin, Rifabutin, Rifampin)
3. Misc. (Bosentan)
4. NNRTIs [Nevirapine (Viramune), efavirenz(Sustiva)]
5. St John's Wort

- Immunosuppresents: [Cyclosporine (Neoral), Sirolimus (Rapamune), Tacrolimus (Prograf)] - effect reduced by "*enzyme inducers"* of CYP 2C9:

1. AEDs, etc. as listed above.

Drug – Drug Interactions

- Warfarin - effect increased by "*enzyme inhibitors*" of CYP2C9 (bleeding):

1. Alcohol intoxication
2. Sulfinpyrazone
3. Azole antifungals (Fluconazole and Miconazole)
4. Antibiotics (Chloramphenol, Metronidazole, Trimethaprine/ Sulfamethoxazole, ciprofloxacin, levofloxacin)
5. Fluoxetine
6. Amiodarone, propafenone
7. Androgens, Tamoxifen, Danazol
8. Capecitabine (Xeloda), Flurouracil
9. Statins (except pravastatin) and Fibrates
10. Disulfiram
11. INH
12. Zafirlukast (Accolate)
13. Oral corticosteroids

Drug-Drug Interactions

- Clopidogrel –effect decreased with enzyme inhibition of CYP2C19. (This CYP is needed to convert clopidogrel to an active metabolite so that it can be an effective anti-platelet agent)
  1. omeprazole* (may use pantoprazole)
  2. esomeprazole
  3. cimetidine
  4. fluconazole
  5. fluoxetine

***No clinical difference in outcome**

Drug – Drug Interaction

- HMG reductase inhibitors

1. Lovastatin
2. Simvastatin (Should not be used above 40 mg/day)

Both produce myopathy if given with the following CYP3A4 "*enzyme inhibitors*":

1. Fluvoxamine (Luvox)*
2. Azole antifungals (ie. Itraconazole)*
3. Grapefruit (limit to 1 quart daily)
4. Macrolide antibiotics (ie. Erythromycin, Clarithromycin)
5. Amiodarone (limit lovastatin to 40 mg and simvastatin to 20 mg/day)
6. HIV protease inhibitors*
7. Danazol, diltiazem, verapamil (limit to 20 mg/day)

Drug – Drug Interactions

1. Ergot alkaloids including dihydroergotamine, ergotamine and methysergide may produce ergotism (St Anthony's Fire) when combined with CYP3A4 *"enzyme inhibitors"*:
    1. Azole antifungals (ie. Fluconazole)
    2. Cyclosporine
    3. Diltiazem
    4. Fluvoxamine (Luvox)
    5. Grapefruit
    6. Macrolide antibiotics (eg. Clarithromycin)
    7. Protease inhibitors (Amprenavir(Agenerase), Atazanavir(Reyataz), Indinavir(Crixivan), Nelfinavir(Viracept), Delavirdine(Rescriptor), Retonavir(Norvir), Saquinavir(Fortivase)
    8. Quinupristin(Synercid)
    9. Telithromycin(Ketek)
    10. Verapamil.

2. Ergots can produce gangrene with the addition of:
    1. Triptans such as Sumatriptan

Drug – Drug Interactions

Immunosuppresants such as Cyclosporine may become toxic if given with CYP3A4 "*enzyme inhibitors*":

1. Azole antifungals (ketoconazole)
2. Grapefruit
3. Macrolides (troleandomycin, telithromycin)
4. PIs (ie Amprenavir)

- Vinca alkaloids vinblastine and vincristine produce toxicity in the presence of *"enzyme inhibitors"* of CYP3A4:

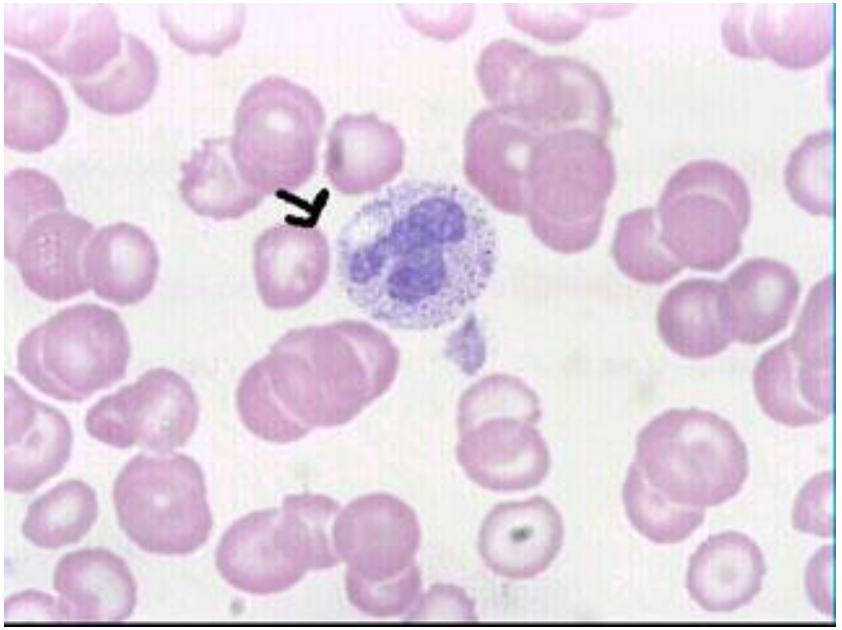
1. Azole antifungals (fluconazole)
2. Cyclosporine
3. Fluvoxamine (Luvox)
4. Grapefruit
5. Macrolides
6. PIs (Ritonavir)

In additiion, Cyclosporine is a potent CYP3A4 and P-glycoprotein inhibitor.

Colchicine is a CYP3A4 and P-glycoprotein substrate.

Thus, give colchicine to a patient on cyclosporine and watch for neutropenia with vacuolization of the neutrophils,

Ie. colchicine toxicity.



Drug - Drug Interactions with agonist and antagonist

- Dopamine agonist such as:

1. Bromocryptine(Parlodel)
2. Pramipexole(Mirapex)

are counteracted by Dopamine antagonist such as:

1. Haloperidol
2. Metochlopramide
3. Phenothiazines
4. Thiothixenes

- Central alpha-adrenergic agonist such as:

1. Clonidine

may lose their antihypertensive effects with

1. Tricyclics(ie. Amitriptyline)
2. Mirtazapine (Remeron) - a tetracyclic, but like the tricylics, it is a central alpha adrenergic receptor antagonist.

Drug – Drug Interactions related to receptor blockade

- Noncardioselective beta blockers such as Nadolol or Sotalol should contraindicate the use of:

  Epinephrine since a violent pressor effect may result.

- Antidiabetic agents from sulfonylureas to insulin should not be used with:

  Noncardioselective beta blockers such as Carvediol or Propranolol because of prolonging hypoglycemia. (OK to use Atenolol, Metoprolol, etc).

Drug – Drug Interactions with altered metabolism or secretion

- Methotrexate may produce bone marrow suppression and GI toxicity by inhibitors of anionic tubular secretion:

1. Aspirin
2. Cipro
3. NSAIDs
4. Omeprazole
5. Pantoprazole
6. Penicillins
7. Probenecid
8. Salicylates
9. Thiazides
10. Trimethoprim.

Antimetabolites _ such as Azathioprine and Mercaptopurine should not be used with:
Allopurinol since the latter inhibits the metabolism of the former and thus makes them toxic.

Drug – Drug Interactions with drugs having similar effects.

Nitrates, Terazosin and Doxazosin may produce hypotension in the presence of phosphodiesterase inhibitors:

1. Sildenafil (Viagra)
2. Tadalafil (Cialis)
3. Vardenafil (Levitra)

Warfarin effects may be potentiated by:

Antibiotics which seem to prolong PT and/or bleeding time, and include:

a. Cephalosporins with a NMTT side chain (ie Cefotetan, Moxalactam)

b. Macrolides

c. Penicillins

d. Quinolones

e. Tetracycline (occasionaly)

Drug – Drug Interactions with drugs with additive effects

MAO inhibitors including Eldepryl and Linezolid may produce excessive serotinergic effects (Serotonin Syn) with agitation, hypertension, myoclonus, hyper-reflexia, hyperpyrexia, seizures, coma etc. in the presence of:

1. Tricyclics (Imipramine)
2. SSRIs (Duloxetin)
3. Sympathomimetics (Dopamine)

Anticholinergic drugs are enhanced by:

1. Tricyclics
2. Antihistamines
3. Antiparkinson drugs
4. Antipsychotics

- Blind as a bat
- Dry as a bone
- Full as a flask
- Mad as a hater
- Red as a beet
- Fast as a flash

Drug – Drug Interactions: *P-gp**

Digoxin has increased levels with inhibitors of P-glycoprotein*

Amiodarone
Azole antifungals
Ca channel antagonist
Clarithromycin and Erythromycin**
Cyclosporine
Propafenone
Quinidine
Ritonavir

1. Dabigatran has decreased effects (ie. stroke or embolization) with P-gp inducers

Rifampin

2. Dabigatran has increased effects (ie. bleeding) with P-gp inhibitors if used in presence of renal insufficiency:

Ketoconazole
Amiodarone, Dronedarone
Verapamil, Diltiazem
Clarithromycan

***** An ABCB1 membrane transporter (ATP dependent efflux pump) involved in excretion. (A similar efflux pump activation is involved in the 2nd gene polymorphism of clopidogrel metabolism)

**Macrolides also kill Eubacterum lentum, decreasing dig metabolism.

Drug – Drug Interactions: *P-gp**

Rivaroxaban and Apixaban have decreased levels (stroke or embolization) with inducers of P-glycoprotein, especially if they also are CYP 3A4 inducers as well (dual effect drugs):

Carbamazepine, Phenytoin

Rifampin

St John's wort

Rivaroxaban* and Apixaban have increased effects (ie. bleeding) with strong dual (P-gp and CYP3A4) inhibitors:

Conivaptin

HIV ptotease inhibitors

Itraconazoole, Ketoconazole

*Even weak to moderate CYP3A4

Inhibitors with dual effects can cause bleeding in renal insufficiency (ie. amiodarone, cimetidine, verapamil, diltiazem, and erythromycin)

Drug – Drug Interactions

Thyroid will have inadequate absorption with:

Aluminum and MG antacids
Calcium carbonate
Carafate
Chromium
Colesevelam(Welchol)
Iron
Lanthanum carbonate (Fos-Renal)

Aminoglycosides toxicity worsened by other antibiotics including:

1. Ampho B
2. Cephalothin
3. Vancomycin

Drug – Drug Interactions

PPIs decrease stomach acid and impair absorption of:

Atazanavir

Rilpivirine

1. What would be an expected reaction to the following drugs: acetaminophen, amoxacillin/clavulanate, INH, phenytoin, and trimethaprim/sulfamethaxozole?
A. renal failure
B. muscle weakness
C. exfoliative dermatitis
D. pleuritis
E. drug induced liver injury

2. A patient on interferon and cytarabine treatment for CML is given erytropoietin for anemia. The patient should be advised of the chance of increased death due to:
A. renal failure
B. tumor Lysis
C. PE
D. sepsis
E. V tach

3. A male patient is taking amiodarone for control of atrial fibrillation. This patient may suffer an exacerbation of his dysrrhythmia with ingestion of:

A. azithromax
B. green tea
C. grapefruit juice
D. St John’s wort
E. ketoconazole

4. A patient on a stable dose of lithium develops vomiting, diarrhea, drowsiness, tremor, ataxia, and muscle weakness after starting HCTZ and lisinopril for hypertension and ibuprofen for DJD. This patient has developed:

A. severe hyponatremia due to SIADH
B. a myasthenic reaction
C. lithium toxicity due to altered excretion
D. acute hepatitis
E. pseudobulbar palsy from lithium

5. What might be expected if a patient on ritonavir boosted PIs were started on simvastatin?

A. depression
B. glucose intolerance
C. peripheral neuropathy
D. rhabdomyolysis
E. pancreatitis

structure of myoglobin

6. A patient on warfarin for atrial fibrillation could suffer an embolic CVA after being started on a (an):
A. azole antifungal
B. macrolide antibiotic
C. amiodarone
D. anticonvulsant
E. protease inhibitor

7. A patient on cefuroxime (Ceftin) may fail to clear pneumonia related to taking:
A. famotidine
B. ASA
C. acetominophen
D. Vitamin C
E. gensing

8. A patient who has been on fluoxetine (Prozac) for depression and selegiline (Eldepryl) for PD is started on 28 days of oral linezolid(Zyvox) for a MRSA infection.
He is in danger of developing:
A. myoclonus, agitation and diaphoresis
B. muscle paralysis and dry mouth
C. bradycardia and anhydrosis
D. miosis, hypersomnolence, and obstipation
E. liver failure with metabolic alkalosis

9. A dialysis patient might be expected to need an increased dose of his thyroid replacement with the addition of what to his program?
A. warfarin
B. famotidine
C. lanthanum carbonate (Fosrenal)
D. amiodarone
E. ciprofloxacin

10. A patient on ibuprofen 600 mg TID with fluoxetine 40 mg daily develops an intractable Gl bleed due to:
A. fluoxetine potentiation of gastric ulcers
B. portal hypertension due to the combination
C. fluoxetine blockage of renal excretion of Ibuprofen
E. prolongation of PT and PTT
D. dysfunctional platelets from decreased serotonin uptake

11. An Asian student at Harvard has new onset seizures. Before starting AEDs it might be wise to obtain:
A. EKG for QTc interval
B. family history for Malignant Hyperthermia.
C. G6PD assay
D. RH factor
E. HLA B typing

12. A patient on a two week course of levofloxacin begins to complain of left shoulder pain. One must be concerned for:
A. SLE
B. MI
C. gout
D. tendonitis
E. pancreatitis

13. An HIV patient on PIs including atazanavir(Reyataz) might develop an increase in his viral load following institution of:
A. omeprazole
B. NSAID
C. grapefruit juice
D. azithramycin
E. interferon

14. A person on cyclosporine (Neoral) may develop a serious BP elevation with the addition of:

A. St John's wort
B. mycelex troches
C. cranbury juice
D. grapefruit juice
E. valerian

15. An HIV patient on glyburide develops hypoglycemia from the addition of sulfamethoxazole to his program. This interaction is probably due to:

A. increased sulfonylurea absorption
B. displacement of glyburide off protein binding sites
C. decreased glyburide excretion
D. CYP induction by the sulfonamide
E. resultant renal insufficiency

16. A patient who has been well controlled on warfarin for DVT prophylaxis is started on a new medicine. In one week the INR has increased to 4.1. Most likely that medicine is:

A. thyroid replacement
B. digoxin
C. rifampin
D. topiramate
E. carafate

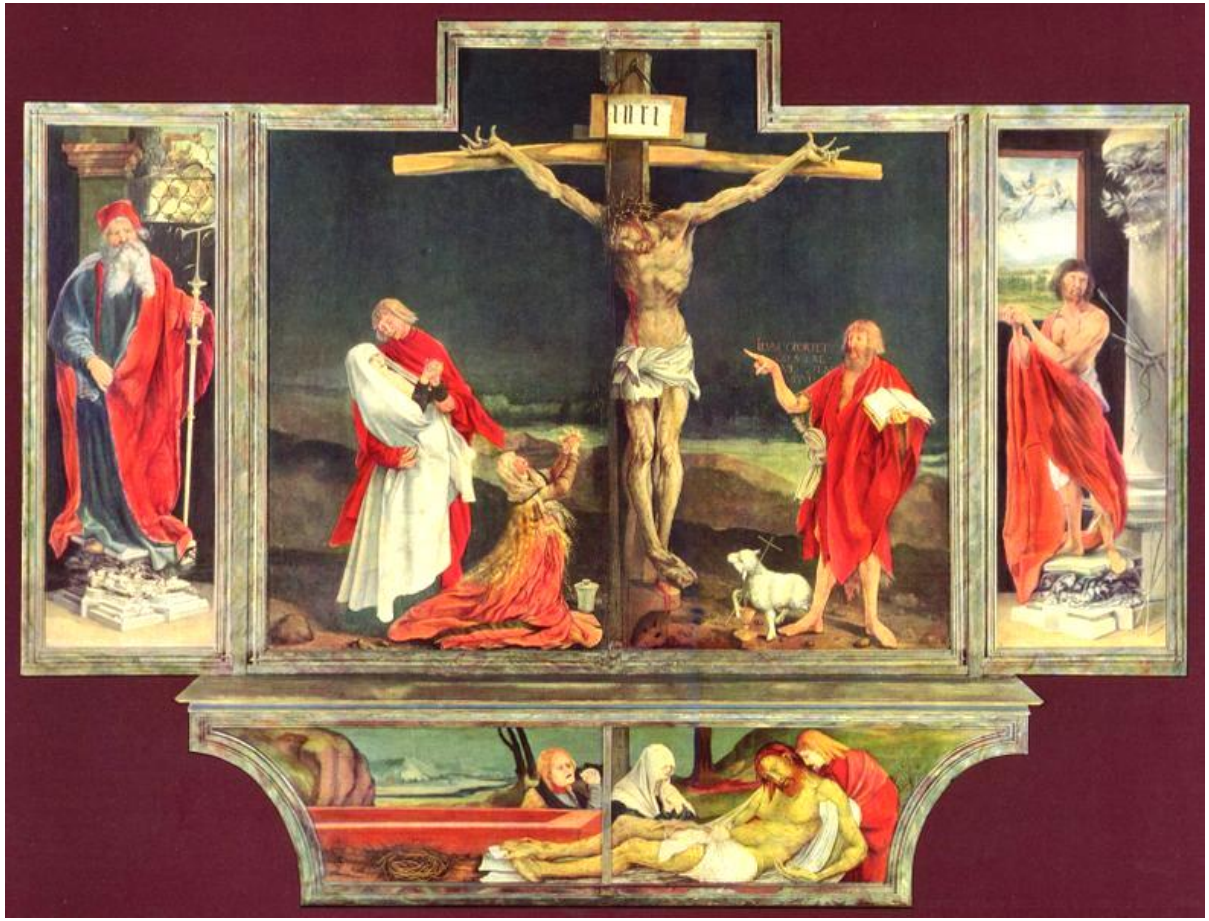
17. A Multiple Sclerosis patient on prednisone 60 mg/day with calcium 500 mg BID and alendronate 70 mg weekly is starting to loose his teeth. What would be the best approach at this point?

A. stop the steroids
B. full mouth extraction
C. stop the alendronate
D. call your lawyer
E. increase the calcium

18. A physician unwittingly places a migrainous patient on Sumatriptan* (Imitrex) not knowing that she was already on ergotamine (Cafergot) from her neurologist. The patient then presents to the ER with:

A. fever
B. St Anthony's fire
C. morbiliform rash
D. asthma attack
E. gout

*triptans are not felt to produce the Serotonin Syndrome since they activate the 5-HT1 BD, and F receptors, while the SS is related to activation of 1A and 2A receptors



The Isenheim Altarpiece by Matthius Grunewald showing effects of ergotamines

19. A patient on an HAART program including Tenofovir (Viread) is prepared for a CT scan of the abdomen with Osmoprep, an osmotic bowel
cleanser. Two days later the patient presents with:
A. renal tubular necrosis
B. MI
C. bowel perforation
D. GI bleeding
E. ischemic colitis

20. A patient with a CYP450 2D6 ultrametabolizer status that is placed on a macrolide along with codeine is in jeopardy of developing:
A. diarrhea
B. cough
C. pain
D. coma
E. seizures

21. A hepatitis C positive HIV patient on HAART presents with a new elevation in liver enzymes with AST twice as high as ALT. Fasting glucose is between 100 and 126 on two occasions. One is most concerned about:

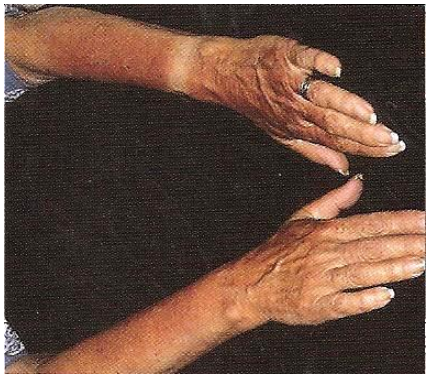
A. pancreatic cancer
B. progression of hepatitis C
C. cirrhosis
D. Immune Reconstitution Syndrome
E. hepatic steatosis

22. A patient who has been stable on spironolactone and lisinopril decides to take ibuprofen for his “bad back”. A month later the patient has hyperkalemia as well as:

A. hypercalcemia
B. hypophosphatemia
C. low CO2 due to Type IV RTA
D. anemia
E. elavated AST and ALT

23. A diabetic drug addict on linezolid (Zyvox) for 28 days for MRSA sepsis is prone to develop:
A. granuloma annulare
B. renal insufficiency
C. C. diff
D. lactic acidosis
E. DKA

24. This patient has been exposed to:
A. polychlorinated aromatic hydrocarbons
B. lisinopril
C. allopurinol
D. quinine
E. minocycline



25. This patient has had a reaction to:
A. doxepin
B. glucophage
C. nevirapine(Viramune)
D. pravastatin
E. tamsulosin(Flomax)

26. An HIV patient on varenicline(Chantrix), phenytoin, and paroxetine is started on a program including efavirenz(Sustiva). This patient is in danger of:

A. suicide
B. impulsive gambling
C. status epileptica
D. rhabdomyolysis
E. hepatitis

27. A patient develops nausea and vomiting and a halo around lights. She reports being on digoxin and was recently started on:

A. erythromycin
B. codeine
C. griseofulvin
D. acetominophen
E. phenobarbital

28. Which of the following is no longer available in the US for colonoscopy bowel preps?

A. Fleets Phospho-Soda
B. GoLytely
C. HalfLytely
D. OsmoPrep
E. Colyte

29. A patient taking amiodarone chronically and started on a quinolone must be concerned about the development of:
A. acute renal failure.
B. atrial fibrillation.
C. lichen planus.
D. alopecia.
E. torsade de pointes.

30. A patient with long standing diabetes and hypertension with renal insufficiency who starts taking famotidine should be alert for the development of:

A. worsening renal failure.
B. mental status change.
C. erythema nodosum.
D. clubbing.
E. Myositis.

The bottom line: Anticonvulsants, Atypical Antibiotics (dicloxicillin, griseofulvin, nafcillin, rifampin and rifabutin), and St John's Wort, are enzyme inducers* and therefore reduce the parent drug.

Most everything else, especially *Amiodarone, Azole Antifungals, Conivaptin, Cyclosporine, Fluvoxamine(Luvox), Grapefruit Juice, Macrolide Antibiotics, Nonhydropyridine Calcium Channel Blockers, PPIs, Protease Inhibitors, and sulfamethoxazole* will act as enzyme inhibitors and raise the parent drug and its effects (unless the parent needs to be changed to an active metabolite, ie clopidigrel and tamoxifen).

**some* NNRTIs (Nevirapine-Viramune, Efavirenz-Sustiva) may be enzyme inducers, as may bosentan.