The Autonomic Nervous System and Toxic Syndromes

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Objectives

- Review the anatomy and physiology of the autonomic nervous system
- Improve understanding of medications that affect the autonomic nervous system
- Use clinical findings to predict potential causes of toxic syndromes
- Go over a bunch of tox cases and make this lecture slightly more enjoyable than a hernia
Central Nervous System (CNS)
- Brain and spinal cord
- Integrative and control centers

Peripheral Nervous System (PNS)
- Cranial nerves and spinal nerves
- Communication lines between the CNS and the rest of the body

Sensory (afferent) division
- Somatic and visceral sensory nerve fibers
- Conducts impulses from receptors to the CNS

Motor (efferent) division
- Motor nerve fibers
- Conducts impulses from the CNS to effectors (muscles and glands)

Sympathetic division
- Mobilizes body systems during activity ("fight or flight")

Parasympathetic division
- Conserves energy
- Promotes "housekeeping" functions during rest

Autonomic nervous system (ANS)
- Visceral motor (involuntary)
- Conducts impulses from the CNS to cardiac muscles, smooth muscles, and glands

Somatic nervous system
- Somatic motor (voluntary)
- Conducts impulses from the CNS to skeletal muscles

Key:
- Red = Structure
- Black = Function

Sub-figure: Schematic diagram of a peripheral nerve with sensory and motor fibers. Stimulation or recording at site A involves both sensory and motor fibers, at site C sensory fibers only, and at B both sensory and motor fibers, since the motor nerve has more sensory fibers.
Autonomic Nervous System

- Temperature regulation
- Fluid and electrolyte balance
- Metabolism rate
- Digestion and excretion
- Cardiovascular function
Autonomic Nervous System

- Responsible for control of involuntary responses
- Two functional divisions:
  - Sympathetic (adrenergic)
  - Parasympathetic (cholinergic)
- Preganglionic fibers – from spinal cord to ganglia
- Postganglionic fibers – from ganglia to target organs
- Synapses – space between nerve cells (endings)
- Neurotransmitters – chemical messengers
  - Norepinephrine (NE)
  - Acetylcholine (Ach)
Autonomic Nervous System

A. Sympathetic (thoracolumbar)
   • Peripheral neurotransmitter = norepinephrine
   • Receptors: alpha (1 and 2) & beta (1 and 2)

B. Parasympathetic (craniosacral)
   • Peripheral neurotransmitter = acetylcholine
   • Cholinergic receptors: muscarinic and nicotinic
Sympathetic

- dilates pupil
- relaxes bronchi
- accelerates heart beat
- inhibits digestion
- contracts vessels

Parasympathetic

- contracts pupil
- constricts bronchi
- slows heart beat
- stimulates digestion
- dilates vessels
Physiologic Receptors in the Autonomic Nervous System

**CHOLINERGIC** (Acetylcholine)
- **Nicotinic**: autonomic ganglia, adrenal medulla, striated muscle
- **Muscarinic**: heart, smooth muscle, glands

**ADRENERGIC** (epinephrine, norepinephrine)
- **Alpha – 1**: blood vessels, eyes, reproductive organs
- **Alpha – 2**: regulate neurotransmitter release
- **Beta – 1**: heart and kidneys
- **Beta – 2**: salivary glands, eyes, lungs, GI tract, arterioles of heart, lungs, skin, skeletal muscle

**DOPAMINERGIC**
- CNS and renal vasculature
Adrenergic Transmission
Parasympathetic Receptors
<table>
<thead>
<tr>
<th>Location</th>
<th>Cellular Function</th>
<th>Systemic Function</th>
<th>Changes in Schizophrenia</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M_1$ Striatum, cortex, hippocampus</td>
<td>Gq; Postsynaptic, modulate fast transmission and metabolic function</td>
<td>Learning, memory, possible role in some types of epilepsy, cleave amyloid precursor protein, IL-2 production</td>
<td>Down in hippocampus, stratum, PFC, NAc</td>
</tr>
<tr>
<td>$M_2$ Basal forebrain, thalamus, heart, brainstem, pupil, exocrine glands, spinal cord</td>
<td>Gi; Presynaptic inhibitory auto/heteroreceptor</td>
<td>Salivation, akinesia, brady-cardia, smooth muscle contractility, bronchoconstriction, tremor, hypothermia, analgesia, axonal growth</td>
<td>Down in striatum</td>
</tr>
<tr>
<td>$M_3$ Brain (evenly distributed), pupil, hypothalamus, exocrine glands, peripheral arteries</td>
<td>Like $M_1$</td>
<td>Salivation, smooth muscle contractility, vasorelaxation, NO release, appetite</td>
<td>Unknown</td>
</tr>
<tr>
<td>$M_4$ Striatum, cortex, hippocampus, spinal cord</td>
<td>Like $M_2$ plus inhibitory postsynaptic</td>
<td>Regulate striatal DA release, modulate PPI, analgesia, keratinocyte migration</td>
<td>Down in hippocampus, stratum, PFC, NAc</td>
</tr>
<tr>
<td>$M_5$ DA neurons, basal ganglia, brain vasculature</td>
<td>Like $M_1$</td>
<td>Cerebral arterial vasorelaxation</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

$M$=muscarinic; $Gq=G$ protein that activates phospholipase $C$; $Gi=inhibitory G$ protein; PFC=prefrontal cortex; DA=dopaminergic; NAc=nucleus accumbens; PPI=pre-pulse inhibition.

### Autonomic NS Receptors

<table>
<thead>
<tr>
<th>Ach</th>
<th>NE (&amp; E)</th>
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<tbody>
<tr>
<td>Nicotinic (Opens Na+/K+ gate)</td>
<td>α_1 (Activates phospholipase C)</td>
</tr>
<tr>
<td>synaptic communication</td>
<td>mucous in saliva</td>
</tr>
<tr>
<td>excites brain</td>
<td>constricts arteries</td>
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<tr>
<td>at neuromuscular junction</td>
<td>constricts bronchioles</td>
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<tr>
<td>Muscarinic (Second messengers)</td>
<td>α_2 (Decreases cAMP)</td>
</tr>
<tr>
<td>watery saliva</td>
<td>inhibits digestive processes</td>
</tr>
<tr>
<td>slows heart rate</td>
<td>inhibits insulin secretion</td>
</tr>
<tr>
<td>constricts bronchioles</td>
<td>β_1 (Increases cAMP)</td>
</tr>
<tr>
<td>stimulates digestive processes</td>
<td>increases heart rate</td>
</tr>
<tr>
<td>increases insulin release</td>
<td>β_2 (Decreases cAMP)</td>
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<tr>
<td></td>
<td>dilates veins</td>
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<tr>
<td></td>
<td>inhibits digestive processes</td>
</tr>
<tr>
<td></td>
<td>dilates bronchioles</td>
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<tr>
<td></td>
<td>β_3 (Increases cAMP)</td>
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<td></td>
<td>fat breakdown</td>
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See Figure 11-5 in Silverthorn
Autonomic Pharmacology

- **Sympathetic**
  - Agonist: sympathomimetic / adrenergic (epinephrine)
  - Antagonist: sympatholytic
    - Alpha receptor blockers (phentolamine)
    - Beta blockers (propranolol, metoprolol)

- **Parasympathetic**
  - Agonist: cholinergic (acetylcholine)
  - Antagonist: parasympatholytic, anticholinergic
    - Muscarinic receptor blocker (atropine)
    - Nicotinic antagonist (neuromuscular blockers, ganglionic blockers)
Toxic Syndromes

- Physical signs
- Patient symptoms
- Characteristic odors, color
- Laboratory findings
- Suggests, but does not confirm, a diagnosis
A 34 y/o female presents with confusion, disorientation and somnolence.

HR 140
RR 16
BP 130/80
T 101.6

Pupils widely dilated, reactive
Skin hot, dry
Bowel sounds decreased
Mouth dry
Speech slurred

CLUE: depressed, took “sleeping pills”
Diagnosis ???
ANTICHOLINERGIC SYNDROME

- Antihistamines: pyrilamine, doxylamine, diphenhydramine, dimenhydrinate
- Phenothiazines, cyclic antidepressants
- Antiparkinson agents: benztropine, trihexiphenidyl
- Plants
  - Jimson weed (*Datura stramonium*)
  - Deadly nightshade (*Atropa belladonna*)
- Some Mushrooms (muscimol, ibotenic acid)
- Atropine, scopalamine
- Antispasmodics (belladonna, hyoscamine)
ANTICHOLINERGIC SYNDROME

Blind as a bat
Dry as a bone
Red as a beet
Hot as Hades
Mad as a hatter
A 24 y/o male presents with seizures and coma.

HR 160
BP 190/100
RR 24
T 102

Pupils, dilated, reactive
Marked diaphoresis
Bowel sound hypoactive

CLUE 1: EKG – narrow complex sinus tach
CLUE 2: Drug abuser
CLUE 3: HR & BP return to normal within 60 minutes
SYMPATHOMIMETIC SYNDROME

- Mixed alpha and beta adrenergic effects
- Clinical effects:
  - Tachycardia
  - Hypertension
  - CNS stimulation
  - Diaphoresis
  - Decreased GI motility
  - Miosis/Mydriasis
SYMPATHOMIMETIC SYNDROME

Dx: cocaine toxicity

Other agents:
- Amphetamines
- Ephedrine
- Pseudoephedrine
- Anoretics (Fen-Phen)
- Propylhexadrine
- Tyramine
Figure 1 compares intensity and duration of the 3 methods of cocaine administration if ingested by a first-time user.

**SMOKING**
Smoking results in a faster, more intense high but also a shorter one with the most marked crashing effect.

**SHOOTING**
Shooting has an almost immediate effect and slower decline but the dysphoria is also substantial.

**SNORTING**
Snorting results in a longer intense high and a less abrupt decline with fewer crashing symptoms.
A 22 y/o male presents with lethargy, confusion, and complaining of severe crampy abdominal pain, vomiting and severe diarrhea.

**HR** 60  
**BP** 110/70  
**RR** 28, labored  
**T** 99

Diaphoretic, cyanotic, drooling  
Marked respiratory distress with rales  
Bowel sounds hyperactive  
Incontinent of bowel and bladder

**CLUE:** depressed Orkin Man recently broke up with his girlfriend
CHOLINERGIC SYNDROME

- Excess acetylcholine at muscarinic and nicotinic receptors

- Dx: Organophosphate insecticide

- Other Agents:
  - Carbamate insecticides
  - Physostigmine
  - Nicotine insecticides
  - Tobacco
  - Mushroom (Clitocybe, Inocybe)
# CHOLINERGIC SYNDROME

<table>
<thead>
<tr>
<th>D</th>
<th>diarrhea, diaphoresis</th>
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<tr>
<td>U</td>
<td>urination</td>
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<tr>
<td>M</td>
<td>miosis</td>
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<tr>
<td>B</td>
<td>bradycardia</td>
</tr>
<tr>
<td>B</td>
<td>bronchorrhea</td>
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<tr>
<td>E</td>
<td>emesis</td>
</tr>
<tr>
<td>L</td>
<td>lacrimation</td>
</tr>
<tr>
<td>S</td>
<td>salivation, sweating</td>
</tr>
</tbody>
</table>
TOXIC SYNDROMES – CASE 4

A 19 y/o male presents with headache and lethargy. No history of vomiting or diarrhea.

HR 60 BP 210/120
RR 16 T 99.9

Pupils dilated, sluggishly reactive
Skin slightly moist
Bowels sounds decreased

CLUE: 30 min later he develops ↓ LOC and hemiparesis. Hx of “street speed”.
ALPHA ADRENERGIC SYNDROME

- **Dx:** Phenylpropanolamine (PPA) Overdose

- **Other agents:**
  - Phenylephrine
  - Methoxamine
  - Imidazolines
    - Tetrahydrozaline (Visine)
    - Oxymetazoline
    - Naphazoline
    - Xylometazoline
# Alpha Adrenergic Drugs

**ALPHA AGONISTS**
- Dobutamine
- Dopamine
- Ephedrine
- Epinephrine
- Ergot alkaloids
- Methoxamine (Vasoxyl)
- Phenylephrine (Neo-synephrine)
- Phenylpropanolamine (PPA)
- Pseudoephedrine (Sudafed)

**ALPHA ANTAGONISTS**
- Doxazosin (Cardura)
- Prazosin (Minipress)
- Terazosin (Hytrin)
- Phentolamine (Regitine)
- Phenoxybenzamine
- Tolazoline (Priscoline)
- Induramine (Baratol)
- Urapidil
- Labetalol (alpha & beta)
A 2 y/o male presents with agitation and bizarre behavior.

HR 190
BP 80/60
RR 24
T 99.8

Tremulous, irritable
Pupils normal size, reactive
Skin and bowel sounds normal

CLUE: older sibling takes liquid medicine for asthma
BETA-ADRENERGIC SYNDROME

- Dx: Albuterol overdose

- Other agents:
  - Terbutaline
  - Metaproterenol
  - Isoproterenol
  - Theophylline
  - Caffeine
Beta Adrenergic Drugs

BETA AGONISTS
- Albuterol (Proventil, Ventolin)
- Bitolterol (Tornalate)
- Dobutamine
- Dopamine
- Epinephrine
- Isoetharine (Bronkosol)
- Isoproterenol (Isuprel)
- Metaproterenol (Alupent)
- Norepinephrine
- Ritodrine (Yutopar)
- Salmeterol (Serevent)
- Terbutaline (Bricanyl, Brethrine)

BETA BLOCKERS
- Acebutolol (Sectral)
- Atenolol (Tenormin)
- Betaxolol (Kerlone)
- Bisoprolol (Zebeta)
- Esmolol (Brevibloc)
- Metoprolol (Lopressor)
- Carteolol (Cartrol)
- Nadolol (Corgard)
- Penbutolol (Levatol)
- Pindolol (Visken)
- Propranolol (Inderal)
- Sotalol (Betapace)
- Timolol (Blocadren)
- Labetalol (Normodyne, Trandate)
Beta Blocker Toxicity

- Bradycardia
- Hypotension
- A-V block
- Heart failure
- CNS depression
- Seizures
A 2 y/o female presents with extreme lethargy.

HR 72 Dusky appearance
BP 70/50 Lips cyanotic
RR 10 Shallow respirations
T 98 Skin Dry

Bowel sounds decreased, present

CLUE 1: The child improves somewhat after a 2mg dose of naloxone

CLUE 2: Grandfather, visiting at child’s house, takes blood pressure medicine
SYMPATHOLYTIC SYNDROME

- Clonidine
- Methyldopa
- Guanabenz
- Sedative / hypnotics
- Opioids
- Alcohol
Imidazolines

- **Antihypertensives:**
  - Guanfacine (Tenex)
  - Guanabenz (Wytensin)

- **Decongestants**
  - Tetrahydrozoline (Visine)
  - Oxymetazoline (Afrin)
  - Naphazoline (Clear Eyes)
TOXIC SYNDROMES – CASE 7

A 45 y/o male presents comatose and cyanotic.

- HR 68
- BP 110/60
- RR 8, shallow
- T 97.8

Pupils constricted
Needle marks on left arm
Bowel sounds decreased

CLUE: wakes up after IV naloxone
**OPIOID SYNDROME**

- **Dx:** Heroin Overdose
- **Triad:** coma, respiratory depression, miosis
- **Other agents**
  - Opiates
  - Clonidine
  - GHB or analogue
A 35 y/o female presents with confusion and lethargy. No nausea or vomiting.

HR 110
BP 120/80
RR 32
T 99

Labs: Na 142 Cl 96 BUN 27 Glucose 100
K 4.1 Bicarb 8 Cr 2.2

Other labs?
ABG: 7.02 / 96 / 25 Measured osmolality = 380. ETOH = 0.

CLUE 1: Ca oxylate crystals in urine
CLUE 2: Empty container of radiator antifreeze found in trash can at home.
The police bring in a 28 y/o female with drowsiness who says she just wants to die. There is a suicide note.

- HR 130
- BP 120/80
- RR 16
- T 98

Skin warm and dry
Bowel sounds decreased
Pupils slightly reactive
15 minutes later:
TOXIC SYNDROMES - CASE 9

The police bring in a 28 y/o female with drowsiness who says she just wants to die. There is a suicide note.

HR 130  Skin warm and dry
BP 120/80  Bowel sounds decreased
RR 16  Pupils slightly, reactive
T 98

CLUE: 15 minutes later she has a seizure lasting 2 minutes, after which she is deeply comatose with agonal respirations. Cardiac monitor shows wide complex tachycardia with a rate of 160. BP 60/40.
TCA Clinical Toxicity

- Lethargy ± agitation
- Sinus tachycardia

Then:
- Seizures, hypotension, ventricular dysrhythmias
Cyclic Antidepressants

- Inhibit catecholamine reuptake
  - NE, 5-HT, DA
- Block ACH_M receptors
- Block fast Na^+ cardiac channels
- Block alpha- adrenergic receptors
- Block K^+ efflux from cardiac cells
- Indirect GABA antagonist
- Block H_1 and H_2 receptors
A 22 y/o female presents with a severe toothache for one week, and mild nausea and vomiting for 3 days. She is seeking pain medication for the persistent toothache. Her friends told her that her eyes were turning yellow.

Vital signs normal
Mild scleral icterus
Right upper quadrant tenderness
Severely abcessed tooth

CLUE: taking 4-5 OTC pain pills at a time every 3 – 4 hours.
TYLENOL® EXTRA STRENGTH

Pain Reliever
Fever Reducer

Acetaminophen

Caplets

500 mg each

Contains no aspirin

Value Size
225 Caplets
A depressed 17 y/o female presents with acute onset of nausea, abdominal pain, hematemesis and diarrhea.

HR 115
BP initially normal but falls to 80/50
Anion gap metabolic acidosis is present

CLUE 1: pregnant
CLUE 2: X-ray shows radiopaque pills in stomach and proximal small bowel
Iron Poisoning

- Direct GI irritant $\rightarrow$ corrosive
- Decreased venous return $\rightarrow$ fall in CO
- Elevated lactate, release of protons as Fe$^{++}$ converted to Fe$^{+++}$
- Catalyzes free radical formation and lipid peroxidation (hepatotoxicity)
- Hyperglycemia, leukocytosis
The Pathophysiology of Shock in Iron Intoxication

Direct Effects of Iron:

- GI Fluid/Blood Loss
- Increased Capillary Permeability
- Loss of Postarteriolar and Venous Tone
- Coagulopathy
- Hypovolemia/Hypoperfusion
- Metabolic Acidosis

Hypovolemia/Hypoperfusion:

- Lactic Acidosis/Ischemia
- Further Loss of Tissue/Vascular Integrity
- Shock
TOXIC SYNDROMES – CASE 12

A 44 y/o female presents with dyspnea, nausea, vomiting and lethargy. It is difficult to obtain a history because the patient is hard of hearing.

HR 96  BP 130/90
RR 28  T 100.6

PE: consistent with advanced rheumatoid arthritis

CLUE:

ABG: 7.48 / 98 / 22
Na 142  Cl 106  Bicarb 14  K 3.5
Salicylates

- Analgesics
  - ASA, Fiorinal
  - Goody, BC powders
- Pepto-Bismol
- Topical liniment analgesics (Ben Gay)
- Suppositories
- Chewing gum
- Flavorings (oil of wintergreen)
- Plants (acacia, hyacinth, calycanthus)
- Chinese / herbal products
Salicylates

- GI irritant
- Stimulates respiratory center
  - Hyperventilation/respiratory alkalosis
- May alter capillary permeability
  - Cerebral/pulmonary edema
- Uncouples oxidative phosphorylation
  - Causing lactic acidosis, ketoacidosis
- Inhibits cyclo-oxygenase
  - Loss of gastric mucosal barrier
  - Platelet dysfunction
A 44 y/o female presents with severe nausea and vomiting.

- HR: 140, irregular
- BP: 110/70
- RR: 18, Agitated, tremulous
- T: 99, Skin, pupils, bowel sounds are normal

Cardiac monitor shows sinus tach with narrow QRS complex and occasional PADS and PVDS. Before any further information can be obtained the patient has a seizure which is not controlled with diazepam and phenytoin.

**CLUE:** husband had asthma

Hypokalemia
Theophylline

- **Mechanism of Action**
  - Inhibition of phosphodiesterase
  - Adenosine receptor antagonism
  - Release of catecholamines

- **Clinical Effects**
  - Gastric acid and pepsin secretion
  - Stimulation of respiratory & vomiting centers in medulla
  - Positive inotropic and chronotropic effects
  - Reduction of peripheral arteriolar resistance
  - Relaxation of bronchial smooth muscle
  - Increase GFR and RBF
  - CNS stimulation
TOXIC SYNDROMES – CASE 14

A 48 y/o male alcoholic presents with confusion and blurred vision.

HR 100
BP 140/90
RR 32
T 99
Confused, lethargic, disoriented

Labs:  
Na 144  Cl 100  Bicarb 10  
K 3.9  Glu 100  BUN 18  
Cr 1.2
ETOH = 0  Measured osmolality = 350

CLUE: emesis has a bluish tint; urinalysis is normal
A 19 y/o male is brought in by 6 policemen for severe agitation and disruptive behavior.

Hypertensive

Nystagmus

Severe agitation alternating with coma
A 55 y/o male alcoholic presents with lethargy, confusion, nausea, vomiting and abdominal pain.

HR 95 – remainder of vital signs normal
Mild epigastric tenderness

Labs: Na 140 Cl 110 Bicarb 24
K 3.8 BUN 21 Cr 1.2
Glucose 100
ETOH = 0
Measured osmolality = 372

CLUE: urine is positive for acetone
A 4 y/o girl is found comatose in a closet in her home. She is dressed in her mother’s clothes, shoes and jewelry. Also in the closet are her doll, several suitcases and several cans of cleaning fluids and pesticides.

In the ED, she is comatose, with a regular HR of 108 bpm and BP 80 mm Hg by palpation. She has pinpoint pupils, dry skin and clear lungs. No bowel sounds are audible.

The parents are certain that all medications in the home are secured in a medicine cabinet, and all other toxic chemicals are locked under the kitchen sink.
The child is stabilized in the ED. The HR decreases to 96 and the BP rises to 90 mm Hg. She becomes awake, alert and her pupils dilate to normal size after receiving a dose of 2 mg naloxone IV.

The parents still emphatically deny the use of any natural or synthetic opiates at home.

Upon returning home, the father, while searching through the closet, discovers an open bottle of Lomotil tablets in an open suitcase. The antidiarrheal medication had been left there after a foreign trip.
Lomotil

- Diphenoxylate 2.5mg + atropine 0.025mg
- Lethargy reported after ingestion of 1 tablet
- CNS depression may be delayed up to 18 hours
- Treatment is supportive
  - Naloxone for opioid effects
  - Physostigmine has been used for anticholinergic toxicity
A mother runs into your office with her 2 year-old son, anxiously stating that he is difficult to arouse. He awoke that morning and had breakfast as usual, then “fell asleep” two hours later. The child has now been “sleeping” for about an hour.

No one witnessed trauma.

Only medications in the house are APAP and ASA – both stored in the bathroom medicine cabinet.

No history of previous similar episodes.
No family history of metabolic disorders.
Pulse 110, BP 90/60, RR 8, T 36 (96.8)
Obtunded, responding only to painful stimuli by crying and moving purposelessly.
Skin cool, slightly diaphoretic.
Pupils midsize, neuro exam non-focal and symmetric, with slight hyporeflexia in all extremities.

At the end of the exam the child has a generalized, tonic-clonic seizure.
Chem-strip blood sugar = 20 mg%

Further history reveals that the parents had hosted a party the night before that had continued late into the night.
Summary
Nervous system

Central nervous system
- Brain and spinal cord

Peripheral nervous system
- All nervous tissue outside of CNS

Autonomic nervous system
- Controls involuntary "automatic" functions

Somatic nervous system
- Controls voluntary "motor" functions

Sympathetic nervous system
- "Fight or flight"

Parasympathetic nervous system
- "Feed or breed"
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<th>$\alpha$</th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
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<tbody>
<tr>
<td><strong>Stimulation</strong></td>
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<tr>
<td>Mydriasis</td>
<td>Miosis</td>
<td>Miosis</td>
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<tr>
<td>Vasoconstriction</td>
<td>Tachycardia</td>
<td>Vasodilatation</td>
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<tr>
<td>Coronary dilatation</td>
<td>Increased cardiac contractility</td>
<td>Bronchodilatation</td>
<td></td>
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<tr>
<td>Decreased GI motility</td>
<td>Accelerated AV conduction</td>
<td>Hyperglycemia</td>
<td></td>
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<tr>
<td>Bladder contraction</td>
<td>Renin release</td>
<td>Decreased GI motility</td>
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<td></td>
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<td>Blockade</td>
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<tr>
<td>Miosis</td>
<td>Hypotension$^b$</td>
<td>Hypoglycemia with hypertension</td>
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<tr>
<td>Postural hypotension</td>
<td>Cardiac arrhythmias</td>
<td>Bronchospasm</td>
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<tr>
<td>Reflex tachycardia</td>
<td>Bradycardia$^b$</td>
<td>Raynaud's phenomenon</td>
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<tr>
<td>Angina (uncommon)</td>
<td>Pulmonary edema</td>
<td>Hyperkalemia (uncommon)</td>
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<tr>
<td>Gastric hyperacidity</td>
<td>Hyperkalemia (uncommon)</td>
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Abbreviations: AV, atrioventricular; GI, gastrointestinal.

* Additional effects not mediated by these adrenergic receptors, largely central nervous system and sympathomimetic, may also be seen.

$^b$ May be obliterated, or hypertension and tachycardia may occur if drug has intrinsic sympathomimetic effects.

Conclusions

- Safe use of cardiovascular and other resuscitation drugs requires understanding of autonomic nervous system
- Assessment for “toxidromes” can assist in diagnosis of intoxication when lab testing is not available
- Call the Poison Center – it’s a free call and not a sign of weakness!!