Study Questions

Choose the ONE best answer.

3.1 Which of the following is correct regarding the autonomic nervous system (ANS)?

A. Afferent neurons carry signals from the CNS to the effector organs.
B. The neurotransmitter at the parasympathetic ganglion is norepinephrine (NE).
C. The neurotransmitter at the sympathetic ganglion is acetylcholine (ACh).
D. Sympathetic neurons release ACh in the effector organs.
E. Parasympathetic neurons release NE in the effector organs.

Correct answer = C. The neurotransmitter at the sympathetic and parasympathetic ganglia is acetylcholine. Sympathetic neurons release NE and parasympathetic neurons release ACh in the effector cells. Afferent neurons carry signals from the periphery to the CNS.

3.2 Which of the following is correct regarding somatic motor neurons?

A. The neurotransmitter at the somatic motor neuron ganglion is acetylcholine.
B. The neurotransmitter at the somatic motor neuron ganglion is norepinephrine.
C. Somatic motor neurons innervate smooth muscles.
D. Somatic motor neurons do not have ganglia.
E. Responses in the somatic motor neurons are generally slower than in the autonomic nervous system.

Correct answer = D. Somatic motor neurons innervate skeletal muscles (not smooth muscle) and have no ganglia. Answers A and B are incorrect, since there are no ganglia. Also, the responses in the somatic motor nervous system are faster compared to the responses in the autonomic nervous system due to the lack of ganglia in the former.

3.3 Which of the following physiological changes could happen when a person is attacked by a grizzly bear?

A. Increase in heart rate.
B. Increase in lacrimation (tears).
C. Constriction of the pupil (miosis).
D. Increase in gastric motility.

Correct answer = A. When a person is in the "fight-or-fligh mode, as in the case of a bear attack, the sympathetic system will be activated. Activation of the sympathetic system causes an increase in heart rate and blood pressure and a decrease (not increase) in gastric motility. It also causes dilation (not constriction) of the pupil and inhibition of lacrimation.

3.4 Which of the following changes could theoretically happen in a person when the parasympathetic system is inhibited using a pharmacological agent?

A. Reduction in heart rate.
B. Constriction of the pupil (miosis).
C. Increase in gastric motility.
D. Dry mouth (xerostomia).
E. Contraction of detrusor muscle in the bladder.

Correct answer = D. Activation of the parasympathetic system causes a reduction in heart rate, constriction of the pupil, an increase in gastric motility and salivation, and contraction of the bladder muscle. Therefore, inhibition of the parasympathetic system causes an increase in heart rate, dilation of the pupil, a decrease in gastric motility, dry mouth, and relaxation of detrusor muscles.

3.5 Which of the following statements is correct regarding the sympathetic and parasympathetic systems?

A. Acetylcholine activates muscarinic receptors.
B. Acetylcholine activates adrenergic receptors.
C. Norepinephrine activates muscarinic receptors.
D. Activation of the sympathetic system causes a drop in blood pressure.

Correct answer = A. Acetylcholine is the neurotransmitter in the cholinergic system, and it activates both muscarinic and nicotinic cholinergic receptors, not adrenergic receptors. Norepinephrine activates adrenergic receptors, not muscarinic receptors. Activation of the sympathetic system causes an increase in blood pressure (not a drop in blood pressure) due to vasoconstriction and stimulation of the heart.

3.6 Which of the following statements concerning the parasympathetic nervous system is correct?

A. The parasympathetic system uses norepinephrine as a neurotransmitter.
B. The parasympathetic system often discharges as a single, functional system.
C. The parasympathetic division is involved in accommodation of near vision, movement of food, and urination.
D. The postganglionic fibers of the pa asympathetic division are long compared to those of the sympathetic nervous system.
E. The parasympathetic system controls the secretion of the adrenal medulla.

Correct answer = C. The parasympathetic nervous system maintains essential bodily functions, such as vision, movement of food, and urination. It uses acetylcholine, not norepinephrine, as a neurotransmitter, and it discharges as discrete fibers that are activated separately. The postganglionic fibers of the parasympathetic system are short compared to those of the sympathetic division. The adrenal medulla is under the control of the sympathetic system.

3.7 Which of the following is correct regarding neurotransmitters and neurotransmission?

A. Neurotransmitters are released from the presynaptic nerve terminals.
B. Neurotransmitter release is triggered by the arrival of action potentials in the postsynaptic cell.
C. Intracellular calcium levels drop in the neuron before the neurotransmitter is released.
D. Serotonin and dopamine are the primary neurotransmitters in the ANS.

Correct answer = A. Neurotransmitters are released from presynaptic neurons, triggered by the arrival of an action potential in the presynaptic neuron (not in the postsynaptic cell). When an action potential arrives in the presynaptic neuron, calcium enters the presynaptic neuron and the calcium levels increase in the neuron before the neurotransmitter is released. The main neurotransmitters in the ANS are norepinephrine and acetylcholine.

3.8 An elderly man was brought to the emergency room after he ingested a large quantity of carvedilol tablets, a drug that blocks α_1, β_1, and β_2 adrenergic receptors, which mainly mediate the cardiovascular effects of epinephrine and norepinephrine in the body. Which of the following symptoms would you expect in this patient?

A. Increased heart rate (tachycardia).
B. Reduced heart rate (bradycardia).
C. Dilation of the pupil (mydriasis).
D. Increased blood pressure.

Correct answer = B. Activation of α_1 receptors causes mydriasis, vasoconstriction, and an increase in blood pressure. Activation of β_1 receptors increases heart rate, contractility of the heart, and blood pressure. Activation of β_2 receptors causes dilation of bronchioles and relaxation of skeletal muscle vessels. Thus, inhibition of these receptors will cause vasorelaxation (α_1 blockade), reduction in heart rate (β_1 blockade), reduction in contractility of the heart (β_1 blockade), reduction in blood pressure, bronchoconstriction (β_2 blockade), and constriction of blood vessels supplying skeletal muscles (β_2 blockade).

3.9 All of the following statements regarding central control of autonomic functions are correct *except*:

A. Baroreceptors are pressure sensors located at various cardiovascular sites.
B. The parasympathetic system is activated by the CNS in response to a sudden drop in blood pressure.
C. The parasympathetic system is activated by the CNS in response to a sudden increase in blood pressure.
D. The sympathetic system is activated by the CNS in response to a sudden drop in blood pressure.

Correct answer = B. When there is a sudden drop in blood pressure, the baroreceptors send signals to the brain, and the brain activates the sympathetic system (not the parasympathetic system) to restore blood pressure to normal values.

Study Questions

Choose the ONE best answer.

4.1 Botulinum toxin blocks the release of acetylcholine from cholinergic nerve terminals. Which of the following is a possible effect of botulinum toxin?

A. Skeletal muscle paralysis.
B. Improvement of myasthenia gravis symptoms.
C. Increased salivation.
D. Reduced heart rate.

Correct answer = A. Acetylcholine released by cholinergic neurons acts on nicotinic receptors in the skeletal muscle cells to cause contraction. Therefore, blockade of ACh release causes skeletal muscle paralysis. Myasthenia gravis is an autoimmune disease where antibodies are produced against nicotinic receptors and inactivate nicotinic receptors. A reduction in ACh release therefore worsens (not improves) the symptoms of this condition. Reduction in ACh release by botulinum toxin causes reduction in secretions including saliva (not increase in salivation) causing dry mouth and an increase (not reduction) in heart rate due to reduced vagal activity.

4.2 A dentist would like to reduce salivation in a patient in preparation for an oral surgical procedure. Which of the following strategies will be useful in reducing salivation?

A. Activate nicotinic receptors in the salivary glands.
B. Block nicotinic receptors in the salivary glands.
C. Activate muscarinic receptors in the salivary glands.
D. Block muscarinic receptors in the salivary glands.

Correct answer = D. Salivary glands contain muscarinic receptors, not nicotinic receptors. Activation of muscarinic receptors in the salivary glands causes secretion of saliva. Blocking muscarinic receptors, using drugs such as atropine, reduces salivary secretions and makes the mouth dry.

4.3 Which of the following is a systemic effect of a muscarinic agonist?

A. Reduced heart rate (bradycardia).
B. Increased blood pressure.
C. Mydriasis (dilation of the pupil).
D. Reduced urinary frequency.
E. Constipation.

Correct answer = A. A muscarinic agonist binds to and activates muscarinic receptors in the heart, endothelial cells (blood vessels), the gut, and iris sphincter (eye) and urinary bladder wall muscles, in addition to several other tissues. Activation of muscarinic receptors by an agonist causes a reduction in heart rate, constriction of circular muscles in the iris sphincter leading to constriction of the pupil (miosis), increased GI motility (hence, diarrhea, not constipation), and contraction of bladder muscles leading to an increase (not decrease) in urination frequency. In the endothelial cells of blood vessels, muscarinic activation produces release of nitric oxide that causes vasorelaxation and a reduction (not increase) in blood pressure.

4.4 If an ophthalmologist wants to dilate the pupils for an eye examination, which of the following drugs/classes of drugs could be theoretically useful?

A. Muscarinic receptor activator (agonist).
B. Muscarinic receptor inhibitor (antagonist).
C. Acetylcholine.
D. Pilocarpine.
E. Neostigmine.

Correct answer = B. Muscarinic agonists (for example, ACh, pilocarpine) contract the circular smooth muscles in the iris sphincter and constrict the pupil (miosis). Anticholinesterases (for example, neostigmine, physostigmine) also cause miosis by increasing the level of ACh. Muscarinic antagonists, on the other hand, relax the circular smooth muscles in the iris sphincter and cause dilation of the pupil (mydriasis).

4.5 In Alzheimer's disease, there is a deficiency of cholinergic neuronal function in the brain. Theoretically, which of the following strategies will be useful in treating the symptoms of Alzheimer's disease?

A. Inhibiting cholinergic receptors in the brain.
B. Inhibiting the release of acetylcholine in the brain.
C. Inhibiting the acetylcholinesterase enzyme in the brain.
D. Activating the acetylcholinesterase enzyme in the brain.

Correct answer = C. Since there is already a deficiency in brain cholinergic function in Alzheimer's disease, inhibiting cholinergic receptors or inhibiting the release of ACh will worsen the condition. Activating the acetylcholinesterase enzyme will increase the degradation of ACh, which will again worsen the condition. However, inhibiting the acetylcholinesterase enzyme will help to increase the levels of ACh in the brain and thereby help to relieve the symptoms of Alzheimer's disease.

4.6 An elderly female who lives in a farm house was brought to the emergency room in serious condition after ingesting a liquid from an unlabeled bottle found near her bed, apparently in a suicide attempt. She presented with diarrhea, frequent urination, convulsions, breathing difficultie , constricted pupils (miosis), and excessive salivation. Which of the following is correct regarding this patient?

A. She most likely consumed an organophosphate pesticide.
B. The symptoms are consistent with sympathetic activation.
C. Her symptoms can be treated using an anticholinesterase agent.
D. Her symptoms can be treated using a cholinergic agonist.

Correct answer = A. The symptoms are consistent with that of cholinergic crisis. Since the elderly female lives on a farm and since the symptoms are consistent with that of cholinergic crisis (usually caused by cholinesterase inhibitors), it may be assumed that she has consumed an organophosphate pesticide (irreversible cholinesterase inhibitor). Assuming that the symptoms are caused by organophosphate poisoning, administering an anticholinesterase agent or a cholinergic agonist will worsen the condition. The symptoms are not consistent with that of sympathetic activation, as sympathetic activation will cause symptoms opposite to that of cholinergic crisis seen in this patient.

4.7 Sarin is a volatile nerve agent that inhibits cholinesterase enzymes. Which of the following symptoms would you expect to see in a patient exposed to sarin?

A. Urinary retention.
B. Tachycardia.
C. Constriction of pupils (miosis).
D. Dilation of the pupils (mydriasis).
E. Dry mouth.

Correct answer = C. Sarin is an organophosphate nerve gas that inhibits cholinesterase enzymes and increases ACh levels. Therefore, symptoms of cholinergic crisis (increased urination, bradycardia, excessive secretions, constriction of pupils, etc.) should be expected in patients exposed to sarin. Urinary retention, tachycardia, mydriasis, and dry mouth are usually seen with muscarinic antagonists.

4.8 Head and neck irradiation in cancer patients can decrease salivary secretion and cause dry mouth. All of the following drugs or classes of drugs are theoretically useful in improving secretion of saliva in these patients *except*:

A. Muscarinic antagonists.
B. Muscarinic agonists.
C. Anticholinesterase agents.
D. Pilocarpine.
E. Neostigmine.

Correct answer = A. Activation of muscarinic receptors in the salivary glands causes secretion of saliva. This can be achieved in theory by using a muscarinic agonist such as pilocarpine or an anticholinesterase agent such as neostigmine (increases levels of ACh). Muscarinic antagonists (anticholinergic drugs) will reduce salivary secretion and worsen dry mouth.

4.9 Which of the following drugs or classes of drugs will be useful in treating the symptoms of myasthenia gravis?

A. Nicotinic antagonists.
B. Muscarinic agonists.
C. Muscarinic antagonists.
D. Anticholinesterase agents.

Correct answer = D. The function of nicotinic receptors in skeletal muscles is diminished in myasthenia gravis due to the development of antibodies to nicotinic receptors in the patient's body (autoimmune disease). Any drug that can increase the levels of ACh in the neuromuscular junction can improve symptoms in myasthenia gravis. Thus, cholinesterase inhibitors help to improve the symptoms of myasthenia gravis. Muscarinic drugs have no role in myasthenia gravis, and nicotinic antagonists will worsen the symptoms.

4.10 *Atropa belladonna* is a plant that contains atropine (a muscarinic antagonist). Which of the following drugs or classes of drugs will be useful in treating poisoning with belladonna?

A. Malathion.
B. Physostigmine.
C. Muscarinic antagonists.
D. Nicotinic antagonists.

Correct answer = B. Atropine is a competitive muscarinic receptor antagonist that causes anticholinergic effects. Muscarinic agonists or any other drugs that can increase the levels of ACh will be able to counteract the effects of atropine. Thus, anticholinesterases such as malathion and physostigmine can counteract the effects of atropine in theory. However, malathion being an irreversible inhibitor of acetylcholinesterase is not used for systemic treatment in patients. Muscarinic antagonists will worsen the toxicity of atropine. Nicotinic antagonists could worsen the toxicity by acting on parasympathetic ganglionic receptors and thus reducing the release of ACh.

Study Questions

Choose the ONE best answer.

5.1 During an ophthalmic surgical procedure, the surgeon wanted to constrict the pupil of the patient using a miotic drug. However, he accidentally used another drug that caused dilation of the pupil (mydriasis) instead. Most likely, which of the following drugs did he use?

A. Acetylcholine.
B. Pilocarpine.
C. Tropicamide.
D. Phentolamine.
E. Bethanechol.

Correct answer = C. Muscarinic agonists such as ACh, pilocarpine, and bethanechol contract the circular muscles of iris sphincter and cause constriction of the pupil (miosis), whereas muscarinic antagonists such as atropine and tropicamide prevent the contraction of the circular muscles of the iris and cause dilation of the pupil (mydriasis). α-Adrenergic antagonists such as phentolamine relax the radial muscles of the iris and cause miosis.

5.2 Sarin is a nerve gas that is an organophosphate cholinesterase inhibitor. Which of the following could be used as an antidote to sarin poisoning?

A. Pilocarpine.
B. Carbachol.
C. Atropine.
D. Physostigmine.
E. Nicotine.

Correct answer = C. Sarin is an organophosphate cholinesterase inhibitor. It causes an increase in ACh levels in tissues that leads to cholinergic crisis by the activation of muscarinic as well as nicotinic receptors. Most of the symptoms of cholinergic crisis are mediated by muscarinic receptors and, therefore, the muscarinic antagonist atropine is used as an antidote for sarin poisoning. Cholinergic agonists such as pilocarpine, carbachol, physostigmine (indirect agonists), and nicotine will worsen the symptoms of sarin poisoning.

5.3 Atropine is one of the ingredients in the antidiarrheal combination diphenoxylate/atropine available in the United States. Which of the following effects is produced by atropine that contributes to its antidiarrheal effect?

A. Increase in gastrointestinal motility.
B. Reduction in gastrointestinal motility.
C. Increase in salivation.
D. Increase in acid secretion.

Correct answer = B. Muscarinic agonists produce an increase in gastrointestinal motility, salivation, and acid secretion. Atropine is a muscarinic antagonist and therefore causes a reduction in gastrointestinal motility that contributes to its antidiarrheal effect.

5.4 A patient with chronic obstructive pulmonary disease (COPD) was prescribed a β_2 agonist for the relief of bronchospasm. However, the patient did not respond to this treatment. Which of the following drugs or classes of drugs would you suggest for this patient as the next option?

A. β_1 Agonist.
B. Muscarinic agonist.
C. Physostigmine.
D. Ipratropium.
E. Phentolamine.

Correct answer = D. Major receptors present in the bronchial tissues are muscarinic and adrenergic-β_2 receptors. Muscarinic activation causes bronchoconstriction, and β_2 receptor activation causes bronchodilation. Therefore, direct or indirect (physostigmine) muscarinic agonists will worsen bronchospasm. Ipratropium is a muscarinic antagonist that can relax bronchial smooth muscles and relieve bronchospasm in patients who are not responsive to β_2 agonists. α_1 and β_1 receptors are not commonly present in bronchial tissues and, therefore, β_1 agonists or α antagonists (phentolamine) do not have any significant effects on bronchospasm.

5.5 Which of the following drugs would be the most effective anti–motion sickness drug for a person planning to go on a cruise?

A. Atropine.
B. Tropicamide.
C. Scopolamine.
D. Darifenacin.
E. Tiotropium.

Correct answer = C. All muscarinic antagonists (anticholinergic drugs) listed above are theoretically useful as anti–motion sickness drugs; however, scopolamine is the most effective in preventing motion sickness in practice. Tropicamide mostly has ophthalmic uses, and tiotropium is used for respiratory disorders (COPD). Darifenacin is used for overactive bladder.

5.6 Which of the following is correct regarding ganglion-blocking drugs?

A. Blockade of sympathetic ganglia could result in reduced blood pressure.
B. Blockade of parasympathetic ganglia could result in reduced heart rate.
C. Nicotine is a nondepolarizing ganglion blocker.
D. Atropine is a nondepolarizing ganglion blocker.

Correct answer = A. Selective blockade (in theory) of the sympathetic ganglion causes reduction in norepinephrine release and therefore reduction in heart rate and blood pressure. Selective blockade (in theory) of the parasympathetic ganglion causes reduction in ACh release and therefore an increase in heart rate. Receptors at both sympathetic and parasympathetic ganglia are of the nicotinic type. Nicotine is an agonist at nicotinic receptors and produces a depolarizing block in the ganglia. Atropine is a muscarinic antagonist and has no effect on the nicotinic receptors found in the ganglia.

Study Questions

Choose the ONE best answer.

6.1 Which of the following is correct regarding adrenergic neurotransmission?

A. Epinephrine is the major neurotransmitter released from sympathetic nerve terminals.
B. Norepinephrine is mainly released from the adrenal glands.
C. Tricyclic antidepressants and cocaine prevent reuptake of norepinephrine into the nerve terminals.
D. Monoamine oxidase (MAO) converts dopamine to norepinephrine in the nerve terminal.

Correct answer = C. Tricyclic antidepressants (TCAs) and cocaine inhibit the transporter protein that prevents the reuptake of norepinephrine into the sympathetic nerve terminals. Norepinephrine, not epinephrine, is the major neurotransmitter released from sympathetic nerve terminals. Epinephrine, not norepinephrine, is mainly released from the adrenal glands. Dopamine is converted to norepinephrine by dopamine β-hydroxylase, not by MAO.

6.2 All of the following are correct regarding adrenergic receptors, *except*:

A. α_1 Receptors are primarily located on the postsynaptic membrane in the effector organs.
B. α_2 Receptors are primarily located on the presynaptic sympathetic nerve terminals.
C. β_1 Receptors are found mainly in the heart.
D. β_2 Receptors are found mainly in adipose tissue.

Correct answer = D. α_1 Receptors are located on the postsynaptic membrane in the effector organs such as blood vessels. α_2 Receptors are mainly found on the presynaptic sympathetic nerve terminals, where they inhibit the release of norepinephrine when activated. β_1 Receptors are found in the heart, in addition to some other tissues, and cause increase in heart rate and contractility when activated. β_2 receptors are found in the lungs, in addition to some other tissues, and cause relaxation of bronchial smooth muscles when activated. β_3 Receptors are found in adipose tissue and are involved in lipolysis.

6.3 A hypertensive patient was accidentally given an α_2 agonist instead of an α_1 blocker. Which of the following is correct in this situation?

A. α_2 Agonists can increase the release of norepinephrine from sympathetic nerve terminals.
B. α_2 Agonists can reduce blood pressure in this patient.
C. α_2 Agonists can increase blood pressure in this patient.
D. α_2 Agonists will not affect blood pressure in this patient.

Correct answer = B. α_2 Agonists activate α_2 receptors located in the presynaptic terminal of sympathetic neurons and cause a reduction in the release of norepinephrine from sympathetic nerve terminals. This leads to a reduction in blood pressure. α_2 Agonists such as clonidine and methyldopa are therefore used as antihypertensive agents.

6.4 Which of the following is correct regarding responses mediated by adrenergic receptors?

A. Stimulation of α_1 receptors increases blood pressure.
B. Stimulation of α_1 receptors reduces blood pressure.
C. Stimulation of sympathetic presynaptic α_2 receptors increases norepinephrine release.
D. Stimulation of β_2 receptors increases heart rate (tachycardia).
E. Stimulation of β_2 receptors causes bronchoconstriction.

Correct answer = A. Stimulation of α_1 receptors, mostly found in the blood vessels, causes vasoconstriction and increase in blood pressure. Stimulation of α_2 receptors on the sympathetic presynaptic terminal reduces the release of norepinephrine. β_2 receptors are not found in the heart, so activation of β_2 receptors does not affect heart rate. Stimulation of β_2 receptors found in the bronchial tissues causes bronchodilation, not bronchoconstriction.

6.5 An asthma patient was given a nonselective β agonist to relieve bronchoconstriction. Which of the following adverse effects would you expect to see in this patient?

A. Bradycardia.
B. Tachycardia.
C. Hypotension (reduction in blood pressure).
D. Worsening bronchoconstriction.

Correct answer = B. A nonselective β agonist activates both β_1 as well as β_2 receptors. β_1 activation causes an increase in heart rate (tachycardia), contractility, and subsequent increase in blood pressure. It relieves bronchoconstriction because of the β_2 receptor activation.

6.6 Which of the following adrenergic agonists is most likely to cause CNS side effects when administered systemically?

A. Epinephrine.
B. Norepinephrine.
C. Isoproterenol.
D. Dopamine.
E. Ephedrine.

Correct answer = E. Ephedrine is more lipophilic compared to the other drugs listed and therefore is more likely to cross the blood–brain barrier when administered systemically. Therefore, ephedrine is more likely to cause CNS side effects compared to other listed drugs.

6.7 A 12-year-old boy who is allergic to peanuts was brought to the emergency room after accidentally consuming peanuts contained in fast food. He is in anaphylactic shock. Which of the following drugs would be most appropriate to treat this patient?

A. Norepinephrine.
B. Phenylephrine.
C. Dobutamine.
D. Epinephrine.

Correct answer = D. Norepinephrine has more α agonistic effects and activates mainly α_1, α_2, and β_1 receptors. Epinephrine has more β agonistic effects and activates mainly α_1, α_2, β_1, and β_2 receptors. Phenylephrine has predominantly α effects and activates mainly α_1 receptors. Dobutamine mainly activates β_1 receptors and has no significant effects on β_2 receptors. Thus, epinephrine is the drug of choice in anaphylactic shock that can both stimulate the heart (β_1 activation) and dilate bronchioles (β_2 activation).

6.8 A 70-year-old patient was brought to the emergency room with a blood pressure of 76/60 mm Hg, tachycardia, and low cardiac output. He was diagnosed with acute heart failure. Which of the following drugs would be the most appropriate to improve his cardiac function?

A. Epinephrine.
B. Fenoldopam.
C. Dobutamine.
D. Isoproterenol.

Correct answer = C. Among the choices, the ideal drug to increase contractility of the heart in acute heart failure is dobutamine, since it is a selective β_1-adrenergic agonist. Fenoldopam is a dopamine agonist used to treat severe hypertension. Other drugs are nonselective adrenergic agonists that could cause unwanted side effects.

6.9 Which of the following adrenergic agonists is commonly present in nasal sprays available over-the-counter (OTC) to treat nasal congestion?

A. Clonidine.
B. Albuterol. (Salbutamol)
C. Oxymetazoline.
D. Dobutamine.
E. Norepinephrine.

Correct answer = C. Drugs with selective α_1 agonistic activity are commonly used as nasal decongestants because of their ability to cause vasoconstriction in the nasal vessels. Oxymetazoline is an α_1 agonist and therefore the preferred drug among the choices as a nasal decongestant. Clonidine is an α_2 agonist, albuterol is a β_2 agonist, dobutamine is a β_1 agonist, and norepinephrine is a nonselective adrenergic agonist.

6.10 One of your patients who is hypertensive and gets mild asthma attacks occasionally bought an herbal remedy online to help with his asthma. He is not on any asthma medications currently but is receiving a β_1-selective blocker for his hypertension. The herbal remedy seems to relieve his asthma attacks, but his blood pressure seems to increase despite the β-blocker therapy. Which of the following drugs is most likely present in the herbal remedy he is taking?

A. Phenylephrine.
B. Norepinephrine.
C. Dobutamine.
D. Ephedrine.
E. Salmeterol.

Correct answer = D. Two drugs among the choices that could relieve asthma are ephedrine and salmeterol, as they activate β_2 receptors in the bronchioles and cause bronchodilation. However, salmeterol is a selective β_2 agonist and should not cause an increase in blood pressure. Ephedrine on the other hand stimulates the release of norepinephrine and acts as a direct agonist at α- and β-adrenergic receptors, thus causing an increase in blood pressure. Phenylephrine (a nonselective α agonist) does not cause bronchodilation. Norepinephrine is a nonselective adrenergic agonist that does not have any stimulatory effects on β_2 receptors. Also, norepinephrine is not active when given orally.

Study Questions

Choose the ONE best answer.

7.1 A 60-year-old female patient started on a new antihypertensive medication recently. Her blood pressure seems to be under control, but she complains of fatigue, drowsiness, and fainting when she gets up from the bed (orthostatic hypotension). Which of the following drugs is she most likely taking?

A. Metoprolol.
B. Propranolol.
C. Prazosin.
D. Clonidine.

Correct answer = C. α-Blockers (prazosin) are more likely to cause orthostatic hypotension compared to β-blockers (metoprolol, propranolol) and α_2 agonists (clonidine).

7.2 A 30-year-old male patient was brought to the ER with amphetamine overdose. He presented with high blood pressure and arrhythmia. Which of the following is correct regarding this patient?

A. Amphetamine can activate all types of adrenergic receptors.
B. β-Blockers are the ideal antidotes for amphetamine poisoning.
C. α-Blockers can normalize the blood pressure in this patient.
D. Miosis could be a possible symptom of amphetamine poisoning.

Correct answer = A. Amphetamine is an indirect adrenergic agonist that mainly enhances the release of norepinephrine from peripheral sympathetic neurons. Therefore, it activates all types of adrenergic receptors (that is, α and β receptors) and causes an increase in blood pressure. Since both α and β receptors are activated by amphetamine, α-blockers or β-blockers alone cannot relieve the symptoms of amphetamine poisoning. Since amphetamine causes sympathetic activation, it causes mydriasis, not miosis.

7.3 A new antihypertensive drug was tested in an animal model of hypertension. The drug when given alone reduces blood pressure in the animal. Norepinephrine when given in the presence of this drug did not cause any significant change in blood pressure or heart rate in the animal. The new drug is similar to which of the following drugs in terms of its pharmacological mechanism of action?

A. Prazosin.
B. Clonidine.
C. Propranolol.
D. Metoprolol.
E. Carvedilol.

Correct answer = E. Norepinephrine activates both α_1 and β_1 receptors and causes an increase in heart rate and blood pressure. A drug that prevents the increase in blood pressure caused by norepinephrine should be similar to carvedilol that antagonizes both α_1 and β_1 receptors. Prazosin is an α_1 antagonist, clonidine is an α_2 agonist, and propranolol and metoprolol are β antagonists, and these drugs cannot completely prevent the cardiovascular effects of norepinephrine.

7.4 A β-blocker was prescribed for hypertension in a female asthma patient. After about a week of treatment, the asthma attacks got worse, and the patient was asked to stop taking the β-blocker. Which of the following β-blockers would you suggest as an alternative in this patient that is less likely to worsen her asthma?

A. Propranolol.
B. Metoprolol.
C. Labetalol.
D. Carvedilol.

Correct answer = B. The patient was most likely given a nonselective β-blocker (antagonizes both β_1 and β_2 receptors) that made her asthma worse due to β_2 antagonism. An alternative is to prescribe a cardioselective (antagonizes only β_1) β-blocker that does not antagonize β_2 receptors in the bronchioles. Metoprolol is a cardioselective β-blocker. Propranolol, labetalol, and carvedilol are nonselective β-blockers and could worsen the asthma.

7.5 A 70-year-old male needs to be treated with an α-blocker for overfl w incontinence due to his enlarged prostate. Which of the following drugs would you suggest in this patent that will not affect his blood pressure significantly

A. Prazosin.
B. Doxazosin.
C. Phentolamine.
D. Tamsulosin.
E. Terazosin.

Correct answer = D. Tamsulosin is an α_1 antagonist that is more selective to the α_1 receptor subtype (α_{1A}) present in the prostate and less selective to the α_1 receptor subtype (α_{1B}) present in the blood vessels. Therefore, tamsulosin does not affect blood pressure significantl . Prazosin, doxazosin, terazosin, and phentolamine antagonize both these subtypes and cause significant hypotension as a side effect.

7.6 A 50-year-old male was brought to the emergency room after being stung by a hornet. The patient was found to be in anaphylactic shock, and the medical team tried to reverse the bronchoconstriction and hypotension using epinephrine. However, the patient did not fully respond to the epinephrine treatment. The patient's wife mentioned that he is taking a prescription medication for his blood pressure, the name of which she does not remember. Which of the following medications is he most likely taking that could have prevented the effects of epinephrine?

A. Doxazosin.
B. Propranolol.
C. Metoprolol.
D. Acebutolol.

Correct answer = B. Epinephrine reverses hypotension by activating β_1 receptors and relieves bronchoconstriction by activating β_2 receptors in anaphylaxis. Since epinephrine was not effective in reversing hypotension or bronchoconstriction in this patient, it could be assumed that the patient was on a nonselective β-blocker (propranolol). Doxazosin (α_1-blocker), metoprolol, or acebutolol (both β_1-selective blockers) would not have completely prevented the effects of epinephrine.

7.7 Which of the following is correct regarding α-adrenergic blockers?

A. α-Adrenergic blockers are used in the treatment of hypotension in anaphylactic shock.
B. α-Adrenergic blockers are used in the treatment of benign prostatic hyperplasia (BPH).
C. α-Adrenergic blockers may cause bradycardia.
D. α-Adrenergic blockers are used in the treatment of asthma.
E. α-Adrenergic blockers reduce the frequency of urination.

Correct answer = B. α-Adrenergic blockers are used in the treatment of BPH because of their relaxant effect on prostate smooth muscles. Being antihypertensive agents, they are not useful in treating hypotension in anaphylaxis. α-Adrenergic blockers generally cause refl x tachycardia (not bradycardia) due to the significant drop in blood pressure caused by them. α-Adrenergic blockers have no significant effects on bronchial tissues and are not useful in treating asthma. They increase (not reduce) the frequency of urination by relaxing the internal sphincter of the urinary bladder, which is controlled by α_1 receptors.

7.8 Which of the following is correct regarding β-blockers?

A. Treatment with β-blockers should not be stopped abruptly.
B. Propranolol is a cardioselective β-blocker.
C. β-Blockers may cause orthostatic hypotension.
D. Cardioselective β-blockers worsen asthma.
E. β-Blockers decrease peripheral resistance by causing vasorelaxation.

Correct answer = A. If β-blocker therapy is stopped abruptly, that could cause angina and rebound hypertension. This could be due to the up-regulation of β receptors in the body. β-Blockers do not cause direct vasorelaxation. Therefore, they do not decrease peripheral resistance and are less likely to cause orthostatic hypotension. Propranolol is a nonselective β-blocker (not cardioselective). Cardioselective β-blockers antagonize only β_1 receptors and do not worsen asthma as they do not antagonize β_2 receptors.

7.9 Which of the following drugs is commonly used topically in the treatment of glaucoma?

A. Atropine.
B. Timolol.
C. Tropicamide.
D. Scopolamine.

Correct answer = B. β-Blockers reduce the formation of aqueous humor in the eye and therefore reduce intraocular pressure, thus relieving glaucoma. Timolol is a nonselective β-blocker that is commonly used topically to treat glaucoma. Atropine, tropicamide, and scopolamine are anticholinergic drugs that might worsen glaucoma.

7.10 Which of the following is correct regarding carvedilol?

A. Carvedilol is a cardioselective β-blocker.
B. Carvedilol is safe for use in asthma patients.
C. Carvedilol has α_1-blocking activity.
D. Carvedilol is contraindicated in the treatment of stable chronic heart failure.

Correct answer = C. Carvedilol is a nonselective β-blocker with α_1-blocking activity. Since it also blocks β_2 receptors in the lungs, carvedilol could exacerbate asthma. Carvedilol is not used in patients with acute exacerbation of heart failure but is used in the treatment of stable, chronic heart failure.

DRUG	RECEPTOR SPECIFICITY	THERAPEUTIC USES
Propranolol	β_1, β_2	**Hypertension** **Migraine** **Hyperthyroidism** **Angina pectoris** **Myocardial infarction**
Celiprolol [1]	B_1, B_2	**Have less adverse bronchonstrictor effect in asthma & may even promote bronchodilation**
Nadolol *Pindolol* [1]	β_1, β_2	**Hypertension**
Timolol	β_1, β_2	**Glaucoma, hypertension**
Atenolol *Bisoprolol* [2] *Esmolol* *Metoprolol* [2]	β_1	**Hypertension** **Angina** **Myocardial infarction**
Acebutolol [1]	β_1	**Hypertension**
Nebivolol	β_1, NO ↑	**Hypertension**
Carvedilol [2] *Labetalol*	$\alpha_1, \beta_1, \beta_2$	**Hypertension**

Figure 7.12
Summary of β-adrenergic antagonists. NO = nitric oxide. [1]*Acebutolol* and *pindolol* are partial agonists, as well. [2]*Bisoprolol*, *metoprolol*, and *carvedilol* are also used for the treatment of heart failure.

Can't cross the BBB

CATECHOLAMINES

- Rapid onset of action
- Brief duration of action
- Not administered orally
- Do not penetrate the blood-brain barrier

Can cross the BBB sooo they have a CNS manifestations

NONCATECHOL-AMINES

Compared to catecholamines:

- Longer duration of action
- All can be administered orally or via inhalation

DRUG	RECEPTOR SPECIFICITY	THERAPEUTIC USES
Epinephrine	α_1, α_2 β_1, β_2	Acute asthma Anaphylactic shock In local anesthetics to increase duration of action
Norepinephrine	α_1, α_2 β_1	Treatment of shock
Isoproterenol	β_1, β_2	As a cardiac stimulant
Dopamine	Dopaminergic α_1, β_1	Treatment of shock Treatment of congestive heart failure Raise blood pressure
Dobutamine	β_1	Treatment of acute heart failure
Oxymetazoline	α_1	As a nasal decongestant
Phenylephrine	α_1	As a nasal decongestant Raise blood pressure Treatment of paroxysmal supraventricular tachycardia
Clonidine	α_2	Treatment of hypertension
Albuterol *Terbutaline*	β_2	Treatment of bronchospasm (short acting)
Salmeterol *Formoterol*	β_2	Treatment of bronchospasm (long acting)
Amphetamine	α, β, CNS	As a CNS stimulant in treatment of children with attention deficit syndrome, narcolepsy, and for appetite control
Ephedrine *Pseudoephedrine*	α, β, CNS	As a nasal decongestant Raise blood pressure

Figure 6.17
Summary of the therapeutic uses of adrenergic agonists. CNS = central nervous system.

TISSUE	RECEPTOR TYPE	ACTION	OPPOSING ACTIONS
Heart			
• Sinus and AV	β_1	↑ Automaticity	Cholinergic receptors
• Conduction pathway	β_1	↑ Conduction velocity, automaticity	Cholinergic receptors
• Myoÿbrils	β_1	↑ Contractility, automaticity	
Vascular smooth muscle	β_2	Vasodilation	α-Adrenergic receptors
Bronchial smooth muscle	β_2	Bronchodilation	Cholinergic receptors
Kidneys	β_1	↑ Renin release	α_1-Adrenergic receptors
Liver	β_2, α_1	↑ Glycogenolysis and gluconeogenesis	—
Adipose tissue	β_3	↑ Lipolysis	α_2-Adrenergic receptors
Skeletal muscle	β_2	↑ Increased contractility Potassium uptake; glycogenolysis Dilates arteries to skeletal muscle Tremor	—
Eye-ciliary muscle	β_2	Relaxation	Cholinergic receptors
GI tract	β_2	↓ Motility	Cholinergic receptors
Gall bladder	β_2	Relaxation	Cholinergic receptors
Urinary bladder detrusor muscle	β_2	Relaxation	Cholinergic receptors
Uterus	β_2	Relaxation	Oxytocin

Figure 6.16
Summary of β-adrenergic receptors. AV = atrioventricular; GI = gastrointestinal.