Study Questions

Choose the ONE best answer.

3.1 Which is correct regarding the sympathetic nervous system?

A. It generally mediates body functions in “rest-and-digest” mode.
B. The neurotransmitter at the sympathetic ganglion is norepinephrine (NE).
C. The neurotransmitter at the sympathetic ganglion is acetylcholine (ACh).
D. Sympathetic neurons release ACh in the effector organs.

Correct answer = C. The neurotransmitter at the sympathetic and parasympathetic ganglia is acetylcholine. The sympathetic system generally mediates body functions in “fight or flight” mode, and the parasympathetic system generally mediates body functions in “rest-and-digest” mode. Sympathetic neurons release NE, and parasympathetic neurons release ACh in the effector cells.

3.2 Why does the somatic nervous system enable a faster response compared to the ANS?

A. Somatic motor neurons have ganglia where neurotransmission is mediated by ACh.
B. Somatic motor neurons have ganglia where neurotransmission is mediated by NE.
C. Somatic motor neurons are not myelinated.
D. Somatic motor neurons are myelinated and do not have ganglia.

Correct answer = D. Somatic motor neurons are myelinated and have no ganglia. This enables faster transmission in the somatic neurons.

3.3 Which physiological change occurs when the parasympathetic system is activated?

A. Increase in heart rate
B. Inhibition of lacrimation (tears)
C. Dilation of the pupil (mydriasis)
D. Increase in gastric motility

Correct answer = D. Activation of the parasympathetic system causes an increase in gastric motility, increase in fluid secretions, reduction in heart rate, and constriction of the pupil. In the “rest-and-digest” mode, the parasympathetic system is more active, which helps with digestion.

3.4 Which physiological change is expected when the sympathetic system is inhibited using a pharmacological agent?

A. Reduction in heart rate
B. Increase in blood pressure
C. Decrease in fluid secretions
D. Constriction of blood vessels

Correct answer = A. Activation of the sympathetic system causes an increase in heart rate, increase in blood pressure, reduction or thickening of fluid secretions, and constriction of blood vessels. Therefore, inhibition of the sympathetic system should theoretically cause a reduction in heart rate, decrease in blood pressure, increase in fluid secretions, and relaxation of blood vessels.

3.5 Which is correct regarding activation of receptors on the effector organs in the ANS?

A. Acetylcholine activates muscarinic receptors.
B. Acetylcholine activates adrenergic receptors.
C. Epinephrine activates nicotinic receptors.
D. Norepinephrine activates muscarinic receptors.

Correct answer = A. Acetylcholine is the neurotransmitter in the cholinergic system, and it activates both muscarinic and nicotinic cholinergic receptors, not adrenergic receptors. Norepinephrine and epinephrine activate adrenergic receptors, not muscarinic receptors.

3.6 Which statement concerning the parasympathetic nervous system is correct?

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

Correct answer = B. 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 is correct regarding neurotransmitters and neurotransmission?

A. Neurotransmitters are released from the presynaptic nerve terminals.
B. Arrival of an action potential in the postsynaptic cell triggers release of neurotransmitter.
C. Intracellular calcium levels drop in the neuron before the release of neurotransmitter.
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 calcium levels increase in the neuron before neurotransmitter is released. The main neurotransmitters in the ANS are norepinephrine and acetylcholine.

3.8 An elderly man is brought to the emergency room after ingesting a large quantity of prazosin tablets, a drug that blocks α_1 adrenergic receptors, which mediate effects of epinephrine and norepinephrine on the blood vessels and urinary bladder. Which symptom is most likely to be seen in this patient?

A. Reduced heart rate (bradycardia)
B. Dilation of blood vessels (vasorelaxation)
C. Increased blood pressure
D. Reduction in urinary frequency

Correct answer = B. Activation of α_1 receptors causes vasoconstriction, reduction in urinary frequency, and an increase in blood pressure, without a direct effect on the heart rate. It may cause reflex tachycardia (increase in heart rate) in some patients. Thus blockade of α_1 receptors could theoretically cause dilation of blood vessels, reduction in blood pressure, and increase in urinary frequency. It should not cause a reduction in heart rate.

3.9 Which statement is correct regarding the autonomic nervous system?

A. Afferent neurons carry impulses from the central nervous system (CNS) to the effector organs.
B. Preganglionic neurons of the sympathetic system arise from the cranial nerves, as well as from the sacral region.
C. When there is a sudden drop in blood pressure, the baroreceptors send signals to the brain to activate the parasympathetic system.
D. The heart receives both sympathetic and parasympathetic innervation.

Correct answer = D. The heart receives both sympathetic and parasympathetic innervation. Activation of sympathetic neurons increases the heart rate and force of contraction, and activation of parasympathetic neurons reduces the heart rate and force of contraction (slightly). Afferent neurons carry impulses from the periphery to the CNS, and efferent neurons carry signals away from the CNS. Preganglionic neurons of the sympathetic system arise from thoracic and lumbar regions of the spinal cord, whereas the preganglionic neurons of the parasympathetic system arise from cranial nerves and the sacral region. When there is a sudden drop in blood pressure, the sympathetic system is activated, not the parasympathetic system.

3.10 Which is correct regarding membrane receptors and signal transduction?

A. ANS neurotransmitters bind to membrane receptors on the effector cells, which leads to intracellular events.
B. Cholinergic muscarinic receptors are ionotropic receptors.
C. Cholinergic nicotinic receptors are metabotropic receptors.
D. Metabotropic receptors activate ion channels directly.

Correct answer = A. Neurotransmitters generally bind to membrane receptors on the postsynaptic effector cells and cause cellular effects. Acetylcholine (ACh) binds to cholinergic muscarinic receptors and activates the second messenger pathway in effector cells, which in turn causes cellular events. Receptors that are coupled to second messenger systems are known as metabotropic receptors. Metabotropic receptors do not directly activate ion channels. ACh also binds to cholinergic nicotinic receptors and activates ion channels on the effector cells. The receptors that directly activate ion channels are known as ionotropic receptors.

Study Questions

Choose the ONE best answer.

4.1 Botulinum toxin blocks the release of acetylcholine from cholinergic nerve terminals. Which 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 patient develops urinary retention after an abdominal surgery. Urinary obstruction was ruled out in this patient. Which strategy would be helpful in promoting urination?

A. Activating nicotinic receptors
B. Inhibiting the release of acetylcholine
C. Inhibiting cholinesterase enzyme
D. Blocking muscarinic receptors

Correct answer = C. Activation of muscarinic receptors in the detrusor muscle of the urinary bladder can promote urination in patients where the tone of detrusor muscle is low. Inhibiting cholinesterase enzyme increases the levels of acetylcholine, and acetylcholine can increase the tone of the detrusor muscle. There are no nicotinic receptors in the detrusor muscle; therefore, activation of nicotinic receptors is not helpful. Inhibiting the release of acetylcholine or blocking muscarinic receptors worsens urinary retention.

4.3 Which of the following drugs could theoretically improve asthma symptoms?

A. Bethanechol
B. Pilocarpine
C. Pyridostigmine
D. Atropine

Correct answer = D. Muscarinic agonists and drugs that increase acetylcholine levels cause constriction of bronchial smooth muscles and could exacerbate asthma symptoms. Bethanechol and pilocarpine are muscarinic agonists, and pyridostigmine is a cholinesterase inhibitor that increases levels of acetylcholine. Atropine is a muscarinic antagonist and therefore does not exacerbate asthma. Theoretically, it should relieve symptoms of asthma (not used clinically for this purpose).

4.4 If an ophthalmologist wants to dilate the pupils for an eye examination, which drug/class of drugs is theoretically useful?

↳ Tropicamide (4-12 hrs)

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

Correct answer = B. Muscarinic agonists (for example, 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 disease, there is a deficiency of cholinergic neuronal function in the brain. Theoretically, which strategy is useful in treating symptoms of Alzheimer 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. Because there is already a deficiency in brain cholinergic function in Alzheimer disease, inhibiting cholinergic receptors or inhibiting the release of ACh worsens the condition. Activating the acetylcholinesterase enzyme increases the degradation of ACh, which also worsens the condition. However, inhibiting the acetylcholinesterase enzyme helps to increase the levels of ACh in the brain and thereby relieve the symptoms of Alzheimer disease.

4.6 An elderly female who lives in a farmhouse 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 difficulties, 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 the symptoms are consistent with a 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 A patient who received a nondepolarizing neuromuscular blocker (NMB) for skeletal muscle relaxation during surgery is experiencing mild skeletal muscle paralysis after the surgery. Which drug could reverse this effect of NMBs?

A. Pilocarpine
B. Bethanechol
C. Neostigmine
D. Atropine

Correct answer = C. Neuromuscular blockers act by blocking nicotinic receptors on the skeletal muscles. Increasing the levels of ACh in the neuromuscular junctions can reverse the effects of NMBs. Therefore, neostigmine, a cholinesterase inhibitor, could reverse the effects of NMBs. Pilocarpine and bethanechol are preferentially muscarinic agonists and have no effects on the nicotinic receptors. Atropine is a muscarinic antagonist and has no effects on nicotinic receptors.

4.8 A 60-year-old female who had a cancerous growth in the neck region underwent radiation therapy. Her salivary secretion was reduced due to radiation and she suffers from dry mouth (xerostomia). Which drug would be most useful in treating xerostomia in this patient?

A. Acetylcholine
B. Pilocarpine
C. Echothiophate
D. Atropine

Correct answer = B. Salivary secretion may be enhanced by activating muscarinic receptors in the salivary glands. This can be achieved in theory by using a muscarinic agonist or an anticholinesterase agent. Pilocarpine is a muscarinic agonist administered orally for this purpose. Acetylcholine has similar effects as that of pilocarpine; however, it cannot be used therapeutically as it is rapidly destroyed by cholinesterase in the body. Echothiophate is an irreversible cholinesterase inhibitor, but it cannot be used therapeutically because of its toxic effects. Atropine is a muscarinic antagonist and worsens dry mouth.

4.9 A 40-year-old male presents to his family physician with drooping eyelids, difficulty chewing and swallowing, and muscle fatigue even on mild exertion. Which agent could be used to diagnose myasthenia gravis in this patient?

A. Atropine
B. Edrophonium
C. Pralidoxime
D. Echothiophate

Correct answer = B. The function of nicotinic receptors in skeletal muscles is diminished in myasthenia gravis due to the development of antibodies to nicotinic receptors (autoimmune disease). Any drug that increases levels of ACh in the neuromuscular junction can improve symptoms in myasthenia gravis. Thus, edrophonium, a reversible cholinesterase inhibitor with a short duration of action can temporarily improve skeletal muscle weakness in myasthenia gravis, serving as a diagnostic tool. Atropine is a muscarinic antagonist and has no role in skeletal muscle function. Pralidoxime is a drug that is used to reverse the binding of irreversible cholinesterase inhibitors with cholinesterase enzyme and helps to reactivate cholinesterase enzyme. Hence, pralidoxime will not be useful in improving skeletal muscle function in myasthenia gravis.

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

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

Study Questions

Choose the ONE best answer.

7.1 A 60-year-old patient started a new antihypertensive medication. His blood pressure is well controlled, but he complains of fatigue, drowsiness, and fainting when he gets up from the bed (orthostatic hypotension). Which of the following drugs is he most likely taking?

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

Correct answer = C. Because they block α_1-mediated vasoconstriction, α-blockers (prazosin) are more likely to cause orthostatic hypotension, as compared to β-blockers (metoprolol, propranolol). Alfuzosin is a more selective antagonist for α_{1A} receptors in the prostate and bladder and is less likely to cause hypotension than prazosin.

7.2 A 30-year-old male patient was brought to the ER with amphetamine overdose. He presented with high blood pressure and arrhythmias. Which drug is the most appropriate to treat the cardiovascular symptoms of amphetamine overdose in this patient?

A. Metoprolol
B. Prazosin
C. Labetalol
D. Nebivolol

Correct answer = C. 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 indirectly by amphetamine, α-blockers (prazosin) or β-blockers (metoprolol, nebivolol) alone cannot relieve the cardiovascular effects of amphetamine poisoning. Labetalol blocks both α_1 and beta receptors and can minimize the cardiovascular effects of amphetamine overdose.

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 mechanism of action of the new drug is similar to which of the following agents?

A. Doxazosin
B. Clonidine
C. Atenolol
D. Carvedilol

Correct answer = D. 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. Doxazosin is an α_1 antagonist, clonidine is an α_2 agonist, and atenolol is a β antagonist, and these drugs cannot completely prevent the cardiovascular effects of norepinephrine.

7.4 A β-blocker was prescribed for hypertension in a patient with asthma. After a week of treatment, the asthma attacks got worse, and the patient was asked to stop taking the β-blocker. Which β-blocker would you suggest as an alternative that is less likely to worsen the 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 the 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 is treated with doxazosin for overflow incontinence due to his enlarged prostate. He complains of dizzy spells while getting up from bed at night. Which drug would you suggest as an alternative that may not cause dizziness?

A. Propranolol
B. Phentolamine
C. Tamsulosin
D. Terazosin

Correct answer = C. Dizziness in this elderly patient could be due to orthostatic hypotension caused by doxazosin. 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 should not affect blood pressure significantly and may not cause dizziness. Terazosin and phentolamine antagonize both these subtypes and cause significant hypotension as a side effect. Propranolol is a nonselective beta-blocker that is not indicated in overflow incontinence.

7.6 A 50-year-old male was in anaphylactic shock after being stung by a hornet. The medical team tried to reverse the bronchoconstriction and hypotension using epinephrine; however, the patient did not fully respond to the treatment. The patient's wife mentioned that he is taking a prescription medication for blood pressure. Which medication is he most likely taking that contributed to a reduced response to 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 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 reflex tachycardia (not bradycardia) due to the significant drop in blood pressure caused by them. 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. Cardioselective β-blockers worsen asthma.
D. 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 with short-term use. 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. Esmolol
B. Timolol
C. Silodosin
D. Yohimbine

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. Esmolol is a short-acting β-blocker that is used intravenously for hypertension or arrhythmias. Silodosin is an α_1 antagonist used for BPH, and yohimbine is a α_2 antagonist used for sexual dysfunction.

7.10 Which of the following drugs has the highest potential to worsen orthostatic hypotension when given together with prazosin?

A. Propranolol
B. Atenolol
C. Nebivolol
D. Labetalol

Correct answer = D. Labetalol is a nonselective β-blocker with α_1-blocking activity. Prazosin causes orthostatic hypotension due to its α_1-blockade, which could be enhanced by adding labetalol. Propranolol, atenolol and

Study Questions

Choose the ONE best answer.

6.1 Which of the following is correct regarding adrenergic neurotransmission?

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

Correct answer = A. Norepinephrine (NE) is the major neurotransmitter released from sympathetic nerve terminals. Epinephrine, not norepinephrine, is mainly released from the adrenal glands. Tricyclic antidepressants (TCAs) and cocaine inhibit the reuptake of norepinephrine into the sympathetic nerve terminals, but they do not prevent the release of NE. Dopamine is converted to norepinephrine by dopamine β-hydroxylase, not by MAO.

6.2 Which of the following adrenergic drugs is used in the treatment of overactive bladder?

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

Correct answer = D. Detrusor muscles in the urinary bladder wall have β_3 receptors. Stimulation of these receptors relaxes the urinary bladder wall and relieves overactive bladder. Mirabegron is a β_3 agonist and therefore used in treating overactive bladder. None of the other drugs listed have β_3 agonist activity.

6.3 Which of the following classes of adrenergic agents has utility in the management of hypertension?

A. α_1 Agonist
B. α_2 Agonist
C. β_1 Agonist
D. β_3 Agonist

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. α_1 Agonists cause vasoconstriction, and β_1 agonists cause increased cardiac output and renin release, so these agents may increase blood pressure. β_3 Agonists are not used in the management of hypertension.

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 sympathetic presynaptic α_2 receptors increases norepinephrine release.
C. Stimulation of β_2 receptors increases heart rate (tachycardia).
D. Stimulation of β_2 receptors causes bronchoconstriction.

Correct answer = A. Stimulation of α_1 receptors, mostly found in the blood vessels, causes vasoconstriction and an 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 adverse effect would you expect 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 and 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 A 22-year-old male is brought to the emergency room with suspected cocaine overdose. Which of the following symptoms is most likely in this patient?

A. Hypertension
B. Bronchoconstriction

C. Bradycardia
D. Miosis (constriction of pupil)

Correct answer = A. Cocaine is an indirect adrenergic agonist that prevents the reuptake of norepinephrine into the nerve terminals, thus increasing the levels of NE in the synaptic cleft. The increase in NE leads to an increase in blood pressure (hypertension), tachycardia (not bradycardia), mydriasis (not miosis), and other symptoms of sympathetic overactivity.

6.7 A 12-year-old boy with a peanut allergy is brought to the emergency room after accidental consumption of peanuts. He is in anaphylactic shock. Which of the following drugs is 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 An elderly patient is brought to the emergency room with a blood pressure of 76/60 mm Hg, tachycardia, and low cardiac output. He is diagnosed with acute heart failure. Which of the following drugs is 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 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. The 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
C. Oxymetazoline
D. Formoterol

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, and formoterol is a long-acting β_2 agonist.

6.10 A patient who has hypertension and mild asthma attacks bought a herbal remedy for asthma online. He does not take any prescription medications for asthma, but takes a β_1-selective blocker for hypertension. The herbal remedy relieves the 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?

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

Correct answer = C. Both ephedrine and salmeterol can relieve asthma symptoms, as they activate β_2 receptors in the bronchioles and cause bronchodilation. However, salmeterol is a selective β_2 agonist and should not increase blood pressure. By contrast, ephedrine 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, so it would not relieve asthma symptoms. Norepinephrine is a nonselective adrenergic agonist that does not have any stimulatory effects on β_2 receptors. In addition, norepinephrine is not active when given orally.

Study Questions

Choose the ONE best answer.

5.1 During an ophthalmic surgical procedure, the surgeon wanted to constrict the pupil using a miotic drug. However, he accidentally used another drug that caused dilation of the pupil (mydriasis). Which drug was most likely used?

A. Acetylcholine
B. Pilocarpine
C. Tropicamide
D. 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 tropicamide prevent contraction of the circular muscles of the iris and cause dilation of the pupil (mydriasis).

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

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

Correct answer = C. Sarin is an organophosphate cholinesterase inhibitor. It causes an increase in ACh levels in tissues that leads to cholinergic crisis through activation of muscarinic and nicotinic receptors. Most 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, and physostigmine (indirect agonists) worsen symptoms of sarin poisoning.

5.3 A patient with Alzheimer disease needs treatment for overactive bladder (OAB). Which drug is the best choice for this patient?

A. Darifenacin
B. Solifenacin
C. Tolterodine
D. Trospium

Correct answer = D. All of agents for OAB except trospium cross the blood–brain barrier to various degrees and could worsen dementia symptoms in Alzheimer disease. Trospium is a quaternary ammonium compound that minimally crosses the blood–brain barrier.

5.4 A patient with asthma was prescribed a β_2 agonist for acute relief of bronchospasm, but did not respond to treatment. Which drug is the most likely next option for this patient?

A. Benztropine
B. Ipratropium
C. Oxybutynin
D. Physostigmine

Correct answer = B. 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 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. Benztropine is used in the treatment of Parkinson disease or relief of extrapyramidal symptoms from antipsychotics. Oxybutynin is used for overactive bladder.

5.5 A 50-year-old male who is noncompliant with medications was recently diagnosed with chronic obstructive pulmonary disease (COPD). His physician would like to prescribe an inhaled anticholinergic that is dosed once or twice daily. Which drug is most appropriate for this patient?

A. Atropine
B. Ipratropium
C. Tiotropium
D. Trospium

Correct answer = C. The physician should prescribe a long-acting muscarinic antagonist (LAMA) so that the patient has to inhale the medication only 1 or 2 times daily. Tiotropium is a LAMA, whereas ipratropium is a short-acting muscarinic antagonist (SAMA). Atropine and trospium are muscarinic antagonists, but are not indicated for pulmonary conditions such as asthma or COPD and are not available as inhaled formulations.

5.6 Which is the most effective drug for motion sickness for a person planning to go on a cruise?

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

Correct answer = C. All muscarinic antagonists (anticholinergic drugs) listed are theoretically useful as antimotion sickness drugs; however, scopolamine is the most effective in preventing motion sickness. Tropicamide mostly has ophthalmic uses, and fesoterodine is used for overactive bladder.

5.7 Which 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 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.

5.8 Which drug is useful in treating sinus bradycardia?

A. Atropine
B. Cisatracurium
C. Neostigmine
D. Succinylcholine

Correct answer = A. Sinus bradycardia is a condition where the heart rate is below normal and most often caused by increased vagal tone (increased release of ACh in the sinoatrial [SA] node that acts on muscarinic receptors to reduce heart rate). A muscarinic antagonist such as atropine is useful in this situation to bring the heart rate back to normal. Succinylcholine and cisatracurium are nicotinic antagonists and have no effect on muscarinic receptors in the SA node. Neostigmine is a cholinesterase inhibitor and can worsen bradycardia by increasing the level of ACh in the SA node.

5.9 An ICU patient with severe lung injury requires a neuromuscular blocking agent to assist in his ventilator management. He has liver disease and is currently in renal failure. Which neuromuscular blocker is the best choice for this patient?

A. Cisatracurium
B. Pancuronium
C. Vecuronium
D. Rocuronium

Correct answer = A. Pancuronium is renally eliminated and the patient has renal failure. Vecuronium and rocuronium are hepatically metabolized and the patient has liver disease. Cisatracurium is cleared by organ-independent metabolism (Hofmann elimination).

5.10 Where would you expect to see the first return of function in skeletal muscles following discontinuation of a nondepolarizing neuromuscular blocking agent?

A. Arms
B. Diaphragm
C. Fingers
D. Pupils

Correct answer = B. Following administration of a neuromuscular blocker, the facial muscles are impacted first, but the pupils are not controlled by skeletal muscle and are not affected. The fingers and arms would be next, with the diaphragm function lost last. Function returns in the opposite order, so function of the diaphragm returns first.