LESSON ASSIGNMENT

LESSON 4
Local Anesthetic Agents.

TEXT ASSIGNMENT
Paragraphs 4-1--4-8.

LESSON OBJECTIVES
After completing this lesson, you should be able to:

4-1. Given one of the following terms: local anesthetic, local infiltration, topical block, surface anesthesia, nerve block, peridural, and spinal anesthesia, and a group of statements, select the meaning of that term.

4-2. From a group of statements, select the statement that best describes the mechanism of action for local anesthetics.

4-3. Given a group of statements, select the statement that best describes why vasoconstrictors are used in conjunction with local anesthetics.

4-4. From a group of statements, select the caution and warning associated with the use of a local anesthetic combined with a vasoconstrictor.

4-5. Given a group of statements, select the statement that best describes why hyaluronidase (Wydase®) is used in conjunction with local anesthetics.

4-6. Given a group of statements, select the statement that describes a caution and warning associated with the use of local anesthetics.

4-7. From a list of toxicities, select the toxicity associated with the use of local anesthetics.

4-8. Given the trade name of a local anesthetic agent and a list of generic names, match the trade name of the agent with its generic name.
4-9. Given the trade and/or generic name of a local anesthetic agent and a group of possible uses or cautions and warnings, select the clinical use or caution and warning associated with that agent.

**SUGGESTION**

After completing the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.
LESSON 4
LOCAL ANESTHETIC AGENTS

Section I. BACKGROUND INFORMATION

4-1. BACKGROUND INFORMATION

In order to understand what a local anesthetic is and how it is used, you need to study/review the following definitions:

a. **Local Anesthetic.** A local anesthetic is an agent that interrupts pain impulses in a specific region of the body without a loss of patient consciousness. Normally, the process is completely reversible—the agent does not produce any residual effect on the nerve fiber.

b. **Local Infiltration (Local Anesthesia).** Local infiltration occurs when the nerve endings in the skin and subcutaneous tissues are blocked by direct contact with a local anesthetic, which is injected into the tissue. Local infiltration is used primarily for surgical procedures involving a small area of tissue (for example, suturing a cut).

c. **Topical Block.** A topical block is accomplished by applying the anesthetic agent to mucous membrane surfaces and in that way blocking the nerve terminals in the mucosa. This technique is often used during examination procedures involving the respiratory tract. The anesthetic agent is rapidly absorbed into the bloodstream. For topical application (that is, to the skin), the local anesthetic is always used **without** epinephrine. The topical block easily anesthetizes the surface of the cornea (of the eye) and the oral mucosa.

d. **Surface Anesthesia.** This type of anesthesia is accomplished by the application of a local anesthetic to skin or mucous membranes. Surface anesthesia is used to relieve itching, burning, and surface pain (for example, as seen in minor sunburns).

e. **Nerve Block.** In this type of anesthesia, a local anesthetic is injected around a nerve that leads to the operative site. Usually more concentrated forms of local anesthetic solutions are used for this type of anesthesia.

f. **Peridural Anesthesia.** This type of anesthesia is accomplished by injecting a local anesthetic into the peridural space. The peridural space is one of the coverings of the spinal cord.

g. **Spinal Anesthesia.** In spinal anesthesia, the local anesthetic is injected into the subarachnoid space of the spinal cord.
4-2. MECHANISM OF ACTION OF THE LOCAL ANESTHETICS

a. The nerve fiber is a long cylinder surrounded by a semipermeable (allows only some substances to pass) membrane. This membrane is made up of proteins and lipids (fats). Some of the proteins apparently act as channels, or pores, for the passage of sodium and potassium ions through the membrane.

b. The movement of nerve impulses along a nerve fiber is associated with a change in the permeability of the membrane. The pores widen, and sodium ions (Na+) move to the inside of the fiber. At the same time, potassium ions (K+) diffuse out through other pores (see figure 4-1). The entire process is called depolarization. Immediately after the nerve impulse has passed, the pores again become smaller. Sodium ions (Na+) are now "pumped" out of the fiber. At the same time, potassium ions are actively transported into the fiber. The nerve membrane is then ready to conduct another impulse.

c. Local anesthetics block depolarization of the nerve membrane. That is, to make the conduction of the nerve impulse impossible.

d. The local anesthetic effect lasts as long as the agent maintains a certain critical concentration in the nerve membrane. There is a potential problem: the local concentration needed to prevent conduction of the nerve impulse is much greater than the tolerable blood level. TO AVOID A SYSTEMIC TOXIC REACTION TO THE LOCAL ANESTHETIC, THE SMALLEST AMOUNT OF THE MOST DILUTE SOLUTION THAT WILL EFFECTIVELY BLOCK THE PAIN SHOULD BE ADMINISTERED.
4-3. THE USE OF VASOCONSTRICTORS IN CONJUNCTION WITH LOCAL ANESTHETICS

a. Indications. Vasoconstrictors (like epinephrine) are sometimes used in conjunction with local anesthetics. Vasoconstrictors are used to prolong the duration of action of local anesthetics. Vasoconstrictors also help to control bleeding. Furthermore, the vasoconstrictor delays the absorption of the local anesthetic by reducing the blood flow to the affected area. This results in a reduction of the toxic effects of the local anesthetic, since the rate of absorption keeps pace with the rate the local anesthetic is metabolized by the body. Vasoconstrictors are of no value in delaying the absorption of the local anesthetic from mucous membranes (that is, topical blocks).

b. Cautions and Warnings of the Combination.

(1) It should be recognized that the injection of epinephrine-containing solutions in or around fingers, toes, and the penis is not recommended.

(2) Freshly prepared combinations of vasoconstrictors and local anesthetics are more effective than commercially premixed epinephrine-containing local anesthetic solutions. This is because a very low pH is required to stabilize the epinephrine in these mixtures. In general, the content of one part epinephrine to 200,000 parts of the local anesthetic agent (is optimum) will minimize the side effects inherent with epinephrine. Great care must be taken in calculating this dilution. Small, precisely calibrated syringes should be used in the mixing process. It should be noted that the standard solution of epinephrine supplied is a 1:1000 (1 to 1000) concentration in each glass ampule. This means that 1 milliliter of the 1:1000 epinephrine solution contains 1 milligram of epinephrine. In preparing a 1:200,000 dilution, epinephrine should be added to a local anesthetic solution on a ratio of 0.1 milliliter-20 milliliters of local anesthetic solution. This does not apply to subarachnoid injections, in which a higher concentration of epinephrine is required.

4-4. ANOTHER AGENT WHICH CAN AFFECT THE ACTIONS OF LOCAL ANESTHETICS

Hyaluronidase (Wydase®) is sometimes used in conjunction with local anesthetics. Hyaluronidase is an enzyme that breaks down the material that binds cells together. Thus, when hyaluronidase is combined with local anesthetic, greater infiltration (movement) of the local anesthetic in the tissues is made possible.
4-5. **CAUTIONS AND WARNINGS ASSOCIATED WITH LOCAL ANESTHETICS**

a. Precautions should be taken against the danger of confusing the various agents with one another or mistaking different concentrations of the same drug.

b. In order to avoid intravascular (into the veins) injection, aspiration in several planes with the plunger of the syringe should always be done before injecting the anesthetic solution into the tissues.

c. The instillation of local anesthetic agents into the trachea and bronchi leads to immediate absorption, which soon reach blood levels comparable to those reached by straight intravenous injection.

d. A previously punctured vial of local anesthetic solution should never be re-autoclaved.

e. Discolored local anesthetic solutions should be immediately thrown away.

4-6. **TOXICITIES OF LOCAL ANESTHETICS**

Essentially all systemic toxic reactions associated with local anesthetics are the result of over-dosage leading to high blood levels of the agent given. Therefore, to avoid a systemic toxic reaction to a local anesthetic, the smallest amount of the most dilute solution that effectively blocks pain should be administered.

a. **Hypersensitivity.** Some patients are hypersensitive (allergic) to some local anesthetics. Although such allergies are very rare, a careful patient history should be taken in an attempt to identify the presence of an allergy. There are two basic types of local anesthetics (the amide type and the ester type). A patient who is allergic to one type may or may not be allergic to the other type.

b. **Central Nervous System Toxicities.** Local anesthetics, if absorbed systematically in excessive amounts, can cause central nervous system (CNS) excitement or, if absorbed in even higher amounts, can cause CNS depression.

   (1) **Excitement.** Tremors, shivering, and convulsions characterize the CNS excitement.

   (2) **Depression.** The CNS depression is characterized by respiratory depression and, if enough drug is absorbed, respiratory arrest.

c. **Cardiovascular Toxicities.** Local anesthetics if absorbed systematically in excessive amounts can cause depression of the cardiovascular system. Hypotension and a certain type of abnormal heartbeat (atrioventricular block) characterize such depression. These may ultimately result in both cardiac and respiratory arrest.
Section II. LOCAL ANESTHETICS AND THEIR CLINICAL USES

4-7. EXAMPLES OF LOCAL ANESTHETICS

The local anesthetics you may encounter in a hospital or fields setting are described below. The discussion does not cover every fact known about the use of a particular drug. Therefore, you are encouraged to read references or to ask knowledgeable personnel your specific questions concerning points not presented in this subcourse.

NOTE: Refer to table 4-1 for an overview of the clinical uses of various local anesthetics.

<table>
<thead>
<tr>
<th></th>
<th>Ophthalmic</th>
<th>Topical</th>
<th>Infiltration</th>
<th>Nerve Block</th>
<th>Spinal</th>
<th>Epidural and Caudal</th>
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<td></td>
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<td>7. Lidocaine</td>
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<td>10. Bupivacaine</td>
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<td>11. Bupivacaine</td>
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</table>

*Surface anesthetics for application to the skin.

Table 4-1. An overview of the clinical uses of various local anesthetics.
a. **Lidocaine Hydrochloride (Xylocaine®).**

   (1) **Clinical uses.** Lidocaine is used as a local anesthetic for infiltrations, nerve blocks, spinal anesthesia, topical anesthesia, and for caudal and epidural anesthesia. It has a rapid onset of action and its effects last from 75 to 150 minutes. It has also been used as a cardiac depressant (anti arrhythmic).

   (2) **Forms available.** Lidocaine is available in injection form (various percentage concentrations), jelly form, and in cream form.

b. **Mepivacaine (Carbocaine®).**

   (1) **Clinical uses.** Mepivacaine is pharmacologically and chemically related to lidocaine. It is used for infiltration, nerve block, peridural, and regional anesthesia. The duration of action for this drug is from 2 to 2 1/2 hours.

   (2) **Forms available.** Mepivacaine is available in injection form.

c. **Prilocaine (Citanes®).**

   (1) **Clinical uses.** Prilocaine is pharmacologically similar to both lidocaine and mepivacaine. It is used for infiltration, nerve block, peridural, and regional anesthesia. This drug is less toxic than lidocaine because it is metabolized and excreted faster than lidocaine.

   (2) **Forms available.** Prilocaine is available in injection form.

d. **Bipivacaine (Marcaine®).**

   (1) **Clinical uses.** Bipivacaine is pharmacologically related to lidocaine. It is used for infiltration, nerve block, and epidural anesthesia.

   (2) **Forms available.** Procaine is available in injection form.

e. **Dibucaine (Nupercainal®, Nupercaine®).**

   (1) **Clinical uses.** Dibucaine is used for spinal and topical anesthesia. It is the most potent local anesthetic. It is one of the most toxic and longest-acting local anesthetics.

   (2) **Forms available.** Dibucaine is available in cream, spray, suppository, ointment, and injection forms.
f. **Procaine (Novocaine®).**

   (1) **Clinical uses.** Procaine is used for infiltration, nerve block, and spinal anesthesia. Procaine is not applied topically. Its duration of action is approximately 1 hour. It is a fairly safe local anesthetic to use since it is metabolized quickly.

   (2) **Forms available.** Procaine is available in injection form.

g. **Chloroprocaine (Nesacaine®, Nesacaine-C®).**

   (1) **Clinical uses.** Chloroprocaine is pharmacologically similar to procaine. Chloroprocaine is used for infiltration, nerve block, caudal, and epidural anesthesia.

   (2) **Forms available.** Chloroprocaine is available in injection form.

h. **Tetracaine (Pontocaine®).**

   (1) **Clinical uses.** Tetracaine is used for topical, nerve block, infiltration, spinal, and caudal anesthesia. Its onset of action is 15 minutes.

   (2) **Forms available.** Pontocaine is available in injection, cream, ointment, and injectable forms.

i. **Proparacaine (Alcaine®, Ophthetic®).**

   (1) **Clinical uses.** Proparacaine is used primarily to produce anesthesia when applied to the eye. It has a rapid onset of action (20 seconds) and its duration of action is approximately 15 minutes.

   (2) **Forms available.** Proparacaine is supplied in solution form.

j. **Benzocaine (Americaine®).**

   (1) **Clinical uses.** Benzocaine is used for topical anesthesia of the mucous membranes and skin. It is used in many over-the-counter spray preparations for the treatment of sunburn and itching.

   (2) **Forms available.** Benzocaine is available in solution, ointment, and spray forms.
k. **Cocaine.**

(1) **Clinical uses.** Cocaine is applied to produce local anesthesia with intensive vasoconstriction on mucous membranes. It is applied to procedure anesthesia in the nose, throat, ear, and in bronchoscopy (a procedure in which an instrument is used to inspect the bronchi).

(2) **Forms available.** Cocaine is supplied in the form of a white powder. Cocaine solution must be compounded. It is a Schedule II controlled substance.

4-8. **LOCAL ANESTHETICS USED FOR TOPICAL APPLICATION ONLY**

a. **Dichlorotetrafluoroethane (Freon®)**

(1) **Clinical uses.** Dichlorotetrafluoroethane is a nonflammable and non-explosive agent for topical anesthesia of the skin. It is especially useful for localized minor surgical procedures. This agent should not be sprayed on the skin for a period that exceeds 45 seconds.

(2) **Forms available.** Dichlorotetrafluoroethane is available in a spray form.

b. **Ethyl Chloride.**

(1) **Clinical uses.** This agent is used for topical anesthesia of the skin.

(2) **Forms available.** Ethyl chloride is available in a spray form.

Continue with Exercises

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EXERCISES, LESSON 4

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the question, by completing the incomplete statement, or by writing the answer in the space provided at the end of the exercise.

After you have completed all of these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. Which of the following statements best defines the term local infiltration?
   a. A type of anesthesia achieved by applying the anesthetic agent to the surface of mucous membranes to block nerve transmissions.
   b. A type of anesthesia achieved when the nerve endings in the skin and subcutaneous tissues are blocked by direct contact with a local anesthetic that is injected into the tissue.
   c. A type of anesthesia accomplished by injecting a nerve that leads to the operative site.
   d. A type of anesthesia accomplished by injecting a local anesthetic into the peridural space.

2. Which of the following statements best describes the mechanism of action of local anesthetics?
   a. Local anesthetics destroy the nerve tissue so that electrical impulses cannot be carried.
   b. Local anesthetics greatly increase the number of electrical impulses being transmitted so that pain cannot be felt in that particular area.
   c. Local anesthetics block depolarization of the nerve membrane so that the conduction of the nerve impulse is impossible.
   d. Local anesthetics remove both potassium and sodium ions from the nerve tissue so that polarity in the nerve cannot be accomplished; therefore, the impulses are not allowed to move past a certain point in the tissue.
3. Why is hyaluronidase (Wydase®) used in conjunction with local anesthetics?
   a. Hyaluronidase concentrates the local anesthetic in a particular area in order that its effects might be prolonged.
   b. Hyaluronidase neutralizes the local anesthetic so that undesired adverse effects are greatly reduced.
   c. Hyaluronidase is an enzyme that acts to tenderize the tissue and make the nerves more sensitive to the effects of the local anesthetic.
   d. Hyaluronidase increases the movement of the local anesthetic through the tissue.

4. Select the caution(s) and warning(s) associated with the use of local anesthetics.
   a. When a local anesthetic is to be injected, the plunger should be aspirated in several planes to ensure the drug is not being injected into a vein.
   b. Discolored solutions of local anesthetic should be thrown away.
   c. A previously used vial of local anesthetic solution should never be reautoclaved.
   d. All the above.

5. Select the toxicity(ies) associated with the use of local anesthetics.
   a. Large amounts of systemically absorbed local anesthetics can cause depression of the cardiovascular system.
   b. Local anesthetics, even when given in small amounts, cause tremors, shivering, and convulsions.
   c. Local anesthetics cause respiratory depression.
   d. Local anesthetics tend to produce hypersensitive reactions in most people.
**SPECIAL INSTRUCTIONS FOR EXERCISES 6 THROUGH 9.** Match the trade and generic names of the local anesthetics.

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Trade Name</th>
<th>Generic Name</th>
</tr>
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<tbody>
<tr>
<td>6.</td>
<td>Tetracaine</td>
<td>Americaine®</td>
</tr>
<tr>
<td>7.</td>
<td>Mepivacaine</td>
<td>Freon®</td>
</tr>
<tr>
<td>8.</td>
<td>Dichlorotetrafluorethane</td>
<td>Pontocaine®</td>
</tr>
<tr>
<td>9.</td>
<td>Benzocaine</td>
<td>Carbocaine®</td>
</tr>
</tbody>
</table>

10. Select the clinical use of ethyl chloride.
   - a. Used to produce anesthesia when applied to the eye.
   - b. Used for topical anesthesia of the skin.
   - c. Used for infiltration and caudal anesthesia.
   - d. Used to produce anesthesia in mucous membranes procedures.

11. What is the clinical use of proparacaine?
   - a. Used to produce topical anesthesia on the skin.
   - b. Used to produce both anesthesia and vasoconstriction when applied to certain tissues.
   - c. Used in nerve block, spinal, and caudal anesthesia.
   - d. Used to produce anesthesia in the eye.

12. What is the clinical use of bupivacaine (Marcaine®)?
   - a. Used to produce anesthesia when applied to the eye.
   - b. Used to produce infiltration, nerve block, and epidural anesthesia.
   - c. Used to produce anesthesia when applied to the skin or mucous membranes.
   - d. Used to produce anesthesia in a localized area when applied topically (that is, bronchoscopy).
13. Select the caution and warning associated with the use of procaine (Novocaine®).

   a. The drug should not be applied topically.

   b. The drug should not be used for infiltration anesthesia.

   c. The drug should not be used to produce spinal anesthesia.

   d. The drug should not be used to produce nerve block anesthesia.

   Check Your Answers on Next Page
SOLUTIONS TO EXERCISES, LESSON 4

1. b (para 4-1b)
2. c (para 4-2)
3. d (para 4-4)
4. d (para 4-5b, d, and e)
5. a (para 4-6c)
6. c (para 4-7h)
7. d (para 4-7b)
8. b (para 4-8a)
9. a (para 4-7j)
10. b (para 4-8b)
11. d (para 4-7i)
12. b (para 4-7d)
13. a (para 4-7f)

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