

General Pharmacology

**EMS Continuing Education
Technician through Technician-Advanced Paramedic**

**Consistent with the
National Occupational Competency Profiles
as developed by
Paramedic Association of Canada
and
“An Alternate Route to Maintenance of Licensure”
as developed by Manitoba Health**

Evaluated for content by:

Dr J. J. Du Preez

Developed by:

**Educational Subcommittee – Paramedic Association
of Manitoba**

Revised July 2011

Disclaimer

These documents were developed for improved accessibility to “An Alternative Route to Maintenance of Licensure” for all paramedics in Manitoba. Regional implementation of Alternate Route is at the discretion of the local EMS Director.

This is a supportive document to the National Occupational Competency Profiles and “An Alternative Route to Maintenance of Licensure.” It is not the intent that this package be used as a stand-alone teaching tool. It is understood that the user has prior learning in this subject area, and that this document is strictly for supplemental continuing medical education. To this end, the Paramedic Association of Manitoba assumes no responsibility for the completeness of information contained within this package.

It is neither the intent of this package to supercede local or provincial protocols, nor to assume responsibility for patient care issues pertaining to the information found herein. Always follow local or provincial guidelines in the care and treatment of any patient.

This package is to be used in conjunction with accepted models for education delivery and assessment, as outlined in “An Alternative Route to Maintenance of Licensure”.

This document was designed to encompass all licensed training levels in the province Technician, Technician-Paramedic, Technician-Advanced Paramedic. Paramedics are encouraged to read beyond their training levels. However, the written test will only be administered at the paramedic’s current level of practice.

All packages have been reviewed by the Paramedic Association of Manitoba’s Educational Subcommittee and physician(s) for medical content.

As the industry of EMS is as dynamic as individual patient care, the profession is constantly evolving to deliver enhanced patient care through education and standards. The Paramedic Association of Manitoba would like to thank those practitioners instrumental in the creation, distribution, and maintenance of these packages. Through your efforts, our patient care improves.

This document will be amended in as timely a manner as possible to reflect changes to the National Occupational Competency Profiles, provincial protocols/Emergency Treatment Guidelines, or the Cognitive Elements outlined in the Alternate Route document.

Any comments, suggestions, errors, omissions, or questions regarding this document may be referred to info@paramedicsofmanitoba.ca , attention Director of Education and Standards.

BASIC PHARMACOLOGY

Conventions Used in this Manual

Black lettering without a border is used to denote information appropriate to the Technician Level and above.

|| Text with the single striped border on the left is information appropriate to Technician-Paramedic and above.

||| Text with the double striped border on the left is information appropriate to Technician-Advanced Paramedic and above.

Table of Contents

Disclaimer	1
Introduction.....	4
Basic Pharmacological Information.....	4
Drug Names	4
Drug Sources.....	5
Plant or Animal Product.....	5
Derivative.....	5
Legal	6
Special Population Considerations	7
Pregnant Patients.....	7
United States Food & Drug Administration Pregnancy Categories	8
Pharmacokinetics	9
Pharmacokinetics	9
Absorption.....	9
Distribution	10
Biotransformation	10
Elimination.....	11
Routes of administration	12
Enteral	12
Parenteral	12
Route for administration: Time until effect	14
Drug Forms	15
Pharmacodynamics	16
Manitoba EMS Drug Formulary.....	18
Appendix A: Metric conversions	19
Appendix B: Drug Dosage Calculations.....	21
Appendix C: Medication Administration Sites.....	24
Appendix D: Knowledge of medications for PCP and ACP as per the National Occupational Competency Profiles.....	28
Glossary	31
References.....	34

Introduction

“The administration of any medication by a paramedic is at the sole discretion of the respective Medical Director.” (National Occupational Competency Profile, Paramedic Association of Canada, c 2000)

Most Paramedics administer drugs in the delivery of pre-hospital care. The study of pharmacology is essential to the effective treatment of patients. It is important to have an understanding of these medications, why they are used and how they work.

In Manitoba, we have the ability to administer many drugs without the need for direct on-line orders. The administration of drugs in the field is a responsibility that Paramedics cannot take lightly. When given correctly they can significantly improve the patient’s condition. If drugs are administered inappropriately, they have the potential to be harmful, or even deadly. Paramedics must also always remember, **a patient has the right to refuse medication.**

Basic Pharmacological Information

Pharmacology is defined as the study of the making, ingredients, uses, and actions of drugs. Frequently, we use the terms drug and medication interchangeably.

Substances that are used to treat, diagnose, or prevent disease (produce a therapeutic effect), are called drugs. Medication is used in reference to drugs used as a treatment in the practice of medicine.

Drug Names

A drug may be known by any of four names. These are names assigned to the drug at different times in its development.

The **Chemical name** identifies the chemical structure of the drug. This is usually the first name assigned to a drug when it is developed.

The **Generic name** is often a shorter version of the chemical name. This name is assigned to the drug before it is officially listed.

The **Trade name** is the name given to it by the manufacturer. A particular drug may have several trade names, depending on how many companies are producing and marketing it.

The **Official name** is the name assigned to the drug by the United States Pharmacopoeia or National Formulary. This indicates that the drug meets their requirements. The official name is commonly the generic name followed by the initials U.S.P. or N.F.

Example 1: midazolam hydrochloride (chemical name)
midazolam (frequently referred to as)
Versed (Trade name)

Example 2: acetylsalicylic acid (chemical name)
ASA (frequently referred to as)
Aspirin (one of its Trade names)

Example 3: furosemide (chemical name)
furosemide (frequently referred to as)
Lasix (Trade name)

Example 4: warfarin (chemical name)
warfarin (frequently referred to as)
Coumadin (Trade name)

Drug Sources

All drugs are derived from four sources: plants, animals, minerals, and synthetics. The majority of pre-hospital medications are synthetic. The source of a particular drug is significant if its origin requires a particular type of storage, e.g. locked, refrigerated, or if it poses a potential risk to the caregiver or patient e.g. radioactivity. This information is supplied with the drug.

The following table illustrates a few such derivatives.

Plant or Animal Product	Derivative
Plant -Tobacco	Nicotine
Plant – Atropa Bella Donna	Atropine
Plant - Digitalis	Digoxin
Plant - Opium	Morphine
Animal - Mare urine	Estrogen
Plant - Coca leaves	Cocaine
Animal-Beef / Pork pancreas	Glucagon
Mineral	Calcium Chloride
Animal-Beef / Pork Pancreas	Insulin
Synthetic	Lidocaine

Reference Materials

- **CPS: Compendium of Pharmaceuticals and Specialties**
- **Health Canada Drug Product Database**
- **PDR: Physician’s Desk Reference**

Drug Profiles

The various properties of a drug are described by its profile; paramedics need to become familiar with drug profiles of the medications they administer. The following will typically be contained within a drug profile.

- *Names.* Include generic and trade names, may include chemical.

- *Classifications.* Broad group to which the drug belongs.
- *Mechanism of Action.* Way it causes its effects; pharmacodynamics
- *Indications.* Conditions that make giving a drug appropriate.
- *Pharmacokinetics.* How the drug is absorbed, distributed, and eliminated.
- *Side Effects.* Untoward/undesired effects
- *Routes of Administration.* How given
- *Contraindications.* Inappropriate conditions to give a drug. A predictable harmful event will occur if given. Differs from Not Indicated.
- *Dosage.* Amount that should be given of a drug.
- *How Supplied.* Includes common concentrations of available preparations
- *Special Considerations.* How the drug may affect certain groups of patients, such as geriatric, pregnant, or pediatrics.

Legal

Some medications used by pre-hospital care providers are regulated by federal legislation. Paramedics should make themselves aware of The Controlled Drugs and Substances Act.(1996 c.19) The Act is divided into eight schedules:

Schedule I drugs have a high potential for abuse and have no medical value, e.g. cocaine, heroin.

Schedule II drugs have a high potential for abuse, but are acceptable for medical use. E.g. morphine, dilaudid.

Schedule III drugs have a lower potential for abuse, and are medically acceptable for use. E.g. Tylenol with codeine.

Schedule IV drugs have a low potential for abuse, but patients can develop physical and psychological dependence on them. E.g. valium, gravol.

Schedule V drugs have a low potential for abuse, but contain small amounts of narcotic in them. E.g. some cough syrups.

Schedule VI (parts A and B) these are precursors and may be used in the illicit production of schedule I drugs e.g red phosphorus used in Methamphetamine production

Schedule VII specific to cannabis related offences

Schedule VIII specific to cannabis related offences

<http://laws.justice.gc.ca/en/C-38.8/>

Paramedics are responsible; legally, morally, ethically for patients under their care;

- They must know the indications and contraindications.
- How to observe and document effects.
- Understand pharmacokinetics and pharmacodynamics.
- Take the time to gain a careful drug history from their patient. This can include; daily dose, name, strength and compliance to prescribed drugs. Use of over-the-counter (OTC) drugs. Use of vitamins, herbal medications. Folk-medicine or folk-remedies. Allergies to drugs.

The Six Rights of Medication Administration

1. **Right Patient.** Is this the right patient for the drug? While there may be indications for giving a drug, do contraindications, such as allergies, mental status, GI status, heart rate, etc. exist?
2. **Right Medication.** Drugs come in similar ampoules, nebulas or vials. Check the drug three times. First as you remove it from the kit, box, or cabinet; check the name, dose and concentration; also check for expiry date and fluid clarity. Second, check again as you draw up the drug into the syringe, pour into a nebulizer mask, or doloing tablets to a patient. Third, immediately before administration. Showing the drug container to your partner, asking for confirmation is a further way to ensure the right drug is given. If uncertain, do not administer. Syringes with left over drug must be labeled with name, concentration.
3. **Right Dose.** Double check your calculations, have your partner also check when practical
4. **Right Route.**
5. **Right Time.** Unlike Nurses who will give drugs to patients on a schedule, Paramedics will often give drugs in urgent or emergency situations, timing can still be important. Giving Nitroglycerin sprays to a patient too rapidly can result in the patient becoming hypotensive; in order to help lower the threshold for defibrillation, epinephrine must be repeated on time.
6. **Right Documentation.** As you are required to document vital signs, splinting, bleeding control etc. so to must you document all drugs given in the field and the patient's response to them. All other providers need to know what has been done for the patient so they can continue to provide care.

Special Population Considerations

- Pregnant patients
- Pediatric patients
- Geriatric patients

Pregnant Patients

When your patient is a female of childbearing years, one must consider the possibility that she is pregnant. The treatment of pregnant patients means that you will be treating two patients. Potential risks to the fetus by a drug, must be outweighed by possible benefits to the mother by the drug.

Two pharmacological problems arise from pregnancy: the potential for drugs to harm the fetus as well as changes in the anatomy and physiology of the mother.

The mother's heart rate, cardiac output and her blood volume all increase as she is entirely supporting the fetus, as a result the onset and duration of action of many drugs can be affected by this altered maternal physiology.

The ingestion of teratogenic drugs in the first trimester has the potential to deform, injure or to kill the fetus. Drugs administered in the third trimester may cross the placental barrier and harm the fetus. They may also be communicated to a newborn during breast-feeding.

United States Food & Drug Administration Pregnancy Categories

Drugs are categorized according to their level of risk to the fetus. The categories are interpreted as follows:

- **Category A:** controlled studies fail to demonstrate a risk to the fetus in the first trimester, and there is no evidence of risk in later trimesters; the possibility of fetal harm appears to be remote.
- **Category B:** either animal reproductive studies have not demonstrated a fetal risk but there are no controlled studies in women *or* animal reproductive studies have shown an adverse effect that was not confirmed in controlled studies on women in the first trimester and there is no evidence of risk in later trimesters.
- **Category C:** either studies in animals have revealed adverse effects on the fetus and there are no controlled studies in women *or* studies in women and animals are not available. Drugs in this category should be given only if the potential benefit justifies the risk to the fetus.
- **Category D:** there is positive evidence of human fetal risk, but the benefits for pregnant women may be acceptable despite the risk, as in life-threatening diseases for which safer drugs cannot be used or are ineffective.
- **Category X:** studies in animals and humans have demonstrated fetal abnormalities, there is evidence of fetal risk based on human experience, or both; the risk of using the drug in pregnant women clearly outweighs any possible benefit. The drug is contraindicated in women who are or may become pregnant.

Pediatric Patients

Pharmacokinetics in pediatric patients are affected by several physiological factors.

Geriatric Patients

In patients older than about 60 years, significant changes in pharmacokinetics may occur. This can be slowed oral absorption from decreased GI motility. Muscle mass decreases while body fat increases, so the absorption and distribution of intramuscular delivery may alter if the volumes are not appropriate for the muscle mass. Decreased liver function may delay or prolong drug action (the liver primarily handles bio-transformation). Elimination may also be delayed due to the aging process's effect on the renal system.

It is not uncommon to find older patients who are on multiple medications or that have multiple underlying disease processes. Interaction of various medications can have a serious impact on a patient. One common example is the concurrent use of sildenafil and nitroglycerine, together they can cause a drastic drop in blood pressure.

Pharmacokinetics

Pharmacokinetics is the study of the basic processes that determine the duration and intensity of a drug's effect. These four processes are absorption, distribution, bitransformation and elimination. (Prehospital Emergency Pharmacology, Bledsoe, Clayden, 2005 Pearson)

In order for a drug to exert its desired effects on the body, it must reach the target tissue in the desired form, in the correct concentration. When the drug has achieved this it will start a chain of events that will lead to the desired physiological changes.

Pharmacokinetics

The following are factors which influence the concentration of a drug at its site of action.

Absorption

When administered to a patient, a drug must find its way to the site of action. Drugs given orally or injected into any place other than the blood stream, its absorption into the blood stream is the first step in this process. There are several factors that affect a drug's absorption. Drugs given intramuscularly are absorbed faster than those given subcutaneously. This is because muscles are more vascular than subcutaneous tissue. Factors such as hypothermia and shock may reduce absorption as they reduce blood flow. Conversely, hyperthermia and fever increase peripheral blood flow and therefore will increase absorption.

Orally administered drugs must first survive the process of digestion prior to being absorbed across the mucosa of the GI system. Some drugs have an enteric coating (a coating added to drugs taken by mouth that need to reach the intestines. Mosby Medical Encyclopedia. Enteric refers to the small intestine) that will not dissolve in the acidic stomach environment, but will in the alkaline duodenum.

In addition to the blood flow, the surface area of the absorbing surface will affect drug absorption. Simply stated, the greater the surface area, the more rapid the absorption.

The drug's concentration also affects its absorption. The higher a drug's concentration, the faster it will be absorbed by the body. This principle is behind the "loading dose" of a drug, followed by a "maintenance infusion". Typically a loading dose is a higher dose of the same concentration of a drug. Occasionally, a more concentrated dose of the same drug is given as a loading dose. Irrespective of the concentration, the goal is to quickly raise the amount of the drug in the body to a therapeutic level. Typically, the loading dose is followed by a maintenance, or continuous infusion to keep the drug at the desired therapeutic level. This is achieved at a slower administration rate, or a lower concentration of the drug.

The method of administration influences the rate of absorption of the drug. A drug given by the intramuscular or subcutaneous or intrabuccal route must be able to absorb into circulation through the walls of capillaries. Factors such as shock, acidosis, hypothermia and edema may reduce absorption. Factors such as hyperthermia and fever may increase absorption. Muscles are more vascular than subcutaneous tissue, therefore may have faster absorption. A drug given endotracheally must be absorbed through the capillaries in the lungs. This is a convenient route when intravenous access is delayed or

unavailable. A drug given intravenously will be absorbed much more quickly and is more predictable. This is the most desired route for many pre-hospital drugs

Bioavailability is the measure of a drug that is still active after it reaches its target tissue. The goal of administering a drug is to ensure sufficient bioavailability of the drug at the target tissue in order to produce the desired affect.

Distribution

Once a drug enters the circulatory system, it is distributed throughout the tissues. Most medications pass easily through the body to the target cells. These drugs tend to have a rapid onset and short duration of effect. Some drugs immediately bind to serum proteins and will have a delayed onset, remaining in the circulatory system for a longer period of time. In general drugs will concentrate in tissues with good blood supplies such as the heart, brain, liver and kidneys.

Most drugs are bound to serum proteins in various degrees. Only unbound or free drug is pharmacologically active, i.e., only nonionized free drug crosses membranes and binds with the receptor for pharmacological action.¹

1. Chan S, Gerson B. Free drug monitoring. Clinics Lab Med 1987; 7:279–87.

Therefore, the therapeutic effects of a drug are primarily from the unbound portion.

Common blood proteins that drugs bind to are [human serum albumin](#), [lipoprotein](#), [glycoprotein](#), α , β , and γ [globulins](#). (Shargel, Leon (2005). *Applied Biopharmaceutics & Pharmacokinetics*. New York: McGraw-Hill, Medical Pub. Division. ISBN 0071375503.)

The blood-brain barrier and the so-called placental barrier exclude some drugs from distribution.

In the case of the blood-brain barrier, the tight junctions of the capillary endothelial cells in the central nervous system vasculature, only allow non-protein-bound, highly lipid-soluble drugs to pass. This is a physical barrier.

The placental barrier is not a physical barrier as its name implies, but rather it is a biochemical barrier at the maternal/fetal interface that restricts certain molecules. Remember, the fetus is exposed to almost all drugs taken by the mother.

Biotransformation

This is the process of a drug changing to another form. Many drugs are inactive at the time of administration, but become active in the body. The transformed form of the drug is called a metabolite. Some drugs are transformed into an active metabolite to become useful to the target tissue or organ. Other drugs are transformed into an inactive metabolite prior to elimination.

Numerous Biotransformation processes happen in the liver. Microsomal enzymes found in the endoplasmic reticula of hepatocytes (liver cells, hepat –liver, cyctes-cells) perform most of the metabolizing. (these enzymes are also found in the lungs, kidney and GI tract in smaller quantities). All drugs absorbed in the GI tract must pass through the liver, as the blood supply from the GI tract passes through the liver via the portal vein. This can partially or completely inactivate the drug, a phenomenon known as the first pass effect. This is why some drugs cannot be given orally but are given intravenously. Drugs that can be given either orally or intravenously will require a higher dose when given orally.

FIRST-PASS EFFECT *The first-pass effect is the term used for the hepatic metabolism of a pharmacological agent when it is absorbed from the gut and delivered to the liver*

via the portal circulation. The greater the first-pass effect, the less the agent will reach the systemic circulation when the agent is administered orally.

Elimination

Drugs are eventually cleared, or eliminated from the body, either in their original form, or as metabolites. Drug clearance is primarily achieved through one or more of the following body systems.

Kidneys / Renal System: Urinary excretion is a major route for elimination of drugs from the body. Changes, such as the reduction of nephrons, the functioning unit of the kidney, associated with aging, can significantly alter drug clearance capacity in the geriatric client. The result of a decline in concentrating ability and decreased excretory function can result in prolonged increased serum levels of certain drugs. Processes, not necessarily associated with aging, such as renal failure, markedly alter clearance, and create a whole new patient management dynamic.

Liver / Hepatic System: One of the factors contributing to the effectiveness of hepatic clearance is blood supply and blood flow. Decreased liver mass and blood flow, as typically seen in the geriatric population, will alter clearance times. Hepatic disease processes will also negatively impact clearance. Some compounds are excreted in the bile.

Gastrointestinal Tract: Some metabolites are excreted in the feces.

Pulmonary System: Some excretion occurs via gas exchange at the alveolar level.

Routes of administration

The **route of administration** (ROA) that is chosen may have a profound effect upon the speed and efficiency with which the drug acts.

The possible routes of drug entry into the body may be divided into two classes:

- • **Enteral**
- • **Parenteral**

Enteral

- To do with Gastrointestinal (GI) tract
- E.g. oral, buccal, rectal

Oral (PO)

By mouth (Per Orum). Typically intermediate between IM and IV in speed of absorption.

Advantages: Convenient - portable, painless, easy, cheap - not sterile, compact, variety – tablets, capsules, fast or slow release.

Disadvantages: May be inefficient - high dose, low solubility, food interaction, local effect - GI flora, unconscious patient - not able to swallow, first-pass effect.

Rectal (PR) (per rectum).

Administered by Suppository or Enema, the rectum is actually a very quick method of drug administration as it is highly vascular and avoids the first-pass effect.. This route is often used in children.

Advantages: Bypass liver, useful - children, non-PO

Disadvantages: Erratic absorption, not well accepted

Buccal/Sublingual (SL)

- Buccal –(in the cheek) often harder – slower with longer disintegration

Example - lorazepam

- Sublingual – (under the tongue) softer - faster release, faster disintegration

Examples - nitroglycerin, steroids

Advantages: avoid first pass effect, rapid absorption, drug stability

Disadvantages: advantages lost if swallowed, small dose limit

Parenteral

– Not enteral

– E.g. IV, IM, SC

Intravenous (IV)

Injection of a drug in liquid form directly into a peripheral vein over 1 to 2 minutes (bolus) or longer as an infusion

Advantages: Rapid response, larger doses can be given by infusion, veins are relatively insensitive.

Disadvantages: Must find a suitable vein, aseptic technique can be challenging in pre-hospital environments, expensive.

Intraosseous (IO)

Allows for direct injection into the medullary cavity.

If intravenous access is not possible in the collapsed, unconscious patient, the use of this route for drug administration is justified to restore spontaneous cardiac output as rapidly as possible. As well as for the administration of the drugs, the intraosseous route can also be used for fluid administration in the hypovolemic patient.

Advantages: large bore needle allows for rapid infusion, relatively safe, provides about the same central venous access as IV.

Disadvantages: risk of infection, fractures, requires extensive training.

Subcutaneous (SC)

Injection just under the skin

Advantages: Can be given by the patient, slow but generally complete absorption, absorption can be increased with massage or heat.

Disadvantages: Painful, absorption can be decreased with vasoconstriction, tissue damage from irritant drugs, maximum of 2 ml injection recommended.

Intramuscular (IM)

Direct injection into the muscle

Advantages: larger volume than SC, muscle is very vascular, so absorption usually faster than SC.

Disadvantages: Can be painful, absorption can be slow, erratic or incomplete; can be difficult in the emaciated patient.

Endotracheal (ET)

Certain drugs can be given down an endotracheal tube. The drugs are given at 2-2.5 times normal IV dose. Drugs are followed with a saline bolus of ~10ml. The acronym for drugs that can go down an ET tube is ALONE:

- A – Atropine
- L – Lidocaine
- O – Oxygen
- N – Naloxone (Narcan)
- E – Epinephrine

Advantages: rapid onset of action due to rapid access to circulation, large surface area, thin membranes separate alveoli from circulation, high blood flow

Disadvantages: requires extensive training, erratic absorption.

Inhalation

* Local effect - bronchodilator

* Systemic effect- general anaesthesia

Advantages: also has a rapid onset of action due to rapid access to circulation, large surface area, thin membranes separate alveoli from circulation, high blood flow, bypass liver; absorption of gases is efficient and rapid.

Disadvantages: Solids and liquids excluded if > 20 micron and exhaled if < 0.5 micron

Topical

Routes are through mucosal membranes (nasal, vaginal, etc.) or skin

Dermal or Injunction - rubbing in of oil or ointment (local action)

Transdermal - absorption through skin (systemic action)

Advantages: stable blood levels, no first pass metabolism, convenience

Disadvantages: for transdermal patch- drug must be potent or patch becomes too large; can be messy; can cause irritation or skin breakdown.

Other ROA's

- Intra-nasal - small dose, avoid first pass
- Intra-arterial - cancer chemotherapy
- Intra-thecal - into the cerebrospinal fluid

Route for administration: Time until effect

intravenous	30-60 seconds
intraosseous	30-60 seconds
endotracheal	2-3 minutes
inhalation	2-3 minutes
sublingual	3-5 minutes
intramuscular	10-20 minutes
subcutaneous	15-30 minutes
rectal	5-30 minutes
ingestion	30-90 minutes
transdermal (topical)	variable (minutes to hours)

Drug Forms

Liquid Drugs: These usually consist of a powder dissolved in a liquid. The drug is referred to as the solute. The fluid it is dissolved in is the solvent. Some examples include:

Solutions: Solutions are preparations in which drugs are dissolved in a solvent, usually H₂O. (D₅ ½, NaCl and salbutamol are examples of a solution)

Syrups: Occasionally, drugs are dissolved in sugar and H₂O to improve taste. These are referred to as syrups. (Cough syrups are examples of this)

Suspensions: These are liquid drug preparations that do not remain mixed. After sitting for even a short time, these preparations will tend to separate. They must be well shaken before being administered. (An antibiotic –Amoxicillin- is an example of a suspension)

Elixir: Elixirs are preparations that contain the drug in an alcohol solvent. Frequently, flavouring is added to improve the taste. (An example of an elixir is Nyquil)

Emulsions: Emulsions are preparations in which an oily substance is mixed with a solvent that cannot dissolve it. After mixing, globules of fat form and float in the solvent.

Liquid drugs administered into the body through intramuscular, subcutaneous or intravenous routes are called **parenteral** drugs. Parenteral refers to a route other than through the digestive tract (enteral tract). Parenteral medications are packaged in several types of containers:

Ampules: These are sterile containers designed to carry a single patient dose. They are either of glass or plastic design, with a twist off top or a top which breaks off. The drug is then drawn into a syringe for administration, and depending on the drug, may need to be diluted in a solvent such as NaCl.

Vials: A vial is a container which stores more than one dose (multi-dose). The amount required for administration is drawn up via a syringe from the vial.

Prefilled Syringes: Many of the intravenous medications used in the prehospital setting, are manufactured and packaged in preloaded syringes. These prefilled syringes already have the drug diluted to the appropriate concentration, and often are prefilled with the exact dose required, where a standard dosing regime exists, as is the case with many front line cardiac drugs.

Solid Drugs: Solid drugs are usually administered orally, but can be administered rectally or vaginally as well. They include:

Pills/ Tablets: These are drugs mixed into a base, and shaped into a form for ease of swallowing.

Capsules: These are small gelatin containers into which a powder is placed. The gelatin is dissolved in the GI tract, allowing for absorption of the drug.

Suppositories: These are drugs mixed into a base which dissolves into surrounding tissue when placed into a body orifice and warmed to body temperature. This then allows for the drug to be absorbed by the mucosa.

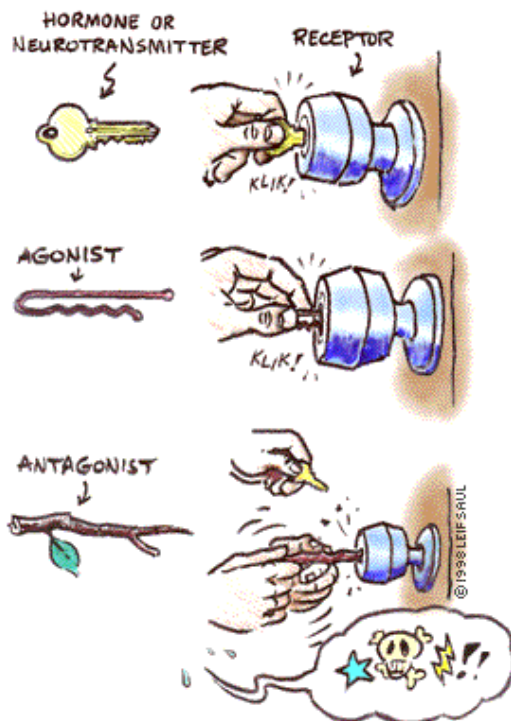
Powders: These are not as common a form of drug. An example is Serevent (salmeterol), which is inhaled for respiratory diseases such as asthma. Some other bronchodilators also come in a powder form to be inhaled.

Pharmacodynamics

Actions of Drugs

Once a drug has reached its target tissue, it must induce a biochemical or physiological response. To do this, most drugs bind to drug receptors. Drug receptors are proteins present on the surface of cell membranes. Drugs that bind to a receptor and cause a response are called agonists. Some drugs can bind to a receptor and block a response, or prevent other drugs from binding to the receptor. These are called antagonists.

Think of the receptor as a lock, and the drug as the key.



In order to be effective, a drug must achieve a certain concentration in the target tissues. The minimum concentration to cause the desired response is called the ***therapeutic threshold***, or minimum effective concentration. If the concentration is below this, it will not induce an effective response. Conversely, if the concentration is too high, it can result in a toxic or fatal response. The difference between therapeutic and toxic levels of a drug is called the therapeutic index.

MISSING: Drugs that Act: by Changing Physical Properties, by Chemically Combining with Other Substances, by Altering a Normal Metabolic Pathway

Drugs that act by changing Physical Properties

Other drugs alter the physical properties of a targeted part of the body. Drugs such as mannitol, (which increase urine output by increasing the blood's osmolarity), are examples of this action.

Drugs that act by chemically combining with other substances

Two common examples of this action are isopropyl alcohol and Antacids, like Tums™. Drugs in this category participate in chemical reactions that change the chemical nature of their substrates (define in glossary?)

Isopropyl alcohol denatures (define in glossary?) the proteins on the surface of bacterial cells; this in turn kills the bacteria by rupturing the cells.

Antacids neutralize hydrochloric acid

Drugs that act by altering a normal metabolic pathway

Some anticancer and antiviral drugs are chemical analogs (define in glossary) of normal metabolic substrates.

RESPONSES TO DRUG ADMINISTRATION

Allergic Reaction

Idiosyncrasy

Tolerance

Cross-tolerance

Tachyphylaxis

Cumulative effect

Drug dependence

Drug interaction

Drug antagonism

Summation

Synergism

Potentiation

Interference

Policies regarding errors in medication administration

Refer to your individual regional policies.

Manitoba EMS Drug Formulary

(See MB Health Emergency Treatment Guidelines)

EMS personnel must be familiar with a number of drugs and other agents in their routine work. EMS personnel should use the generic names when referring to any drug or agent. While indication, contraindication, drug doses, and other relevant information are included in this formulary for information purposes, EMS personnel should refer to specific treatment protocols regarding use of any of these drugs or agents.

Drugs included in this formulary include:

acetylsalicylic acid	amiodarone
atropine	dextrose (D50W)
diazepam	diphenhydramine
epinephrine	furosemide
glucose	glucagon
heparin sodium	lidocaine
lorazepam	midazolam
morphine	naloxone
nitroglycerine	nitrous oxide/oxygen
oxygen	oxytocin
salbutamol	

Appendix A: Metric conversions

The metric system is used universally as the standard system of weights and measures in science and medicine. The metric system is based on the unit 10, and all units are 10 times larger than, or 1/10 as large as the next unit. This makes conversion simple.

Physical descriptions in science and medicine rest upon three measurements.

Mass Quantity of matter in a substance.
Length Distance between two points.
Volume Space occupied by a substance.

The metric system has three fundamental units for these measurements.

Mass Measured in grams (g)
Length Measured in meters (m)
Volume Measured in liters (L or l)

All other metric units used to describe mass, length and volume are derivatives of these fundamental units.

The following table identifies the most commonly used prefixes and abbreviations for drug related measurements.

Prefix	Multiplier	Symbol
deci-	$10^{-1} = 0.1$	d
centi-	$10^{-2} = 0.01$	c
milli-	$10^{-3} = 0.001$	m
micro-	$10^{-6} = 0.000,001$	μ

The system is structured simply, so that a prefix can be added to one of the three metric fundamental units for measurement, to express accurate mass, length or volume.

Example 1: 1/100 of a meter is expressed as a centimeter.
The symbols are combined - cm

Example 2: 1/1000 of a liter is expressed as a milliliter.
The symbols are combined - mL

Example 3: 1/100,000 of a gram is expressed as a microgram.
The symbols are combined - μ g

An important item to note is that conversion between cubic centimeter (cc) and milliliter (mL) is often used in medicinal applications. One mL of H₂O occupies 1 cubic centimeter of space. Therefore: 1 cc = 1 milliliter (mL)

Weight	
Pounds	Kilograms
330	150
275	125
220	100
209	95
198	90
187	85
176	80
165	75
154	70
143	65
132	60
121	55
110	50
99	45
88	40
77	35
66	30
55	25
44	20
33	15
22	10
15	7

Other useful conversions

Volume:

1 tsp = 5 ml

1 tbsp = 15 ml

1 fluid oz = 28 ml

1 quart = 946 ml

Length:

1 inch = 2.54 cm

1 foot = 30.5 cm

Weight: 1 oz = 28 grams

1 pound = 454 grams

2.2 pounds = 1 kg

Appendix B: Drug Dosage Calculations

Non-parenteral medications

Capsules and un-scored tablets are rounded to the nearest whole tablet. Scored tablets are rounded to the nearest 1/2 tablet. Liquid medications are rounded to one decimal place (tenths).

The dosage in which the drug is manufactured is considered a conversion factor; such as 1 tablet = 0.5 mg is 0.5 mg/tablet.

Ratio-proportions

Ratios indicate a relationship between two numbers with a colon between the numbers. The colon represents division. For example $3:4 = 3/4$.

Proportions are equations containing ratios of equal value. For example $3:4 = 6:8$. This may also be written as fractions, $3/4=6/8$.

Means are the two inner numbers, in this case 4 & 6.
Extremes are the two outer numbers, 3 and 8.

$$3:4 = 6:8$$

The formula method:

$$D/H \times Q = X$$

D - dosage desired or ordered

H - what is on hand (available)

Q - unit of measure that contains the available dose. When using solid products (tablets, capsules) Q is always 1 and can be eliminated. Q varies when using liquid measures.

X - the unknown dosage you need to administer

Example: Order: Potassium Chloride 20 mEq added to the IV.
Available: 40 mEq per 10cc.

How much potassium will you add?

$$D = 20 \text{ mEq} \quad H = 40 \text{ mEq} \quad Q = 10 \text{ cc}$$

$$20 \text{ mEq} \times 10 \text{ cc} = X$$

$$40 \text{ mEq}$$

$$0.5 \times 10 = X = 5 \text{ cc}$$

It doesn't matter if you use ratios, fractions or the formula; the answer will be the same.

Points to remember:

1. The maximum number of tablets and capsules administered to achieve a desired dose is usually 3.
2. No more than 10% variation should exist between the dose ordered and the dose administered.
3. Make sure your answer seems reasonable. Think about whether the dose should be larger or smaller than what is available.

Parenteral Medications

The same methods, ratio-proportion or formula, are used to determine the amount to be given.

Injectable medication guidelines:

1. Intradermal - the volume to be administered is 0.1 ml or less
2. Subcutaneous - the volume to be administer is 1.0 ml or less
3. Intramuscular - depends upon the size of the person
 - a. A healthy, well developed person can tolerate 3.0 ml in large muscles - this does NOT include the deltoid.
 - b. For elderly, thin clients or children the total amount should not exceed 2.0 ml.
 - c. No more than 1.0 ml should be given to young children and older infants.

Calculating dosages in units (insulin, heparin, pitocin, vitamins, some antibiotics)

Example: Ordered: Heparin 8000 units subcutaneous q12h
Available: Heparin 10,000 units per ml
How much will you administer?

$$\text{Formula: } \frac{8000 \text{ units}}{10,000 \text{ units}} \times 1 \text{ ml} = 0.8 \text{ ml}$$

$$\begin{aligned} \text{Ratio: } 10,000 \text{ units} : 1 \text{ ml} &= 8000 \text{ units} : x \\ 8000 \text{ units} \times 1 \text{ ml} &= 10,000 \text{ units} \times x \\ 8000 / 10,000 &= x \\ 0.8 \text{ ml} &= x \end{aligned}$$

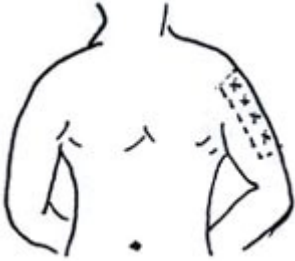
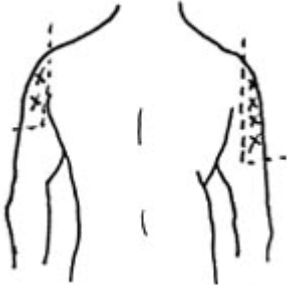
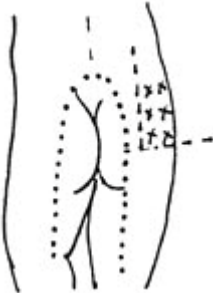
If the answer is greater than 1, you probably calculated the problem incorrectly. Rarely, the desired dose is large and you will have to administer it in more than one site.

Reconstituting powdered drugs:

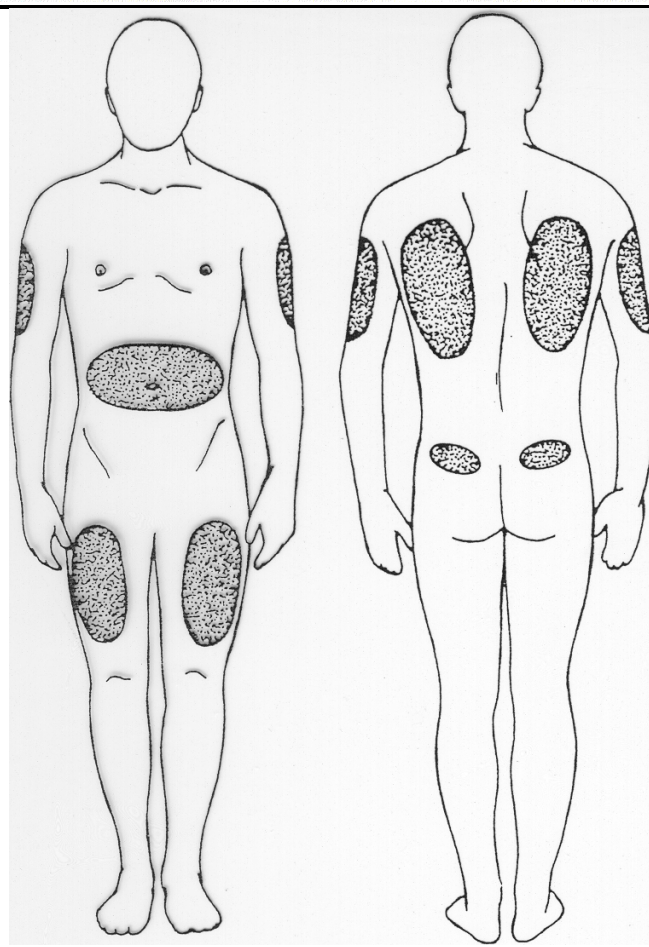
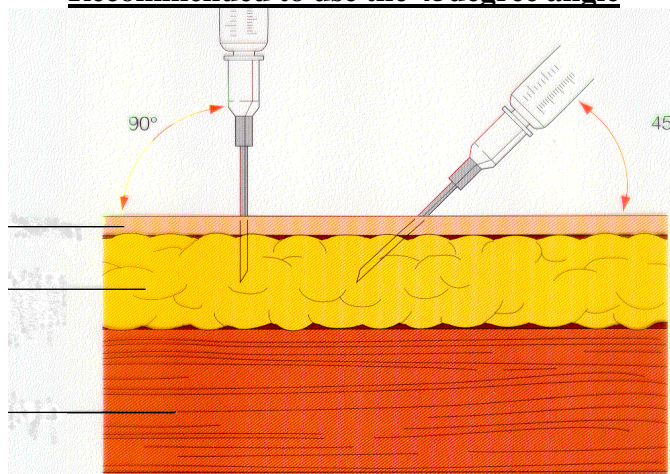
Read the label for the amount of fluid to add, the type of fluid and the final concentration of the reconstituted fluid. The label will also tell you how long the mixture may be stored and what conditions are required for storage. The final volume will be larger than the amount of fluid you add because the powder will take up some room when diluted. If you are not given a final volume calculate the concentration based on the amount of fluid you added. You will calculate the amount to administer from the final concentration.

Appendix C: Medication Administration Sites

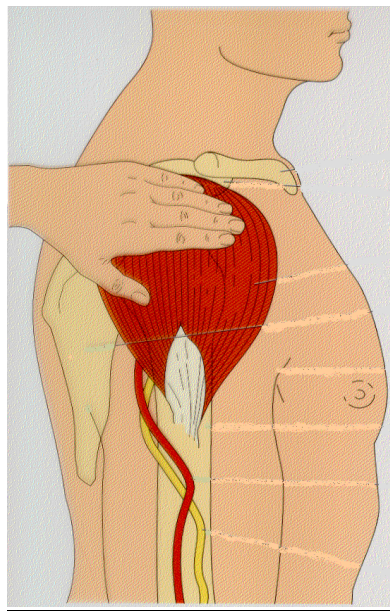
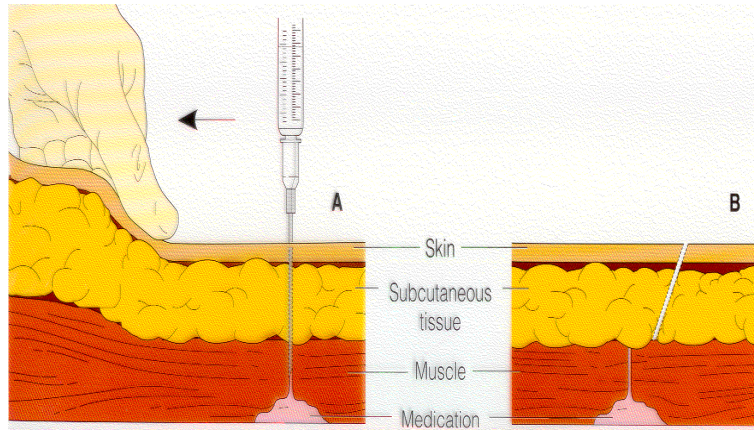
Injection Sites

<p>Preferred Sub-Q Site Sub-Q injection site in arm</p>  <p>Sub-Q: Use middle to upper-outer portion of arm, abdomen, or top of leg above knee</p>	<p>Preferred Sub-Q Site Last Choice for IM IM or Sub-Q injection site in arm</p>  <p>IM: Upper outer portion of arm (Deltoid Muscle) Sub-Q: Use middle to upper-outer portion of arm</p>
<p>Preferred IM Site IM injection site on buttocks</p>  <p>IM: Use the upper-outer portion of the buttocks to avoid the sciatic nerve (Gluteus Medius or Gluteus Maximus)</p>	<p>Key:</p> <p>xxxxx injection sites sciatic nerve ----- site section</p>

Subcutaneous injections
Recommended to use the 45degree angle

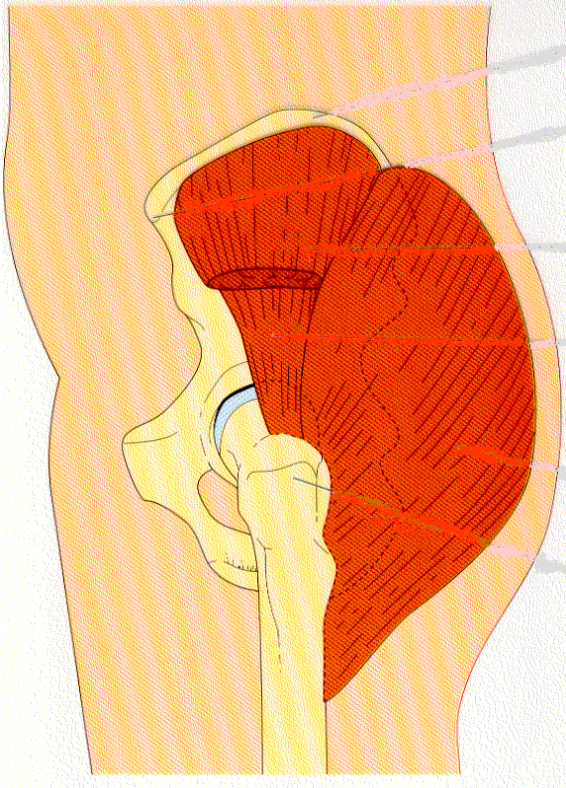


Intramuscular Injections



deltoid site

2 in. below acromion
process, midpoint on
lateral aspect of muscle



Ventrogluteal - site preferred as no large nerves or blood vessels in this area. Patient placed on back or side with knee and hip flexed to relax gluteal muscles. Place heel of hand on greater trochanter – index finger on anterior superior iliac spine, middle finger on iliac crest, thumb toward groin

Dorsogluteal – used for adult & children w/ well-developed gluteal muscles; child must be walking (over age 3). Palpate posterior superior iliac spine and greater trochanter and draw imaginary line; site is lateral and superior to line; avoid striking area of sciatic nerve, major blood vessels and bone

Appendix D: Knowledge of medications for PCP and ACP as per the National Occupational Competency Profiles

Technician-Paramedic

Adrenergic agonists (Appendix 5A B.1)

Epinephrine

Salbutamol

Analgesics (non narcotic) (Appendix 5A A.7)

Acetaminophen

Nitrous Oxide

Antagonists (opioid) (Appendix 5A A.1)

Anti-anginal agents (Appendix 5A D.7)

Nitroglycerin

Antihypoglycemic agents and insulin (Appendix 5A H.2)

Dextrose

Glucagon

Oral hypoglycemic agents

Antiplatelet Agents (Appendix 5A E.3)

Acetylsalicylic acid

Benzodiazepines (anxiolytics and anticonvulsants)

Lorazepam

Bronchodilators (Appendix 5A C.1)

Ipratropium bromide

Salbutamol

Technician-Paramedic Advanced

Adrenergic agonists (Appendix 5A B.1)

Isoproterenol

Analgesics (opioid)

Morphine

Fentanyl

Antocoagulants

Low molecular weight heparin
Unfractionated heparin

Antidysrhythmic agents
Classes 1-4
Amiodarone
Lidocaine
Procainamide

Antihypoglycemic agents and Insulin
Insulin

Antihypertensive agents
Labetalol
Verapamil

Anti-inflammatory Agents (non steroidal)
Acetylsalicylic acid
Ibuprofen

Antihistamines
Diphenhydramine

Antinauseant agents
Dimhydrinate

Antiparkinsonism agents
Levodopa

Antiplatelet Agents (Appendix 5A E.3)
Platelet receptor inhibitors

Benodiazepines (anxiolytics and anticonvulsants)
Diazepam
Midazolam

Cardiac Glycosides
Digoxin

Cholinergic antagonists
Atropine
Ipratropium bromide

Diuretics

Furosemide

Muscle relaxants (depolarizing)

Succinyl choline

Muscle relaxants (non depolarizing)

Vecuronium

Pancuronium

Rocurnium

Neuroleptics

Haldol

Thrombolytic agents

Tissue plasminogen activator

Streptokinase

Uterotonics

Oxytocin

Antibiotics

Antidotes or Neutralizing agents

Flumazenil

Immunizations

Glossary

The following are common terms with which the Paramedic should be familiar:

Adrenergic: Pertaining to the neurotransmitter norepinephrine.

Agonist: Drug or substance that causes a physiological response

Antagonism: This signifies the opposition between medications; that which counteracts something else.

Autonomic ganglia: Groups of autonomic nerve cells located outside the central nervous system.

Biotransformation: Chemical changes a substance undergoes in the body, as may occur by the action of an enzyme on a substance.

Blood brain barrier: A protective mechanism that selectively allows the entry of a limited number of compounds in the brain.

Bolus: A single, often large dose of medication.

Cholinergic: Pertaining to the neurotransmitter acetylcholine.

Chronotrope: Drug or chemical that affects the heart rate.

Contraindications: The medical or physiological conditions present in a patient that may cause harm when an otherwise appropriate medication is administered.

Cumulative action: Occurs when a drug is administered in several doses, causing an increased effect. This is usually due to a build-up of the drug in the blood.

Depressant: A medication that decreases a bodily function or activity.

Drug: Chemical agents used in diagnosis, treatment, and prevention of disease.

Drug receptors: Proteins present on the membrane of a cell which serve as binding sites for certain drugs.

Enzyme: Substance produced by living cells which aids in speeding up the process of chemical reactions in the body.

Habituation: A physical or psychological dependence on a drug.

Half life: Amount of time required to reduce a drug level to half its initial value.

Hypersensitivity: A state of altered reactivity to some foreign substance, with an exaggerated immune response.

Idiosyncrasy: An individual reaction to a drug that is unusual, or different from the norm.

Indication: Refers to the medical condition(s) in which a drug has been proven to be of therapeutic value.

Inotrope: Drug or chemical that affects the contractile force of the heart.

Metabolites: Chemical variations of a drug within the body, a result of biotransformation.

Neuroeffector junction: A specialized synapse between a nerve cell and the specific organ or tissue that it innervates.

Neurotransmitter: A chemical messenger that conducts a nervous impulse across a synapse.

Neuron: A nerve cell.

Potentiation: The enhancement of the effects of one drug by another.

Pharmacology: The study of drugs and how they affect the body.

Pharmacokinetic: The study of how drugs enter the body, reach their targeted site of action and are ultimately eliminated.

Pharmacodynamics: The study of a drug's action on the body.

Pre-ganglionic nerves: Nerve fibres that extend from the central nervous system to the autonomic ganglia.

Post –ganglionic nerves: Nerve fibres that extend from the autonomic ganglia to the target tissues.

Refractory: Patients who do not respond to a drug are said to be refractory to that drug.

Side effects: Undesired effects that a drug could cause.

Stimulant: A drug that increases a bodily function or activity.

Synapse: A space between nerve cells. Electrical impulses are transmitted across the synaptic cleft by neurotransmitters.

Synergism: The combined action of two drugs that is much stronger than the effects of either one alone.

Therapeutic action: The intended action of a drug given in the appropriate medical condition.

Tolerance: When a patient has been on a drug for an extended period of time, they may require increased dosages to achieve required effect. This patient has a tolerance to the drug.

Untoward effect: A side effect that is harmful to the patient.

References

“An Alternative Route to Maintenance of Licensure”, Manitoba Health Emergency Services, Revised March 14, 2001

“National Occupational Competency Profiles”, Paramedic Association of Canada.

“Paramedic Emergency Care”, Third edition, Brady, Prentice Hall Inc., 1997

“Prehospital Emergency Care”, Fifth edition, Brady, Prentice Hall Inc., 1996