Common Antiseptics: Mechanism Of Action And Its Uses In Animal

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Abstract: Antiseptics are extensively used in Hospital and other health care setting for a variety of topical applications. In particular antiseptics are essential part of infection control practice and aid in the prevention of nosocomial infection. A wide variety of active chemical agents (biocides) are found in these products, many of which have been used for hundreds of years including alcohol and iodine. Chlorhexidine, hydrogen peroxide, and potassium permanganates are also among the commonly used antiseptics. Most of these active agents demonstrate broad spectrum antimicrobial activity. Antiseptics may have lethal effect (e.g., Sporocidal, virucidal and bactericidal) or static effect on microorganisms. They are applied to unbroken skin or mucus membrane, to burns and to open wounds to prevent sepsis by removing or excluding microbes from this area. The efficacy of antiseptics affected by several factors including: concentration and contact time, temperature, ph, presence of organic other material, type and concentration of offending organism. Therefore, selecting of appropriate antiseptic is critical before use for particular purpose.

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1. Introduction

Antiseptics are antimicrobial substance that are applied to living tissue (skin) to reduce or inhibit the possibility of infection, sepsis or putrefaction (Jim *et al,* 2013). Terminologies such as Cleanser, Antiseptic and Disinfectant are sometimes used interchangeably. However they are differentiated by their intended use and characteristic properties and not by their chemical content. Cleanser aids in physical removal of foreign material and is not germicide; disinfectants are germicides that are applied to inanimate objects and antiseptic are germicide applied to living tissue (Taylor, 1999).

The antiseptics and disinfectants should not be used interchangeably because certain antiseptic may be inactivated on inanimate surface and certain disinfectant are hazardous to living tissue even products with the identical active chemical moiety may be formulated in such way to prevent their interchangeable use (Adams, 2001). Most chemical agents can be used as both an antiseptic and a disinfectant. The purpose for which it is used is determined by its concentration. For example hydrogen peroxide 6% solution is used for cleansing wounds, while stronger solutions (>30%) are used in industry as a bleach and oxidizing agent (Drosou *et al,* 2003).

An ideal antiseptic would have broad spectrum of activity, low toxicity and high penetrability, would maintain activity in the presence of pus and necrotic tissue and would cause little skin irritation or interference with normal healing process and cheapness of its coast. Antiseptics have multiple target and broad spectrum activity which include bacteria, fungi, virus, protozoa and even prion (Tan *et al*., 2009).

A wide variety of active chemical agents are found in these products, many of which have been used for hundreds of years for antisepsis, disinfection, and preservation (block, 1991). This review considered the use of antiseptic and their mechanism of action to reduce or to inhibit the growth of microbes, factors influencing efficacy of antiseptics.

2. Common Antiseptics And Their Uses.

Antiseptics are mainly used to reduce levels of microorganisms on the skin and mucus membranes. The skin and mucus membrane of mouth, nose and vagina are home to large number of what are usually harmless microorganisms. However when the skin or mucus membrane are damaged or breached in surgery, antiseptics can be used to infect the area and reduce the chance of infection and although variety of antiseptics have been administered by intrauterine infusion for the treatment of endometritis (Andrews *et al.,* 2001).

Antiseptics are applied to preoperative skin disinfection, mucus membrane disinfection, preventing and treating infected wounds and burns. It is also important that people who are treating patient with wounds or burn adequately wash their hands with antiseptic solution to minimize the risk of cross infection (Jim *et al 2013*).

Health care antiseptic are products intended for use by health care professionals and consist of health care personnel hand wash, surgical hand scrubs and patient preoperative skin preparations. Consumer antiseptics also called antiseptic hand wash which are largely marketed as antibacterial soap and are intended for hand washing and general body cleansing (Taylor, 1999).

Table 1: Important consideration for safe and effective use of antiseptics

	Problem	**Solution**
Occupational exposure	vapours may cause respiratory problems and skin exposure may cause dermatitis	Handle with care Follow manufacturers' instructions Wear masks and gloves
Resistance	Improper use means that antimicrobials may no longer work to kill disease-causing bacteria	Use only when indicated. Dilute according to manufacturers' instructions
Storage	Improper or prolonged storage may lead to growth of bacteria in them	Store according to manufacturers' instructions. Use within expiry dates.
Preparation	Improper dilution may result in contamination of the solution	Dilute according to manufacturers' instruction.
Use	Improper use can lead to resistance, growth of bacteria, harm to the environment and to people, loss of potency.	Accurate directions are important for proper use Contact time needs to be adequate to achieve desired level of disinfection.
Disposal	Unsafe disposal can harm the environment	Contact time needs to be adequate to achieve desired level of disinfection

(Source: Patel *et al*., 2009).

A wide variety of active antiseptics are found, many of which have been used for hundreds of years. Some of the commonly used antiseptics in veterinary medicine are discussed below.

2.1. Alcohol

Although many alcohols are germicidal, the two most commonly used are ethyl and isopropyl alcohols. Alcohol also exhibit rapid broad spectrum antimicrobial activity against vegetative bacteria (including mycobacterium), viruses and fungi but not sporicidal. They are, however known to inhibit sporulation and spore germination (Jim *et al.,* 2013). But the effect is reversible because of lack of sporicidal activity, alcohols are not recommended for sterilization but are widely used both hard surface disinfection and skin antisepsis (Husain, 2008).

Ethyl and isopropyl alcohols compounds are both lipid solvent and protein denaturants they kill microorganisms by mode of action solubilizing the lipid cell membrane and by denaturing cell membrane protein. Alcohols are most effective when diluted with water to final concentration of 70% ethyl or 50%. Isopropyl alcohols by weight it's thought that a greater concentrations, initial dehydration of cellular protein make them resistance to denaturing effect (Molinari and Runnel, 1991).

In general, isopropyl alcohol is considered slightly more efficious against bacteria (Swanson *et al.*, 2014) and ethyl alcohol is more potent against viruses: however this dependent on the concentration of both active agent and the test microorganism .(Charles *et al.,*2004). The antimicrobial activity of alcohol is significantly lower at concentration below 50% and optimal in 60% to 90% range.

2.2. Chlorhexidine

Chlorhexidine is the most popular antiseptic. It has potent antimicrobial activity against vegetative bacteria and mycobacteria, and has moderate activity against fungi and viruses. Chlorhexidine is most effective against gram positive and somewhat less active against other bacteria. Because of its persistence, chlorhexidine has residual activity (bactericidal effect) when used repeatedly. The activity of chlorhexidine is relatively unaffected by the presence of blood, pus or necrotic tissue, but surfactants can neutralize its action. It is non-irritating to skin, and oral toxicity is low because of poor absorption (Desmond, 2011).

At physiologic pH chlorhexidine salt dissociates and release the positively charged chlorhexidine cation. Low concentrations of chlorhexidine are bacteriostatic, while high concentrations are bactericidal. Bacteriostatic is the result of chlorhexidine binding to the negatively charged bacterial cell wall (e.g., lipopolysaccharides), where it interferes with membrane transport systems. High chlorhexidine concentrations cause intracellular protein precipitation and cell death (Charless *et al*, 2004).

In veterinary medicine, chlorhexidine is used as general purpose disinfectant for cleansing wound, skin, instrument, and equipment. These products normally

contain around 1.5% chlorhexidine gluconate and are diluted with water by factor of 1 in 30 to 1 in 100 before use (Blowey and Edmondson, 2010).

Chlorhexidine is also used in teat dips and spray as an aid in control of mastitis. This product is normally applied at a concentration between 0.4% and 0.8% post milking to the whole herd. Chlorhexidine is also used in oral cleansing solution in case of gum inflammations and periodontal diseases. Side effect of chlorhexidine is allergic reaction, irritation or rash in some case (McDonnell and Rossell, 1999).

2.3. Hydrogen peroxide

Hydrogen peroxide (H_2O_2) is widely used biocide for disinfection, sterilization, and antisepsis. It is clear, colorless liquid that is commercially available in variety of concentrations ranging from 3 to 90%. Hydrogen peroxide is considered environmentally friendly, because it can rapidly degrade into innocuous products water and oxygen. Although pure solutions are generally stable, most contain stabilizers to prevent decomposition. Hydrogenperoxide demonstrate broad spectrum efficacy against viruses, bacteria, yeast and bacterial spore (Russell *et al.,* 1999).

In general, great activity is seen against gram positive than gram negative by mode of action release of nascent oxygen which irreversibly alters microbial protein that liberate oxygen when contact with catalase present on wound surfaces and mucus membrane. The effervescent action mechanically helps remove pus and cellular debris from wounds and is valuable for cleaning and deodorizing infected tissue. However, the antimicrobials action is of short duration and is limited to the superficial layer of the applied surface because there is no penetration of tissue (Ngan *et al.,* 2015).

Although its usefulness as antiseptic is limited, hydrogen peroxide finding increased application as disinfectants in water treatment and food processing facilities and for sterilization of dental and surgical instrument.However, side effect of hydrogen peroxide of 3% has been shown to be damaging to tissue including fibroblast and also it is not considered assuitable for routine wound care (Swanson *et al.,* 2014).

2.4. Iodine

Iodine is a highly effective topical antimicrobial that has been used clinically in the treatment of wounds for more than 170 years. It has a broad spectrum of antimicrobial activity with efficacy against bacteria, mycobacterium, fungi, protozoa and viruses and can be used to treat both acute and chronic wounds, it is also relatively inexpensive and easy to use, but is often underused as a topical antiseptic due to its perceived toxicity (Sibbald *et al*., 2011).

Elemental iodine has activity against gram positive and gram negative bacteria, bacterial spore, fungi, and most viruses. The mechanism action of iodine is by diffusing into cell interfering with metabolic reaction and by disrupting protein and nucleic acid structure and synthesis. Iodine is not soluble in water and thus prepared in alcohol (tincture) and it has characteristics of odor and corrosive to metals (Cynthia *et al.,* 2005).

Tincture of iodine used as early 1839, in French civil war, is most effectively formulated as 1 to 2% iodine solution and 2.4% sodium iodide in 70% ethyl alcohol in this form 90% of bacteria are killed within three minute of application. The antibacterial activity of this combination is greater than that of alcohol alone. Tinctures of iodine however, are irritating, allergenic and stain skin and clothing. It's so painful when applied to open wound and is harmful to host tissue: therefore it can delay healing and thereby increase the chance of infection (Fumal *et al.,* 2002).

Efforts to reduce the undesirable aspect of tincture while retaining the powerful killing action of iodine have led to introduction of tamed iodine known as iodosphore. In this preparation iodine is solubilized by surfactant which allow it remain a dissociable form. Application of this product allow for slow continual release of free iodine to exert germicidal effects. The iodosphore have similar spectrum of activity to aqueous solution; are less irritating, allergenic, and staining and have prolonged activity after application(4-6 hours) (Adams, 2001). Literature reports indicate that iodosphore is quickly bactericidal, virucidal, and mycobactericidal but may require prolonged contact time to kill certain fungi and bacteria spores. Iodosphore formulated as antiseptic are not suitable as land surface and disinfectant due to insufficient concentration of iodine (Cyanthia *et al.,* 2005).

Iodine dressing must be used under medical supervision in patients with thyroid diseases, known or suspected iodine sensitivity, Long-term use of PVP has been loosely associated with mild hyperthyroidismand long-term use is not recommended for patients with impaired thyroid function (Sibbald *et al.,* 2011).

2.5. Potassium permanganate

Potassium permanganate is an inorganic chemical compound with the chemical formula $KMno_4$. It is a salt consisting of K^+ and Mno_4^- ions. Formerly known as permanganate of potash or condys crystals, it is a strong oxidizing agent. It dissolves in water to give intensely pink or purple solutions, the evaporation of which leaves prismatic purplish –black glistening crystals. The main form of use is a potassium permanganate solution that is made by dissolving crystals or powder in water (Ngan *et al.,* 2015).

The primary mode of pathogen inactivation by potassium permanganate is direct oxidation of cell material or specific enzyme destruction (Charles*et al*., 2004). In the same fashion, the permanganate ion (MnO_4-) attacks a wide range of microorganisms such as bacteria, fungi, viruses, and algae. Application of potassium permanganate results in the precipitation of manganese dioxide. This mechanism represents an additional method for the removal of microorganisms from potable water (Patel *et al.,* 2009). In colloidal form, the manganese dioxide precipitant has an outer layer of exposed OH groups. These groups are capable of adsorbing charged species and particles in addition to neutral molecules. As the precipitant is formed, microorganisms can be absorbed into the colloids and settled (Danny *et al*., 2001).

Potassium permanganate is useful in the following dermatological conditions; infected eczema and blistering skin conditions, wound cleansing, specially weeping ulcers or abscesses, fungal infections such as athlete's foot. Potassium permanganates bath are effective for the treatment of infected eczema when there are blisters, pus and or oozing. A potassium permanganate concentration of 1:10000 should be used (pink color). If using 400mg tablets add one to each 4L of water and the tablet should be dissolved in hot water before pouring into the bath. The disadvantage of potassium permanganate is; Long contact time is required, potassium permanganate is toxic and irritating to skin and mucous membranes (Ngan *et al.,* 2015).

3. Factors Affecting Efficacy Of Antiseptic

Several factors are influence the efficacy of antiseptic including concentration and contact time, temperature, ph, presence of organic or other material, type and concentration of offending organism (Swanson *et al*,2014).

3.1. Concentration

The time to effectively kill organism is inversely dependent up on antimicrobial concentration for certain compounds. Small decrease in concentration may result in large increase in time required for killing whereas other compounds are less sensitive to changes in concentration. Alcohols are very concentration dependent while chlorhexidine is sensitive (Adams, 2001).

3.2. Temperature:

Increased temperature results in increase antimicrobial activity. The efficacy of most germicide against bacterial spore increase with temperature; however the most effective method against bacteria spore is moist heat (115^{o}c) (Ngan *et a*l., 2015).

3.3. Ph

The ph at site of action may affect a compounds activity by influencing the compound itself or the microbial cell. Certain molecules and certain acids (hypochlorous acid) or bleach effective only in the unionized form; thus as ph increase they become less efficacy. Increased ph result in higher number of negative charges on a cell surface with which positively charged molecules such as chlorhexidine can interact, thereby increasing their activity. Lastly in a process similar to absorption through any cell membrane, ph can affect partitioning from the bathing solution into the cell interior (Cynthia *et al.,* 2005).

3.4. Contamination

The most important step in attempting to maximize the efficacy of antisepsis and disinfection is through cleansing of the site. Organic matter such as blood, pus, feces, soil, food and milk are believed to directly reduce the activity of antimicrobial compounds via a chemical reaction that results in smaller amount of compound available for killing microorganism or by spatial non reaction (the inability) (Adams,2001).

3.5. Organism type

The sensitivity of different microorganism to antiseptics is quietly different. Within each group however difference in sensitivity to various chemical compound that may render a particular disinfection process ineffective against certain microbes while effective against other. Gram positive bacteria's are in general less resistance to antiseptic compound than gram negative organism due to less complex and lipid rich outer membrane (Tan *et al.,* 2009).

Conclusion And Recommendations

Antiseptics are antimicrobial substance that are applied to living tissue (skin) to reduce or inhibit possibility of infection, sepsis or putrefaction. Antiseptics are mainly used to reduce levels of microorganisms on the skin and mucus membranes. The an ideal antiseptic would have broad spectrum of activity, low toxicity and high penetrability, would maintain efficacy in the presence of pus and necrotic tissue and would cause little skin irritation or interference with normal healing process. Proper selecting of antiseptics and its concentrations to what we need activity is the critical points. Antiseptics have multiple target and broad spectrum of activity which include bacteria, fungi, virus, protozoa and even prion unlike antibiotics that have specific activity.

Based on the above conclusion the following recommendations are forwarded:-

- Proper selecting of antiseptics should be important according to types of microorganisms.
- Handle, store, indication and concentration of antiseptics should follow manufacturers' instructions.
- Accurate directions and proper use Contact time should be adequate.

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References

1. Adams, H.R. (2001): Veterinary pharmacology and Therapeutics. Pp. 783-794.
2. Andrews, A.H, Blowery, R.W, Boyd, H. and Eddy, R.G. (2001): Bovine medicine diseases and husbandry of cattle. Pp. 524.
3. Block, S.S. (1991): Historical review. Disinfection, sterilization, and preservation. 4th Ed. Pp. 3–17.
4. Blowey, R. and Edmondson, P. (2010): Mastitis control in dairy herds, 2nd ed. CAB international. UK. Pp. 120.
5. Charles, R.C. and Robert, E.S. Stitzel, L.W (2004): Modern pharmacology with clinical applications. 3rd Ed.
6. Charles, W., Block, J. Gisvold, O. and Beale, J. (2004): Wilson and Gisvold textbook of organic medicinal and pharmaceutical chemistry .11 Ed. Pp. 219.
7. Cynthia, M., Kahn, B.A. and Scottline, M.A. (2005): The Merck Veterinary Manual, 9th Ed. Pp. 2153-2158.
8. Danny, S., William, H. Miller, J. and Craige, G. (2001): Small animal dermatology. 6th Ed. Pp. 230-233.
9. Desmond, B. J. (2001): The physiological basis of veterinary clinical pharmacology. Black well science. 1st Ed.
10. Drosou, A., Flabella, A. and Kirsner, R.(2003): Antiseptics on Wounds: An Area of Controversy 15.
11. Fumal, I., Braham, C., Paquet, P., Pierard-Franchimont, C. and Pierard, G.E. (2002): The beneficial toxicity paradox of antimicrobials in leg ulcer healing impaired by a polymicrobial flora: A proof-of-concept study. Dermatology. Pp. 70-74.
12. Husain, A. (2008): Chemotherapy: antiseptics and Disinfectants Pp. 18.
13. Jim, E., Riviere, Mark, G. and Papich. (2013): Veterinary pharmacology and Therapeutics. Pp. 819.
14. McDonnell, G. and Rossell, A.D. (1999): Antiseptics and Disinfectants: Activity, Action Against and Resistance: *Clinical Microbiology*, 12:147-179.
15. Ngan, V. and Writer, S. (2015): Antiseptics. *Derm NetNz.*
16. Patel, A., Mubangizi, P. and Cepuch, C. (2009): Antiseptics and disinfectants: Practical Pharmacy for Developing Countries.
17. Russell, A. D. (1985): The role of plasmids in bacterial resistance to antiseptics, disinfectants and preservatives. *Journal of Hospital Infection,*6: 9–19.
18. Sibbald, R.G, Leaper, D.J, and Queen, D. (2011): Modern Iodine Preparation: Iodine made easy.
19. Swanson, T., Asimus, A., and McGuiness, B. (2014): Pharmacology in wound management. Pp. 281- 287.
20. Tan, R., Heng, D. and Dodge, J. (2009): Antiseptics and disinfectants: practical pharmacy for developing country.4th year Pharmacy students; University of Otago, Dunedin, and New Zealand.
21. Taylor, B. (1999): Principles and Practice of Disinfection, Preservation and Sterilization. In Russell AD, Hugo WB, Ayliffe GAJ 3rded. Oxford, England: Blackwell Science. Pp. 1-7.

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