Granulated sugar provides an excellent topical dressing for treating open wounds, especially those wounds that are contaminated. Advantages of using sugar include its rapid antibacterial action, enhanced tissue formation and epithelialization, and accelerated wound healing; it is also readily available and inexpensive.

The use of finely powdered sugar to clean wounds was first reported by Scultetus in 1679 but the mechanism of action was not elucidated until the twentieth century. Many recent reports show excellent results with the use of granulated (table) sugar to treat contaminated wounds.\(^1\)\(^-\)\(^9\) Granulated sugar is currently used worldwide to treat human patients with contaminated wounds or infected body cavities, but the cleansing and healing properties of granulated sugar are not widely known in veterinary medicine. For many years, surgeons at the Ontario Veterinary College (OVC), Guelph, Ontario, Canada, have used granulated sugar to treat contaminated wounds in cats and dogs. Animals with these types of wounds often have associated problems, such as pain, shock, or sepsis, and these conditions must be treated appropriately prior to or during wound management.

Sugar therapy is suitable for treating patients with degloving injuries caused by motor vehicle accidents; infected surgical wounds; necrotizing fasciitis due to Escherichia coli, Pseudomonas aeruginosa, Streptococcus canis, and other organisms; decubitus ulcers; self mutilation; burns; and other skin defects that require a healthy granulating bed to heal. No adverse effects have been reported with the use of sugar.

* A companion article entitled “Wound Management Using Honey” appears on page 53.
HEALING PROPERTIES OF SUGAR

Scientific support for treatment of wounds using granulated sugar is based on the low water content (or high osmolality) that sugar creates in a wound.\(^1\) In addition, because the high osmolality of sugar draws lymph into a wound, dissolved nutrients within the lymph provide nutrition for regenerating tissue.\(^6\) The water requirements for microorganisms (and all other forms of life) can be defined in terms of water activity (a\(_w\)) of substrate.\(^1\) Every microorganism has a limiting a\(_w\) below which it cannot grow.\(^2\) When the aqueous solution in the organism’s environment is concentrated by the addition of solutes (e.g., sucrose), the effects on microbial growth are mainly due to the change in a\(_w\). The minimum a\(_w\) for most bacterial pathogens (e.g., E. coli, Pseudomonas, Klebsiella, Corynebacterium, Clostridium perfringens, and other clostridia and streptococcal species) is 0.91 or more but is 0.86 for Staphylococcus aureus. All bacterial growth was inhibited at an a\(_w\) of 0.858 (195 g sugar/100 ml of water). When compared with a test medium of brain–heart infusion in which the a\(_w\) was 0.993 (which supported rapid bacterial growth), the medium was adjusted to an a\(_w\) of 0.858 by adding sugar, which caused complete inhibition of growth.\(^1\) This action has been produced in the clinical setting. When a wound is filled with sugar, the sugar dissolves in the tissue fluid, creating an environment of low a\(_w\), which inhibits bacterial growth. As the concentrated sugar solution causes migration of water and lymph out of the tissues and into the sugar solution, the solution becomes diluted, thereby raising the a\(_w\). Therefore, in order to retain an environment of low a\(_w\), large amounts of granulated sugar should be used on wounds. Dressings should be changed once or twice per day initially to maintain the antibacterial a\(_w\), especially when treating large wounds (see box on this page). As the infection and edema become controlled, bandage changes can be reduced to once daily or every other day.

Other mechanisms associated with the wound cleansing and healing properties of sugar (which are similar to those of honey\(^4\)) include decreased inflammatory edema, attraction of macrophages to further cleanse the wound, accelerated sloughing of devitalized tissue, provision of a local cellular energy source, and formation of a protective layer of protein on the wound and a healthy granulation bed.\(^3\) Sugar also has a deodorizing action, whereby the infecting bacteria utilize the sugar instead of the amino acids, resulting in the production of lactic acid rather than malodorous compounds.\(^10\)

USE OF A SUGAR PASTE

Human patients have reported that the wound man-

\(^{1}\)For further information, see the companion article entitled “Management of Wounds Using Honey” on page 53.

Guidelines for the Treatment of Wounds with Sugar

Case Selection
- Crush injuries
- Thermal burns with skin slough
- Extensive deep tissue infection
- Grossly contaminated wounds following mechanical debridement
- Wound bed preparation for skin grafting
- Wounds in which tissue viability is questionable

Guidelines for Use
- Lavage and debride wound or surgically excised area of concern. Frequently, in road injuries, the area is lavaged with copious amounts of body temperature tap water and not debrided. The sugar will debride the area of devitalized tissue.
- Use an excess of sugar (pour to approximately 1 cm thickness).
- Change bandage once or twice daily initially. Frequency varies with size of wound and production of exudates. Bandages should be changed if strike through occurs. (As a guide, when granulated sugar is still present in the wound, less frequent bandage changes are recommended.)
- Lavage wound at each bandage change with body temperature tap water. Sterile saline may be used as a substitute for tap water but is more expensive and has no benefit. Sterile saline delivered with a 60-ml syringe and 18-gauge needle may be used to lavage crevices that are difficult to access.
- Pat the area dry with a sterile cotton towel before reapplying the sugar.
- Monitor the patient’s hydration status and serum protein level during high fluid losses.
- Treat the wound until all pockets and undermined tissue are closed.
- When the debridement is complete, a healthy granulation bed is present, and epithelialization has begun, stop sugar therapy and switch to Furacin ointment.

agement procedure using sugar therapy is not painful, especially when compared with gauze packing (which is painful).\(^3,6\) Occasionally, some human patients complain of a burning sensation when dry sugar is placed into a cavity; therefore, a sugar paste, which is not associated with pain, can be useful for infusion into such cavities as decubitus ulcers or abscesses. The paste can be made from 400 g castor sugar, 600 g icing sugar, 480 ml glycerin BP, and 7.5 ml hydrogen peroxide 3% BP (100 vol). Hydrogen peroxide should be combined with the glycerin and stirred; the sugars should then be added and the ingredients mixed in a blender. This paste can then be “squirted” into deep cavities.\(^4\) A simi-
lar sugar paste used on wounds has been shown to reduce water available and inhibit bacterial growth; however, granulation tissue is still allowed to form and epithelialization takes place at a rate similar to that for wounds that are kept moist and covered with OpSite® plastic film (Smith & Nephew, London).

**CLINICAL STUDIES USING SUGAR THERAPY**

One study reported that packing cavity wounds (e.g., infected, malodorous decubitus ulcers) with a thick sugar paste cleared the foul odor and debrided the necrotic tissue after several days. Granulated sugar or sugar paste can be instilled into deep wounds or cavities instead of packing them with ribbon gauze and antiseptics, which delays healing and can be very painful to remove. In addition, gauze becomes enmeshed with the developing granulation tissue, which is then torn away when the dressing is removed. In human patients, it is recommended that when a healthy granulation bed has formed, the sugar paste should be replaced with an alginate, hydrogel, or hydrocolloid dressing because application of the sugar paste may cause bleeding. Bleeding has not been a problem at the OVC when using granulated sugar to treat animals. When healthy granulation tissue has formed, most wounds are surgically closed using various techniques based on wound size and location. Otherwise, epithelialization is allowed to continue until secondary healing has occurred. This may be accomplished with the application of nonadhesive bandages.

Traumatic wounds, diabetic ulcers, peritonitis, and thoracic cavity lesions have been treated using sugar. A study by Trouillet and colleagues illustrates the efficacy of using sugar to treat major wounds. Granulated sugar was used to treat 19 critically ill adult humans with open mediastinitis after cardiac surgery; 11 patients were treated immediately with sugar, and 8 patients were treated with sugar after irrigation with povidone–iodine and physiologic saline was unsuccessful. Eighteen wounds were contaminated with _Staphylococcus_, _Streptococcus_, _Enterobacter_, _E. coli_, _Klebsiella_, _Pseudomonas_, or _Serratia_. The mediastinum was packed with about 150 to 400 ml sterile granulated sugar (obtained from the supermarket); additional sugar was added every 3 to 4 hours to keep the cavity full. Dressings were changed twice daily, at which time the wounds were irrigated using physiologic saline mixed with povidone–iodine. Debridement occurred at each dressing change. Almost complete debridement of the wound and rapid formation of granulation tissue occurred in all patients after 5 to 9 days of treatment; only three patients required surgical debridement, and none developed hyperglycemia. Because sugar is a complex molecule, it cannot be directly absorbed from the wound.

In another report, sugar paste was used to heal liver abscesses and infected chest cavities without development of hyperglycemia. A case study that compared the healing properties of granulated sugar to conventional methods of chlorhexidine wound lavage and subsequent packing with gauze in postoperative wound infections was carried out on nine human patients (age range, 4 months to 32 years) and two older patients (65 and 80 years old). In this study, healthy granulation tissue formed earlier in the wounds treated with sugar and the wounds were less painful than those treated using conventional methods.

**DRESSING TECHNIQUE USING SUGAR**

When using sugar, the old adage “more is better” holds true. Various types of injuries, burns, and infected or necrotic wounds are all managed using a similar technique. Grossly contaminated wounds are lavaged initially with body temperature tap water using a kitchen-type spray nozzle over a grate to allow drainage (Figure 1). Although not all wounds require irrigation, irrigation of wounds with tap water under pressure may be a reasonable alternative to saline irrigation. Large breed dogs may require up to 50 L of...
Case 1—Dog Dragged by a Truck

A 1-year-old rottweiler fell off the back of a moving truck traveling 40 to 50 km/hour and was dragged for 2 to 3 km. The dog’s injuries included loss of all skin and some cartilage over the lateral aspect of the left ear; loss of skin and subcutaneous fat of the left thorax, abdomen, and flank from dorsal midline to ventral midline and thigh; loss of all tissue and cortical bone of the humerus and scapula; and loss of skin and subcutaneous fat over the stifle and distal extremities. An estimated 40% of total body surface area was lost. After stabilization with intravenous crystalloids, whole blood transfusion, and morphine, initial wound management included debridement of necrotic tissue and foreign material and lavage with body temperature tap water. Chlorhexidine-soaked lap sponges were placed over the wounds, which were then covered with an absorbent, nonstick cotton layer, and a tertiary conform layer. A systemic first generation cephalosporin antibiotic was administered. Because the dog was inappetent, it was anesthetized on the third day for percutaneous placement of a gastrotomy tube (A).

On the fifth day after injury, an obvious odoriferous discharge was present. *Pseudomonas aeruginosa*, *Bacillus* species, and nonhemolytic *Streptococcus* were cultured from the wound. Because *P. aeruginosa* was also cultured from the urine, treatment with enrofloxacin was started. Sugar therapy was also instituted at this time. Within 24 hours, the wound was much cleaner and *Pseudomonas odor* was diminished. At 48 hours after wound lavage, a fine, pale layer of granulation tissue and a shiny film were observed over the wound and no odor was detected. The combination of sugar and tissue fluid resulted in a yellow discharge (B). This has been described previously and is not associated with pathogenic organisms. Cultures at this time were negative for bacterial growth. Sugar therapy was continued for a total of 4 days, at which time a healthy granulation bed had formed over the torso (C). Adjustable horizontal mattress sutures were placed on the third day, and wound closure commenced by daily retightening over the buttons (D).

At the surgeon’s discretion, sugar therapy was discontinued and silver sulfadiazine topical antibacterial cream was placed on the wound. Due to the expense, this therapy was discontinued after one treatment. From this point until complete closure, the
lavage fluid to irrigate large, dirty-infected wounds. After the wound is irrigated, it should be patted almost dry with sterile towels. Resection of necrotic tissue or debridement of a traumatic or surgical wound should be performed prior to the application of sugar. When superficial contamination of wounds occurs in an otherwise healthy animal, systemic antibiotics are frequently avoided and topical treatment with sugar alone is used (systemic antibiotics were administered in Case studies 1 and 2 because the dogs were bacteremic).

Granulated sugar is poured into the wound (the layer should be at least 1 cm thick) and should fill all pockets and undermined areas (Figure 2). The wound must be filled because the osmolarity within the wound area must remain high in order for bacterial killing to occur. Sterile absorbent towels can be used as a primary bandage layer for large dogs, and sterile lap sponges can be used for cats and small dogs. A large amount of absorbent material is required to absorb the fluid. A secondary bandage layer should be added to hold the absorbent material in place. This should be covered with an adhesive tertiary layer. Because edema fluid is mobilized due to the hygroscopic nature of sugar, a plastic bag or plastic kitchen wrap can be used to further cover the bandage to prevent seepage during the first few days. For wounds that are difficult to bandage, kitchen wrap may be used until gross contamination is cleared, which usually takes a day (Figure 3). The sugar is diluted rapidly when wounds (especially large ones) are initially infected and edematous, and thus bandages should be changed and sugar replaced at least twice daily to maintain a high osmolarity. Bandage changes can be reduced to daily or alternating days as granulation tissue forms. Moderately infected wounds are usually clean in 2 to 4 days; large, severely infected wounds may require 5 days or longer. In distal limb injuries, once-daily bandage changes are adequate in most cases.

A guideline to when bandage changes are required is the presence or absence of granulated sugar in the wound. The lack of or presence of only small amounts of sugar indicates that frequent changes are needed, whereas the presence of a good covering of granular sugar indicates that change interval can be lengthened. Bandages should be changed any time strike through occurs. After removal of the covering bandage material at the appropriate bandage change interval, the wound should be gently lavaged with body temperature tap.
Case 2—Dog with Fasciitis

A 5-year-old spayed dachshund was referred to the OVC; the animal was in septic shock secondary to fasciitis of the right lateral thorax (A) that appeared following administration of subcutaneous fluids. Shock therapy was instituted, and the dog stabilized. No bacteria were visible on cytologic examination of a wound aspirate; however, numerous toxic neutrophils were present. The aspirated fluid was submitted for culture and susceptibility testing. Because streptococcal fasciitis was suspected, clindamycin was administered. The area was surgically resected, leaving a large defect covering the lateral thorax (B). Subsequently, a multiresistant *Pseudomonas aeruginosa* was cultured from the wound; imipenem–cilastin was started and clindamycin discontinued.

Sugar management of the wound began 24 hours after surgical resection (C). For 7 days the wound was managed with daily cleaning with tap water (using a shower nozzle), packed with sugar, covered with sterile towels, and bandaged. A noticeable improvement in the wound was noted on the second day, and a healthy granulation tissue bed was clearly visible on day 5 (D). On day 8, there was a healthy granulation bed and the wound was cultured and shown to be sterile. The wound was partially closed surgically on day 16 and completely closed on day 21 (E).
A 5-year-old spayed dalmatian sustained a typical degloving injury from a motor vehicle accident (A). Sugar was applied liberally to the wound (B). The bandages required daily changes until the exudate was minimal. Alternate day bandage changes were performed and application of sugar continued until granulation tissue covered all exposed bone and all "pockets" were eliminated, which took approximately 4 weeks. Granulation tissue confers stability to the joint, often negating the use of articular stabilizing techniques. The defect was surgically closed at this time.
REFERENCES


ARTICLE #3 CE TEST

The article you have read qualifies for 1.5 contact hours of Continuing Education Credit from the Auburn University College of Veterinary Medicine. Choose the best answer to each of the following questions; then mark your answers on the postage-paid envelope inserted in Compendium.

1. Which of the following statements regarding a_w of a wound is true?
   a. An increase in a_w increases the bacterial growth rate.
   b. A decrease in a_w decreases the bacterial growth rate.
   c. Water activity has no effect on bacterial growth rate.
   d. S. aureus has a much higher a_w than Pseudomonas.

2. When a wound is filled with sugar and the sugar dissolves in the tissue fluid, it
   a. has no effect on the a_w in the wound.
   b. increases the a_w of the wound.
   c. decreases the a_w of the wound.
   d. forces water and tissue fluids back into the surrounding tissues.

3. Sugar does not
   a. attract macrophages to the wound site.
   b. act as a local source of cellular energy.
   c. promote the formation of a protective protein layer on the wound.
   d. decrease the formation of granulation tissue in the wound.

4. A sugar paste is most useful in the treatment of
   a. abscess cavities.
   b. bite wounds.
   c. burns.
   d. traumatic wounds.

5. When treating wounds using sugar,
   a. a large volume of sugar should be used to ensure a high a_w level.
   b. a small volume of sugar should be used to ensure a low a_w level.
   c. systemic antibiotics should always be used due to the lack of antibacterial activity of sugar.
   d. a large amount of absorbent bandaging is required because sugar draws fluids from wounds.

6. In Case 1, a granulation bed finally closed the defect over the rottweiler’s proximal humerus at ____ days when final skin closure was performed.
   a. 12  c. 41
   b. 32  d. 51

7. Sugar therapy is suitable for treating animals with
   a. degloving injuries caused by motor vehicle accidents.
   b. infected surgical wounds.
   c. necrotizing fasciitis caused by E. coli, P. aeruginosa, S. canis, and other organisms.
   d. all of the above

8. A sugar paste can be made from combining 400 g castor sugar, 600 g icing sugar, 480 ml glycerin BP, and 7.5 ml hydrogen peroxide (___%).
   a. 0.3  c. 30
   b. 3  d. 300

9. In human patients, it is recommended that when a healthy granulation bed has formed, the sugar paste should be replaced with ___________ dressing.
   a. an alginate
   b. a hydrogel
   c. a hydrocolloid
   d. all of the above

10. Large breed dogs may require up to _____ L of lavage fluid to irrigate large, dirty-infected wounds.
    a. 20  c. 40
    b. 30  d. 50