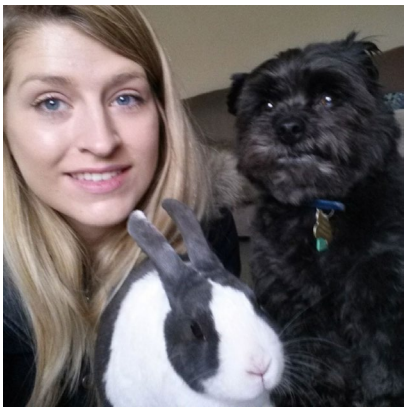

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# Optimal pressures and irrigation techniques used in small-animal wound management

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ABSTRACT: Wound management is a vital aspect of veterinary nursing. This article reflects on common wound management techniques and when they should be applied in practice. Owners are the first to identify when their pet has a wound so when they bring them into the practice for treatment is crucial; wound management should occur in the first 6 hours post-injury to encourage optimal healing. This article will discuss cleansing techniques, as well as ideal irrigating pressures and the appropriate solutions to be used when presented with a wound.

## Introduction

Many studies have sought to determine optimal wound management. In the reviewed literature, three topics of wound management are discussed frequently. This literature review will focus upon these three topics, which are: wound cleansing techniques, optimal pressures, and appropriate irrigating solutions. Although the literature conveys these topics in a range of contexts, this review will focus on their application to successful wound healing.

## Wound healing

It is important for veterinary nurses (VNs) to understand the wound healing-process to successfully manage wounds and take the correct course of action. Wound healing has three main stages. The inflammatory phase is the formation of a blood clot immediately after an injury occurs, which is activated by the presence of platelets and fibrin (Chivers, 2010). The release of growth factor triggers the cell proliferation phase, and fibroblasts produce a new medium where endothelial cells can transfer across, creating new capillaries, and epithelialisation occurs, the result of which is the formation of granulation tissue (Hosgood, 2006). Finally, in the remodelling phase, a layer of collagen is formed and a scar can be seen. Over time, this scar will remodel and strengthen (Chivers, 2010). Recognising these phases will help VNs to determine abnormalities if they occur.

Wound complications can arise through any phase of the healing process, so VNs should be familiar with the risk factors of wound complications. Khalil, Cullen, Chambers, Carroll and Walker (2015) acknowledged the following factors affecting wound healing in humans and animals alike: the presence of comorbidities, age, malnutrition and certain medications. Canines have been reported as being more vulnerable to wound complications than felines (Elliston, Heayns, & Fish, 2012). However, this statement is limited in that the study was undertaken on ovariohysterectomy procedures, which typically take longer in bitches than queens and duration is a high-risk factor for post-surgical site infections. Wound healing in patients that fall into the categories discussed should be monitored closely for complications.

Client compliance is a crucial factor that ultimately affects wound healing. By providing clients with literature explaining the choice of dressing and the healing process, the client can become more educated and have a better understanding of the importance of wound management (Calder, 2012). Alternatively, forming a plan with the client will help them feel more involved and encourage them to comply to reach the common goal (Wiggins, 2016). In effect, this will also provide good client and patient care

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**Figure 1.** The bulb syringe, a recognised irrigation technique

and build a relationship between VN and client (Calder, 2012). Decisions should be made between the veterinary surgeon and VN to provide the best wound management for individuals, these decisions should be made based on evidence and both patient and client circumstances (Brölmann et al., 2012). By effective communication and follow-ups, VNs can maintain and encourage client compliance.


**Figure 2.** Sterile saline, a popular irrigation solution

## Cleansing techniques

Irrigation assists in the removal of foreign material and bacteria and should be performed as soon as possible (Aldridge, 2013). The initial six hours following injury is known as the "golden period"; if irrigation is not carried out in this period, the risks of infection are considerably more (Hussey & Bagg, 2011). Wounds retaining more than $10^5$ bacteria per gram of tissue will become infected (Moscati, Mayrose, Reardon, Janicke, & Jehle, 2007). In one investigation, the study group had wounds irrigated and in 9 days the wounds were healed; meanwhile, the control group had wounds swabbed and these healed in 12 days (Mak et al., 2015). Furthermore, the investigation revealed that the study group experienced less pain than did the control group, who had swabs taken during wound cleansing, in addition to reduced healing time (Mak et al., 2015). Applicants were chosen at a general outpatient clinic where patients' wounds were presented and advised to heal by secondary intention, and then the study started for the individual (Mak et al., 2015). It is clear that irrigation is capable of reducing healing times, and is additionally less painful than other therapies.

It is important to exert optimal pressure onto wounds to gain maximum benefit with few contraindications. Moscati, Mayrose, Fincher and Jehle (1998) found that pressures of seven pounds per square inch (psi) or less were inadequate in wound cleansing due to the adhesiveness of contaminants on tissue; higher pressures were considered more suitable and effective. More recently, Gall and Monnet (2010) found pressures of 8 psi or more were damaging to surrounding tissue. High-pressure irrigation can spread fluid into surrounding tissues, exposing risks of oedema and leaving the wound more susceptible to infection, so its use should be limited to heavily contaminated wounds where the contraindications are outweighed by the need to remove the more adhesive bacteria (Edlich et al., 2008). A suitable pressure for clean wounds is 0.5 psi; the bulb syringe exerts pressures of 0.5 psi only, making this an appropriate technique to use (Atiyeh, Dibo, & Hayek, 2009). Different irrigation techniques are capable of different pressures, so it is important to be aware of the advantages and disadvantages of alternative practices.

Open wounds should be treated to ensure a healthy and ideal environment that will encourage successful healing. A study was performed where goats had *Pseudomonas aeruginosa* injected into wounds.

**Table 1.** A comparison of irrigation techniques.

| Technique | Benefits | Disadvantages |
|---|---|---|
| Bulb syringe | • Ideal for clean wounds due to its 0.5 psi (Atiyeh et al., 2009)<br>• Little or no risk of damage to surrounding tissues Gall & Monnet (2010) | • Not ideal for contaminated wounds (Brown et al., 1978) |
| Pulsatile jet lavage | • Has been recognised to reduce bacterial counts (Brown et al., 1978) | • Risk of damage to surrounding bone structure and soft tissue, and delaying wound healing due to its high pressures (Crowley, Kanakaris, & Giannoudis, 2007)<br>• Exerts pressures of around 50 psi (Brown et al., 1978) |
| 19-gauge needle and 20-ml syringe | • Exerts pressures of 8 psi which is considered strong enough to dislodge adhesive contaminants (Aldridge, 2013)<br>• Pressure is significantly less likely to cause wound trauma (Aldridge, 2013) | |

Irrigation methods were then employed (Owens,White, & Wenke, 2009). The study concluded that the bulb syringe technique removed significantly more bacteria than did pulsatile lavage systems (Owens et al., 2009). However, there exists a disagreement between Owens et al. (2009) and Brown, Shelton, Bornside and Cohn (1978). Pulsatile jet lavage eliminated more *Escherichia coli* than did the bulb syringe in the study of Brown et al. (1978). While this is true, these wounds were heavily contaminated which, as discussed earlier, require higher pressures of irrigation which the bulb syringe cannot perform. Furthermore, in this study, the pulsatile lavage technique exerted pressures of 50 psi (Brown et al., 1978). This investigation proves the need for different pressures on individual wounds; however, it must be remembered that the study by Brown et al. (1978) is significantly older than that of Owens et al. (2009).

A syringe with a needle attached is a commonly recognised technique. An 18-gauge needle attached to a 20-ml syringe releases pressures of 7 psi onto the wound, so it is considered a low-pressure technique (Atiyeh et al., 2009). On the other hand, a 19-gauge needle attached to a 20- or 35-ml syringe will exert pressures of 8 psi, making it a high-pressure technique (Quinn & Macias, 2006). Needles and syringes are readily available in practice, making them the technique of choice most of the time (Aldridge, 2013). Some practices have combined the use of a 3-way tap and a giving set attached to a bag of saline to reduce the time taken during irrigation; this also enables better control over the exertion pressure (Aldridge, 2013). High pressures should be limited to a maximum of 15 psi to avoid tissue trauma, or used with caution (Aldridge, 2013). In summary of the previous points, based on the degree of wound contamination, the most suitable wound irrigation technique should be employed, with heavily contaminated wounds needing higher pressures between 8 and 15 psi to remove adhesive bacteria, and less contaminated wounds requiring pressures of 7 psi or below (see **Table 1**).

## Irrigation solutions

Wound irrigation solutions should be non-irritant to tissues and reduce bacterial counts with no adverse reactions (Atiyeh et al., 2009). Antiseptic solutions are likely to cause tissue damage and impair wound healing (Moscati et al., 2007). They can destroy bacteria, and research has shown they are also detrimental to many of the host's cells including erythrocytes, leukocytes and osteocytes (Anglen, 2001). Evidently, their use in irrigation is counteractive due to these effects on tissues. A study discussed earlier, carried out by Owens et al. (2009), found that castile soap solution was most effective initially with reduced bacteria levels, although saline solution proved longer-lasting as bacterial regrowth was significantly less when compared to the other solutions in 48 hours. Surfactants such as castile soap function by reducing surface tensions and inhibit bacterial adhesion, allowing easier removal (Anglen, 2001). Like antiseptics, castile soap solutions have been found to damage the host's cells; therefore, their use should be restricted to highly contaminated wounds and followed by saline irrigation (Anglen, 2001). VNs should be aware of the risks of using these solutions, and their use should be justified (see **Table 2**).

Alternative solutions have been studied against more traditional solutions in irrigating wounds to find the most beneficial. Tap water was used to irrigate in-vitro canine fibroblasts; however, distinct degenerative changes occurred, causing disturbances to the cells (Buffa, Lubbe, Verstraete, & Swain, 1997). Ringer's lactate solution, on the other hand, proved physiologically suitable because of its neutral pH and osmotic nature, making it like plasma (Buffa et al., 1997). It must be remembered that this investigation was carried out *in vitro* and normal healing physiology would make the results potentially less valid. Sterile saline has been the preferential solution for two reasons: it does not disturb normal wound healing physiology and it is an isotonic solution and therefore does not disturb osmotic balance among the tissues (Atiyeh et al., 2009). In a study, tap water was more cost-effective and efficacious in irrigating

**Table 2.** A comparison of common irrigation solutions used in practice.

| Solution | Benefits | Disadvantages |
|---|---|---|
| Antiseptic solutions | • Capable of destroying bacteria (Anglen, 2001) | • Research suggests they are detrimental to the host's cells such as erythrocytes (Anglen, 2001) |
| Castile soap | • Owens et al.'s (2009) study found they could reduce initial bacterial counts | • The study also concluded that bacterial regrowth was significantly higher than with saline over 48 hours (Owens et al., 2009)<br>• Its use has been found to damage the hosts cells (Anglen, 2001) |
| Tap water | • It is cheap and efficacious (Moscati et al., 2007) | • A study concluded that degenerative changes occurred to the cells after irrigation (Buffa et al., 1997) |
| Sterile saline | • Does not disturb normal physiology (Atiyeh et al., 2009)<br>• An isotonic solution so does not disturb the tissues osmotic balance (Atiyeh et al., 2009) | |

wounds (Moscati et al., 2007). However, this study focused on infection rates and did not look at the pathological state of the tissues after using tap water. Its hypotonic nature was briefly linked to potential cell lysis, although this was not discussed further. In summary, tap water is a reasonable choice for quick and effective initial wound care in the emergency department, but its use should not replace saline in normal circumstances (Moscati et al., 2007).

## Ethical considerations

The research undertaken has made it clear that there are ethical implications to be considered. When carrying out investigations in the UK, the researcher must obtain a project licence granted by the Secretary of State. When carrying out investigations in the United Kingdom, the researcher must obtain a project license granted by the Secretary of State, when applying for the license they must specify the programme of work and the location and participants involved in the study (Animals (Scientific Procedures) Act, s.5, p.a, 1986a). The location must be a certified scientific procedure establishment (ASPA, s.6, part b, 1986b); for instance, Owens et al. (2009) carried out their investigation in an 'Association for Assessment and Accreditation of Laboratory Animal Care-accredited' laboratory, a non-profit organisation where the use of animals is acceptable when there are no alternatives for the advancement of research (AAALAC International, 2016).

## Recommendations for future practice

Research has shown that the bulb syringe is the least perilous method with normal saline solution in reducing bacterial counts, maintaining healthy tissues and encouraging successful healing. Hussey and Bagg (2011) and Gall and Monnet (2010) all agree that the risks of using high pressures will potentially force bacteria deeper into the tissues, resulting in recolonisation later on. While high-pressure irrigation evidently has its advantages in lowering bacterial counts, low pressures of 0.5 psi are more suitable on clean wounds (Atiyeh et al., 2009). It is worth noting that pressurised irrigation is more cost-effective than other techniques because of the shortened healing time associated with it (Mak et al., 2015). While tap water has been shown to be efficacious, its use should be limited to emergencies only where saline is not readily available.

## Conclusion

A number of studies have investigated the effects and outcomes of different strategies in wound irrigation. From the research undertaken the use of sterile saline is by far the most efficacious and reliable. Although tap water has similarities, its cellular effects are still not fully explored; however, it would be a justifiable choice in an emergency situation. It is clear from the above that no single optimal pressure, solution or technique is appropriate for all wounds. High pressures have often been used, but their effects pose risks in the spread of bacteria deep within the wound site instead of eliminating the bacteria altogether, so higher pressures up to 15 psi should be restricted to heavily contaminated wounds.

Furthermore, wound irrigation has been reviewed widely in the human field, but to a lesser extent in the veterinary field. While some literature from the veterinary field was analysed for this review, most of it was based upon research undertaken in human medicine, and this leaves a gap in this field of research. Investigations could be performed to determine protocols among practices in the UK to identify those that differentiate between pressures and deliberate over the appropriate techniques to be employed on presenting wounds. This could be carried out by contacting practices directly and compiling data to indicate what strategies are commonly being operated. Studies would be extremely interesting academically and clinically, particularly if they were to result in better wound management in small animals.

#### References


AAALAC International. (2016). *About AAALAC*. Retrieved 2016, 26 January from www.aaalac.org/accreditation/faq_landing.cfm#A1

Aldridge, P. (2013). How to carry out initial treatment of traumatic wounds: Assessment, preparation and lavage. *The Veterinary Nurse, 3*, 169–173. doi:10.12968/vetn.2013.4.3.168

Anglen, J. O. (2001). Wound irrigation in musculoskeletal injury. Journal of the American Academy of Orthopaedic Surgeons, *4*, 219–226. Retrieved from http://journals.lww.com/jaaos/Abstract/2001/07000/Wound_Irrigation_in_Musculoskeletal_Injury.1.aspx

Animals (Scientific Procedures) Act, No. 14/1986, s. 5. (1986a).

Animals (Scientific Procedures) Act, No. 14/1986, s. 6. (1986b).

Atiyeh, B. S., Dibo, S. A., & Hayek, S. N. (2009). Wound cleansing, topical antiseptics and wound healing. *International Wound Journal, 6*, 420–430. doi:10.1111/j.1742-481X.2009.00639.x

Brölmann, F. E., Ubbink, D. T., Nelson, E. A., Munte, K., Van der Horst, C. M. A. M., & Vermeulen, H. (2012). Evidence-based decisions for local and systemic wound care. *British Journal of Surgery, 99*, 1172–1183. doi:10.1002/bjs.8810

Brown, L. L., Shelton, H. T., Bornside, G. H., & Cohn, I. (1978). Evaluation of wound irrigation by pulsatile jet and conventional methods. *Annals of Surgery, 2*, 170–173. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1396479/

Buffa, E. A., Lubbe, A. M., Verstraete, F. J. M., & Swain, S. F. (1997). The effects of wound lavage solutions on canine fibroblasts: An in vitro study. *Veterinary Surgery, 6*, 460–466. doi:10.1111/j.1532-950X.1997.tb00517.x

Calder, C. (2012). Approaches to wound management – part 1. *Veterinary Nursing Journal, 8*, 303–306. Retrieved from www.tandfonline.com/doi/abs/10.1111/j.2045-0648.2012.00200.x

Chivers, E. (2010). Wound healing and management of open wounds. *The Veterinary Nurse, 2*, 107–114. http://dx.doi.org/10.12968/vetn.2010.1.2.106

Crowley, D. J., Kanakaris, N. K., and Giannoudis, P.V. (2007). Irrigation of the wounds in open fractures, *The Bone and Joint Journal*, 5, 580-585. Retrieved from http://www.bjj.boneandjoint.org.uk/content/89-B/5/580?related-urls=yes&legid=jbjsbr;89-B/5/580&cited-by=yes&legid=jbjsbr;89-B/5/580

Edlich, R. F., Rodeheaver, G. T., Thacker, J. G., Lin, K. Y., Drake, D. B., Mason, S. S., … Vissers, R. J. (2008). Revolutionary advances in the management of traumatic wounds in the emergency department during the last 40 years: Part II. *The Journal of Emergency Medicine, 2*, 201–207. doi:10.1016/j.jemermed.2008.09.029

Elliston, R., Heayns, B., & Fish, C. (2012). A clinical audit to identify factors contributing to surgical wound healing complication. *The Veterinary Nurse, 3*, 190–195. doi:10.12968/vetn.2012.3.3.188

Gall, T. T., & Monnet, E. (2010). Evaluation of fluid pressures of common wound-flushing techniques. *American Journal of Veterinary Research, 11*, 1384–1386. doi:10.2460/ajvr.71.11.1384

Hosgood, G. (2006). Stages of wound healing and their clinical relevance. *Veterinary clinics of North America: Small Animal Practice, 4*, 667–685. doi:10.1016/j.cvsm.2006.02.006

Hussey, M., & Bagg, M. (2011). Principles of wound closure. *Operative Techniques in Sports Medicine, 4*, 206–211. Retrieved from http://www.sciencedirect.com/science/article/pii/S1060187211001092

Khalil, H., Cullen, M., Chambers, H., Carroll, M., & Walker, J. (2015). Elements affecting wound healing time: An evidence based analysis. *Wound Repair and Regeneration, 4*, 550–556. doi:10.1111/wrr.12307

Mak, S. S., Lee, M.-Y., Cheung, J. S., Choi, K., Chung, T., Wong, T., … Lee, T. (2015). Pressurised irrigation versus swabbing method in cleansing wounds healed by secondary intention: A randomised controlled trial with cost-effectiveness analysis. *International Journal of Nursing Studies, 1*, 88–101. Retrieved from www.sciencedirect.com/science/article/pii/S0020748914002089

Moscati, R., Mayrose, J., Fincher, L., & Jehle, D. (1998). Comparison of normal saline with tap water for wound irrigation. *The American Journal of Emergency Medicine, 4*, 379–381. Retrieved from www.sciencedirect.com/science/article/pii/S0735675798901334

Moscati, R. M., Mayrose, J., Reardon, R. F., Janicke, D. M., & Jehle, D. V. (2007). A multicentre comparison of tap water versus sterile saline for wound irrigation. *Academic Emergency Medicine, 5*, 404–409. doi:10.1111/j.1553-2712.2007.tb01798.x

Owens, B. D., White, D. W., & Wenke, J. C. (2009). Comparison of irrigation solutions and devices in a contaminated musculoskeletal wound survival model. *The Journal of Bone and Joint Surgery, 1*, 92–98. Retrieved from http://jbjs.org/content/91/1/92

Quinn, R. H., & Macias, D. J. (2006). The management of open fractures. *Wilderness and Environmental Medicine, 1*, 41–48. doi: 10.1580/PR09-05.1

Wiggins, H. (2016). How to run a successful nurse clinic. *The Veterinary Nurse, 5*, 286–290. http://dx.doi.org/10.12968/vetn.2016.7.5.286