

# Wounds and Their Treatment

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**W**OUNDS occur so frequently in animals that their proper treatment is one of the most important subjects in veterinary surgery. A wound is a break in the continuity of tissue in any part of the body and is usually produced by an external instrument. When a wound is made by a sharp instrument the edges are smooth and there is little damage to the tissue. If the wound is made by a blunt instrument, the skin may or may not be broken. The trauma of the tissues produces a bruising of the tissue with rupture of the capillaries, small arteries, veins and lymphatics. The escape of blood and lymph into the tissues produces a swelling that varies with the size of the tissue and degree of traumatism.

Lacerated wounds are jagged, irregular wounds resulting from the tearing of tissues. These wounds are frequently produced by barbed wire and may be very extensive. Avulsions are those wounds in which there is actual loss or tearing away of tissue. The amount of pain is usually less than might be expected from the severity of the injury. Penetrating wounds are those in which the external opening is small, but the depth is great. These wounds are especially dangerous because of the possibility of damage to underlying structures and because they afford favorable conditions for the development of certain anaerobic infections.

Favorable healing of wounds depends to a great extent upon early treatment according to the principles of wound physiology. The result of any wound is an immediate inflammatory reaction and the

various stages in the process of inflammation are fundamentally the same regardless of the cause.

The extent and location of the wound, the structures affected, the resistance of the tissues and the virulence of the infecting organisms are all variable factors to be considered by the surgeon in the treatment. If wound healing is to progress in a normal manner it must be free of dead or devitalized tissue, debris and foreign bodies. When any of these substances are present in a wound they retard the healing of the tissues. The dead or devitalized tissues provide excellent food for the growth of bacteria and divert the energies of the living cells from that of repair to elimination of foreign bodies. If sutures are tied too tightly they will have the effect of strangulating the blood supply. When the blood supply to tissues is seriously reduced or destroyed, healing is delayed.

## Wound Repair

In the repair of wounds, the living cells promote the repair by their activity and growth and the role of the different cells varies only to meet the demands of the wounds. When healing of the wound is complete, the growth of new tissue from the cells stops. Every wound may be properly regarded as a new growth, and our every effort should be directed toward promoting its growth. We know that when healing is complete the process will be terminated. With these principles in mind, one can evaluate the progress of the wound and the treatment may be changed to meet the ever changing demands of a wound or to meet those of

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different kinds of wounds.

The science of surgery is primarily dependent upon the ability of the various tissues to repair any injury either intentional or accidental. Knowledge of the processes of repair and the extent to which restoration of normal structure may be expected is essential to the surgeon. Usu-



**Fig. 1. Wound in which there has been extensive destruction of tissue.**

ally the more highly specialized tissue repairs injuries by the formation of fibrous tissue, while the less specialized tissue may rebuild itself with tissue identical with the normal structures.

Epithelium regenerates very readily. In the skin and mucous membrane there is

rapid repair and often complete restoration of the typical cellular arrangement.

Fibrous connective tissue has great ability to regenerate and is the main tissue which repairs defects.

Muscle tissue does not regenerate or take part in the process of repair. Defects are obliterated by fibrous connective tissue, and if careful approximation of the edges is secured, the resulting scar is as strong as the original tissue. In suturing muscle, the fascia surrounding the muscle should be approximated securely.

All necrotic or severely damaged muscle in a wound should be removed, because it will not be regenerated and its presence will only retard healing. The smaller the amount of scar tissue that is formed, the less interference there will be with function.

Tendon regeneration begins as early as the second day with outgrowth of fibrous tissues from the peritendineum. After division or rupture of a tendon, exudate and blood fill the space between the ends. A moderately rapid growth of granulation tissue replaces the exudate, and soon fibroplastic proliferation into the granulation tissue occurs. In a short time the tissue becomes avascular and takes on the characteristic tendinous form.

Bone heals by a special process due to its structure. When the fracture occurs there is laceration of the periosteum and trauma of the surrounding soft parts. A large clot is formed in the defect, and this becomes organized and is replaced by granulation tissue. After 6 to 10 days the granulation tissue undergoes a change to callus which is characterized by areas of cartilage, calcification and ossification. The new bone formation usually begins beneath the periosteum at the ends of the fracture and progresses down through the callus, which is later absorbed.

Cartilage regenerates slowly; apparently from the perichondrium. A callus-like tissue is formed, and this is gradually replaced by cartilage. In some cases a fibrous tissue union may occur.

Nerve cells which have been destroyed are not replaced, but the processes may regenerate if the cell remains alive. When a peripheral nerve is divided, the axon

will grow in a peripheral direction and function will be restored. As in other specialized tissue, however, the connective tissue grows more rapidly than the specialized, and consequently may surround the axon and check the further growth.

Blood vessels usually respond to injury by thrombosis extending back to the nearest proximal branch and the development of collateral channels to maintain the circulation.

The development of granulation tissue is essential in the healing of wounds. A wound may heal by first, second or third intentions, depending upon the amount of granulation tissue that is formed.

Healing by first intention is primary healing of a wound which occurs in the absence of such retarding influences as infection, foreign objects or poor apposition of tissues. Primary healing occurs in a wound that is aseptic, where there is little tissue injury and is free of infection.

Healing by second intention occurs when there is poor approximation of tissue, infection is present or foreign bodies or both. There is an excessive amount of granulation tissue laid down until the causative factors are removed. Infection in most cases is the principal cause of excessive granulation tissue and the retardation of healing. The large amount of granulation tissue may result in a large scar, in deformity and in certain locations, impairment of function.

Healing by third intention occurs when there is a larger amount of granulation tissue formed due to location, movement of tissues and other factors previously mentioned. A larger scar and more deformity occurs due to the larger amount of granulation tissue developed. Any mechanical restriction to the arterial blood such as tight bandages, excessive pressure from splints or excessive suture tension may produce some of the mechanical causes that are responsible for non-healing.

The lack of certain vitamins, particularly vitamin C, may retard wound healing. It has also been suggested that deficiencies of vitamins A and D might be an important inhibiting factor to the rate of

repair of wounds. The use of cod liver oil applied on the wound has been suggested as a good therapeutic procedure. However, if there is a deficiency of vitamins A and D, in the light of our present knowledge, the best results would be obtained by administering these vitamins systemically rather than locally. If the wound is to heal in a normal manner



**Fig. 2.** By the use of bandages the edges of the skin healed together.

there must be an adequate amount of protein available. If there is a protein deficiency it will retard fibroplastic proliferation.

With the introduction of the sulfonamides there has been widespread local use of these antiseptics on the wound. If the sulfonamides are administered systemically they do not interfere with wound healing. When large amounts of the sulfonamides are used locally they do interfere with wound healing. This is due to the dead spaces created and the cakes or

concretions that are formed if the less soluble sulfonamides are used. If used in amounts of 0.1 Gm. per square inch of wound surface, Zintel found that sulfanilamide did not interfere with normal wound healing.

In some wounds the destruction of tissue has been so extensive that it will be necessary to assist the tissues in the healing process. The extensive destruction of tissue in Fig. 1 occurred when the mare ran through a barbed wire fence. It was necessary to use pressure bandages to bring the edges of the skin together. By this means excellent healing was obtained in this very extensive wound as shown in Fig. 2. Due to the destruction of the normal muscle tissue and replacement by fibrous connective tissue there was interference with the normal extension of the limb.

When the wound does not receive assistance in the healing process the edges of the skin may not heal together. In Fig. 3, this wound was not bandaged and the area between the edges of the skin filled in with fibrous connective tissue.

There is practically no tendency for wounds above the knee and hock to develop exuberant granulation tissue. When the wound is exposed to sunlight and air it will heal more rapidly than when it is bandaged. The antiseptics used on wounds should not be so strong as to destroy the newly forming cells or fibrous connective tissue will develop in the wound.

The wounds below the knee and hock have a tendency to develop exuberant granulation tissue. This may be prevented by keeping the tissue healthy by using mild, efficient antiseptics. Using bandages to keep pressure on the wound prevents the development of exuberant granulation tissue.

Some wounds may occur where important structures are divided, such as tendons, and there is interference with normal functioning. In Fig. 4, the long digital extensor has been divided and there is difficulty in extending the digit. However, these cases do not require any special treatment as the patient is able in a few days to extend the digit in a normal manner.

Only in recent years have chemotherapeutic drugs become available that can be used systemically and be effective against bacterial parasites. For such a drug to be effective it must retain its activity in the body while it is being transported by the circulation to the site of infection and there provide a direct attack on the causative bacteria. To prevent



**Fig. 3. Bandages were not used and the edges of the skin did not heal together.**

confusion in terminology the word antiseptic should be used for those agents that may be applied to sterilize the skin or for topical application on open wounds.

The sulfonamide group of drugs has been found to have definite bacterial chemotherapeutic action. A more or less constant search for a dye that was effective against pathogenic organisms, but would not injure the tissues, resulted in

the discovery of prontosil. It was soon discovered the effectiveness of prontosil was due to the sulfanilamide in the molecule. The sulfanilamide split off from the dye as a result of the action on enzymes in the body fluids and was then carried in the circulation in free and active form. It was Colebrook who observed that after treatment with sulfanilamide the blood of the patient became rapidly endowed with the capacity of killing many times the number of hemolytic streptococci that would be killed by the blood of a normal subject or of the blood of an infected patient prior to receiving the drug. He believed the important action of the sulfanilamide was to interfere with the ability of hemolytic streptococci to multiply in the body.

A number of American workers observed that the use of sulfanilamide in the body was limited in proportion to the amount of breakdown of tissue. The necrosis and suppuration in the infected area resulted in the liberation of substances which were specifically antagonistic to sulfanilamide. The foregoing principles have continued to apply to the field of sulfonamide therapy even with the development of many new drugs that exert a range of activity greater than sulfanilamide.

The sulfonamides are limited in their usefulness in surgical infections in several important ways. In most of the surgical infections a suppurating focus of infection develops in the soft tissue or bone at some stage of the process. When sulfanilamide is administered at a sufficiently early stage of the infection before tissue breakdown has occurred from bacterial enzymes and interference with blood supply, the progress of the infection may be checked. But when breakdown of tissue has occurred, the effectiveness of the drugs on the bacteria in the focus is destroyed and it is then necessary to resort to surgery in eradicating the lesion.

Another limiting factor of the sulfonamides in the treatment of infections is the low degree of activity of sulfathiazole and sulfadiazine on *Staphylococcus aureus*. Many of the infections of a surgical nature in both operative and accidental wounds

are due to this infection. While the administration of these drugs has aided in the localization of these infections and reduced the fatalities, in many cases the usefulness of the sulfonamides in these lesions falls short of what might be hoped for from the ideal chemotherapeutic agent.

The development and use of penicillin has provided an effective means of treating infections due to staphylococci. Unlike the sulfonamides, penicillin is not inhibited by the products of tissue break-



Fig. 4. Attitude of the limb with division of the long digital extensor.

down and is extremely active against staphylococci when it comes in contact with them.

Penicillin is utilized more efficiently when administered parenterally than when given by mouth. When penicillin is injected intramuscularly or intravenously, it is transported rapidly throughout the circulating body fluids and lymph. However, it does not appear in significant concentration in the saliva, tears, sweat or spinal fluid. The excretion of penicillin

occurs very rapidly through the kidneys and bile, so that a dose administered intravenously has been eliminated in 2 or 3 hours.

If penicillin is to be effective in severe infections, it must be administered intramuscularly at intervals not exceeding 3 hours in length. If the drug is not given in sufficient quantity to maintain an adequate blood level concentration the infecting organism may become penicillin resistant. Penicillin does not appear in the spinal fluid in any significant concentration, therefore it is logical to employ intrathecal injections for meningitis and other related conditions.

The use of penicillin on wounds is not very practical because of the inability to retain it for any period of time when used in aqueous solution or powdered form.

The most important characteristic of penicillin is its freedom from any toxic action in the body. Due to the excellent results obtained by using the sulfonamides and penicillin modern chemotherapy has been developed around the utilization of these 2 types of agents. Both of these agents possess the characteristics of having sufficiently low toxicity to the tissues and activity against surgical infections when they are present in the circulating blood and tissue fluids. In this way they differ from most chemical agents which include the so-called antiseptics which are toxic to bacteria. Therefore, when thinking of these drugs it is very important to remember this fundamental distinction.

#### References

- Lockwood, J. S.: Observations on Mode of Action of Sulfanilamide and Its Application to Surgical Infections. *Ann. Surg.* 108, (1938):801.
- Keefer, C. S., et al.: Penicillin in Treatment of Infections; Report of 500 cases; Statement by Committee on Chemotherapeutic and Other Agents. Division of Medical Science, National Research Council. *A. A. M. A.* 122, (1943): 127.
- Lockwood, J. S.: Sulfanilamide and Its Derivatives in Surgical Infections: Review: Mode of Chemotherapeutic Action of the Sulfonamides. *Surgery* 10, (1941):493.
- Hawkins, F.: Local Concentration of Sulfonamide Compounds Inserted into Wounds. *Lancet* 1, (1941):786.

## Clip Sheet Published

Recently, the AVMA Executive Board approved the publication of a news clip sheet for circulation to rural newspapers. The objective is to disseminate news that reflects the progress of veterinary medicine, thereby enhancing public confidence in the abilities of the practicing veterinarian and attracting wider interest in the activities of the profession as a whole. The material is carefully selected with a view to making it of timely and practical value to livestock growers and pet owners.

The title of the clip sheet is "A.V.M.A. Animal Health Topics" and the first issue was mailed to over 4,500 newspapers in rural areas. By expanding its public relations program to reach the readers of country newspapers, the AVMA is now able to inform all sectors of the public throughout the nation of the developments in veterinary science.

The Association's public relations program, as now carried out, comprises radio broadcasts, releases to all major news services and extension editors, articles in magazines, an information and consultant service for writers and publishers, rural newspaper coverage, and an AVMA-planned sub-program for use by state veterinary associations in publicizing their activities. It is beyond question the most extensive program ever carried on along this line in AVMA history, and its effectiveness is evident in the rapidly increasing interest news editors are showing in veterinary subjects.

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Heart failure can result when cattle are deprived of vitamin E, but this deficiency seems to have no effect upon the fertility of the animals. If this vitamin is constantly absent from the ration, the heart becomes progressively weaker and death occurs suddenly.

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**The annual meeting of the American Animal Hospital Association will be held in Tulsa, Okla., April 22, 23, and 24, 1947.**