

An Experimental Evaluation of Methods Used to Prevent Infection in Wounds which Have Been Contaminated with Feces *

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THE CLINICAL evaluation of various agents used to prevent infection in wounds and promote wound healing is constantly being carried out by practitioners of medicine and surgery. As a result of such experience, usually limited to a statistically insignificant number of cases and without adequate controls, there is often great enthusiasm for this or that medication or procedure. We have all seen wounds, which seem to be responding unsatisfactorily, suddenly overnight show marked improvement. This may follow the use of a specific drug or may occur without any form of therapy. Realizing that results in animals may not always be transposed to interpret similar situations in the human, we believe that much may be learned in such controlled experiments, which are impossible to reproduce in clinical experience.

Obviously the best method of avoiding wound infection from colon organisms at the time of bowel surgery is to prevent contamination of the wound. This is of prime importance whether the bowel has been prepared with intestinal antibiotics or not; however, in many traumatic injuries contamination will have already occurred.

We have reported previous experiments that have led us to the following impres-

sions concerning wounds contaminated with feces:⁹

1. Irrigations of wounds significantly reduced the incidence of wound infection.
2. Where saline was used, increasing the volume of the irrigating solution decreased the incidence of infection.
3. Out of a number of agents used, 1% neomycin solution was the most effective irrigating agent in preventing wound infection.
4. We could demonstrate no significant difference in the effect of tight or loose wound closure.

The following experiments were devised to further study the prevention of wound infection after contamination of wounds by feces.

Experimental Methods

Guinea pigs were used as the experimental animal. Under local or ether anesthesia an incision approximately 2 cm. in length was made through the muscle fascia over the shoulder and hips. The area had been previously shaved and prepared with Phisohex®. The wounds were contaminated with a direct smear of fresh human fecal material and closed with one black silk suture after treatment. Other wounds were contaminated and closed without treatment as controls. The presence of pus in the wound at 72 hours after contamination was used in this study as the indication of in-

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TABLE 1. *Comparison of Effectiveness in Preventing Infection by Irrigation of Fecal-Contaminated Wounds with 100 cc. Normal Saline One Hour and Four Hours after Contamination, and Four Hours after Contamination with Freshening of the Wound with Gauze*

Saline Irrigations after Contamination	Number Incisions	Number Infected	Number Uninfected	Per Cent Infected
One hour	45	23	22	51.1
Four hours	30	22	8	73.3
Four hours with freshening of wound	30	14	16	46.6
Control (no treatment)	76	63	13	82.9

fection. All data was subjected to the "proportional t test" for statistical significance.

Time Delay and Freshening of Wound: To determine the importance of a four-hour delay before treatment on the incidence of infection, and to determine if freshening the wound after such a delay before irrigation would decrease this incidence, the following procedure was carried out. Four hours after contamination one-half the wounds were scrubbed with gauze sponges, following which all wounds were irrigated with either 100 cc. normal saline or 20 per cent Sulfamylon®. Other wounds were irrigated one hour after contamination.

Comparison of Soaps: PhisoHex®, Dial®, and tincture of green soap were compared. In one group the soap solution was instilled into the wound, followed by closure after 60 seconds. In another group the wounds were scrubbed for 60 seconds with four small gauze sponges, followed by closure.

Buried Sutures: To determine if buried chromic catgut sutures increased the incidence of infection, wounds were made

and contaminated in the usual manner. In approximately one hour the incisions were irrigated with 100 cc. 1 per cent neomycin solution. In one-half of these wounds two sutures of chromic catgut #2-0 were used to approximate the muscle fascia. All wounds were then closed in the usual manner.

Kanamycin: To determine the effectiveness of kanamycin, wounds were made, contaminated and irrigated in approximately one hour with 30 cc. 1 per cent kanamycin followed by closure in the usual manner.

Results

Time Delay and Freshening of Wound: Results of this study are illustrated in Table 1 and Table 2. The incidence of infection was significantly increased by a four-hour time delay between contamination and irrigation of the wound in comparison to a one hour time delay. Freshening the four-hour wounds with gauze sponges before irrigation significantly reduced the incidence of infection when both normal

TABLE 2. *Comparison of Effectiveness in Preventing Infection by Irrigation of Fecal-Contaminated Wounds with 100 cc. 20% Sulfamylon Four Hours after Contamination, and Four Hours after Contamination with Freshening of the Wounds with Gauze*

Sulfamylon Irrigations after Contamination	Number Incisions	Number Infected	Number Uninfected	Per Cent Infected
One hour	38	9	29	23.7
Four hours	30	13	17	43.3
Four hours with freshening of wound	30	8	22	26.6
Control (no treatment)	76	63	13	82.9

TABLE 3. Comparison of Effectiveness in Preventing Infection of Phisohex, Dial and Green Soap in Fecal-Contaminated Wounds both by Instillation into the Wound and by Active Scrubbing of Wounds

Treatment Used	Number Incisions	Number Infected	Number Uninfected	Per Cent Infected
Phisohex	30	10	20	33.3
Phisohex with scrubbing	30	5	25	16.7
Dial	30	11	19	36.6
Dial with scrubbing	30	3	27	10.0
Green soap	30	14	16	46.6
Green soap with scrubbing	30	12	18	40.0
Scrubbing without soap	30	23	7	76.6
Control (no treatment)	30	25	5	83.3

saline and 20 per cent Sulfamylon® were used.

Soap Solutions: The results of the use of soap solutions are illustrated in Table 3. All soap solutions used significantly reduced the incidence of infection in comparison with controls. Scrubbing the wound with the soap solution was significantly more effective than the instillation of the solutions only. There was no significant difference in Phisohex® or Dial® soaps. However, Phisohex® and Dial® were significantly more effective than tincture of green soap. Scrubbing the wound without soap showed no significant lowering of the incidence of infection.

Buried Sutures: The results of the use of buried sutures are illustrated in Table 4. There was no significant difference in the wounds with two buried sutures of chromic catgut #2-0 and the controls using 1 per cent neomycin as the irrigating agent.

Kanamycin: The results of kanamycin irrigation are illustrated in Table 5. Kanamycin significantly reduced the incidence of infection in comparison to controls. There was no significant difference between the

results obtained with 1 per cent kanamycin in this experiment and results obtained with 1 per cent neomycin in earlier work, although both were significantly better than 20 per cent Sulfamylon®.

Discussion

Howes³ found that treatment of experimentally contaminated crushed wounds in rabbits with Sulfamylon-streptomycin solution prevented infection if treatment was carried out immediately after wound contamination. When the period between contamination of the wound and treatment became greater than three hours, infection was not prevented unless the wound was freshened by debridement. He believed that many of the bacteria had entered leukocytes in which position the solution could not reach them unless the leukocytes were destroyed and the bacteria were again freed. Bacteria freed from the leukocytes and not destroyed would then be capable of re-initiating infection. By debridement of the wound, prevention of infection was found effective as late as 48 hours after wounding when the solutions

TABLE 4. Effect of Buried Chromic Catgut #2-0 Sutures in Wounds Contaminated with Fecal Organisms and Irrigated with 1% Neomycin

1% Neomycin Irrigations	Number Incisions	Number Infected	Number Uninfected	Per Cent Infected
No buried sutures	30	2	28	6.6
Two buried sutures	30	3	27	10.0

were employed in the same manner. Our experiments further indicate that the freshening of a wound is important in reducing the incidence of infection.

Peterson⁵ has reported that there was a lesser incidence of infection in wounds contaminated with hemolytic *Staphylococcus aureus* in dogs when wounds were washed with gauze or cotton and soap for 60 seconds in comparison with wounds soaked with soap for one-half hour, but with a greater incidence of infection than in untreated wounds or wounds irrigated with saline after contamination. Our studies suggest that washing the wounds with gauze and soap was significantly more effective than soap instilled into the wound alone, but both gave a lower incidence of infection than in the untreated wound. It is interesting to note that scrubbing the contaminated wound with the newer soaps seemed to give a beneficial result which is almost as effective as in those irrigated with antibiotics.

Although it has been generally accepted that buried sutures increase the incidence of infection in wounds, we were unable to demonstrate this by our experimental methods where neomycin was used to irrigate the wound.

Cohn¹ has evaluated kanamycin as an intestinal antiseptic and recommends it as one of the most effective available. Prigot⁶ reported that 0.5 Gm. of kanamycin in sterile distilled water could be instilled into the peritoneal cavity with safety and without toxic reactions when necessary precautions were observed. He also believed that when employed in conjunction with systemic broad spectrum antibiotics, the

intraperitoneal use of kanamycin was a valuable adjunct in the surgical management of established peritonitis and peritoneal contamination. Our work indicates that kanamycin is effective in the prevention of wounds contaminated by fecal organisms in the guinea pig.

Our experiments would suggest that the irrigation of the actually or potentially fecal contaminated wound with 1 per cent neomycin or kanamycin would be the procedure of choice in preventing wound infection. Although complications such as respiration arrest have been described following peritoneal irrigation with neomycin, it is doubtful that irrigation of the wound with aspiration of all of the solution would lead to difficulties of this sort. On the other hand, some surgeons have become disenchanted with antibiotics. Because of such complications as pseudomembranous enterocolitis² and moniliasis⁷ in the bowel where the normal flora has been changed with intestinal antibiotics, some believe that intestinal bowel preparation of this type is not warranted. It has been suggested that tumor metastases following colon surgery may be enhanced with the absence of bacteria that might destroy free tumor cells.¹⁰ We have previously reported evidence that in rendering the feces relatively sterile with antibiotics that immunity to intestinal organisms is not developed with such stool contamination as might be expected from untreated feces.⁸ There is also the problem of the development of resistant organisms. Neomycin resistant organisms have already been reported.⁴ With this in mind it is interesting to note that scrubbing the contaminated wound

TABLE 5. Results of Irrigation of Wounds Contaminated with Fecal Organisms with 1% Kanamycin

Treatment Used	Number Incisions	Number Infected	Number Uninfected	Per Cent Infected
Control (no irrigation)	30	16	14	53.3
Irrigation with 1% kanamycin	30	3	27	10.0

with the newer soaps seems to give a beneficial result which is almost as effective as in those irrigated with antibiotics.

Summary

Methods of preventing infection in wounds contaminated by feces have been studied, using guinea pigs as the experimental animal.

A time delay of four hours between contamination and treatment resulted in a significant increase in the number of infections as compared to one hour controls treated in the same manner. This greater incidence of infection was effectively reduced by freshening the wounds before irrigation with normal saline or 20 per cent Sulfamylon® as compared with irrigations without scrubbing the wound edges.

There was no significant difference between PhisoHex® and Dial® soap solution in reducing the incidence of infection although both were significantly better than tincture of green soap. All soap solutions used with active scrubbing of the wound with gauze significantly reduced the incidence of infection of wounds when compared to simple instillation of the soap solution into the wound.

Kanamycin was an effective agent in the prevention of infection in wounds contaminated with fecal organisms when used as a topical irrigating agent.

Scrubbing the contaminated wounds with detergents seemed to give a beneficial result which was almost as effective as in

those irrigated with antibiotics without the problems associated with antibiotic therapy.

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