# Management of the Umbilical Cord: Care Regimens, Colonization, Infection, and Separation

JoDee M. Anderson, MD,*
Alistair G.S. Philip, MD, FRCPE†

## Objectives

After completing this article, readers should be able to:

1. Describe the most serious infection that may result from inappropriate management of the umbilical cord and potential sources.
2. Describe the relationship between infant bacterial colonization and postpartum infection.
3. List the most common neonatal staphylococcal infections.
4. List the factors that affect the timing of cord separation.
5. Delineate the probable causes of drainage from the umbilical stump.

## Introduction

This review addresses several aspects of the care of the umbilical cord: how to ligate and cut it, what (if anything) to apply to it, the problems that may be associated with ligation and cutting, and the natural history of cord separation.

## Methods of Ligation

The traditional method of ligating the umbilical cord was to use string or twine to tie the cord before cutting it. In Southern Sudan, fine stringlike roots are used to tie the cord. More recently in the United States, special cotton tape (umbilical tape) was used and still is found on most trays used for insertion of catheters into umbilical blood vessels.

Because the umbilical cord tends to shrink after birth, these types of ligature proved somewhat unreliable in preventing hemorrhage. Although the umbilical arteries tend to constrict rapidly after birth because of the muscular walls, this does not occur with the umbilical vein. Consequently, more efficient and effective methods of ligation were sought in the middle of the 20th century.

The first method was to use constricting rubber bands, which were effective, but somewhat difficult to apply. This method recently found favor in a developing country (Ethiopia). However, the more usual method in developed countries currently is plastic or metal clamps, which produce safe, reliable constriction. In particular, the plastic Hollister® clamp (Double-Grip Umbilical Cord Clamp, Hollister, Libertyville, IL) has been very successful in preventing bleeding from the cord. These devices are removed before neonates are discharged from nurseries.

It is important to remember that, not very long ago, the plastic clamp was a sorely needed innovation. In 1971, Schaffer and Avery (1) noted, "All sorts of ties, hemostats and patent clamps have been proclaimed as the foolproof method of assuring permanent closure of the raw end of the cord. However, ties may become untied, hemostats may open, and clamps may slip off." In 1963, Neligan and Smith (2) reported the death of a 7-hour-old infant due to bleeding from the umbilical cord; the cord tie had neither come off nor apparently loosened. Review of their experience at one hospital during the preceding 15 years revealed that bleeding from the cord stump during the first 24 hours after birth had occurred in 26 infants (2). In response to this, they changed to a plastic clamp that was sufficiently elastic to grip the cord tightly as the cord volume shrank.

*Fellow in Neonatology.
†Professor of Pediatrics, Division of Neonatal and Developmental Medicine, Stanford University School of Medicine, Palo Alto, CA.

## Methods of Cutting

In primitive communities, sharp stones or other sharp objects are used to sever the cord, but in developed countries, sterile knives, scissors, or scalpels are used. Razor blades also have been used in less developed countries, and in Asia (eg, Thailand, Bangladesh), a traditional bamboo sheath formerly was used. The importance of the sterility of the cutting object is attested to by the occurrence of neonatal tetanus in communities where unsanitary knives are used for the procedure. The incidence of neonatal tetanus in Haiti has decreased markedly in recent years, due in part to providing sterile razor blades to village midwives as well as maternal immunization.

According to Lawrence Gartner, MD, early in the 17th century, the Chinese recognized the importance of prevention of infection and used "flamed instruments for cutting the umbilical cord." (3) An alternative was "tying the cord tightly with silk, wrapping it in clean linen and having the mother chew through the cord with her teeth!"

## Cord Management and Neonatal Tetanus

In 1952, Parmelee (4) reminded clinicians that the cord stump is an open wound that offers potential access for invasion of pathogenic bacteria until it is healed completely and that it should be treated accordingly. More than 50 years later, this admonition remains true. In some countries, despite attempts to educate clinicians, the most serious infection that may result from inappropriate management of the umbilical cord is neonatal tetanus due to *Clostridium tetani*. The major source of this infection is the application of cow dung to the umbilical region, a practice that has its origins in religious or cultural tradition, primarily in India, Pakistan, Bangladesh, Turkey, and some African countries (eg, Zaire, Nigeria, Sudan). This practice now is restricted to the rural areas of these countries, and although it usually is performed by untrained "dai," as recently as 1988 it was reported that trained midwives were contributing to this practice. Another practice, apparently confined to rural mountainous regions of Northern Pakistan, is "bundling." (5) This consists of wrapping an infant for prolonged periods in a sheepskin after dried cow dung is applied. This demonstrates the vulnerability of the umbilical wound to exposures any time during the first days after birth.

More recently, health care workers in the Punjab region of Pakistan have used topical agents applied to the umbilical area to protect against tetanus, in combination with maternal immunization using tetanus toxoid. The most promising agents in this setting appear to be nitrofurazone, bacitracin, and povidone-iodine ointments. (6)

Tetanus is not limited to less developed countries; it has been reported in the United States (Montana) as recently as 1998, following regular application of a "healing clay" to a baby's umbilical cord after 3 days of age (on the advice of a lay midwife). (7) In contrast, by the third century B.C., the Chinese had "identified the umbilical cord as the site of entry. . . and recognized the danger of exposing the newborn infant to the soil." (3)

One approach to changing these practices is to find a substitute agent for application. For example, in mountain villages of the Chitral District in northwestern Pakistan, dried cow dung is used as Westerners would use talcum powder. Accordingly, local health workers have advocated the substitution of talcum powder for cow dung. (8)

## Cord Management and Other Bacteria

In the preantibiotic era, Hess and Lundeen (9) advised that no medication be applied to a dry cord and that tincture of merthiolate by applied to a moist cord. This mercury-containing compound has fallen out of favor in recent years; more typical applications have been alcohol (70%) or triple dye. However, in the 1950s, with the rise in penicillin-resistant organisms, *Staphylococcus aureus* became the scourge of many nurseries. The umbilical cord area was colonized first, followed by the groin and subsequently the axilla and neck folds. At that time, hexachlorophene washing became very popular, until it was discovered that the agent might cause cystic brain lesions in preterm infants who were bathed repeatedly. Chlorhexidine was introduced at about the same time.

The past decade has seen a reconsideration of what, if anything, should be applied to the umbilical cord after birth. Many authors have suggested leaving the cord dry, which may promote earlier cord separation. Different approaches to cord care have been evaluated in terms of their impact on the timing of cord separation, bacterial colonization, and infection. The American Academy of Pediatrics supports dry care of the umbilical stump after birth, although many recent investigations suggest that colonization rates with *S aureus* are unacceptably high without application of topical antiseptics to the stump.

Establishing an association between colonization and infection has been at the center of recent debates regarding antiseptic treatment of the umbilical stump. Before birth, the fetus is essentially in a sterile environment; at delivery, microorganisms come into contact with the infant. Some of these microorganisms are derived from

the mother via vaginal delivery, breastfeeding, or handling; many are derived from the medical staff. Despite aseptic nursing techniques and emphasis on hand washing, adherence to such protocols is known to be poor, and infant-to-infant transmission can be high. Organisms establish themselves and produce microcolonies when the host defenses are ineffective, thereby colonizing the host. The factors that influence the type and number of microorganisms at any body site include the availability of oxygen, the availability of appropriate receptor sites for attachment, the pH of the host site, the availability of nutrients, the influences exerted by other microorganisms at the site, and the immunologic response of the host. Gram-positive organisms influence the number of gram-negative organisms and vice versa; both groups affect the concentration of yeasts. *S aureus* colonizes the skin and mucous membranes of 30% to 50% of healthy adults and children and may carry significant pathogenicity. (10) Among hospitalized infants, cross-contamination from other infants is the source of infection when *S aureus* outbreaks are studied, with the umbilical stump serving as the reservoir. When a particularly virulent or resistant strain is introduced into a nursery, the outcomes can be devastating.

## Colonization

The umbilicus usually is the initial site of colonization in the neonate, and evidence suggests a convincing correlation between newborn infection and the level of umbilical colonization. (11)(12) In 1985, Meberg and Schoyen (13) reported that the organism with which infants were colonized caused 87% of infections that occurred after hospital discharge. Large epidemiologic studies in neonates have shown that the incidence of *S aureus* infection has been increasing steadily over the past few decades. Up to 90% of newborns who are not treated with umbilical antiseptics are colonized with *S aureus* at discharge, and the risk of developing infection is related to the degree of colonization. (13) In an era of early postpartum discharge, the detection of such an infection rests in the hands of the parents. Stark and Harrison (11) examined dry cord care in 370 infants and reported a 12% rate of infection with *S aureus.* There was a significant difference in infection rates between infants who were heavily colonized and those who were not. The infections included septic blisters, eye infections, and umbilical infections. Janssen and associates (14) reported a 0.9% risk of serious infection (omphalitis, defined as erythema of the abdominal skin extending 5 mm beyond the umbilicus) from an untreated umbilical cord.

In the following review, dry cord care is defined as cleaning the cord with water and soap for the initial bath, followed by no further application of antiseptics. A review of the literature suggests that 23% to 91% of infants who are not treated with cord antiseptics become colonized with *S aureus* in the first 72 hours after birth. Stark and Harrison (11) graded the degree of colonization on a scale of 1 to 5, with 5 indicating very heavy colonization. Among infants who received no antiseptic cord care, 49% were heavily colonized, and 85% of the heavily colonized infants subsequently developed infection with *S aureus.* When Dore and colleagues (15) solicited caregiver opinions about the appearance of the umbilical cord with different cord care regimens, mothers described dry cords as "smelly," "mucky," and appearing more infected. Educating parents and other caregivers to recognize the signs and symptoms of infection can be difficult when dry cord care regimens are used because dry cords and infected cords may have common characteristics. On the other side of this debate, Mugford and associates (16) reported that fewer than 1% of 781 newborns treated with dry cord care had signs of infection. Barclay and associates (17) reported no infections among 890 infants in Australia who received dry cord care or chlorhexidine treatments. Unfortunately, the applicability of these data is diminished by the following factors: lack of randomization; apparent infections not being cultured; and no information regarding rooming in, length of stay, and open visiting (Table 1).

The most commonly used antiseptics include chlorhexidine, triple dye, hexachlorophene, and 70% alcohol. As noted previously, dry cord care is associated with higher rates of colonization with *S aureus* than any other regimen; chlorhexidine decreases *S aureus* colonization by at least one third (Figure). (12)(13)(14)(18)(19)(20)(21)(22)(23)

## Infection

Neonatal staphylococcal infections include skin pustules, bullous impetigo, conjunctivitis, scalded skin syndrome, pyoderma, paronychia, and omphalitis. Most cases of necrotizing fasciitis in the neonate are attributable to a secondary infection of omphalitis. Necrotizing fasciitis in the neonate carries a mortality risk of 59% to 85%, and the most common organism cultured is *S aureus.* (14) This high mortality rate is due partially to the rapid progression from omphalitis to necrotizing fasciitis, which often occurs within 24 hours. Early recognition of the signs and symptoms of omphalitis followed by prompt, aggressive treatment are essential to prevent progression to necrotizing fasciitis.

Because the open wound of the umbilical stump

Table 1. Dry Cord Care Colonization Rates

| Author/Year | Percent Colonized With *S aureus* | Percent Colonized With *S epidermidis* | Percent Colonized With Group B *Streptococcus* | Percent Colonized With *E coli* | Study Design |
|---|---|---|---|---|---|
| Seeberg and Brinkhoff/1984 (12) | 90% (627/694) | | 10% (71/694) | 10% (72/694) | Nonrandomized |
| Meberg and Schoyen/1985 (13) | 91% (101/111) | 48% (53/111) | 20% (22/111) | 39% (43/111) | Prospective, randomized, controlled trial |
| Stark and Harrison/1992 (11) | 68% (237/348) | | | | Prospective, nonrandomized |
| Verber and Pagan/1993 (18) | 47% (80/171) | | | | Prospective, assigned by unit |
| Watkinson and Dyas/1992 (19) | 53% (26/49) | 47% (23/49) | 4% (2/49) | 29% (14/49) | Prospective, nonrandomized |
| Pezzati et al/2002 (20) | 23% (40/177) | | 5.5% (10/177) | 14% (30/177) | Prospective, assigned by month |
| Janssen et al/2003 (14) | 31% (96/308) | 69.5% (214/308) | | 34% (105/308) | Prospective, randomized, controlled trial |

remains a portal for pathogenic bacteria, rapid healing of the cord is an important aspect of infection prevention. Therefore, management of the cord must consider the role that dehydration plays in the cord detachment process. Cord care regimens must be effective against the gram-positive and gram-negative organisms that colonize the neonate, including *S aureus, S epidermidis, Escherichia coli,* and Group B *Streptococcus.* Because the environment affects the growth of microorganisms, cord care regimens also should create an inhibitory environment. Consideration of cord care management must be determined and updated according to the prevailing organisms in an institution and community because microbial susceptibility is changing continually.

## Umbilical Cord Separation

In the older literature, the dried-up, gangrenous umbilical cord usually was reported to separate (or slough) by the fourth to sixth postnatal day. Hess and Lundeen (9) stated that the cord usually falls off later in the preterm infant than the term infant and suggested that it may not drop off until the 14th to 18th day after birth.

In the term infant, an umbilical cord that remained attached beyond 2 weeks after birth was considered delayed; attachment beyond 3 weeks was outside the range of normal. When this occurred, it was suggested that the infant was more susceptible to infection because of immunodeficiency. Because granulocyte influx and phagocytosis are involved in resorption of the umbilical cord base, leading to involution and separation, neutrophil function may be defective in infants in whom cord separation is delayed. Leukocyte adhesion defects have been seen in more than 150 newborns who had delayed cord separation. Because cord separation requires the influx of leukocytes, genetic defects in the B subunit of the integrin molecule profoundly impair leukocyte mobilization into extravascular sites, thereby delaying cord detachment.

In addition to cord care regimens, other factors that affect the timing of cord separation include leukocyte adhesion defects and superimposed bacterial infection. Anatomic anomalies of the urachus also are associated with delayed cord separation. The urachus obliterates in the fourth or fifth gestational month and becomes a fibrous cord extending from the dome of the bladder to the umbilicus. Urachal anomalies seen to delay cord separation include subumbilical cyst (consisting of a portion of the urachus), patent urachus, urachal sinus communicating with the umbilicus, and vesicourachal diverticulum communicating with the bladder.

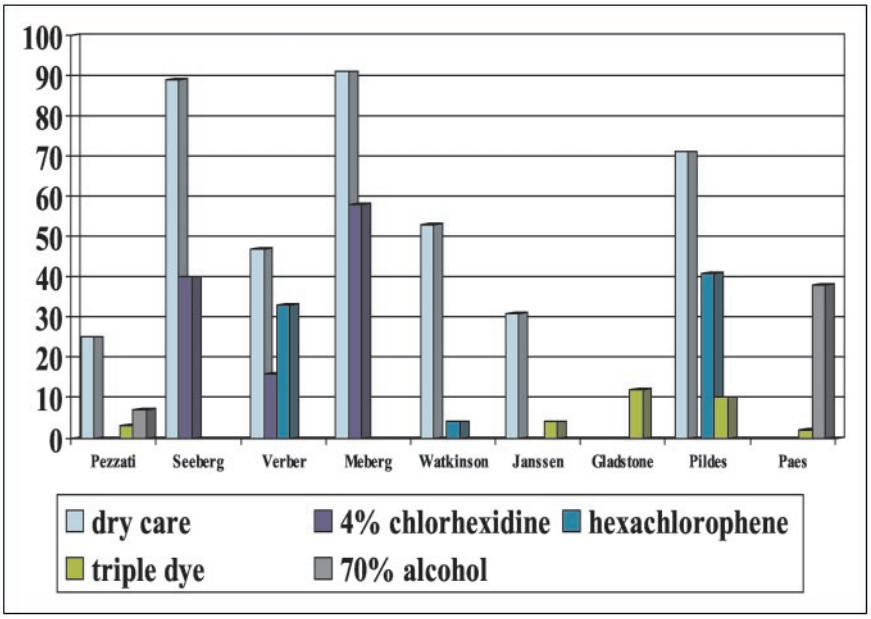


**Figure.** Rates of *S aureus* colonization associated with various umbilical cord care regimens.

## Umbilical Cord Management and Separation

More recently, it has been noted that delayed cord separation may be associated more closely with the care of the cord than with immunodeficiency. In a study from Seattle, it was not uncommon for cord separation to occur after more than 21 days. (24) In another study of 245 infants treated with triple dye application while in the nursery and alcohol daily after discharge, 25 infants had separation of the cord at 3 weeks of age or later. (25) The mean age of cord separation was 15.0±7.2 days. The authors concluded that the study of neutrophil function probably should be reserved for infants who have both late cord separation and umbilical infections.

Numerous efforts have been made to address the disparity in the timing for cord separation seen with different cord care regimens (Table 2). In a prospective, randomized study of eight cord care regimens, Pezzati and associates (20) found that treatment with powdered antiseptics rather than aqueous antiseptics resulted in shorter time to cord separation. The cords separated in 5.6±2.3 days for infants treated with salicylic sugar powder, 6.7±2.2 days for infants treated with green clay powder, 11.6±6.6 days for infants treated with triple dye, and 16.9±7.5 days for infants treated with 70% alcohol. In 1993, Verber and Pagan (18) reported that 3.7% of cords treated with hexachlorophene remained attached at 10 days compared with 27.9% of cords treated with chlorhexidine and 7.1% of untreated cords. Dore and colleagues (15) found a statistical difference in cord separation between cords treated with alcohol (9.8 d) and untreated cords (8.2 d). Hsu and associates (29) compared single triple dye application versus multiple triple dye treatments in 97 neonates and found umbilical separation time prolonged with multiple treatments (12.6±0.45 d versus 16.7±0.65 d). Gladstone and colleagues (21)

**Table 2.** Days to Umbilical Cord Separation Based on Cord Care Regimen

| Cord Care Regimen | Author | Mean Time to Separate (d) | Standard Deviation | Range (d) | Number of Infants Studied |
|---|---|---|---|---|---|
| Dry care | Dore et al 1998 (15) | 8.16 | ±3.1 | 1 to 24 | 907 |
| Dry care | Mugford et al 1986 (16) | 7.27 | ±2.09 | | |
| Dry Care | Oudesluys-Murphy et al 1990 (26) | 7.4 | ±3.3 days | 1 to 29 | 911 |
| Dry care | Pezzati et al 2002 (20) | 7.5 | ±3.1 days | | 177 |
| Triple dye | Pezzati et al 2002 (20) | 11.6 | ±6.6 days | | 195 |
| 70% alcohol | Dore et al 1998 (15) | 9.8 | ±4.6 | 2 to 49 | 900 |
| 70% alcohol | Golombek et al 2002 (27) | 10 | | | |
| 70% alcohol | Mugford et al 1986 (16) | 7.14 | ±2.09 | | |
| 70% alcohol | Pezzati et al 2002 (20) | 16.9 | ±7.5 days | | 178 |
| 70% alcohol | Rais-Bahrami et al 1993 (28) | 10.9 | | 3 to 43 | 293 |
| Salicylic acid powder | Pezzati et al 2002 (20) | 5.6 | ±2.3 days | | 167 |

**Table 3. Risks Associated With Cord Care Regimens**

| Regimen | Complication | Reference |
|---|---|---|
| Silver sulfadiazine | Kernicterus (sulfa component) | Payne et al/1992 (30) |
| Povidone-iodine | Transient hypothyroxinemia, hypothyroidism | Pyati et al/1977 (31) |
| Isopropyl alcohol | Percutaneous toxicity, central nervous system depression, skin necrosis | Roberts/1984 (32) |
| Crystal violet (triple dye) | Carcinogenicity | Rosenkranz and Carr/1971 (33) |
| Neomycin | Neural deafness | Rutter/1987 (34) |
| Hexachlorophene | Spongiform myelinopathy | Rutter/1987 (34) |
| Chlorhexidine | Delayed cord separation | Siegfried and Shah/1999 (35) |
| Salicylic acid | Metabolic acidosis | West et al/1981 (36) |

found comparable results with triple dye application in 249 infants.

Treating the cord with antiseptics carries the risk of selecting for resistant organisms because neonates are colonized by *S aureus* and increasingly by coagulase-negative staphylococci. Creating resistance could have a serious impact on nosocomial infections. These regimens are associated with other risks as well (Table 3).

## Management of the Preterm Umbilical Cord

In a review of the Cochrane database, Zupan and Garner (37) recognized the lack of data regarding care of the umbilical cord in preterm infants. These infants differ from term infants in factors that could predispose them to infection. Their immune systems are less mature, their umbilical cords more frequently are cannulated, and their risk of exposure to nosocomial infection is higher, rendering them more susceptible to infection. The stratum corneum layer of their dermis is immature, allowing for increased systemic absorption of antiseptics. Recently, Pezzati and colleagues (38) studied two cord care regimens in preterm infants (salicylic sugar powder and chlorhexidine). The results of this randomized, controlled trial favored the use of salicylic sugar powder in the preterm population; there was significantly less umbilical cord colonization at 3 days after birth in the salicylic sugar powder-treated group (73.1% negative) than in the chlorhexidine-treated group (53% negative). More studies of the care of the umbilical cord in preterm infants are necessary to compare different regimens.

## The Umbilical Area After Cord Separation

The major concern after separation of the umbilical cord is drainage from the umbilical stump. There are three probable diagnoses to consider:

- Excessive granulation tissue, which may result in serosanguineous drainage
- Patent urachus, a congenital malformation in which a tract connects the bladder to the umbilicus and in which the drainage usually is urine
- Persistent omphalomesenteric duct that communicates with the gut, making the drainage intestinal secretion

With excessive granulation tissue, the drainage generally is clear or pink, and with patent urachus and persistent omphalomesenteric duct, the drainage usually is yellow. However, if the drainage is purulent, infection (usually staphylococcal) also should be considered.

## Conclusion

According to the American Academy of Pediatrics guidelines for perinatal care, no single method of umbilical cord care has proven to be superior in preventing colonization and disease. Despite technologic advances in antiseptic techniques and antimicrobial agents, omphalitis remains a potential threat to the neonate. An absolute association between colonization and infection is suggested but not yet established. History may be informative, however. Cow dung was applied to umbilical cords because of its high moisture absorption rate, a property familiar to soil engineers. Cow dung dried the cord rapidly, which was an advantage because in many traditional cultures, the mother and baby could not join the rest of the household until the cord fell off. Pezzati and colleagues (38) found more rapid cord separation when powdered agents were applied than when aqueous solutions were applied to the cord. The moist umbilical cord is an open wound that serves as both a reservoir for bacteria and a portal for bacterial invasion. Perhaps agents that promote rapid healing of the cord, such as powders that have high moisture absorption rates, deserve more attention.

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## NeoReviews Quiz

7. The method of ligation of the umbilical cord must be efficient in application, effective in preventing bleeding, and free from infection hazard. Of the following, the *most* common method of ligation of the umbilical cord in developed countries is:

   A. Cotton tape.
   B. Plastic clamp.
   C. Rubber band.
   D. String.
   E. Twine.

8. The umbilical cord stump is an open wound that remains a potential portal for invasive pathogenic microorganisms. Of the following, the *most* serious infection that may result from inappropriate management of the umbilical cord is caused by:

   A. *Clostridium tetani.*
   B. *Escherichia coli.*
   C. Group B *Streptococcus.*
   D. *Listeria monocytogenes.*
   E. *Staphylococcus aureus.*

9. Care of the umbilical cord stump has evolved over the years and included several topical applications. Of the following, the approach toward the care of the umbilical cord stump supported by the American Academy of Pediatrics is the application of:

   A. Chlorhexidine.
   B. Crystal violet.
   C. Dry care.
   D. Hexachlorophene.
   E. Isopropyl alcohol.

10. *Staphylococcus aureus* is the most common microorganism responsible for colonization of the umbilical cord stump. Of the following, the regimen of umbilical cord care associated with the *highest* rate of colonization with *S aureus* is the application of:

    A. Chlorhexidine.
    B. Crystal violet.
    C. Dry care.
    D. Hexachlorophene.
    E. Isopropyl alcohol.

11. Granulocyte influx and phagocytosis are involved in the resorption of the umbilical cord at its base and its involution and separation within 1 week after birth in term neonates. Of the following, a delay in the separation of the umbilical cord is associated *most* closely with:

    A. Cord care regimen.
    B. Leukocyte adhesion defect.
    C. Patent urachus.
    D. Persistent omphalomesenteric duct.
    E. Umbilical infection.

12. Treating the umbilical cord stump with antiseptics carries the potential risk of generating resistant microorganisms. Additionally, the use of antiseptics may cause deleterious effects in the neonate. Of the following, the antiseptic *most* associated with the development of spongiform myelinopathy is:

    A. Hexachlorophene.
    B. Neomycin.
    C. Povidone-iodine.
    D. Salicylic acid.
    E. Silver sulfadiazine.

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