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SAFE MOTHERHOOD

CARE OF THE UMBILICAL CORD:

A REVIEW OF THE EVIDENCE

Division of Reproductive Health (Technical Support)
Family and Reproductive Health
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EXECUTIVE SUMMARY

Cord infections and neonatal tetanus contribute significantly to high neonatal mortality rates in developing countries. These infections are preventable and can be reduced by practising clean delivery and clean cord care, by avoiding harmful practices, and by increasing tetanus toxoid immunization coverage.

Current standards of cord care are based on the principles of asepsis, the aim of which is to decrease the likelihood of cord infections. However, the introduction of nurseries for newborns in hospitals in the 1940s increased the risk of staphylococcal skin and cord infections by facilitating the spread of bacteria among infants. In developing countries, where most deliveries take place at home, some traditional practices such as applying unclean substances to the cord stump, conflict with principles of cleanliness and greatly increase the risk of cord infection and tetanus.

Current recommendations for cord care are chiefly based on research in hospital nurseries in developed countries. Some of these recommendations do not apply in developing countries where resources are scarcer, most deliveries take place at home and different bacteria cause cord infections. Despite the lack of data from developing countries, this document attempts to make some recommendations for cord care in these countries on the basis of the soundest evidence available.

The timing of cord cutting will depend on the use of active management (a combination of routine oxytocin administration, early cord cutting and controlled cord traction) of the third stage of labour. If active management is practised, as is the case in many obstetric departments worldwide, then it is mandatory to clamp the cord early. The use of active management of the third stage may decrease the risk of postpartum haemorrhage; nevertheless, doubts remain about its application to low-risk women. Physiological management (no oxytocin, no controlled cord traction, delaying cord cutting until pulsations stop or the placenta is delivered) is not associated with adverse effects, is in accordance with traditional beliefs, may play a role in the prevention of iron deficiency anaemia and can be recommended for normal deliveries at home and in institutions.

Clean cord care at birth and in the days following birth is effective in preventing cord infections and tetanus neonatorum. Clean cord care practices at birth include washing hands with clean water and soap before delivery and again before cutting and tying the cord, laying the newborn on a clean surface and cutting the cord with a sterile instrument.

Clean cord care in the postnatal period includes washing hands with clean water and soap before and after care, and keeping the cord stump dry and exposed to air or loosely covered with clean clothes (if custom demands binding of the abdomen, a sanitary method such as using a clean piece of gauze and clean bandage can be recommended). If soiled, the cord should be washed with clean water and soap (cleaning with alcohol seems to delay healing). The napkin should be folded below the umbilicus.

Other practices that may reduce the risk of cord infection are the use of 24-hour rooming-in instead of nurseries in institutions and skin-to-skin contact with the mother at birth to promote colonization of the newborn with non-pathogenic bacteria from the mother's

skin flora. Early and frequent breast-feeding will provide the newborn with antibodies against infections.

Research from developed countries has shown that, compared to no treatment, application of a topical antimicrobial on the cord stump reduces colonization by harmful bacteria in hospital nurseries. The effect of topical antimicrobials in reducing infections is less clear. Chlorhexidine, tincture of iodine, povidone-iodine, triple dye or silver sulphadiazine seem to be the most effective in reducing colonization. Topical antibiotics are effective but their use should be questioned in light of the development of resistance.

There is not enough evidence to recommend the widespread use of topical antimicrobials on the cord stump. The decision to use them will depend very much on local circumstances. In hospital nurseries it is probably best to apply a topical antimicrobial to the cord stump after cutting the cord and once a day for the first three days. The choice of the substance will depend on the predominant flora (usually *S. aureus*, though sometimes gram negative organisms are also prevalent). If this is not known, the antiseptic used should have a broad spectrum of activity and should be culturally acceptable, affordable and available (see summary table on antimicrobials, page 26). If a 24-hour rooming-in system is in place, the mother is the main care-giver and clean cord care is practised, application of an antiseptic to the stump is probably not needed as the risk of contaminating the cord is low.

For home deliveries or for cord care after discharge from the hospital, clean cord care is sufficient and an antiseptic is not required. In areas at high risk of neonatal tetanus or where harmful practices such as putting cow dung on the stump are prevalent, a topical antimicrobial can be recommended, if necessary, as a transitional measure to help wean the community away from harmful substances. The chosen antimicrobial should have a broad spectrum of activity against bacteria and should be cheap, culturally acceptable (a coloured substance is usually preferred) and available.

Countries should take steps to promote clean delivery, clean cord care practices and immunization of pregnant women with tetanus toxoid. National policy and standards should be set and needs assessed. Institutions may have to revise their policies and standards for newborn care in accordance with national recommendations and the staff may need additional training. Supplies and equipment for clean delivery, clean cord care and tetanus toxoid immunization should be made available. At community level, achievement of the objective of clean delivery and cord care requires a well developed and culturally sensitive motivation and education programme. Disposable delivery kits containing at a minimum a new razor blade, clean ties, a piece of soap and instructions for use can be made available to mothers and traditional birth attendants (TBAs).

Recommendations for cord care are summarized below in Table 1.

Table 1. Summary table for recommendations on cord care

INTERVENTION	HOME DELIVERY	INSTITUTIONAL DELIVERY
CORD CARE AT BIRTH		
Cleanliness	Wash hands with clean water and soap before delivery *and* before cutting/tying cord Clean surface to receive baby Wear gloves (institutions)	
When to cut/clamp the cord	Wait until cord stops pulsating or placenta is delivered	Same for normal deliveries; if active management is used, clamp cord early
What kind of ties	Clean string ties, threads or narrow tapes, at least 15 cm in length, tied tightly in 2 places (infant end and maternal end)	Sterile ties (at least 15 cm in length), clamps or rubber bands applied/tied tightly in 2 places
Length of stump left	2-3 cm or longer, according to local custom	
Cutting instrument	Sterile blade (razor blade in original packing is considered sterile); if unavailable, knife or scissors that have been boiled for 10 minutes	Sterile scissors or blade
Topical antimicrobial on stump after cutting cord	None unless necessary, as a temporary measure, according to local situation (e.g. in neonatal tetanus endemic areas, or to replace a harmful traditional substance)	24-hour rooming-in: none unless necessary, according to local situation Nurseries/intensive care units: chlorhexidine, tincture of iodine, povidone-iodine, triple dye or silver sulphadiazine
POSTNATAL CARE OF CORD STUMP		
Cleanliness and protection from contamination	Wash hands with clean water and soap before and after care Keep the stump exposed to air or loosely covered with clean clothes Fold napkin below stump Avoid applying unclean substances, touching the cord and covering it with bandages	
Beneficial practices that may decrease the risk of cord infection	Keep the baby with the mother (in institutions: 24-hour rooming-in, no nurseries), skin-to-skin contact, early and frequent breast-feeding	
How to clean the cord when soiled	Wash with clean water and soap, dry thoroughly	
Topical antimicrobials on cord stump	None unless necessary, according to local situation (e.g. in neonatal tetanus endemic areas, or to replace a harmful traditional substance) as a temporary measure	Rooming-in: none unless necessary, according to local situation Nurseries/intensive care units: chlorhexidine, tincture of iodine, povidone-iodine, triple dye, silver sulphadiazine (once daily for 3 days)

INTRODUCTION

Tetanus and infections are among the leading causes of neonatal mortality. Each year some 500 000 infants die of neonatal tetanus and a further 460 000 die as a consequence of severe bacterial infection. A substantial proportion of deaths from infection are due to cord infections. Infants with neonatal tetanus often have a concomitant cord infection,[1] which points to a common cause (i.e. unclean delivery and cord care practices). Strategies to reduce the risk of neonatal tetanus and cord infections include promoting clean delivery and clean cord care and increasing tetanus toxoid immunization coverage in women of reproductive age.

The purpose of this document is to review the available evidence on cord care, establish recommendations on clean cord care for policy-makers, managers of health facilities and senior health professionals, and to assist them in their implementation. Information is given on the normal physiological process of cord separation and the signs and pathology of cord infections. Traditional practices are briefly reviewed and examples are given of practices that are beneficial, harmless and harmful. Current medical practices regarding when and how to cut the cord, the length of the remaining stump, the choice of cord ties and the application of antimicrobials on the stump are identified. Evidence for or against these practices is examined. Recommendations for cord care at home and in institutions are made on the basis of the best available evidence, and suggestions for future research are given.

IMPORTANCE OF CORD CARE

In developed countries, individual cases and epidemics of cord infections continue to occur, even in supposedly aseptic nurseries for newborns. Neonatal tetanus and cord infections continue to be an important cause of neonatal morbidity and mortality in developing countries. A number of factors contribute to the high incidence of tetanus and infection in these countries: most deliveries take place at home, often in unhygienic circumstances, deliveries are conducted by untrained birth attendants, and some traditional cord care practices are harmful.

Cord care is thus an important issue that needs to be addressed. As in the case of research into other aspects of pregnancy and delivery care, research on cord care has focused more often on interventions such as early cord clamping and the use of topical antimicrobials on the stump and much less on practices that are based on "natural" or physiological processes. Interventions require additional supplies and training, and thus need to be studied carefully to see if they really have more advantages than a non-interventionist approach.

Infections are not the only concern. Bleeding from the cord stump - although more rare than infection - can rapidly be fatal. Bleeding can, however, be effectively prevented by tight tying or clamping and by prevention of infection.

Cost is another aspect of cord care. In countries where mothers receive postnatal visits, problems with the cord often determine the number of visits. If cord separation and healing

are delayed, as when some antimicrobials are used, the cost of postnatal care may unnecessarily increase.[2]

Pathophysiological background

The umbilical cord is a unique tissue, consisting of two arteries and one vein covered by a mucoid connective tissue called Wharton's jelly and a thin mucous membrane. During pregnancy, the placenta supplies all material for fetal growth and removes waste products. Blood flowing through the cord brings nutrients and oxygen to the fetus and carries away carbon dioxide and metabolic wastes. After birth, until the placenta separates and while the cord is still pulsating, a small volume of blood may be transfused from the placenta to the newborn. The amount transfused depends on when the cord is cut and the level at which the baby is held in relation to the mother at the time of cord clamping.

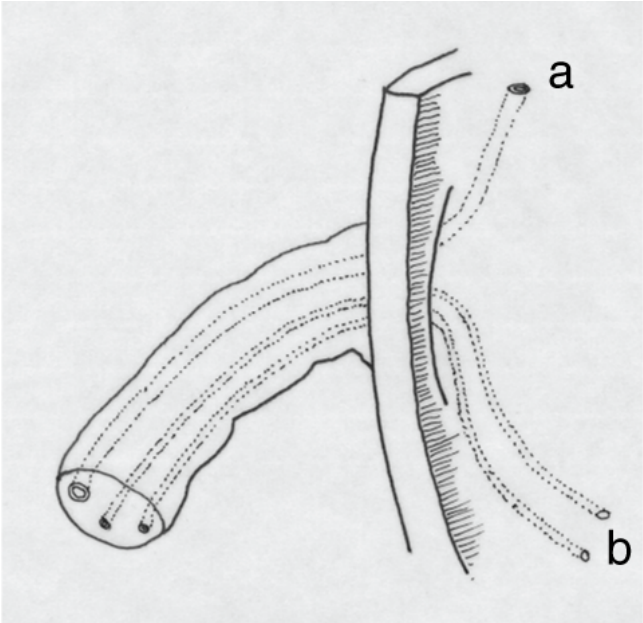

Figure 1 *A transaction of the abdominal wall: a cord stump with one vein (a) and two arteries (b) entering the abdominal wall*

When the cord stops pulsating, the umbilical vessels are constricted but are not yet obliterated. Therefore the cord has to be tied/clamped tightly in order to keep the umbilical vessels occluded and prevent bleeding.

To separate the newborn from the placenta, the cord must be cut. The instrument used cuts through living tissue and vessels that are still connected to the infant's blood stream (Figure 1); it therefore needs to be sterile to avoid infection.

When the cord is cut, the cord stump is suddenly deprived of its blood supply. The stump soon starts to dry and turns black and stiff (dry gangrene). Drying and separation of the stump is facilitated by exposure to air. The devitalized tissue of the cord stump can be an excellent medium for bacterial growth, especially if the stump is kept moist and unclean substances are applied to it. The umbilical vessels are still patent for a few days following birth, thus providing direct access to the bloodstream. The umbilical stump is a common means of entry for systemic infection in the newborn infant. Keeping the stump clean and dry is therefore very important if infection is to be prevented.

The newborn has no protective flora at birth. Normal skin flora begin to be acquired within 24 hours. The umbilicus is colonized by bacteria from environmental sources such as the mother's vagina,[3] her skin flora, and the hands of caregivers.[4] In hospital nurseries, *S. aureus* is the most common colonizing organism and is acquired mostly from the hands of nursery personnel. Once colonized, the umbilicus acts as a reservoir of bacteria that may cause cross-infection in the nursery.[5] The factors that cause colonization of the cord stump to progress to infection are poorly understood.

If a baby is kept with its mother (by rooming-in), the bacteria colonizing the baby come mostly from its mother's normal skin flora and are predominantly non-pathogenic. Colonization rates with pathogenic organisms[6] and infections[7,8] are significantly lower in rooming-in babies than in babies kept in nurseries, with a 24-hour rooming-in system being most effective. In hospitals that have daytime rooming-in only, a large proportion of newborns have significant umbilical colonization with *S. aureus* at discharge.[9]

Separation of the umbilical cord stump is mediated by inflammation of the junction of the cord and the skin of the abdomen with leucocyte infiltration and subsequent digestion of the cord. During the normal process of separation, small amounts of cloudy mucoid material may collect at that junction; this may be misinterpreted as pus, and the cord may appear moist, sticky or smelly. The cord normally falls off between 5 and 15 days after birth.[10] Factors that delay the process are the application of antiseptics to the stump, infection and caesarean section. Delayed cord separation with antiseptics may be due to destruction of the normal flora around the umbilicus (navel) and a subsequent decrease in the number of leucocytes attracted to the cord.[11]

After the cord separates, the umbilicus continues to elaborate small amounts of mucoid material until complete healing takes place, usually a few days after separation. During this time the umbilicus is still susceptible to infections, although less so than in the first 2-3 days. Infection may delay healing, causing the umbilicus to stay moist for longer periods.

Cord infections

The exact incidence of cord infections is unknown. They appear to be relatively rare in developed countries, but they are probably under-reported as babies may be discharged early from hospital and not followed up at home. In one large hospital study of newborns who were routinely bathed with hexachlorophene, the 6-year incidence of cord infections was 0.5% in newborns of normal weight and 2.08% in those born prematurely. The mean age of infants when cord infection appeared was 3.2 days.[12]

There is evidence that cord infections are common in developing countries. One hospital study found that, in 47% of infants hospitalized with sepsis, cord infection was the source of the illness, and that 21% of infants admitted for other reasons had omphalitis (cord infection)[13]. A prospective study in urban slums found an incidence for umbilical sepsis of 30/1000.[14]

Among the most common organisms causing cord infections in nurseries in developed countries are *S. aureus, E. coli* and group B streptococci.[15] Little is known about which organisms cause cord infections in developing countries, whether at home or in institutions. In one study, 72% of the cord infections in babies born in hospital were due to gram-negative organisms (mostly Klebsiella and *E. coli*), whereas gram-positive infections were slightly more common in babies born at home. *S. aureus* was the single most commonly isolated bacterium both at home and in the hospital.[13]

The greatest period of risk for umbilical stump contamination with bacteria including *C. tetani,* is the first three days of life. Risk decreases with time as the umbilical wound heals

and the stump separates.[16] The risk of cord infection is increased by unhygienic cutting of the cord and the application of unclean substances to the stump.

Infection may remain localized or may spread inwardly. Infection delays or prevents obliteration of umbilical vessels, and organisms thus have direct access to the newborn's bloodstream. Septic thrombi may form within the umbilical vessels, sending septic emboli to various organs - including the lungs, pancreas, heart and kidneys - and causing infection of these organs as well as septicaemia. Infection may also spread by direct extension into the peritoneal cavity, causing peritonitis (Figure 1).[17] Omphalitis is thus a serious infection that needs aggressive treatment.

Signs of inflammation (erythema, oedema, tenderness) of the tissues surrounding the cord support the diagnosis of omphalitis. As infection delays or prevents obliteration of the vessels, umbilical bleeding is a common sequel. There may also be a purulent discharge from the stump. However, no data are available on the predictive value, sensitivity or specificity of these signs for umbilical infection. Peri-umbilical erythema may also be produced by vigorous cleaning of the cord with alcohol or by the use of metal clamps. Associated signs such as fever, lethargy and poor feeding suggest systemic complications. In many instances, the diagnosis of cord infection is uncertain: the cord may appear unusually moist or smelly, with or without discharge, but there are no other signs. Sometimes there are no obvious outward signs of infection, and the diagnosis can be made only at autopsy. One study found that up to one-third of neonates with septicaemia due to cord infection had no obvious external sign of the infection.[1] The index of suspicion should therefore always remain high.

Omphalitis should be treated with systemic antibiotics. Questions remain about when such treatment should start - whether it should be initiated at the first sign of redness at the base of the cord, or whether one should wait for more obvious signs such as pus draining from the stump or oedema. The size of the red area at the base of the cord has been used by some clinicians to decide antibiotic treatment, an area greater than 2 cm being an indication for immediate treatment and an area less than 2 cm requiring only monitoring.[18] When the newborn has systemic signs of infection such as fever, lethargy or poor feeding, it must be treated as for severe bacterial infection and antibiotics should preferably be given intravenously (if this is not possible and referral is difficult, they may be given intramuscularly). The choice of antibiotics will depend on the best guess about the bacteria causing infection; if this is unknown, a combination of ampicillin and gentamycin can be used against most organisms.

In cases of neonatal tetanus, high doses of penicillin should be given intravenously and tetanus antitoxin should be given to neutralize the unbound toxin. In one study, 33% of cases of neonatal tetanus also had omphalitis and septicaemia. Thus, in cases of neonatal tetanus, it is appropriate to have a high index of suspicion of infection from other bacteria and to start appropriate antimicrobial therapy within the first 24 hours of admission in addition to the treatment for tetanus.[1]

CORD CARE PRACTICES

Traditional practices

About two-thirds of births in developing countries take place outside health facilities and almost half of the women are delivered by untrained traditional birth attendants, family members or deliver on their own. A wide variety of traditional practices and beliefs are associated with care of the umbilical cord. Traditional beliefs must be taken into account when introducing clean cord care programmes in a community since these beliefs may conflict with programme recommendations. Some traditional practices such as applying unclean substances to the cord are dangerous and should be discouraged or replaced with safer alternatives. Practices will not change unless people are convinced that the new practice is indeed better. Some traditional practices are beneficial and should be promoted, while others may be ignored.

The following are examples of traditional cord care practices:

In many cultures, people believe that all life from the placenta must be transferred to the newborn for otherwise the baby may die. Therefore the cord is usually cut after cord pulsations stop or after the delivery of the placenta. This practice is harmless and may even be beneficial to the baby. In some areas the cord is milked, especially if the baby is not breathing, in order to bring the baby's soul back from the mother.[19]

Materials used to tie the cord include strings, threads and strips of cloth. In Nepal, the custom is to use home-made cord ties of raw cotton in accordance with the saying, "a new thread for the new baby".[20] Sometimes blades of grass, bark fibres, reeds or fine roots are used: this is harmful because such materials often harbour tetanus spores from the soil and thus increase the risk of neonatal tetanus.[21] In some areas, no tie is used or the cord is tied only if bleeding occurs.[22,23] This practice increases the risk of bleeding from the stump. In traditional societies in India, the practice of waiting for placental expulsion and using a blunt instrument to cut the cord, which results in more vessel spasm than using a sharp one, ensures that cord bleeding is uncommon even if the cord is not tied very tightly.[24]

A variety of tools are used to cut the cord. They are usually items that are available in the house, or that relate to the father's trade, such as scissors, knives, broken glass, stones, sickles, or used razor blades. These are rarely cleaned or boiled before use and are dangerous sources of infection. Some cultures have more beneficial customs such as heating the knife over a fire or candle before cutting the cord.[25]

The umbilical cord is left long in most traditional cultures. Exceptionally, it is cut very short, as in some communities in Uganda (this practice is associated with the danger of umbilical bleeding as it makes the cord hard to tie).[26] In Ecuador, the cord is left 12-15 cm long in girls because it is believed that anything shorter than that would cause a girl to have a small uterus and narrow hips later in life and therefore have difficulty in childbirth.[27] The effect of leaving the cord long on cord infections has not been studied. It is, however, harder to keep the cord dry and clean if it is long, and it could more easily come into contact with urine and faeces (though this would not happen where the cord is tied loosely around the neck or arm, as is the custom in some African countries).

In most cultures, some kind of substance is applied to the cord stump. Ash, oil, butter, spice pastes, herbs and mud are substances that are commonly used. These substances are often contaminated with bacteria and spores and thus increase the risk of infection. One of the most dangerous practices is the application of cow, chicken or rat dung to the stump; this is associated with a high risk of neonatal tetanus. Ghee application has also been found to be a risk factor for tetanus.[28] The most common reasons given for applying a substance to the cord are to prevent bleeding from the stump, to promote separation of the stump, and to keep spirits away. The effect of these practices on bleeding and separation has not been studied. Some Latin American cultures have beneficial customs regarding treatment of the cord, such as cauterizing the stump with a candle flame, hot coal or burning stick.[27] In KwaZulu-Natal[29] and in some communities in Kenya,[25] some women apply expressed breast milk (colostrum) to the cord stump (this could in fact be beneficial in view of the antibacterial factors present in breast milk).

In many cultures it is common to bind the newborn's abdomen with cloth or bandages. This practice keeps the stump moist, thus delaying healing and increasing the risk of infection, especially if the material used is unclean. Various reasons are given for the custom of binding, such as to prevent the umbilicus from bulging or protruding from the body, to secure the newborn's internal organs, or to protect the stump from "bad air" which is considered in some cultures to be a cause of illness.[30,31] Table 2 gives examples of practices that are beneficial, harmless or harmful.

Table 2. Examples of beneficial, harmless and harmful traditional cord care practices

PROCEDURE	BENEFICIAL PRACTICES	HARMLESS PRACTICES (OR UNKNOWN EFFECT)	HARMFUL PRACTICES
Timing of cord cutting	Cutting cord after pulsations stop (most cultures)	Milking cord if the baby is asphyxiated (Asia, Africa)	
Ties	Using new cotton thread (Nepal)		Using unsterile string or thread, reeds, roots (Sudan), chewed bark fibres (Zimbabwe); Not tying the cord
Cutting instrument	Passing knife or scissors through flame (Mexico, Guatemala, Papua New Guinea)		Using unclean tools (e.g. scissors, knife, sickle, stones)
Length of cord stump		Cord is left long (Asia, Africa, Latin America)	Cord is cut very short (Uganda)
Dressing on cord stump		Applying expressed breast milk (KwaZulu-Natal, Kenya)	Applying ashes, herbs, animal dung, mud, oil, ghee (India); Binding of abdomen (Latin America, Asia)

Medical practices

During the 1800s in Western countries, thousands of infants died every year from umbilical infections, including tetanus neonatorum. Many newborn infections were spread by medical attendants who failed to recognize the value of washing their hands. The importance of cleanliness gradually became apparent and these infections were rare by the early 1900s. Current medical practices - washing hands before cord care, clamping the cord with sterile clamps, and cutting it with sterile scissors or blade - are based on the principle of aseptic technique. They have led to a reduction in omphalitis, neonatal tetanus and sepsis. Although aseptic technique at birth decreased cord infections, other practices that were introduced in hospitals had the opposite effect.

When hospitals started separating mothers and babies in the 1940s, placing babies in nurseries for newborns to facilitate care, the risk of nosocomial infections and cross-infection among infants increased steeply. Staphylococcal epidemics of pyoderma and omphalitis emerged and the umbilicus was found to be an important reservoir for dissemination of *S. aureus.* Prophylactic routine application of antimicrobial agents to the cord stump helped control these epidemics. However, successes in preventing colonization by one organism sometimes resulted in colonization by others of equal or greater pathogenicity. The practice of applying an antiseptic to the cord is now common not only in hospital nurseries but also outside hospitals, yet it has not been thoroughly evaluated.

A wide variety of regimens exist for cord care in hospital nurseries, suggesting an uncertainty about what is most effective. The purpose of these regimens is to reduce colonization and thereby reduce infection of the cord stump with hospital microorganisms, the most common of which is *S. aureus*. Regimens for cord care are, however, not always based on firm evidence that they are effective.

Routine care of the cord usually includes daily cleaning of the stump with alcohol and application of a dusting powder or an antimicrobial solution. Powders currently used contain varying proportions of zinc oxide, talc, starch or alum and other ingredients. Some powders also contain hexachlorophane or chlorhexidine. The most common antimicrobial agents include triple dye, tincture of iodine, iodophors, antibiotic ointments, silver sulphadiazine and chlorhexidine. The frequency of treatment also varies. In some cases the cord stump is cleaned and/or treated only at the time of delivery; in others, care is repeated daily or at every diaper change until the umbilicus heals.

The use of umbilical binders was discontinued in most hospitals in developed countries in the late 1950s and early 1960s when it was found that they frequently harboured bacteria and hindered healing by not allowing the cord to dry.

REVIEW OF EVIDENCE ON CORD CARE PRACTICES

Opinions vary on what constitutes the best umbilical care. This section reviews the evidence from available studies on cord care and attempts to formulate some recommendations on the basis of the evidence.

Timing of cord clamping

The umbilical cord can be clamped immediately after birth or later. Late clamping after cord pulsations have ceased is the usual procedure in traditional births, and early clamping is common in institutions. The timing of cord clamping may have effects on both mother and infant.

The effects on the mother have been studied in some trials. Although there was some evidence that early clamping reduces the duration of the third stage of labour, there was no significant effect on the incidence of postpartum haemorrhage.[32,33,34] The combined use of oxytocin, early cord clamping and controlled cord traction (active management of the third stage of labour) has been shown in some studies to decrease the incidence of postpartum haemorrhage.[35,36] Although prophylactic oxytocin is effective in reducing the risk of postpartum haemorrhage, doubts remain about combining it with early cord clamping and controlled cord traction, and about the routine use of active management in healthy low-risk women.[37] Early cord clamping should be avoided in rhesus negative women as it increases the risk of feto-maternal transfusion. However, allowing free bleeding from the placental end of the cord reduces this risk.[38,39,40]

A number of observational studies and trials have been conducted on the effects of the timing of cord clamping on the neonate. Delayed cord clamping results in a shift of blood from the placenta to the infant. The volume transfused varies between 20% and 50% of neonatal blood volume, depending on when the cord is clamped and at what level the baby is held prior to clamping.[41,42,43,44] Trials in which newborns were placed on the mother's abdomen[45] or on the bed where she lay[46,47] and the cord was clamped only when it stopped pulsating showed that these babies had blood volumes 32% higher than babies whose cords were clamped immediately after birth. Placental transfusion was about 80% at 1 minute and was practically completed at 3 minutes.

There have been concerns that the increase in the newborn's blood volume and red blood cell volume that is associated with delayed cord clamping could result in overload of the heart and respiratory difficulties. These effects have not, however, been demonstrated. In fact, there is probably a self-regulatory mechanism in the infant which limits the extent of placental transfusion.[47] Moreover, there is evidence that the circulatory system of the newborn is capable of rapid adjustment to an increase in blood volume and viscosity by increased fluid extravasation and dilation of blood vessels.[46,48]

Placental transfusion may not occur in the usual manner in newborns with perinatal complications. For example, one study found that blood volume in asphyxiated newborns was high in spite of immediate cord clamping, possibly due to a prepartum redistribution of blood between fetus and placenta.[49] Delaying cord clamping in these babies may cause hypervolaemia and cardio-respiratory complications, although this has never been demonstrated.

Placental transfusion associated with delayed cord clamping provides additional iron to the infant's reserves and may reduce the frequency of iron-deficiency anaemia later in infancy. [50,51,52] This is of particular significance in developing countries where iron deficiency is common. Delaying cord clamping also favours early contact between mother and baby. In addition, it also reduces splashing of blood, which helps protect the birth attendant in areas where HIV infection is common.[53]

Early cord clamping reduces the extent of placental transfusion to the baby and results in significantly lower haematocrit and haemoglobin levels in newborns.[32,54,55,56] However, these differences diminish quickly over time and become negligible by 3 months of age. Neonatal bilirubin levels are lower after early cord clamping but there is no significant difference in the incidence of jaundice.[34,54,57]

The physiological consequences of early as opposed to late cord clamping have been studied even less in the preterm infant than they have in infants born at term. One randomized trial found that vaginally delivered preterm infants who had been held 20 cm below the introitus for 30 seconds before the cord was clamped required fewer transfusions for anaemia and fewer high inspired-oxygen concentrations than infants whose cords had been clamped within 10 seconds.[58] More trials are needed to compare the effects of early versus delayed cord clamping on the major adverse outcomes of preterm infants, such as respiratory distress syndrome, sepsis, intracranial haemorrhage and necrotizing enterocolitis.

In conclusion, there is no clear evidence to favour one practice over the other. Delaying cord clamping until the pulsations stop is the physiological way of treating the cord and is not associated with adverse effects, at least in normal deliveries. Early cord clamping conflicts with traditional beliefs and is an intervention that needs justification. If controlled cord traction after oxytocin administration is practised, early cord clamping is mandatory (the cord should be shielded with a sterile covering to minimize blood spraying during the procedure). More research is needed on the effects of the timing of cord clamping on the preterm infant.

Choice of ties

The cord must be always be ligated or clamped at the baby's side prior to cutting, since leaving it untied can cause excessive bleeding. The usual recommendation is also to ligate at the placental side, although this may be less essential. Not ligating on the mother's side may even be beneficial in some circumstances, such as in the case of rhesus negative mothers.[38]

Many kinds of clamps and ties have been used in institutions to tie the cord and prevent bleeding from the stump. No study has investigated which method is best. Plastic cord clamps effectively close all vessels in the umbilical cord and are easy to use. However, they are more expensive and may not be easily available.

The advantages and disadvantages of simple string ties or tapes have not been evaluated. There are no reservations about their use and they are widely available. The tie should be at least 15 cm in length to allow effective tying, i.e. tight enough to occlude the umbilical vessels in order to prevent bleeding when the jelly shrinks and dries.

No study comparing sterile ties with clean ties or clamps was found. It is generally recommended that the ties/clamps be sterile since they are in contact with a mucous membrane.

Some authors suggest clamping the cord with a rubber band since inelastic tying material such as thread or string may loosen after a day and increase the risk of bleeding and infection. However, an instrument is needed to apply the rubber band.[59] The rubber band must be very small to be effective.

Cutting the cord

A sterile and sharp instrument, such as a new razor blade or scissors, is usually recommended for cutting the cord. Experience with a blunter instrument resulted in more vessel spasm and thus less blood loss.[24] However, using a blunt instrument could possibly result in an increased incidence of infection due to more trauma to the tissues. The cord must always be clamped or tied tightly before cutting.

Length of the cord stump

The recommended length of the stump after cutting is usually 2 or 3 cm. Some authors recommend clamping the cord 3-4 cm clear of the abdominal wall to avoid pinching the skin or clamping a portion of the gut which, in very rare instances, may be inside the cord. A long stump could possibly increase the risk of infection because it is harder to keep clean and dry. However, this has not been demonstrated in any study. In many cultures the custom is to leave the cord long for reasons that are believed to be of vital importance to the newborn (see section on traditional practices above); in such cases, the importance of keeping the cord clean and dry and of not letting it come in contact with urine and faeces should be explained to the family.

Care of the cord stump

Clean cord care at birth and in the days following birth is effective in preventing cord infections and tetanus neonatorum. Clean cord care is accomplished by the maintenance of aseptic technique so that the umbilical cord is uncontaminated by pathogens.

At birth, hands should be washed with clean water and soap before delivery, after any vaginal examination, and again before tying and cutting the cord. The newborn should be laid on a clean surface (such as the mother's abdomen) and the cord should be cut with a sterile instrument.

In the postnatal period, clean cord care includes washing hands with clean water and soap before and after care, and keeping the cord dry and exposed to air or loosely covered with clean clothes. The napkin should be folded below the umbilicus. Touching the cord, applying unclean substances to it and covering it with bandages should be avoided.

Other practices that may reduce the risk of cord infections are the use of 24-hour rooming-in instead of nurseries in institutions[7,8] (rooming-in also has many other benefits such as facilitating breast-feeding and bonding, and increasing the mother's confidence), and

skin-to-skin contact with the mother to promote colonization with non-pathogenic bacteria from the mother's skin flora. Early and frequent breast-feeding will provide the newborn with antibodies to help fight infections.

No study could be identified on methods of cleaning the cord should it become sticky or soiled; using clean water and soap (or just clean water if soap is unavailable) seems the most sensible. Cleaning with alcohol is not recommended as it delays healing and drying of the wound (see information on alcohol in the annex).

Over the years, mothers have been advised not to immerse an infant in a tub for bathing until the cord has separated because it has been assumed that immersing the cord in water would promote infection, prevent drying and delay separation. Daily baths in the form of sponge baths are, however, common practice in many hospitals because they are considered infection control measures. A study comparing daily bathing with no bathing has shown no difference in umbilical cord colonization or infection between the groups, and that immersing the newborn in a tub is not harmful to the cord.[60] However, the main issue here is thermal protection since bathing the newborn can induce hypothermia. The newborn should not be bathed before six hours after birth, or longer if possible, and measures should be taken to ensure that no heat loss occurs. Current recommendations direct that newborns should not be bathed routinely.

While there is general consensus that clean cord care decreases the risk of cord infection, the application of topical antimicrobials to the cord stump is more controversial. A 1997 systematic review of randomized controlled studies comparing different methods of cord care, was unable to conclude that application of topical antimicrobials is superior to just keeping the cord clean.[61] Studies from developed countries show that in hospital nurseries, the use of an antiseptic on the stump significantly reduces umbilical colonization rates. However, as mentioned earlier, the effect of such agents in reducing cord infections is less clear. Since most infections with hospital-acquired bacteria occur after discharge from the hospital, it is important that the evaluation of regimens for umbilical disinfection should prospectively follow up the infants after discharge. Unfortunately very few studies have done this. Some non-randomized studies that have followed up infants suggest that applying antiseptics to the cord stump reduces staphylococcal infections in the nursery and after discharge.[62,63] However, one randomized controlled study found no such effect.[9]

According to available studies, chlorhexidine, tincture of iodine, povidone-iodine, silver sulphadiazine and triple dye appear to be of most value in controlling umbilical colonization in hospital nurseries (see annex for more information on individual antimicrobials). Alcohol does not promote drying, is less effective against bacteria than other antimicrobials and delays cord separation. It is therefore not suitable either for cleaning or for routine application to the cord stump. While umbilical disinfection seems to be necessary in hospital nurseries to prevent the spread of bacteria, no studies indicate that this is needed in rooming-in babies or at home where clean cord care is practised.

Studies have shown that antimicrobials prolong the time it takes the cord to separate.[11,64,65,66] The clinical significance of this delay has not been studied, but it appears to be of no medical consequence. However, late separation of the cord is disliked by parents as it worries them and entails more home visits by midwives, thus increasing their workload and the cost of postnatal care.[2]

Another disadvantage of using topical antimicrobials is increased cost. Depending on the products used, the cost of this intervention ranges from about US$ 0.38 to US$ 1.50 for each baby.[66]

There are very few studies of the effect that applying antimicrobials to the stump has on the incidence of cord infections in developing countries, either in institutions or at home.

A population-based study in rural parts of Pakistan, where mothers delivered at home under unclean conditions and where living areas are often in close proximity to animals and animal dung, found that the use of a topical antimicrobial on the cord stump at delivery and during the first few days after delivery was highly protective against neonatal tetanus as compared to applying nothing to the wound.[67]

In conclusion, clean cord care practices should be the main focus of any clean delivery and cord care programme. There is not enough evidence to recommend the widespread use of topical antibiotics in developing countries. There is some evidence, however, that they are protective against neonatal tetanus when applied to the cord stump for the first few days. In some high risk areas, especially where the custom is to apply dangerous substances to the stump, it might therefore be useful to advise using a topical antimicrobial as a transitional measure to help wean the community away from harmful substances.[68] The use of antiseptics for cord care at home gives rise to some concern, however. There is a danger that the solutions used could be expired, of inappropriate concentration or contaminated, and may be applied with an unsterile rag. Use of antiseptics at home, and the logistics of supply, therefore need close supervision.

IMPLEMENTATION OF CLEAN CORD CARE PRACTICES

Countries with a high incidence of neonatal tetanus and sepsis and with high maternal mortality rates need to make a strong commitment to eliminating neonatal tetanus and reducing sepsis from cord infections. These countries should take steps to promote clean delivery, clean cord care practices and the immunization of pregnant women with tetanus toxoid, and should set national policies and standards for these measures. Target areas for priority action, such as deliveries at home and at peripheral maternity facilities in high-risk areas, need to be selected. Objectives, targets and strategies for attaining the targets and monitoring indicators (e.g. percentage of births attended by a trained attendant) have to be defined.

Institutions may have to revise policies and standards for newborn care in accordance with national recommendations, and staff may need additional training to meet the new standards. Supplies and equipment for clean delivery, clean cord care and tetanus toxoid immunization should be made available. There should be a written policy on cleanliness for birth and cord care and for the immunization of pregnant women with tetanus toxoid that is routinely communicated to all staff. Nurseries for newborns should be replaced with 24-hour rooming-in. The necessary equipment and supplies to ensure clean delivery and cord care should be made available. These include a water supply, soap, sterile ties/clamps, scissors/blades, gauze and topical antimicrobials if necessary. If an institution has no sterilization facilities available, disposable delivery kits could be used.

At community level, the introduction and maintenance of clean delivery and clean cord care practices is relatively easy in most homes. However, living conditions in some rural areas - where there is an inadequate supply of clean water, lack of fuel and supplies, and unsanitary housing - can make some of the recommended practices more difficult to implement. The provision of disposable delivery kits containing at a minimum a new razor blade, clean ties and a piece of soap, will facilitate clean cord care in these settings and elsewhere. Traditional birth attendants and families should be trained in the correct use of these kits. If the kits are not available, local technologies can be exploited: for instance, leaves used locally as detergents can be used instead of soap, and the knife for cutting the cord and local materials used for ties can be boiled before use.

Traditional practices may also conflict with recommendations. The application of cow dung or another harmful substance to the cord stump may be deeply rooted in the local culture, for example, and applying nothing to the cord may be unacceptable. Suggesting the use of a safe alternative substance (e.g. an antiseptic) may therefore be appropriate in such circumstances. If cultural tradition demands binding of the newborn's abdomen to protect the stump from "bad air", it may be difficult to recommend air drying of the stump. In this situation it will be more beneficial to provide information on more sanitary methods of binding, such as covering the stump with a clean piece of gauze and a clean bandage that is frequently changed.[30]

Teaching traditional birth attendants and families about clean cord care is not always an easy undertaking as people's traditional frame of reference is often based on religious or supernatural beliefs as opposed to the physical and technical approach of scientific medicine. Local practices and the intention behind them must be understood properly before change can be introduced. People's traditions and beliefs must be used as a basis for introducing new practices. For example, to help people understand the phenomenon of bacterial contamination of the cord stump by hands, ties and cutting tools, comparisons can be drawn with other local concepts and practices that are beneficial, and local terminology on the transmission of diseases can be used.[69]

Educational activities and the provision of disposable delivery kits should be complemented by increased coverage of women of childbearing age with tetanus toxoid immunization.

CONCLUSIONS AND RECOMMENDATIONS

There is a wide variety of practices for cord care at birth and until the separation of the stump. Some are clearly harmful and should be eliminated or replaced with safer alternatives, others are beneficial and should be encouraged. But for many practices insufficient evidence exists to support a clear recommendation. In developing countries, some traditional practices and unclean living conditions increase the risk of neonatal tetanus and umbilical sepsis. In developed countries, hospital nurseries increase the risk of cord infections by facilitating the spread of staphylococcal and other bacteria. The variety of cord care regimens raises the issue of the cost associated with unnecessary routines.

Current medical cord care practices are overwhelmingly based on research from hospital nurseries in developed countries. Some of these practices, such as early cord clamping/active management of the third stage or applying antiseptics to the cord may not apply to developing countries where most deliveries take place at home and resources are scarcer. There is still no complete answer to the question of what constitutes the best cord care. More research is needed on cord care, especially in situations of limited resources. However, despite the lack of data from developing countries, some recommendations can be made on the basis of the soundest available evidence. These recommendations are summarized below.

Timing of cord cutting will depend on the use of active management (combination of routine oxytocin administration, early cord cutting and controlled cord traction) of the third stage of labour. If active management is practised, as is the case in many obstetric departments worldwide, then early cord clamping is mandatory. The use of active management of the third stage may decrease the risk of postpartum haemorrhage but doubts remain about its application to low-risk women. Physiological management (no oxytocin, no controlled cord traction, delaying cord cutting until pulsations stop or the placenta is delivered) is not associated with adverse effects, is in accordance with traditional beliefs, may play a role in the prevention of iron deficiency anaemia and can be recommended for normal deliveries at home and in institutions.

Clean cord care at birth and in the days following birth is effective in preventing cord infections and tetanus neonatorum. Clean cord care practices at birth include washing hands with clean water and soap before delivery, laying the newborn on a clean surface, washing hands again before tying and cutting the cord, and cutting the cord with a sterile instrument.

Clean cord care in the postnatal period includes washing hands with clean water and soap before and after care, and keeping the cord dry and exposed to air or loosely covered with clean clothes (if custom demands binding of the abdomen a sanitary method such as the use of a clean piece of gauze can be recommended). The cord should be washed when necessary with clean water and soap (cleaning with alcohol seems to delay healing), and the napkin should be folded below the umbilicus. Touching the cord, applying unclean substances to it and applying bandages should be avoided.

Other practices that may also reduce the risk of cord infection are the use of 24-hour rooming-in instead of nurseries, and skin-to-skin contact with the mother at birth to promote

colonization of the newborn with non-pathogenic bacteria from the mother's skin flora. Early and frequent breast-feeding will provide the newborn with antibodies.

Research from developed countries has shown that, compared to no treatment, application of a topical antimicrobial to the cord stump reduces umbilical colonization by harmful bacteria in hospital nurseries. Chlorhexidine, tincture of iodine, povidone-iodine, triple dye and silver sulphadiazine seem to be the most effective. Although topical antibiotics are effective, their use should be questioned in light of the development of resistance.

There is not enough evidence to recommend the widespread use of topical antimicrobials on the cord stump. The decision to use them will depend very much on local circumstances. In hospitals, if newborns are kept in nurseries or in intensive care units, it is probably best to apply a topical antimicrobial to the cord stump at birth and for the first three days to prevent umbilical colonization with pathogenic bacteria and cross-infections. The choice of the substance will depend on the predominant flora (usually *S. aureus*, but sometimes also gram-negative organisms). If this is unknown, the chosen antiseptic should have a broad spectrum of activity and should be culturally acceptable, affordable and available (see summary table on antimicrobials, page 26). If a 24-hour rooming-in system is in place and the mother is the main care-giver, application of an antiseptic is probably not needed as the risk of contaminating the cord is much lower.

For home deliveries and for cord care after discharge from hospital, clean cord care is sufficient and the application of an antiseptic is not required. In areas at high risk of neonatal tetanus or where harmful practices such as putting cow dung on the stump are prevalent, an antimicrobial can be recommended to replace the harmful substance. The chosen antimicrobial should have a broad spectrum of activity against bacteria and should be cheap, culturally acceptable (a coloured antiseptic is usually preferred) and available. If other harmful practices are prevalent, they should be discouraged or replaced with safer alternatives: for example, if it is the custom to put bandages on the cord stump, a more sanitary alternative such as a clean piece of gauze can be recommended.

Countries should take steps to promote clean delivery, clean cord care practices and the immunization of pregnant women with tetanus toxoid. Institutions may have to revise policies and standards for newborn care in accordance with national recommendations and the staff may need additional training. Supplies and equipment should be made available. At community level, local cord care practices should be studied. Information, education and communication (IEC) activities for families and traditional birth attendants should be carried out on the basis of such research. Beneficial practices should be promoted, neutral ones left alone and harmful ones replaced with safer alternatives that are acceptable to the community. Disposable delivery kits containing at a minimum a new razor blade, clean ties, a piece of soap and instructions for use can be made available to mothers and traditional birth attendants through prenatal clinics or women's groups. Coverage of women of childbearing age with tetanus toxoid immunization should be increased.

FUTURE RESEARCH

Future research on cord care should focus on the following:

- Timing of cord clamping, to identify which timing has most beneficial effects for term and preterm infants and their mothers.

- The normal process of cord separation.

- Care of the cord stump. Hospital and community-based studies are needed in developing countries to compare the risk of cord infection and neonatal tetanus when the cord is kept clean and dry and nothing is applied to it with the risk when an antimicrobial or a dusting powder is used. The research questions to be answered include:
  - Will the application of an antimicrobial agent to the cord at the time of cutting and in the first few days after birth decrease the rate of cord infections and neonatal tetanus, particularly in situations where the recommended clean delivery and clean cord care practices are unlikely to be met (home deliveries)?
  - If yes, which antimicrobial agent is most effective - on the basis of what is known about biology, safety and cost?
  - How often must the agent be applied each day and for how many days after birth?
  - Which outcome measures will be evaluated and how will they be monitored?

- Most common bacteria causing neonatal umbilical infections in developing countries.

- Effective antimicrobials for the control of umbilical infection in high-risk areas.

- Antibiotics for treatment of umbilical infections.

- Appropriateness of using antimicrobials for cord care when the risk of cross-infection is low (24-hour rooming-in, cord care at home in clean environments, no harmful traditional practices).

- Qualitative and behavioural research in communities:
  - What are local cord care practices, and which ones are harmful, beneficial or neutral?
  - How can families and traditional birth attendants be convinced that harmful practices are indeed harmful, and what safe, acceptable alternatives can be suggested?
  - What are appropriate local technologies that can be exploited (for cutting cord, for ties, for washing hands etc.)?

- Research to establish the pharmacological properties of traditional substances (e.g. herbs or leaves used as detergents for washing hands) or antiseptic and drying properties of traditional substances used on the cord stump (including breast milk/colostrum).

ANNEX

THE MOST COMMON TOPICAL ANTIMICROBIALS

Below, in alphabetical order, are the antimicrobials most commonly used for cord care. The characteristics of each antimicrobial and the experience with its use, as gathered from review of the literature, are described. Almost all evidence for effectiveness comes from studies in hospital nurseries in developed countries.

Alcohol

Alcohol (e.g. 70% ethanol, or isopropanol) rapidly kills most bacteria within two minutes, provided the area is kept moist. However, when alcohol is applied with a single wipe and left to evaporate, no more than a 75% reduction of bacterial flora should be expected. Alcohol has no prolonged action and is not sporicidal. It is sometimes used as a vehicle for other germicidal compounds, such as iodine preparations, and increases their efficacy. Applied to wounds or raw surfaces, alcohol not only increases the injury but also forms a coagulum under which bacteria may subsequently thrive.[70] Isopropanol is more irritating than ethanol and has been associated with skin burns in neonates.

Alcohol has been shown in many hospital studies to be less effective in controlling umbilical colonization and skin infections than other antimicrobials such as triple dye or chlorhexidine.[62,71,72] Alcohol has also been shown to delay cord separation.[66,73] Theoretically alcohol has a drying effect; however, clinical observations show that cleaning the cord with alcohol even once renders it soft and moist.[64]

Chlorhexidine

Chlorhexidine is rapidly bactericidal to both gram-positive and gram-negative bacteria, although some gram-negative bacilli are relatively resistant (some species of Pseudomonas and Proteus). Chlorhexidine is weakly virucidal, is not sporicidal and has little effect on fungi. It has a long duration of action and a low toxicity. It is effective in the presence of soaps, blood and pus, although activity may be somewhat reduced. Skin sensitivity to chlorhexidine has occasionally been reported.[70]

Chlorhexidine as a 4% detergent water solution (Hibiscrub) has been shown to be more effective than alcohol and 10% iodosan in controlling staphylococcal and streptococcal umbilical colonization and infections of the skin and cord, but it was associated with significantly longer cord separation time, resulting in an increased workload for community midwives. It has thus been suggested that use of chlorhexidine be limited to the first few days in hospital and not be continued by the mother after discharge.[62,72,74] One study found that delay in cord separation did not occur with 1% chlorhexidine powder (Hibitane); this was attributed to the astringent properties of zinc oxide in the powder.[75]

There are occasional reports of the percutaneous absorption of chlorhexidine in neonates. One study found that this happened when preterm newborns were treated with a 1% solution of chlorhexidine in ethanol. No absorption was observed in term infants similarly

treated or in preterm infants treated only with a dusting powder containing 1% chlorhexidine.[76] Thus the use of the powder is a better choice for preterm newborns.

Dusting powders

Several studies have shown that dusting powders promote rapid healing of the umbilical stump and early separation time.[2,73] Dusting powders formulated with talc, starch or alum and zinc oxide have been shown to promote faster healing of the stump than powders containing hexachlorophene.[2] Zinc oxide with its astringent properties is probably important in promoting drying and healing of the stump.

Gentian violet

Gentian violet (crystal violet) is a dye which, like the other components of triple dye, is effective against gram-positive organisms and some yeasts such as Candida. It is less effective against gram-negative organisms, and ineffective against acid-fast bacteria and bacterial spores. Gentian violet is normally used as a 0.5% solution for the treatment of skin pustules and mycotic infections. There are no studies of its effectiveness with respect to cord care.

Hexachlorophene

Hexachlorophene is not recommended for newborns because it is absorbed through the skin and has been shown to be neurotoxic.[77,78,79] In the past, it was used as a 3% solution in hospital nurseries for bathing newborn babies to control staphylococcal colonization.

Dermal absorption of hexachlorophene is very low when it is used as a powder in 0.33% concentration.[80] Hexachlorophene powder reduces bacterial colonization of the cord but also delays healing and necessitates more postnatal visits by midwives where a system of visiting is in place.[2]

Iodine tincture

Iodine tincture contains approximately 2% iodine and 2.4% sodium iodide diluted in 50% ethanol. Iodine is bactericidal, sporicidal, cysticidal and virucidal. Gram-positive and gram-negative bacteria are almost equally affected. Its action persists for several hours although it gradually diminishes after 15 minutes. It is of low toxicity to tissues.

Tincture of iodine has been widely used for cord care. No systematic evaluation of its effectiveness was found.

Iodophor agents

Iodophors (e.g. 10% povidone-iodine) are loose complexes of elemental iodine with a carrier molecule which serves as a sustained-release reservoir of iodine. The organic carrier augments dispersibility and penetrance. At 10% concentration, povidone-iodine is bactericidal against gram-positive bacteria and most gram-negative bacteria, has good fungicidal and virucidal activity, but is inactive against spores. Water solutions can be used on mucous membranes. The effects of povidone-iodine on skin flora are not as marked as

those of iodine tincture and, contrary to what one would expect, the duration of action is not longer. The effects are influenced by the presence of organic matter. Allergic reactions may occur.[70]

Povidone-iodine was shown in one study to be as effective as triple dye, silver sulphadiazine and bacitracin in controlling umbilical colonization in a hospital nursery and was associated with the shortest cord separation time.[81] However, other studies have shown that iodophor agents are not as effective as chlorhexidine or bacitracin ointment.[74,82]

0.5% povidone-iodine was shown to be effective *in-vitro* against *Neisseria gonorrhoea*, *Chlamydia trachomatis* and the herpes simplex type II virus.[83] Another study showed that 2.5% povidone-iodine is an effective agent for ocular prophylaxis to prevent ophthalmia neonatorum.[84] This finding is of practical interest as a single solution could be used for eye and cord care. Povidone-iodine has no reported toxicity to the cornea and conjunctiva when applied topically in a single dose to the ocular surface.

Iodine is absorbed through the skin and its use for cord care has been associated with an increase in the rate of transient hypothyroidism, interfering with congenital hypothyroidism detection programmes. The effect on the thyroid was related to the number of applications and was reversible. Thyroid function tests quickly returned to normal after treatment was discontinued.[85,86] It is not known whether povidone-iodine would have the same effect on the thyroid in iodine-deficient populations. Povidone-iodine is most probably safe to use in healthy full-term infants with no iodine exposure other than umbilical applications.

Silver sulphadiazine

Silver sulphadiazine contains sulphonamide which is active against many gram-positive bacteria. The silver ions it contains exert a prominent action against Pseudomonas and gonococci. It has an immediate germicidal effect and a sustained bacteriostatic action. Bacterial resistance to sulphonamide and allergic reactions may result from its use.[70]

Several studies have shown that silver sulphadiazine is as effective in reducing umbilical colonization as triple dye, bacitracin and povidone-iodine, and that it is superior to bathing with soap. Silver sulphadiazine was found to be more effective against group B streptococci and gram-negative organisms than triple dye, but less effective against *S. aureus*.[87,88,89]

Topical antibiotics

Bacitracin and nitrofurazone (Furacin) ointments are effective against a variety of gram-positive and gram-negative bacteria, including clostridia. Furacin imparts a yellow colour to the skin. The aminoglycoside neomycin is ineffective against clostridia, as is the antibiotic polymyxin.

Several studies have shown that topical antibiotics are effective in controlling umbilical colonization in hospital nurseries but these trials are small and fail to deal with the potential development of resistant organisms or with the effect of these agents on colonization by other bacteria. .[81,82,90]

To reduce risk of development of resistance, antimicrobials that are used systemically should not be used topically

Triple dye

Triple dye is a combination of brilliant green (0.2%), proflavine hemisulfate (0.1%) and gentian violet (0.1%). It is bacteriostatic against gram-positive bacteria but less effective against gram-negative bacteria. It is fungicidal but has weak virucidal activity and is not sporicidal. It colours the skin bright purple. Triple dye has the advantage of a prolonged antibacterial effect after a single application.

In several studies, triple dye was found to be more effective in reducing umbilical colonization by staphylococcal and streptococcal organisms in hospital nurseries than alcohol, [91] hexachlorophene,[92] bacitracin ointment[93] and povidone-iodine.[94] It is effective even if applied only once. Triple dye has also been shown to reduce colonization by methicillin-resistant *S. aureus* although it could not totally eradicate the organism.[95]

However, triple dye is not effective against group B haemolytic streptococcal organisms; it may in fact promote colonization from this organism, as well as from gram-negative organisms.[96,97] Triple dye may increase cord separation time.[81,98] Crystal violet, one of the components of triple dye, has been associated with necrotic skin reactions in adults and babies.[99] Sensitization to brilliant green, another component of triple dye, has been reported.[100]

Summary table of antimicrobials for cord care

Substance	Action					Advantages	Disadvantages	WHO drug list	Price US$
	G+	G-	Clostridia		Prolonged action				
			Spores	Vegetative cells					
Alcohol 70%	++	++	No	?	No	Cheap, available	Less effective than other antiseptics No drying effect Delays cord separation	Yes	0.38 for 100 ml
Chlorhexidine 4% detergent solution	++	+	No	Yes	Yes	Good persistent effect, low toxicity	Expensive	Yes	0.51 for 100 ml
Dusting powder with zinc oxide	No	No	No	No	No	Promotes drying and healing, cheap	No effect on micro-organisms	No	NA
Gentian violet 0.5% water solution	++	+	Poor	Yes		Available, effective	Stains skin and clothing No evidence on use for cord care	Yes	1.39 for 25 g powder pack
Iodophors 10% water solution	V+	+	No	Yes	No	Effective, short cord separation time	Mild suppression of thyroid function (reversible) Allergic reactions may occur	No	0.42 for 100 ml
Iodine tincture 2% alcohol solution	++	++	Poor	Yes	No	More effective than iodophors	Mild suppression of thyroid function (reversible)	Yes	2.1 for 100 ml
Silver sulphadiazine 1%	++	+	No	Yes	Yes	Good persistent effect	Bacterial resistance to sulphonamides can occur Allergic reactions in 1%	No	NA
Triple dye (0.2% brilliant green, 0.1% proflavine hemisulfate, 0.1% gentian violet) water solution	++	Fair	No	Yes	Yes	Effective	Increases cord separation time Stains skin and clothing Not effective against group B haemolytic streptococci	No	NA
Topical antibiotics	++	++	No	Yes (bacitracin and nitrofurazone)	Yes	Good persistent effect	Potential development of resistant organisms Expensive	No	NA

Legend: G+ = gram-positive bacteria; G- = gram-negative bacteria; ++ = very good; + = good

GLOSSARY

Asepsis or aseptic technique: the combination of efforts made to reduce the number of microorganisms on both living surfaces (skin and tissue) and inanimate objects (e.g.instrument used to cut the cord)to a safe level in order to prevent infection.

Antimicrobial: an agent that kills or inhibits microorganisms.

Antiseptic: an agent applied on the skin or other body tissue that kills or inhibits microorganisms.

Colonization: the implantation and growth of microorganisms on a host.

Controlled cord traction: this involves traction on the cord, combined with counterpressure upwards on the uterine body by a hand placed immediately above the symphysis pubis.

Extravasation: leaking out of fluid from the blood vessels into the tissues.

Flora (of skin): microorganisms which normally live on the skin without causing disease.

Hypervolaemia: abnormally increased volume of blood.

Normal birth: a birth at term that is spontaneous in onset, low-risk at the start of labour and remains so throughout labour and delivery; the infant is born spontaneously and in the vertex position; after birth the infant and mother are in good condition.

Nosocomial infection: an infection acquired in the hospital from cross-infection and/or lack of hygienic precautions.

Omphalitis: infection of the umbilicus.

Pathogenic: causing disease.

Patent: open.

Prophylactic: a prophylactic measure is one which attempts to prevent disease from occurring.

Rooming-in: a hospital care system for newborns in which the baby is kept with its mother during the hospital stay.

Skin-to-skin contact: a method of keeping the newborn warm by placing the baby naked or lightly dressed directly on the mother's (or other adult's) skin (chest or abdomen).

Topical: applied externally, on the skin or a mucous membrane.

Umbilicus: the cord stump.

Viscosity: how easily blood flows in the vessels; for example an increase in the number of red blood cells could cause increased stickiness of blood resulting in slower blood flow.

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