Percutaneous catheter use in newborn infants with parenteral nutrition

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Abstract

The well known negative effect of infection on nutrition causes the cycle ‘infection–malnutrition–infection’. Prolonged parenteral nutrition requires central venous catheterization. Due to the possibility of ‘catheter related sepsis’ (CRS) catheters should be used correctly to avoid septic complications. A very high percentage of central venous catheters (CVC) removed because of presumed infections are not infected when culture is done. In some patients infections are successfully treated with antibiotics without catheter removal. Removal of the line is recommended when catheter-associated sepsis is suspected or proven, but not for the extremely ill preterm infant or when such removal may be impractical. A therapeutic protocol is suggested to avoid future canalizations in the neonate, sometimes in a critical situation. Current literature referring to CRS in the newborn infant is reviewed. © 1998 Elsevier Science Ireland Ltd. All rights reserved.

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1. Introduction

The use of a central venous catheter (CVC) has become a common paediatric practice. It has many benefits but sometimes the high risk of infection is neglected. The risk of catheter infection is increasing in Neonatal Units due to the frequent use of CVC in immature newborn infants.

Catheter-related sepsis (CRS) is defined as confirmed clinical sepsis and positive culture of the same microorganism in blood and in the catheter tip.
The use of CVC is sometimes necessary but when CRS is suspected the moment to remove it has not been defined. Some authors recommend treating the infection with antibiotics to avoid another canalization. In daily practice, the dilemma is whether to remove the catheter or to treat the infection. It seems logical to use antibiotics in stable neonates but, what should be done when dealing with non-stable neonates, preterm neonates or when there is evidence of CRS? To answer this question a therapeutic protocol to be applied when there is risk of sepsis has been developed.

2. Catheter related sepsis: Initial evaluation

In every newborn infant with CVC and symptoms of sepsis (lethargia, abnormal respiratory patterns, including apnea, thermic instability, . . . ) there exists the possibility of CRS. The following risk factors may confirm the suspicion of CRS [1].

2.1. Parenteral nutrition

The establishing composition of parenteral nutrition facilitates the colonization and growth of microorganisms. The risk of infection is higher as long as the time of parenteral nutrition lasts [5].

The presence of lipids in parenteral nutrition is considered an important risk factor of nosocomial bacteremia. The pathogenic hypotheses are: (a) intravenous lipid emulsion facilitates the growth of bacteria and Candida species in the catheter; (b) lipid emulsions have been reported to impair a number of neutrophil and macrophage antibacterial functions, and so infection can easily appear. A common situation of CRS is the combination of an immature newborn infant with CVC and parenteral nutrition supplemented with lipids.

2.2. Slime producing microorganisms

When sepsis is due to microorganisms such as S. epidermidis or Candida, CRS must be considered. All microorganisms can adhere to the irregular surface of the catheter but some have a viscous extracellular substance, presumably polysacharide, that sticks them to the catheter surface [2]. This substance has three functions: adhesion, forming a barrier around the bacteria to avoid the penetration of antibiotics, and protecting the organism from the host defenses.

2.3. Very small infants of low birthweight (< 1.500 g) or born before 32 weeks gestation

There is an inverse relationship between weight at birth and the risk of infection. Some authors refer to birth weight as the risk factor that has most relation to infection in neonates, especially if the weight is < 1.500 g and/or birth occurs before 32 weeks’ gestation.
2.4. Previous antibiotics

The use of broad spectrum antibiotics can affect the resistance of normal flora to colonization. It facilitates the proliferation of pathogens and the appearance of resistant microorganisms.

2.5. Postnatal age at the time of catheterization

The older the neonate, the greater is the risk of complications, remembering that a neonate is colonized by microorganisms at the fifth day of life. Coagulase-negative staphylococci are among the main microorganisms in the first week of life, and at the same time are the most important microorganisms in CRS.

2.6. Duration of catheterization

The longer the catheter is maintained, the higher is the risk of sepsis. This risk greatly increases after the seventh day. There is a direct relationship between the duration of catheterization and the risk of infection.

2.7. Technical conditions for catheterization

A strictly aseptic technique is needed for insertion of the central venous line under sterile conditions. Any neonatal unit utilizing central catheters should develop specific protocols in conjunction with the surgeons and the infectious disease coordinator.

2.8. Types of catheterization

Central catheterizations become more frequently infected than peripheral ones but the catheter infection/duration of catheterization rate is lower in central catheters, perhaps because of the greater distance between skin and blood.

3. Pathogenesis [6,7]

The most common microorganisms in sepsis are those colonizing the skin and mucous membranes, and the material of the catheter. CRS pathogenesis is based on the following two considerations.

3.1. Routes of infection

- *Skin and extraluminal progression:* 48–72 h after inserting the catheter into the vascular space, it develops an external fibrine sheath. If microorganisms colonize this sheath, they can easily grow, unaffected by any host defence.
- *Endoluminal connection and progression:* In many cases, CRS occurs due to incorrect manipulation of the catheter infusion system.
Contamination of the liquid to be injected: This is not common, but has been described.
Colonization of the catheter secondary to bacteremia.
Catheter composition: Silicone has been found to be the safer material for long canalizations because of its lower risk of infection.

3.2. Microorganisms

Staphylococci are the most common pathogens producing CRS. This is because they are ubiquitous cutaneous microorganisms, easily adapted to the surrounding areas and have the capacity to colonize catheters [3].

4. Diagnostic [4,8–10]

4.1. Clinical diagnosis

There is no pathognomonic sign of sepsis in neonates, and sometimes it can be suspected in apparently healthy neonates with lethargy, digestive intolerance or thermic instability. The presence of inflammatory signs around the puncture site is also indicative.

4.2. Laboratory diagnosis

4.2.1. Haemogram

Occasionally, these patients could present neutropenia, leukopenia, increasing rates of immature neutrophils/total neutrophils, trombocytopenia . . .

4.2.2. C-reactive protein

C-Reactive Protein is the most commonly used acute phase reactant. Many studies have demonstrated its utility in assessing a neonate with suspected sepsis; this is an important diagnostic test for discriminating infection and contamination.

4.2.3. Other laboratory diagnoses

Metabolic acidosis, hyperglycemia, hypoglycemia . . . In late-onset injection, the cerebrospinal fluid and coagulation (fibrinogen) abnormalities are less common than in early onset injection.

4.3. Microbiological techniques

These are necessary to confirm infection in the puncture site, to determine the presence of bacteremia and to predict colonization of the catheter without removing it.
4.3.1. Techniques to confirm infection in the puncture site

4.3.1.1. Qualitative cultures. This technique requires the removal of the distal segment of the catheter and its submersion in a liquid medium. Infection is diagnosed when a microorganism appears; however, the technique does not distinguish between infected or contaminated catheters or those contaminated on removal.

4.3.1.2. Semiquantitative cultures. The Maki’s technique consists of rotating 4 distal cm of the removed catheter in a blood agar plate at 5% at least 4 times. Fifteen or more CFU/ml is considered positive, and suggests catheter infection, while <15 CFU/ml indicates a colonized catheter. False negatives may appear because microorganisms on the internal surface of the catheter could not be detected.

4.3.1.3. Quantitative cultures. The Cleri’s technique consists of aseptically removing the distal segment of the catheter and dividing it into a 1 cm proximal fragment (subcutaneous) and another segment of variable length including the intravascular portion of the catheter. The subcutaneous fragment is introduced into 2 ml of tryptic soy broth (TSB). The intravascular segment is introduced into 2 or 10 ml of TSB, depending on length, and then both are washed. From each tube 0.1 ml is plating in blood agar plate. It is considered positive if 1000 or more CFU are found. This technique enables contamination on both sides of the catheter to be identified that is important as the intravascular side has been shown to present a higher rate of colonization than the subcutaneous.

4.3.1.4. Quick technique. Introducing the catheter with cebro oil into different sumps to visualize the external and internal presence of microorganisms. This is a very criticized technique, but it has predictive results superior to those obtained 24 h later with Maki’s technique.

4.3.2. Techniques to investigate the presence of bacteremia

Qualitative blood cultures obtained from peripheral veins demonstrate bacteremia, but not the origin.

4.3.3. Techniques to predict colonization of the catheter without removing it

Two techniques are: (a) quantitative blood cultures; (b) superficial cultures.

5. Prophylaxis

5.1. Indications for percutaneous central nervous catheterization

Use central venous catheterization only when required. Catheter use should be inspected daily. Duration of catheterization must be as short as possible. The catheter should not be routinely removed.
5.1.1. Indications

(a) To administer parenteral nutrition when osmolarity of solution is too high for peripheral vessels.
(b) For long-term intravascular access for administration of medications.
(c) A less common indication in premature babies is monitoring central nervous venous pressure.

5.2. Type of cannula

Always use the least trombogenic and flebotoxic cannula (silastic, teflon).

5.3. Technique

Insertion must be strictly aseptic and the cannula securely fixed.

5.4. Insertion site

Upper veins have less incidence of infection than lower ones.

5.5. Supervision of insertion site

Perform a daily inspection of the insertion site to evaluate the development of clinical signs of infection.

5.6. Perfusion systems

The system should be completely changed every 48 h. Surrounding areas must be disinfected to create a sterile zone, paying special attention to connection points.

Other considerations relevant to prophylaxis are the addition of heparine in a dose of 1 UI/ml to intravenous nutrition solutions as it has been shown to decrease the incidence of positive cultures in catheters and sepsis. The operators should be well trained to work with parenteral nutrition and intravenous liquids; and, finally, prophylaxis with low doses of vancomycin or teicoplanin in neonates weighing < 1.500 g is used in some Intensive Care Neonatal Units, to prevent coagulase negative staphylococcal sepsis.

6. Treatment

If the infant develops clinical signs indicative of infection, an evaluation following our protocol is conducted including a complete blood cells count and cultures of blood, urine, and cerebrospinal fluid when indicated. Blood is extracted through a peripheral catheter and antibiotic therapy initiated or optimized, including fungal treatment (Fig. 1).
The first question to consider is the possibility of removing the central line and continuing with a peripheral catheter. This can be done in stable neonates and in those not needing very high osmolar solutions. If an infected catheter is removed at the beginning of sepsis, recovery can sometimes be achieved without using antibiotics.

If changing to a peripheral catheter is not possible, local signs of infection should be considered (erythema, inflammation, gross evidence of purulence). Note that venous thrombosis is sometimes not infectious, depending on the duration of the catheterization and on therapies such as vancomycin. In these cases, we always...
remove the catheter because the risk of infection in phlebitis is 8 times higher. If the infant does not develop signs of local infection, drawing blood through the central catheter should be considered. If possible, blood is extracted through the peripheral catheter line to perform a differential recount of CFU/ml. If this recount is 4 times higher in the central catheter than in the peripheral catheter, it is evident that bacteremia is caused by catheter infection and its removal is necessary. This technique cannot be used with neonates because of the high risk of coagulation or breakage of the catheter in central canализаtions. If drawing blood through the central catheter line is not possible, or the CFU count is lower than 4 times that of the peripheral catheter, sepsis and blood culture evaluations should be considered after 48 h of antimicrobial therapy.

6.1. Sepsis evaluation

If there is improvement in the neonate the catheter will continue to be used; if there is no improvement, risk factors should be considered. If two or more risk factors are present the catheter must be removed and antibiotic therapy optimized. If there are no risk factors the sepsis is evaluated 24 h after administering appropriate antibiotics. If there is improvement, the catheter should be kept in place; otherwise, the catheter must be removed (Fig. 2).

6.2. Blood culture evaluation

A blood culture which is positive to Candida species requires instruction in addition to fungal treatment. Some authors propose the use of echocardiography to evaluate the possibility of endocarditis, as fungus, enterococci and staphylococci are known to be the main microorganisms in endocarditis in neonates fitted with catheters. If the blood culture is negative but clinical and laboratory tests are positive fungal infections must be considered. There are many cases of fungal sepsis with a

1. Limo producer microorganisms

2. Very small infants of low birthweight (less than 1,500 g) or born before 32 weeks’ gestation

3. Previous antibiotics

4. Parenteral nutrition lasting more than four days

5. Infants’ postnatal ages at the time of catheterization five or more days

6. Catheterization being more than seven days with treatment

Fig. 2. Risk factors.
negative blood culture for which the treatment must be optimized. If the blood culture is positive the appropriate antibiotics are administered via sterile connections through the CVL. If on re-evaluating the blood culture obtained through the catheter, after 24–48 h of treatment, bacterial growth is still apparent, the line should be removed and an echocardiograph obtained. It is obvious that if we remove the catheter for examination, catheter related sepsis will be confirmed.

References