

# Neonate with intravenous therapy: a literature review addressed to risk prevention

Clara Teresita Morales-Álvarez <sup>1\*</sup>; Maritza Lizeth Cárdenas-Rodríguez <sup>2</sup>; María Mercedes Moreno González <sup>3</sup>; José Manuel Herrera Paredes <sup>4</sup>

## ABSTRACT

**Introduction:** Neonatal intravenous therapy is the most used tool for the relief of several pathologies. This therapy is indispensable to administer drugs, parenteral nutrition, blood products, liquids and electrolytes in ill or critically ill newborns. Therefore, it should be considered as a lifeline, since it results essential for the success of the treatment, and for that reason its care should be meticulous. **Objective:** Provide an update in the praxis of the neonate intravenous therapy, which allows health care personnel to make assertive decisions in regards to care, and subject to scientific evidence. **Methodology:** A review of the scientific work was performed in English and in Spanish in scientific and medical databases such as PubMed, Scielo, Lilacs, and Science Direct. **Results:** 104 articles about topics related to neonate child intravenous and pediatric therapy were found, those which reported concrete data about the analysis population were chosen, and those which only mentioned pediatric population data among their results, were excluded. **Conclusions:** Available national and international scientific literature allows the health personnel to improve the neonate care in regards to the intravenous therapy, by inviting to the reflection on the risk-free practice, in an informed way, and, consequently, more humane.

**Key words:** Newborn; nursing care; intravenous infusion (DeCS).

<sup>1</sup> Master Degree in Nursing. Universidad de Guanajuato. Department of Nursing and Obstetrics. E-mail: [tmorales@ugto.mx](mailto:tmorales@ugto.mx)

<sup>2</sup> Master Degree in Nursing. Universidad de Guanajuato. Division of Health Sciences and Engineering. E-mail: [liz-a-y@hotmail.com](mailto:liz-a-y@hotmail.com)

<sup>3</sup> PhD in Nursing. Universidad de Guanajuato. Department of Nursing and Obstetrics. E-mail: [ma.moreno@ugto.mx](mailto:ma.moreno@ugto.mx)

<sup>4</sup> PhD in Nursing. Universidad de Guanajuato. Department of Nursing and Obstetrics. E-mail: [manuelherrera.seade@gmail.com](mailto:manuelherrera.seade@gmail.com)

**Received:** 4/11/2019

**Accepted:** 13/03/2020

\*Corresponding author: [tmorales@ugto.mx](mailto:tmorales@ugto.mx)

Copyright © 2020 SANUS  
Open Access article distributed under the  
terms of the Creative Commons License



### How to cite this article

Morales-Álvarez CT, Cárdenas-Rodríguez ML, Moreno-González MM, Herrera Paredes JM. Neonate with intravenous therapy: a literature review addressed to risk prevention. 2020; (13):1-14. [Access \_ \_ \_]; Available at: \_\_\_\_\_.  
month day year URL/DOI

---

# Neonato con terapia intravenosa: una revisión de la literatura dirigida a la prevención de riesgos

## RESUMEN

**Introducción:** La terapia intravenosa neonatal es la herramienta más utilizada para el alivio de diversas patologías. Ésta resulta indispensable para administrar fármacos, nutrición parenteral, hemoderivados, líquidos y electrolitos en neonatos enfermos o críticamente enfermos. Por lo tanto, debe ser considerada como una línea de vida, ya que resulta indispensable para el éxito del tratamiento y, por ello, su cuidado debe ser meticuloso. **Objetivo:** brindar una actualización en la praxis de la terapia intravenosa neonatal que permita al personal de salud tomar decisiones asertivas en el cuidado y con apego a la evidencia científica. **Metodología:** se desplegó una revisión de las obras científicas en idioma inglés y español en bases científicas PubMed, Scielo, Lilacs y ScienceDirect. **Resultados:** Se encontraron 104 artículos que abordaban tópicos relacionados con la terapia intravenosa neonatal y pediátrica, se eligieron los que reportaron datos concretos en la población de análisis y se excluyeron a los que entre sus resultados solo mencionaban datos de población pediátrica. **Conclusiones:** la literatura científica nacional e internacional disponible permite al personal sanitario mejorar la atención del neonato respecto a la terapia intravenosa, invitando a la reflexión sobre la praxis libre de riesgos, con conocimiento de causa y en consecuencia, más humana.

**Palabras clave:** Recién nacido; atención de enfermería; infusiones intravenosas (DeCS).

---

# Recém nascido com terapia intravenosa: uma revisão de literatura endereçada à prevenção de riscos

## ABSTRATO

**Introdução:** A terapia intravenosa neonatal é a ferramenta mais utilizada para o alívio de varias patologías. Esta terapia é indispensável paa administrar medicamentos, nutrição parenteral, productos de sangue, líquidos e eletrólitos em recém-nascidos doentes ou gravemente enfermos. Portanto, debe ser considerado como uma tábua de salvação, uma vez que resulta essencial para o sucesso do tratamento, e por ese motivo, seu cuidado debe ser meticoloso. **Objetivo:** Fornecer uma atualização na praxis da terapia intravenosa do neonato, que permite ao pessoal de saúde tomar decisoes assertivas em relacao ao atendimento e sujeito a evidencias científicas. **Metodologia:** Uma revisão do trabalho científico foi realizada em inglês e espanhol em bancos de dados científicos e médicos, como PubMed, Scielo, Lilacs e Science Direct. **Resultados:** Foram encontrados 104 artigos sobre tópicos relacionados à terapia intravenosa e pediátrica em recém-nascidos, aqueles que relataram dados concretos sobre a população analisada foram escolhidos, e aqueles que apenas mencionaram dados da população pediátrica entre seus resultados forma excluidos. **Conclusões:** A literatura científica nacional e internacional disponível permite que o pessoal de saúde melhore o atendimento ao recém-nascido em relação à terapia intravenosa, convidando para a reflexão sobre a prática sem risco, de forma informada, e, conseqüentemente, mais humano.

**Palavras chave:** Recém nascido; cuidados de enfermagem; Infusões Intravenosas (DeCS).

---

## INTRODUCTION

Intravenous therapy (IVT) is a technique consisting of the placement of a catheter in the lumen of a venous vessel, by means of which parenteral solutions, drugs, and blood products <sup>(1)</sup> are administered into the human body. In the newborn patient, the most used catheters are the short (midline) peripheral venous catheter (PVC), umbilical venous catheter (UVC), peripherally inserted central catheter (PICC) and the central venous catheter (CVC). Each one has specific indications for their insertion and maintenance with the objective of prolonging their life and ensuring success in the intravenous treatment.

Historically, the IVT has helped substantially in the evolution of medication for health care, since pursuant to the increase of premature birth rates in Mexico <sup>(2)</sup>; thus, to achieve survival of such neonates (NB) the need to use the IVT also increases. Nevertheless, their placement and maintenance should be considered as a detailed procedure in this type of patients, due to the fact that the anatomical-physiological and clinical conditions are different to other pediatric and adult patients. For such reason, it is required to count with trained and updated health care personnel in order to ensure the optimal newborn intravenous therapy (NIT), that is, with the minimum of adverse events.

The maintenance of the IVT involves a risk of error since it is a procedure carried out by humans and, accordingly, it is not exempt of the probability that adverse events occur, understanding as adverse events those "unintentional injuries or damages caused to the patient by the assistance intervention and not by the underlying pathology" <sup>(3)</sup>. Among the main adverse events in these patients we may enunciate: pain, bacteremia, sepsis, surrounding skin lesion, catheter breaking, infiltration and extravasation; consequently, the well-being of the patient is at risk and the hospital stay and financial outlay will increase, due to related complications.

The motivation of this work is to provide an updating regarding the praxis of the NIT, which may allow the health personnel to make assertive decisions in matters of care and in conformity with scientific evidence; starting with the epidemiological situation of premature and mature neonates, as well as the morbidity and mortality due to infection of the bloodstream associated to the central line (CLABSI) or catheter-related bacteremia (CRB), term known in the national context and which form part of the Infections Associated with Health care (IAHC).

Later on, the NIT is conceptualized and important aspects of the NB's vulnerability to the health system are mentioned, making emphasis on the anatomical-physiological conditions, their adaptation process, and immature organs make it difficult that the actions of the multidisciplinary team are fully effective, since despite the technological advancement of the last years it results impossible to speed up their full development and adaptation to extra-uterine

life. Lastly, CLABSI and BR (bacteremia) are described, as well as the secondary technical effects to the NIT placement and the care to be taken for their prevention.

## METHODOLOGY

A bibliographical review was conducted in the following databases: PubMed, Scielo, ScienceDirect, and Lilacs. The Descriptors in Health Sciences (DeCS) used in such search were neonates, nursing care, intravenous administrations, nosocomial infections, premature, phlebitis, and extravasation, combining the Boolean operators AND, OR, and NOT. Articles published between 2000 and 2019 that included the subject of interest were chosen. Afterwards, an integrating analysis was performed on innovations in the use of the newborn intravenous therapy. Likewise, regulatory documents that showed a national epidemiologic overview of the subject of interest were included.

## RESULTS

One hundred four (104) articles were found: 2 case-control studies, 12 systematic reviews, 7 randomized clinical trials, 8 quasi-experimental trials, 51 observational-descriptive studies, 6 of revision, 4 of case reports, 1 experimental, 6 co-related studies, 3 multicentric studies, and 3 narrative studies. Those studies that in their results jointly included pediatric and neonatal pediatric population data were included, and that, additionally, mentioned specific issues of neonates and excluded those which only dealt with pediatric patients (Figure 1). From these studies, the following subsections were developed:

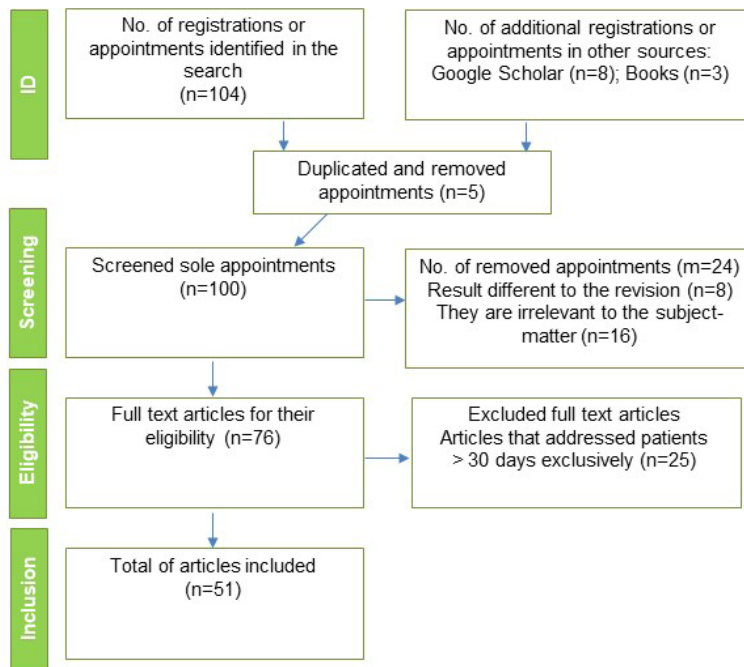
### Newborn Intravenous Therapy (NIT)

Intravenous therapy (IV) is a method consisting of the placement of a catheter in the lumen of a vein, through which parenteral fluids are administered to the patient. When this procedure is used in the newborn, either premature or mature, the aforementioned concept referred to by NOM 022 SSA3-2012 is ideal to describe the NIT <sup>(1)</sup>.

The objectives of this procedure are to retain and substitute corporal reserves of nutritional fluids and elements in the patient who does not have an ideal oral feeding, as well as to reestablish the acid-base balance, restoration of blood volume and that of its components, offer some way to administer drugs, as well as to establish an urgent absorption, and prevent fluid and electrolyte imbalance <sup>(4)</sup>.

It is important to mention that the IV is a procedure attributed mainly to the Nursing professional, due to the fact that they provide the maintenance care, continuously assessing whether this is being appropriately administered, and in most of the cases, it is them who remove the peripheral and central venous access routes <sup>(4)</sup>. The NIT requires high complexity care, and, therefore, time-consuming. Moreover, due to the

**Figure 1.** Flow chart that summarizes the process of identification and election of articles



**Source:** Own development.

characteristics of immaturity and invasive processes presented by the patient, it is exposed to the lack of expertise of all the people involved in the health care, such as physicians, nurses, and students.

### **Anatomic and physiological vulnerability presented by the newborn to NIT**

The NB is placed in a vulnerable position due to different causes within the hospital environment; for instance, his inability to clearly communicate in case of pain or of any anomaly related to his venoclysis. In addition to this, most of the regulations for the neonatology services in Mexican hospitals do not allow any accompanying family member 24 hours a day, situation that increases the vulnerability of the neonate, since the family member is the communication link between the newborn and the health personnel, and this family member is the one in charge of notifying any change.

Additionally, the anatomy of the NB is characterized for its being a predisposing factor for the development of the infiltration and extravasation due to its capillary fragility and to its short and small-caliber veins. Aside from the fact that its subcutaneous tissue is flexible and spreads easily in the presence of liquids, the venous integrity is labile which facilitates the capillary leak, and infiltrations may be present in a significant measure <sup>(5-6)</sup>.

Uncontrolled infiltrations may provoke a reduced tissue perfusion, and ultimately, necrosis. This is due to the fact that large volumes may produce necrosis by pressure and in con-

sequence, the newborn would need a surgical intervention resulting in large scars, a limitation of the function or even an amputation <sup>(7)</sup>. Another long-term effect is the complex regional pain syndrome (CRPS) that implies management of chronic pain <sup>(8)</sup>.

In addition, the neonates are particularly susceptible to thromboembolism with a 40:1 probability ratio with respect to another age during childhood due to the tiny caliber of the capillaries, to the scarce development of the thrombolytic systems, and the hemostatic instability caused by comorbidities such as the perinatal asphyxia, dehydration, congenital heart disease, and in particular those neonates who require CVC <sup>(9)</sup>. The above is due to the fact that the coagulation factors that depend on vitamin K (II, VII, IX, X) and the factors of contact (XII, XI, pre-kallikrein and kininogen of high molecular weight) are below the normal value. The fibrinogen and factors V, VIII, and XIII show values that are similar to the values of the adult person and the level of the Von Willebrand factor almost doubles that of the adult person <sup>(9)</sup>.

### **Characteristics of the newborn skin**

Skin is sensitive to thermal, tactile, and painful stimulus. In mature neonates, it produces an acid substance with bactericide properties and the pH turns acid as of the fourth day of birth <sup>(10)</sup>. The neonates in intensive care are more susceptible to the sepsis acquired by the transcutaneous portal vein, mainly premature children of 24 weeks or less

of age, who lack the aforementioned protection and are affected by gram-negative bacteria such as *Staphylococcus aureus*, *Staphylococcus epidermis*, and *Candida albicans* <sup>(11)</sup> between the second and seventh postnatal day.

The less mature the newborn skin is, the greater the risks of damage, since it is not only more permeable to bacteria but also unarmed to fight the percutaneous absorption of toxic agents <sup>(10)</sup>, for which reason the handling of antiseptics also results into a challenge for the prevention of the IAAS. Frequent inspections are required, and it is advisable that the number of premature neonates under the care of a nurse remains at its minimum, since it has been demonstrated that the higher the ratio between patient and nurse is, the probability of complications in the care of peripheral and central catheters increases <sup>(12)</sup>.

### Epidemiological situation of the NIT

The epidemiological records in regard to the IAAS in Mexico are not accurate, since there is a diversity of information regarding health care systems, which generates representativeness problems. Currently, the Mexican Information System does not have real figures of this issue <sup>(13)</sup>, but the figures reported in 2015 allow having a general overview of the morbidity and mortality risk due to IAAS in neonates. The Epidemiological Surveillance Network Committee or RHOVE reports that in 2015 bloodstream infections (ITS) related to catheter, contamination of solutions, and secondary to procedures had the first place of the IAAS with 24% and the most affected ones due to such infections were children under the age of 5, of which children under the age of 1 month represented 4,893 cases <sup>(13)</sup>.

The same network mentions that the presence of CVC (14%) or PVC (13.2%) represents a factor of risk to develop IAAS, and the UVC shows greater incidence of bacteremia due to *Staphylococcus epidermis* <sup>(14)</sup>; additionally, it emphasizes that the services where greater distribution of infections was reported were Pediatric Department and the Neonatal Intensive Care Unit (NICU) ranked three and five, respectively <sup>(14)</sup>.

Another important finding is that 122 outbreaks of IAAS were notified in 2015, 30% more in comparison to 2014. The most affected were neonates less than one month old, and the areas where there were outbreaks of IAAS with greater frequency rate were the NICU and the Adult Intensive Care Unit (AICU). In these outbreaks, *acinetobacter baumannii* was the main agent <sup>(14)</sup>.

In the international context, the IAAS, also denominated infections of bloodstream associated to the central line (CLABSI), their origin is similar to what has been described in the national bibliography; for instance, they may be bacteria found in the catheter or those associated to medications and solutions. In the first ones, *Staphylococcus* is adhered to Teflon or Vialon surfaces; with regard to the second ones, they are usually contaminated by *Klebsiella*

tribe, due to the fact that it has the capacity to use the intravenous liquids as culture means. Both ways of contamination increase the risk, and, consequently, the risk of death <sup>(15, 16)</sup>.

The IAAS, or CLABSI, is not only devastating because of their manifestation; once they have developed or even disappeared, the risk continues. Premature children who develop this type of infections have higher rates of mortality, lower growth, lower weight gain, affectation in the neurological development, and, consequently, more prolonged hospital stays <sup>(17-19)</sup>.

Since the year 2000, several authors reveal the inadequate handling of parenteral solutions (Table 1). However, this poor practice is still present in the neonatology services, predominantly in medical institutions of basic specialties and advanced specialties, situation which is reflected in the morbidity and mortality reported by the RHOVE and discussed in the previous section.

### Other secondary complications to the NIT

The IAAS and BSI are not the only threats to the NB with central or peripheral catheters, other undesirable effects are extravasation, infiltration, and occlusion of the catheter's lumen that put the newborn at risk of alteration in tissue and skin integrity, which when these ones get harsher, the probability of dying increases <sup>(1)</sup>.

Infiltration and extravasation imply the undesired leak of solution in the surrounding tissue <sup>(20)</sup>. Consequences vary from local irritation to amputation, and in spite of the high rates of infiltration and extreme damage, there is an important lack of interest and research regarding the care of injuries in newborn population <sup>(12)</sup>. The frequency of secondary complications to venoclysis in neonates oscillates between 95 and 63.15% <sup>(21)</sup>; among the most frequent ones are the infiltration and extravasation with a prevalence of 78 to 79.2% and 12.27%, respectively <sup>(6, 21, 22)</sup>; immediately followed by phlebitis with 3.5 to 7.84% <sup>(6, 21)</sup>.

Body areas with more complications are the upper limbs, being the left one of higher prevalence ( $n = 85$ ; 19.95%) in comparison with the right one ( $n = 77$ ; 18.08%). The metacarpal regions were the most common ones ( $n = 80$ ; 18.78%), although there have also been difficulties observed in the underarms ( $n = 8$ , 1.88%) and the external jugular vein ( $n = 2$ ; 0.47%), and the head ( $n = 36$ , 8.45%). It should be emphasized that it has been observed that the less weight of the NB on the puncture day, the greater the risk of complications ( $p = 0.0093$ ,  $RR = 1.29$  and  $RR = 1.25$ ) <sup>(6)</sup>.

Faced with this panorama, the care of the neonates who have CVC and PVC are a challenge to the Nursing Professionals given the particular characteristics of this population. From the year 2000 to date, the IVT technology has evolved, there are new devices of infusion, closed-system and needle free equipment, catheters with better biocompatibility, fastening methods and materials, but with this evolution, other factors of risk to suffer CLABSI (Table 2) have emerged.

<b>Table 1.</b> Improper Practices in the Handling of Parenteral Solutions in Hospitals of Developing Countries	
1.-	Doctors indicate home-made mixtures of parenteral solutions.
2.-	Nurses mix solutions in improper areas, without a laminar flow hood.
3.-	There are failures in the aseptic technique during the preparation of solutions, including hand washing.
4.-	In failed cannulations, punctures are repeated using the same catheter.
5.-	Syringes are shared for the application of medications in the intravenous systems.
6.-	In pediatrics, the same bottle is used to carry systems or to dilute medications of different patients.
7.-	Open bottles of solutions are used during the 8-hour shift or during the day.
8.-	There is no protocol or guide for the handling and storage of medications and parenteral solutions.
9.-	"Y" connections are made in the systems using needles.
10.-	Se colocan sondas de alimentación a manera de catéteres endovenoso

**Source:** Macías A et al. <sup>(45)</sup> Intravenous handling in pediatrics and its infectious complications: problem definition and solution proposal, 2000.

### Prevention of IAAS or CLABSI

Not only the technology of the NIT has changed due to the search of a better quality in the care of the critically ill newborn patients, but altogether modifications have occurred in the health standards, such as the Mexican Official Standards NOM-022-SSA3-2012 which specifies the conditions for the administration of infusion (intravenous) therapy in Mexico <sup>(23)</sup> and the NOM-045-SSA2-2005 for the epidemiologic surveillance, prevention, and control of nosocomial infections <sup>(24)</sup>. They address preventive aspects that have to do with the period of change in lines and catheters, handling of needles, syringes, and needle-free devices, use of antiseptics, how drugs are prepared and managed, and special aspects addressed to neonates are also addressed: "In hospitals that provide neonatology services, it will only be allowed to use intravenous solutions whose presentation is in 50 and 100 milliliters, to be used only in one patient; glass or plastic vials should be used exclusively when they are opened and the remaining solution shall be discarded; moreover, the sterility of the contents has to be guaranteed when they are opened" <sup>(24)</sup>.

In spite of this advancement, team work is required, as well as the continuous training of all the personnel involved in the care of central lines such as parents, directors, health managers, as well as nurses, doctors, technicians, and health assistants <sup>(25)</sup> in order that the initiative to improve the quality is continuous and progressive toward the discovery of better practices as safer and more efficient agents for skin antiseptics or the identification of optimal results <sup>(15)</sup>. Likewise, the renovation of the archetype regarding the NIT handling from a

routine assisting approach to a care based on the timely detection of risks and execution of preventive care packages (Table 3) <sup>(26)</sup>.

### Prevention of phlebitis, infiltration, and extravasation

#### *Use of the infusion pump*

These pumps are necessary to control the quantity of solution and time of infusion, thus, facilitating the solution control. Nevertheless, nurses often trust the alarms emitted by this device, despite the occurrence of infiltration or extravasation; sometimes, the internal pressure increases in a closed space and the infusion pump continues infusing, even without activating the obstruction alarm <sup>(5)</sup>. Therefore, the use of these devices requires that the nurse supervises the place of insertion every hour in order to identify early signs <sup>(12)</sup>.

A study performed in Australia and New Zealand made a survey about protocols for the prevention of injuries caused by extravasation (LE by its acronym in Spanish) in tertiary hospitals and it turned up that 18 of the 27 NICUs used protocols to prevent such complications by means of the adoption of written policies for the prevention of the injuries caused by extravasation (LE), continuous observation and revision of the insertion zone, visible place of puncture, and rinsing of saline solution before administering substances potentially harmful <sup>(27)</sup>.

Additionally, infusion pumps require normodroppers or microdrip equipment that is longitudinally longer in relation to conventional equipment; therefore, this is another



**Table 2.** Risk Factors for CLABSI or IAAS in Neonates

Premature neonates <sup>(46)</sup>	Neonates with CVC are associated to a greater risk of CLABSI in comparison to the PICC <sup>(48)</sup> Heel punctures <sup>(49)</sup> Active intrabdominal pathology <sup>(49)</sup> Patients with multiple CVC have 4.2 times greater risk to present CLABSI <sup>(50)</sup> With installed PICCs and peripheral puncture <sup>(51)</sup> as well. Newborn punctured 6 or more times, without simultaneous use of antibiotics <sup>(51)</sup>
Low weight at birth <sup>(46)</sup>	
Presence of peripheral venous catheter <sup>(46)</sup>	
Oxygen treatment <sup>(46)</sup>	
Male gender <sup>(47)</sup>	
Total Parenteral Nutrition Administration (NPT) <sup>(47)</sup>	

**Source:** Own development

factor that may affect the NIT. The infusion equipment placed 70 cm below the pump reduces the flow rate, producing 1.5 seconds without flow in rigid and little flexible equipment, and 6.8 seconds for the flexible equipment. The displacement of the infusion pump also have an impact, if this is placed 30 cm above the catheter tip, the speed of supply is 7 times greater than the pre-programmed flow rate. In contrast, if the displacement is 50 cm downwards, a stationary state occurs and the insertion of the solution takes 180 seconds to be fully administered <sup>(28)</sup>.

On the basis of the above data, in critical states the neonates require of low preprogrammed flow rates (for example 0.3 ml/hour), but at the same time in multi-infusion, that is, the base solution maybe at a rate of 1.5 ml/hour, sedation at 0.8 ml/hour, and amines at 1.2 ml/hour, among other infusions; for such reason, efforts should be made to ensure that the pumps remain at the same height of the catheter insertion in order not to affect the flow rate, especially with the inotropic and sedative medications. Apart from the foregoing, any alteration of the flow rate and the high risk of producing blood clots it may result in unnecessary clogging to the NIT or acting to the detriment of the catheter by wanting to unblock the obstruction using elevated pressures.

The recommendations for PVC are not any different to those of the CVC, that is, the nursing team should pay attention to the early recognition of swelling signs, using continuous observation and tactile palpation of the puncture site in search of swelling signs and exudate. These actions reduce to the minimum the pain and suffering of the NB since the resulting complications of the IVT are reduced <sup>(2)</sup>.

That is, nurses should adopt a "hyper vigilant" approach for the control of the intravenous access <sup>(12)</sup>. This hyper vigilance should be applied 24 hours a day without decrease of attention during the night shift, since some authors

report that the removal of catheters due to complications are lower in the daytime shift ( $p = 0.0114$ ). Bearing in mind that it is more common to find complications during the first 48 hours after the catheter puncture site ( $p = 0.0121$ ) <sup>(2)</sup>.

### **Administration of intravenous drugs**

Nurses guarantee that the administration of the infusion therapy complies with the following items: 1) Look for allergy history, 2) proper medication, 3) correct patient, 4) correct doses, 5) correct route, 6) correct time, 7) correct frequency, 8) detect pharmacological reactions, and 9) make registries in accordance to the standards <sup>(4)</sup>. It should be pointed out that 2 other correct items should be added to the NIT, these are: a) Right flow rate, and b) correct duration. In face of the situation already mentioned in the anatomy and physiology of the NB, the flow rate is low (0.1 to ~5ml.h-1) in comparison to that of adult people <sup>(28)</sup>, for such reason the duration of the administration of drugs occur over a more extended period of time.

It is also important that nurses administer drugs and parenteral solutions with full knowledge of the pH, osmolarity, incompatibility, among other pharmacological properties of the medications; the central venous catheter allows the administration of solutions and medications with extreme pH, being irritating those whose pH is greater than 7.45 and vesicants those whose pH is lower than 7.35. It also allows the administration of solutions and hyperosmolar medications, that is  $\geq 350$  mOsm/L; and other solutions and medications for extended periods of time in patients with venous peripheral accesses <sup>(29)</sup>.

The maximum osmolarity that peripheral veins of neonates tolerate ranges between 600 to 800 milliosmoles per liter (mOsm/L) and the final concentration of glucose in the mixture that the neonatal veins tolerate is lower than 10% <sup>(30)</sup>. It should be mentioned that an osmolarity greater than the osmolarity of the human serum may alter the osmotic gradient through the



**Table 3.** Scientific Evidences for the Prevention of CLABSI or IAAS in Neonates

- The elective replacement of UVC before day 4th may have a lower risk tendency to present CLABSI in comparison to a late replacement <sup>(52)</sup>.
- PICC should be an alternative to CVC in the pediatric and neonatal intensive care environment for the prevention of CLABSI <sup>(53)</sup>.
- In case a PICC breaks, the scientific evidence supports restoring the line with a repair kit instead of removing or replacing the line <sup>(54)</sup>.
- For the diagnose of bloodstream infections related to the central catheter in neonates, the culture of blood extracted from the catheter, the tip of the catheter, and peripheral hemocultures are efficient methods <sup>(16)</sup>.
- The introduction of care packs reduces CLABSI rates in central catheters confirmed by the laboratory <sup>(55)</sup>.
- The Use of non-sterile gloves after hand washing and before contact with the patient and the intravenous line is associated to fewer infections of the bloodstream in premature babies <sup>(56)</sup>.
- There is low risk of CLABSI in inactive PICCs and CVCs and that were surgically installed in neonates hospitalized in the NICU, which justifies their maintenance until they are discharged from the hospital <sup>(57)</sup>.
- The increase in hospital stay was not associated to a greater risk of CLABSI for the PICCs. It is not recommended to routinely replace uninfected PICCs <sup>(58)</sup>.
- The adequate skin preparation and the insertion technique are fundamental factors to prevent infections related to catheters. Chlorhexidine is recommended for the skin antiseptis; (ii) a bandage of semipermeable sterile polyurethane is recommended <sup>(59)</sup>.
- The gluconate of chlorhexidine 0.2% in acetate reduces skin injuries, without increasing the risk of CLABSI in comparison to the chlorhexidine 0.5% with alcohol 70%, in extremely premature infants <sup>(60)</sup>.
- Curation of CVC insertion sites in premature neonates with chlorhexidine at 2% - isopropyl alcohol at 70% or iodopovidone at 10% is recommended, since since in their application no differences were found with respect to the infection rate <sup>(61)</sup>.
- In the developing countries NICU's, the rate of CLABSI per 1000 days of central line decreased from 8.64 to 4.28 after the implementation of the use of chlorhexidine baths in neonates <sup>(62)</sup>.
- It is recommended to continue with the most used care in central catheters, to change the curative every 7 days or when there is moisture, or in cases where the semipermeable bandage is coming off, change cannulas, equipment and extensions every 72h and parenteral nutrition equipment every 24h, rubbing the connections that cover the catheter before manipulating them with alcohol 70% <sup>(34)</sup>.

**Source:** Own development

cellular membrane leading to an intracellular dehydration and its death <sup>(31)</sup>.

However, in order to keep the caloric supply of the NB in fasting situation, a flow of 6 mg/kg/min is required in continuous infusion <sup>(32)</sup> with glucose solution 10%, which has 550 mOsm/L; regularly, in practice electrolytes (calcium and potassium) are added to this solution generating a hyperosmolar solution that may produce ischemia by prolonged depolarization of the smooth capillary muscle <sup>(31)</sup>, in addition to protein precipitation. Therefore, the risk of suffering necrosis secondary to the NIT is elevated and more for premature neonates who have a more fragile venous network, due to the pro-

longed intravenous therapy with multiple irritating drugs and solutions, which provokes an exhaustion of the venous network during the hospital stay <sup>(33)</sup>.

### **Trombus Prevention and Handling**

In neonates it is necessary to have special care in the handling of drugs; correct dilution, verification of compatibility to prevent their precipitation, rate of infusion, and after its administration, cleanliness of the line <sup>(35)</sup>.

Whenever required to close a CVC or a port for 24 hours or for 7 days, there is not enough evidence to determine

the effects of administering intermittent rinse of heparin versus saline solution (36). To prevent the intra-lumen occlusion, it is recommended to avoid the use of phenytoin and diazepam through the peripherally inserted central catheter (PICC) because they form crystals inside of the catheter (34). However, this precaution should be considered for all the central catheters (CVC, UVC).

Another relevant consideration will be not to supply blood products due to the risk of hemolysis and obstruction, and not extract a blood sample by the catheter due to its tiny caliber, since there is the imminent risk that the walls of the catheter will collapse (except in PICCs since they have the valve of Groshong). When the occlusion is already in place, the use of urokinase 5000 iu/ml is efficient to unblock catheters occluded by thrombus. Nevertheless, their use in neonatology should be evaluated (34), and also it should have to be considered that the adverse effects of this medication have a high risk for the critical conditions of the neonates who require a central catheter.

It should not be forgotten that there is a homeostatic deficit of most coagulation elements when one is born. In critical condition neonates, conventional coagulation tests do not seem to provide reliable information; therefore, scientists propose the thrombus-elastography or thrombus-elastometry as promising methods for a fast evaluation of all the homeostatic potential, which allows an immediate intervention. However, there are still scarce reference values, in particular those of premature children (37).

## DISCUSSION

The handling of the intravenous therapy in the newborn requires care not only of the people in charge of direct care, but also of the entire health care system. Notwithstanding technological advancement, more scientific studies are required to have a positive impact on the prevention of infections and complications related to NIT. The evidence of recommendations in the IA or IB classification is still low; most of them are category II (38). Adding to the fact that these infections impose a high financial burden (39), the development of controlled clinical trials that will help to eradicate the CLABSI in neonates (38) is urgent.

Furthermore, PICC is the catheter that shows lower risk to the newborn. Nevertheless, nursing care in the evaluation of the blood vessels is fundamental to improve the rate of success in the puncture (40) and duration of this type of catheter. Even so, this catheter is not available in all of the neonatal care services of public hospitals. For reasons of economy, the UVCs are installed in greater numbers, but their risk of infection is greater due to the process of necrosis of the umbilical cord stump, especially in premature neonates, regardless of the use of antibiotics and the duration of the catheter (41). This situation allows reflecting on the cost/benefit rate and the invitation to limit their installation only for emergencies.

Concerning secondary complications such as pain, phlebitis, and infiltration in the central and peripheral catheters, surveillance is still essential for their prevention (42). With respect to the extravasation, the research continues with a tendency to repair damaged tissue. A recent research shows the efficiency of the use of enzymatic debridement (43) and the allograft of dehydrated human amniotic membrane in severe injuries (44), provisions that no doubt will contribute to the challenge faced by healthcare personnel towards NIT.

## CONCLUSIONS

With the scientific evidence available, NIT care may improve. Continuous theoretic and practical training is required in this topic, including those who manage health establishments in order to ensure their supply and, also, that the quality of the material adapts to the needs of the newborn, inviting to the reflection about a risk free practice, with knowledge and understanding, and as a consequence, more humane.

Nurses should be motivated to perform randomized clinical trials targeted to a more efficient care, in order to reduce secondary complications regarding the use of peripheral and central catheters in neonates, and incorporate these evidences to regulatory documents.

## CONFLICT OF INTEREST

None

## FINANCING

None

## BIBLIOGRAPHIC REFERENCES

1. Norma Oficial Mexicana NOM-022-SSA3-2012, Que instituye las condiciones para la administración de la terapia de infusión en los Estados Unidos Mexicanos. DOF Secretaria de Salud [Internet]. 2012. [Consultado 19 Septiembre 2019]. Disponible en: [http://dof.gob.mx/nota\\_detalle.php?codigo=5268977&fecha=18/09/2012](http://dof.gob.mx/nota_detalle.php?codigo=5268977&fecha=18/09/2012).
2. González-Pérez D, Pérez-Rodríguez G, Leal-Omaña C, Ruíz-Rosas R, González-Izquierdo J. Tendencia y causas de mortalidad neonatal en el Instituto Mexicano del Seguro Social 2011-2014, a nivel nacional. *Rev Mex Pediatr* [Internet]. 2016. [Consultado 13 Septiembre 2019]; 83 (4): 115-123. Disponible en: <https://www.medigraphic.com/pdfs/pediat/sp-2016/sp164c.pdf>
3. Martínez C. Eventos Adversos en el cuidado de enfermería brindado a niños hospitalizados. *REVISALUD Uni-*

- sucresincelejo [Internet]. 2014; 2 (1): 66-69. Disponible en: [10.24188/23394072.v2.n1.2014.133](https://doi.org/10.24188/23394072.v2.n1.2014.133).
4. Castañeda A, Pérez J, Soto M. Eficacia de la práctica de enfermería en la Terapia de Infusión Intravenosa. *Rev Conamed* [Internet]. 2015. [Consultado 3 Agosto 2019]; 20 (1): S27-S34. Disponible en: <https://www.medigraphic.com/pdfs/conamed/con-2015/cons151e.pdf>
5. Park H, Kim K, Lee H, Jeon E, Kim K, Suh D. Compartment syndrome due to extravasation peripheral parenteral nutrition: extravasation injury of parenteral nutrition. *Korean J pediatr* [Internet]. 2015; 58 (11): 454-458. Disponible en: doi: 10.3345/kjp.2015.58.11.454.
6. Danskin M, Mingorance P, Derdried J, Vayego S, Lind J. Incidence of local complications and risk factors associated with peripheral intravenous catheter in neonates. *Rev esc enferm USP* [Internet]. 2016; 50 (1): 22-28. Disponible en: doi: 10.1590/S0080-623420160000100003.
7. Driscoll M, Langer M, Burke S, El M. Improving detection of IV infiltrates in neonates. *BMJ Qual Improv Rep* [Internet]. 2015; 4 (1): 1-5. Disponible en: doi: 10.1136/bmjquality.u204253.w3874.
8. Hadaway L. Infiltration and Extravasation. *Am J Nurs* [Internet]. 2007; 107 (8): 64-72. Disponible en: doi: 10.1097/01.NAJ.0000282299.03441.c7.
9. Bacciedoni V, Attie M, Donato H. Trombosis en el recién nacido. *Arch Argent pediatr* [Internet]. 2016. [Consultado 17 Octubre 2019]; 114 (2): 159-166. Disponible en: [https://www.sap.org.ar/docs/publicaciones/primer0/2016/Act\\_Bacciedoni\\_anticipo\\_2-3-16.pdf](https://www.sap.org.ar/docs/publicaciones/primer0/2016/Act_Bacciedoni_anticipo_2-3-16.pdf)
10. Ponnusamy V, Venkatesh V, Clarke P. Skin antisepsis in the neonate: what should we use?. *Curr Opin Infect Dis* [Internet]. 2014; 27 (3): 244-250. Disponible en: doi: 10.1097/QCO.0000000000000064.
11. Tamez R, Pantoja M. *Enfermería en la Unidad de Cuidados Intensivos Neonatales: asistencia del recién nacido de alto riesgo*. Buenos Aires: Panamericana; 2016.
12. Tong R. Preventing extravasation injuries in neonates. *Paediatr Nurs* [Internet]. 2016; 19 (8): 22-25. Disponible en: doi: 10.7748/paed2007.10.19.8.22.c4462.
13. Rodríguez M. Frecuencia de infecciones asociadas a la atención de salud en los principales sistemas de información de México. *Boletín CONAME-OPS* [Internet]. 2018. [Consultado 18 Septiembre 2019]; 3 (17): 15-20. Disponible en: [http://www.conamed.gob.mx/gobmx/boletin/pdf/boletin17/frecuencia\\_infecciones.pdf](http://www.conamed.gob.mx/gobmx/boletin/pdf/boletin17/frecuencia_infecciones.pdf)
14. Dirección General de Epidemiología. Informe anual 2015 Red Hospitalaria de vigilancia epidemiológica. Secretaría de Salud en México [Internet]. 2016. [Consultado el 13 de noviembre 2019]. Disponible en: [www.epidemiologia.salud.gob.mx](http://www.epidemiologia.salud.gob.mx)
15. Mobley R, Bizzarro M. Central line-associated bloodstream infections in the NICU: Successes and controversies in the quest for zero. *Seminars in Perinatology* [Internet]. 2017; 41 (3): 166-174. Disponible en: 10.1053/j.semperi.2017.03.006.
16. Ferreira J, Camargos P, Clemente W, Romanelli R. Clinical usefulness of catheter-drawn blood samples and catheter tip cultures for the diagnosis of catheter-related bloodstream infections in neonatology: A systematic review. *Am J Infect Control* [Internet]. 2018; 46 (1): 81-87. Disponible en: doi: 10.1016/j.ajic.2017.06.030.
17. Garland J, Kanneberg S, Mayr K, Porter D, Vanden A, Kurziak J, McAuliffe T. Risk of morbidity following catheter removal among neonates with catheter associated bloodstream infection. *J Neonatal Perinatal Med* [Internet]. 2017; 10 (3): 291-299. Disponible en: doi: 10.3233/NPM-16137.
18. Kieran E, O'Sullivan A, Miletin J, Twomey A, Knowles S, Finbar C. 2% chlorhexidine-70% isopropyl alcohol versus 10% povidone-iodine for insertion site cleaning before central line insertion in preterm infants: a randomised trial. *Arch Dis Child Fetal Neonatal Ed* [Internet]. 2018; 103: F101-F106. Disponible en: doi: 10.1136/archdischild-2016-312193.
19. Wen J, Yu Q, Chen H, Chen N, Huang S, Cai W. Peripherally inserted central venous catheter-associated complications exert negative effects on body weight gain in neonatal intensive care units. *Asia Pac J Clin Nutr* [Internet]. 2017; 26 (1): 1-5. Disponible en: doi: 10.6133/apjcn.112015.07.
20. Doellman D, Hadaway L, Bowe-Geddes L, Franklin M, LeDonne J, Papke-O'Donnell L, et al. Infiltration and extravasation: update on prevention and management. *J Infus Nurs* [Internet]. 2009; 32 (4): 203-211. Disponible en: doi: 10.1097/NAN.0b013e3181aac042.
21. Beall V, Hall B, Mulholland J, Gephart S. Neonatal Extravasation: An Overview and Algorithm for Evidence – Based Treatment. *Newbor Infant Nurs Rev* [Internet]. 2013; 13 (4): 189-195. Disponible en: doi: 10.1053/j.nainr.2013.09.001.
22. Pettit J. Assessment of the infant with a peripheral intravenous device. *Adv Neonatal Care* [Internet]. 2003; 3 (5): 230-240.
23. Norma Oficial Mexicana NOM-022-SSA3-2012, Que instituye las condiciones para la administración de la terapia de infusión en los Estados Unidos Mexicanos. DOF

---

Secretaria de Salud [Internet]. 2012. [Consultado 3 Noviembre 2019]. Disponible en: <http://www.salud.gob.mx/unidades/cie/doctos/NOM-022-SSA3-2012.PDF>

24. Norma Oficial Mexicana NOM-045-SSA2-2005 para la vigilancia epidemiológica, prevención y control de infecciones nosocomiales. DOF Secretaria de Salud [Internet]. 2005. [Consultado 3 Noviembre 2019]. Disponible en: <http://iner.salud.gob.mx/descargas/normatecainterna/MJ-normasmexicanas/NOM-045-SSA2-2005.pdf>

25. Savage T, Hodge D, Pickard K, Myers P, Powell K, Cayce J. Sustained Reduction and Prevention of Neonatal and Pediatric Central Line-Associated Bloodstream Infection Following a Nurse-Driven Quality Improvement Initiative in a Pediatric Facility. *Journal of the Association for Vascular Access* [Internet]. 2018; 23 (1): 30-41. Disponible en: doi: 10.1016/j.java.2017.11.002.

26. Hawes J, Lee K. Reduction in Central Line-Associated Bloodstream Infections in a NICU: Practical Lessons for Its Achievement and Sustainability. *Neonatal Netw* [Internet]. 2018; 37: 105-111. Disponible en: doi: 10.1891/0730-0832.37.2.105.

27. Restieaux M, Maw A, Broadbent R, Jackson P, Barker D, Wheeler B. Neonatal extravasation injury: prevention and management in Australia and New Zealand—a Survey of current practice. *BMC Pediatrics* [Internet]. 2013; 13:3. Disponible en: doi: 10.1186/1471-2431-13-34.

28. Vander E, Roland M, Dankelman J, Bert J S. A literature review on flow-rate variability in neonatal IV therapy. *Pediatr Anesth* [Internet]. 2013; 23: 9-21. Disponible en: doi: 10.1111/pan.12039.

29. Fajuri P, Pino P, Castillo A. Uso de catéter venoso central de inserción periférica en pediatría. *Rev Chil Pediatr* [Internet]. 2012; 83 (4): 352-357. Disponible en: doi: 10.4067/S0370-41062012000400005.

30. Daza W. Manual práctico de nutrición parenteral en pediatría. Colombia: Panamericana; 2012.

31. Hansen A, Puder M. Manual de cuidados Intensivos en Cirugía Neonatal. México: Editorial médica Panamericana; 2012.

32. Guía de Práctica Clínica Diagnóstico y tratamiento de la hipoglicemia neonatal transitoria. Secretaria de salud [Internet]. 2010. [Consultado 14 Octubre 2019]. Disponible en: [http://www.cenetec.salud.gob.mx/descargas/gpc/CatalogoMaestro/446\\_GPC\\_Hipoglucemia\\_neonatal/GER\\_Hipoglucemia\\_neonatal.pdf](http://www.cenetec.salud.gob.mx/descargas/gpc/CatalogoMaestro/446_GPC_Hipoglucemia_neonatal/GER_Hipoglucemia_neonatal.pdf)

33. Rodrigues A, Gomes C, Justina C, Oliveira J, Machado

A, Rodrigues E. Assessment of phlebitis, infiltration and extravasation events in neonates submitted to intravenous therapy. *Esc Anna Nery* [Internet]. 2011; 15 (3): 472-479. Disponible en: doi: 10.1590/S1414-81452011000300005.

34. Tomazi A, Chollopetz M. Eventos adversos relacionados con el uso de catéteres venosos centrales en recién nacidos hospitalizados. *Rev Latino-Am Enfermagem* [Internet]. 2010. [Consultado 12 Mayo 2019]; 18 (2): 196-202. Disponible en: [http://www.scielo.br/pdf/rlae/v18n2/es\\_09.pdf](http://www.scielo.br/pdf/rlae/v18n2/es_09.pdf)

35. Protocolo para el manejo estandarizado del paciente con catéter periférico, central y permanente. Secretaria de Salud [Internet]. 2012. [Consultado 19 septiembre 2019]. Disponible en: [http://www.cpe.salud.gob.mx/site3/publicaciones/docs/protocolo\\_manejo\\_estandarizado.pdf](http://www.cpe.salud.gob.mx/site3/publicaciones/docs/protocolo_manejo_estandarizado.pdf)

36. Bradford N, Edwards R, Chan R. Heparin versus 0.9% sodium chloride intermittent flushing for the prevention of occlusion in long term central venous catheters in infants and children. *Int J Nurs Stud* [Internet]. 2016; 59: 51-59. Disponible en: doi: 10.1016/j.ijnurstu.2016.02.014.

37. Konstantinidi A, Sokou R, Parastatidou S, Lampropoulou K, Katsaras G, Boutsikou T, et al. Clinical Application of Thromboelastography/Thromboelastometry (TEG/TEM) in the Neonatal Population: A Narrative Review. *Semin Thromb Hemost* [Internet]. 2019; 45 (5): 449-457. Disponible en: doi: 10.1055/s-0039-1692210.

38. Eichel V, Papan C, Mutters N. Update Hygiene; Prevention of vascular Catheter – Associated Infections in Premature and Newborn Infant. *Klin padiatr* [Internet]. 2019; 231 (4): 177-182. Disponible en: doi: 10.1055/a-0883-5350.

39. Karagiannidou S, Zaoutis T, Maniadas N, Papaevangelou V, Kourlaba G. Attributable Length of stay and cost for pediatric and neonatal central line-associated bloodstream infection in Greece. *J Infect Public Health* [Internet]. 2019; 12 (3): 372-379. Disponible en: doi: 10.1016/j.jiph.2018.12.004.

40. Renfeng L, Xia C, Tian S, Xiong L. Application of peripherally inserted central catheters in critically ill newborns experience from a neonatal intensive care unit. *Medicine* [Internet]. 2019; 98 (32): e15837. Disponible en: doi: 10.1097/MD.00000000000015837.

41. Sobczak A, Klepacka J, Amrom D, Zak I, Kruczek P, Kwinta P. Umbilical catheters as vectors for generalized bacterial infection in premature infants regardless of antibiotic use. *J Med Microbiol* [Internet]. 2019; 68 (9): 1306-1313. Disponible: doi: 10.1099/jmm.0.001034.

42. Ly C. The care of skin lesions caused by extravasation of

- intravenous fluids in peripheral venous perfusión. Arch Pediatr [Internet]. 2017; 24 (9): 884-893. Disponible en: doi: 10.1016/j.arcped.2017.06.011.
43. Huelte E, Bartley W, Morris D, Reasbeck D, McKtrick-Bandy B, Yates C. Collagenase for Wound Debridement in the neonatal intensive Care Unit: A Restrospective Case Series. Pediatr Dermatol [Internet]. 2017; 34 (3): 277-281. Disponible en: doi: 10.1111/pde.13118.
44. Boyar V, Galiczewski C. Efficacy of deshidrated Human Amniotic Membrane Allograft for the treatment of severe extravasation injuries in preterm neonates. Wounds [Internet]. 2018; 39 (8): 224-228.
45. Macias A et al. Manejo intravenoso en pediatría y sus complicaciones infecciosas: definición del problema y propuesta de solución. 2000; 14 (2): 98-105.
46. Chabni N, Regagba D, Meguenni K, Ghomari S, Smahi M. Facteurs de risque de l'infection nosocomiale au niveau du service de néonatalogie polyvalente de l'établissement hospitalier spécialisé mère-enfant de Tlemcen à l'Ouest algérien, "étude cas-témoins". Jourbak de Pediatrie et de Puériculture [Internet]. 2015; 28 (2): 71-79. Disponible en: doi: 10.1016/j.jpp.2015.02.006.
47. Dubbink-Verheij G, Bekker V, Pelsma I, van Zwet E, Smits-Wintjens V, Steggerda SJ Te Pas A, Lopriore E. Bloodstream Infection Incidence of Different Central Venous Catheters in Neonates: A Descriptive Cohort Study. Frontiers in pediatrics [Internet]. 2017; 5 (142): 1-7. Disponible en: doi: 10.3389/fped.2017.00142.
48. Yamaguchi R, Noritomi D, Degaspere N, Muñoz G, Porto A, Costa S, et al. Peripherally inserted central catheters are associated with lower risk of bloodstream infection compared with central venous catheters in paediatric intensive care patients: a propensity-adjusted analysis. Intensive Care Med [Internet]. 2017; 43 (8): 1097-1104. Disponible en: doi: 10.1007/s00134-017-4852-7.
49. Dahan M, O'Donnell S, Hebert J, Gonzales M, Lee B, Chandran A, et al. CLABSI Risk Factors in the NICU: Potential for Prevention: A PICNIC Study. Infect Cont Hosp Epidemiol [Internet]. 2016; 37 (12): 1446-1452. Disponible en: doi: 10.1017/ice.2016.203.
50. Concannon C, Van Wijngaarden E, Stevens V, Dumyati G. The Effect of Multiple Concurrent Central Venous Catheters on Central Line-Associated Bloodstream Infections. Infect Cont Hosp Epidemiol [Internet]. 2014; 35 (9): 1140-1146. Disponible en: doi: 10.1086/677634.
51. Cheng H, Lu C, Huang L, Lee P, Chen J, Chang L. Increased frequency of peripheral venipunctures raises the risk of central-line associated bloodstream infection in neonates with peripherally inserted central venous catheters. J Microbiol Immunol [Internet]. 2016; 49 (2): 230-236. Disponible en: en: 10.1016/j.jmii.2014.06.001.
52. Sanderson E, Yeo K, Wang A, Callender I, Bajuk B, Boilisetty S, Lui K. Dwell time and risk of central-line-associated bloodstream infection in neonates. J Hosp Infect [Internet]. 2017; 267-274. Disponible en: doi: 10.1016/j.jhin.2017.06.023.
53. Silveira R, Teixeira D, Viu N, Ortega G, Matos A, Figueiredo S, et al. Peripherally inserted central catheters are associated with lower risk of bloodstream infection compared with central venous catheters in paediatric intensive care patients: a propensity-adjusted analysis. Intens Care Med [Internet]. 2017; 43 (8): 1097-1104. Disponible en: doi: 10.1007/s00134-017-4852-7.
54. Gnannt R, Patel P, Temple M, Brashdi Y, Amaral J, Parra D, et al. Peripherally Inserted Central Catheters in Pediatric Patients: To Repair or Not Repair. Cardiovasc Inter Rad [Internet]. 2017; 40 (6): 845-851. Disponible en: doi: 10.1007/s00270-017-1580-x.
55. Arnts I, Schriivers N, van der Filer M, Groenewpud J, Antonius T, Liem K. Central line bloodstream infections can be reduced in newborn infants using the modified Seldinger technique and care bundles of preventative measures. Acta Paediatr [Internet]. 2015; 104 (4): 152-157. Disponible en: doi: 10.1111/apa.12915.
56. Kaufman D, Blackman A, Conaway M, Sinkin R. Nonsterile glove use in addition to hand hygiene to prevent late-onset infection in preterm infants: randomized clinical trial. JAMA Pediatr [Internet]. 2014; 168 (10): 909-916. Disponible en: doi: 10.1001/jamapediatrics.2014.953.
57. Litz C, Tropf J, Danielson P, Chandler N. The idle central venous catheter in the NICU: When should it be removed?. J Pediatr Surg [Internet]. 2018; 53 (7): 1414-1416. Disponible en: doi: 10.1016/j.jpedsurg.2017.10.060.
58. Greenberg R, Cochran K, Smith B, Edson B, Schulman J, Lee Henry, et al. Effect of Catheter Dwell Time on Risk of Central Line-Associated Bloodstream Infection in Infants. Pediatrics [Internet]. 2015; 136 (6): 1081-1086. Disponible en: doi: 10.1542/peds.2015-0573.
59. Wu J, Mu D. Vascular catheter-related complications in newborns. J Paediatr Child Health [Internet]. 2012; 48 (2): 91-95. Disponible en: doi:10.1111/j.1440-1754.2010.01934.x.
60. Janssen L, Tostmann A, Hopman J, Liem K. 0.2% chlor-

---

hexidine acetate as skin disinfectant prevents skin lesions in extremely preterm infants: a preliminary report. *Arch Dis Child Fetal Neonatal Ed* [Internet]. 2018; 103 (2): 97-100. Disponible en: doi: 10.1136/archdischild-2017-312694.

61. Kieran E, O'Sullivan A, Miletin J, Twomey A, Knowles S, Finbarr C, et al. 2% chlorhexidine–70% isopropyl alcohol versus 10% povidone–iodine for insertion site cleaning before central line insertion in preterm infants: a randomised trial. *Arch Dis Child-Fetal* [Internet]. 2018; 103: 101-106. Disponible en: doi: 10.1136/archdischild-2016-312193.

62. Cleves D, Pino J, Patiño J, Rosso F, Vélex J, Pérez P. Effect of chlorhexidine baths on central-line-associated bloodstream infections in a neonatal intensive care unit in a developing country. *J Hosp Infect* [Internet]. 2018; 100 (3): 196-199. Disponible en: doi: 10.1016/j.jhin.2018.03.022