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A Molecular Biology Strategy to Save Central Venous Catheters in Cases of Bloodstream Infections in Preterm Infants

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Abstract

Background: Preterm infants are at a high-risk of infection. Among healthcare-associated infections (HAIs) in the neonatal intensive care unit (NICU), bloodstream infections linked to central venous catheters (CVCs) are the most prevalent. The most frequent causes of HAIs in preterm infants are coagulase-negative staphylococci (CoNS).

Objective: The primary objective of the study was to employ diagnostic methods to distinguish between bloodstreams infection of unknown origin and those related to CVCs, and to compare two procedures for characterizing CoNS-related central venous catheter bloodstream infections: phenotypic methods and genotypic techniques.

Methods: A retrospective study was conducted using clinical data from 28 preterm infants admitted to the NICU between 2018 and 2021 who experienced at least one episode of CoNS bloodstream infection. The strains were isolated from both central blood and CVC tip cultures. The Wilcoxon-Mann-Whitney test and Fisher's exact test were employed to analyze the variables. The Akaike information criterion and the Bayesian information criterion were employed for model selection. Of the 28 CoNS isolates, 24 were analyzed genotypically using Pulsed-Field gel electrophoresis (PFGE), while all 28 underwent phenotypic characterization through biotyping and antibiotyping.

Results: The primary CoNS isolates included Staphylococcus haemolyticus (32.5%), Staphylococcus epidermidis (30%), and Staphylococcus saprophyticus (12.5%). Nearly all strains exhibited high resistance levels to penicillin and cefoxitin (100%). PFGE analysis identified five distinct patterns (A to E).

Conclusions: Preterm newborns infected with CoNS exhibited risk factors that facilitated the colonization and subsequent development of catheter-related bloodstream infections (CRBSIs). Risk factors for CoNS CRBSI include birth weight, age at infection onset, plasma lactate levels, platelet count, catheter duration of stay, use of lipid emulsion, antenatal corticosteroids, antenatal antibiotics, neonatal antibiotics, patent ductus arteriosus, and proton pump inhibitors.

Keywords: Coagulase-negative staphylococci; Central venous catheter; Catheter-related bloodstream infection; Risk factors; Methicillin-resistant CoNS; Neonatal intensive care unit.

List of Abbreviations

AIC: Akaike information criterion; AUC: Area Under the Curve; BIC: Bayesian information criterion; bpm: beats per min; BSI: bloodstream infection; BW: birth weight; CABSI: catheter-associated bloodstream infection; CFU: colony-

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forming units; CI: confidence interval; CLABSI: central line-associated bloodstream infection; CoNS: coagulase-negative staphylococci; cpm: cycle per min; CRBSI: catheter-related bloodstream infection; CRP: C-reactive protein; CVC: Central vein catheter; ECDC: European Centre for Disease Prevention and Control; ELBW: extremely low birth weight; GA: gestational age; HA-BSI: hospital-acquired bloodstream infection; HAI: healthcare-associated infection; ICU: intensive care unit; LBW: low birth weight; NICU: Neonatal intensive care unit; PFGE: Pulsed Field Gel Electrophoresis; PFGEp: PFGE patterns; PICC: peripherally inserted central catheter; PLAT: platelet; PN: parenteral nutrition; PPI: proton pump inhibitor; RF: risk factors; ROC: Receiver Operating Characteristic; SD: standard deviation; UHAP: University Hospital of Amiens-Picardie; VLBW: very low birth weight; WBC: white blood cell;

Introduction

CVCs, which include peripherally inserted central catheters (PICCs), are intravenous lines inserted into large veins to provide direct access to the central venous system and are commonly used in critically ill patients within the intensive care unit (ICU). CVC provides multiple benefits for the treatment of ICU patients. However, indwelling CVCs carry the risk of several complications, including CRBSI, phlebitis, catheter occlusion, catheter erosion, and venous thrombosis [1]. Multiple studies have shown that CRBSI is strongly associated with increased patient morbidity and mortality, as well as extended hospital stay [2]. While the average incidence of CRBSI in ICU in Chinese ICU is reported as 1.5/1000 catheter days [3], lower rates have been observed in Oman [4]. This discrepancy may stem, in part, from variations in how surveillance, diagnostic criteria, patient conditions, and catheterization procedures are defined across different countries and regions. Although catheter-associated bloodstream infections (CABSI) are largely preventable, they result in significant morbidity and mortality [5]. Regular monitoring by infection prevention and control teams is essential for tracking and preventing CABSI. Surveillance systems primarily monitor central line-associated bloodstream infections (CLABSI) in patients with non-tunneled, short-term CVCs [6]. CVCs are frequently indispensable for delivering fluids, medications, blood products, and parenteral nutrition, as well as to monitor hemodynamic status and to provide hemodialysis [7]. In contrast, routine surveillance often overlooks peripheral venous catheters [5]. Long-term catheters, including PICCs and tunneled catheters like Hickman lines or implantable ports, are also inadequately captured [5]. While tunneled catheters enhance venous access in patients with hematological diseases and malignancies, they are also linked to complications such as CABSI [8]. CLABSI is among the most significant and preventable causes of morbidity and mortality in NICUs [9,10]. It is linked to a wide range of adverse outcomes in neonates, such as mortality, extended hospital stays, increased reliance on broad-spectrum antibiotics, neurodevelopmental impairment, and elevated healthcare expenses [10]. Hospital-acquired bloodstream infections (HA-BSI) represent a significant contributor to morbidity and mortality in hospitalized patients [11]. Both the incidence of HA-BSI and the mortality associated with these infections are higher in hematology-oncology units compared to the general hospital population [11]. HA-BSI encompassesses CABSI, secondary bloodstream infections (BSIs) originating from an infection at another site, and HA-BSI from an unknown source. A CVC infection is defined as the presence of microorganisms on the internal and/or external surfaces of the CVC that result in either local or systematic infection. Every patient admitted to the NICU is outfitted with a comprehensive set of interventions, including vascular access, central venous lines, hypertonic solution infusions, parenteral nutrition, chemotherapy, hemodynamic monitoring, temporary cardiac pacing, continuous hemofiltration, central venous pressure measurement, intravenous antibiotic therapy, and specialized care for patients with limited venous access [12].

Pediatric patients' hematological and oncological disorders are at a heightened risk of developing infections. In most instances, these infections are linked to the use of long-term CVCs. Estimates suggest that 14% and 57% of CVC placements in children with malignancies may be complicated by bacteremia, with an infection incidence rate of 1.4 to 1.9 episodes per 1000 CVC days [7]. However, the use of CVCs can lead to BSIs, which are often specifically termed CRBSIs. CRBSIs are the most common iatrogenic hospital-acquired conditions and constitute a primary risk associated with parenteral nutrition. HAIs are common among very low birth weight (VLBW) infants during their stay in NICU, with late-onset BSI (those occurring ≥ 72 hours after birth) representing the most frequent nosocomial infectious complication [13]. Evidence suggests a connection between BSI and deficits in both early and late neurodevelopmental outcomes. The majority of BSIs in this vulnerable population are associated with the use of invasive devices, particularly CLABSI, which are often necessary to deliver critical life support [14,15]. HAIs have emerged as a worldwide issue driven by various factors, including inadequate hospital environments and the extensive use of invasive devices such as catheters. The more often the vein is manipulated, the greater the risk that the catheter will become contaminated relative to the infusion. Catheter colonization occurs through two primary mechanisms: extraluminal contamination, which is the most frequent and results from catheter insertion or subsequent site colonization, and endoluminal contamination, which is the most common cause and stems from the handling of networks and connections. Even though the hematogenous route is rare, it should always be considered in cases of Gram-positive cocci BSIs [16]. Although intestinal translocation is

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rare, colonization stemming from an infectious focus is not uncommon, particularly in patients with weakened immune and physical defenses, such as preterm newborns and those suffering from hematological disorders. Even with some advancements in prevention, infections resulting from CVC use continue to represent 10-20% of all HAIs. CRBSIs are a main reason for HAIs and high treatment costs. The most severe form of CRBSI is attributed to its association with elevated rates of morbidity and mortality [17]. Health care-associated BSIs have been reported as the most frequent site of health care-associated infections across various studies and are associated with increased costs. Among these, CRBSI has a more significant impact on both patient prognosis and cost burden. The estimated additional costs associated with CRBSIs or CLABSI typically range from €33,000 to €75,000 per case, which translate to approximately €35.9 to €163.9 million per country annually across Europe, depending on the specific nation. In the USA, it was estimated that approximately 12.32% of patients with CRBSI would die. Estimates for the cost of CRBSI in the USA range from $69,332 to $71,443, while in Europe the costs range from €13,585 to €29,909 [1]. As reported in the literature, the development of CRBSI is influenced by multiple factors, including the patient's condition, catheter insertion technique, catheter type, the use of subcutaneous infusion ports versus tunneled catheters, duration of catheter placement, and colonization by microorganisms capable of biofilm formation [17]. CVCs are prone to BSIs influenced by factors such as the duration of catheter placement, local care protocols, and the clinician's level of expertise. As noted in reference [18,19], risk factors (RFs) for CLABSI associated with CVC include thrombosis, repeated catheterizations, frequent manipulations, and the presence of another septic focus. In preterm newborns, intestinal colonization is primarily composed of Gram-positive bacteria, particularly CoNS. When CoNS BSI occurs, regardless of catheter presence, the CVC that replaced the umbilical cord is often implicated. This is essential for delivering nutritional support to preterm infants weighing more than 1200 g. The study sought to use diagnostic methods to differentiate between BSI of unknown origin and those caused by CVC, and to compare two approaches for characterizing CoNS CRBSI: phenotypic methods (biotyping and antibiotyping) and genotyping techniques (PFGE).

Materials and Methods

Study design

We conducted a retrospective cohort study of newborns presenting with sepsis symptoms who were admitted to the NICU of the University Hospital of Amiens-Picardie (UHAP) between 2018 and 2021. All anonymized patient data were extracted from their electronic medical records. During this period, data regarding demographic characteristics, underlying conditions, and clinical and laboratory findings were gathered.

Inclusion and exclusion criteria

All preterm neonates admitted to the NICU during the study period, born before 37 weeks of gestation, who experienced at least one episode of CoNS BSI with strains isolated from both central blood cultures and catheter tip cultures were considered for inclusion. In the case of repeat CABSI episodes with the same organism within 14 days, only the first episode was included. Among 157 preterm newborns who took part in the study, 28 (17.8%) had a positive blood culture. The remaining 128 (82.2%) preterm newborns, who had negative blood cultures, patient age >18 years, catheter type not documented, and multiple catheters of different types in situ at the time of BSI were excluded from the study.

Outcomes and definitions

Catheter type was classified as follows: short-term CVC (non-tunneled, e.g., jugular or subclavian CVC); long-term catheter (PICC or tunneled catheter such as Hickman or implantable port); arterial catheter (central or peripheral); dialysis catheter (short-or long-term); peripheral venous catheter (PVC) [5].

Clinical and biological data of sepsis

During the first three days of life, clinical signs of sepsis in neonates may include fever, cold extremities, feeding refusal, vomiting, abdominal distension, respiratory distress (e.g. grunting, apnea, cyanosis), jaundice, pallor, lethargy, excessive crying, convulsions, diarrhea, tachycardia (<180 bpm), bradycardia (<100 bpm), polypnea (>60 cpm) with desaturation, and hemodynamic or conscious alterations. Commonly assessed biological indicators of infection include C-reactive protein (CRP; normal <10 mg/L), plasma lactate (normal, 0.88-2.2 mmol/L), white blood cell (WBC) count (normal, 6,000-18,000/mm^3), and platelet (PLAT) count (normal,150,000-400,000/mm^3).

The manuscript's preparation

The instructions for this manuscript were the result of collaboration among all authors, which included meetings and future discussions. These showed that, as stated in the «Authors contribution brankruptcy», each author had access to information that would describe people at some point during and after the statistical series.

Blood samples and CVC tip cultures

Less than 0.5 mL of blood was collected from both the CVC and a peripheral vein, inoculated into a Bactec Peds Plus F bottle, and incubated using a BactecTM system (Becton Dickinson Diagnostic Systems, Spark, MD, USA). Subcultures were inoculated onto 5% sheep blood Columbia agar (BCA; Oxoid, Dardilly, France), and mannitol salt agar

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(MSA ; Bio-rad, Marnes-la-Coquette, France) plates from the initial blood culture broth [20]. Following extraction, the CVC segments were evaluated using the quantitative Brun-Buisson method [21]. For long CVCs, the distal 5 cm segment, or for short CVCs, the entire indwelling segment, was vigorously vortoxed in 1 mL of 0.9% sterile saline solution for 1 minute. Each type was seeded onto BCA and MSA plates in 100 µL aliquots. The agar plates were incubated aerobically at 35±2°C for 24 hours. The number of colony-forming units (CFU) was quantified in the catheter tip culture. BSIs were confirmed using a pair of blood cultures that exhibited a central-peripheral quantitative ratio of ≥5 and a difference in time to positivity between the central and peripheral samples of at least ≥ 2 hours. This indicates the presence of a BSI episode [22]. Catheter tip cultures were considered positive when the CFU/mL were $\geq 10^3$. Following the procedure previously described [20,23], all staphylococcus spp. strains were analyzed using Matrix-Assisted-Laser Desorption/Ionization Time-of-Flight Mass Spectrometry (MALDI-TOF-MS) (Bruker Daltonics, Bremen, Germany). Two mL blood samples were collected, and the serum was analyzed using colorimetric methods at 450 nm. CRP was measured using the Human CRP Kit from Thermo Fisher Scientific (Invitrogen, France) following the manufacturer's instructions. Lactate levels were measured using an L-lactate assay Kit (Abcam, France) in accordance with the manufacturer's instructions.

Antibiotic susceptibility testing

The antimicrobial susceptibility of all CoNS isolates was assessed using the disk diffusion method in accordance with issued by the European Committee on Antimicrobial Susceptibility Testing (EUCAST) [24], with testing conducted against penicillin, cefoxitin, kanamycin, gentamicin, tobramycin, erythromycin, pristinamycin, rifampin, ofloxacin, vancomycin, fusidic acid, trimethoprim-sulfamethoxazole, and fosfomycin.

Pulsed-field gel electrophoresis (PFGE) typing

Chromosomal DNA macrorestriction analysis was performed according to the manufacturer's instructions (Bio-Rad, France) using SmaI (5 U/µL) as the restriction enzyme, with separation carried out on a contour-clamped homogeneous electric field system (CHEF-DRII; GenePath, Bio-Rad, France) at 14°C and 200V for 19.7 hours. The patterns were interpreted as outlined in the previous section [25].

Risk factors for CoNS infection in mothers and preterm infants

Maternal risk factors (RFs) that increase the likelihood of infection include the mode of delivery, antenatal corticosteroid use, and antenatal antibiotic therapy. For preterm infants, the RFs under consideration include gestational age (GA in weeks), birth weight (BW in grams), age at infection onset (in days), hemodynamic disorders, use of lipid emulsion, proton pump inhibitors (PPIs), patent ductus arteriosus, history of jaundice, neonatal antibiotic therapy, catheter length of stay, CRP levels, plasma lactate, WBC count, and PLAT count. Patients were divided into two groups according to their RFs, with Group 1 consisting of those who had positive results for both bloodstream and catheter tip cultures (CVC+). Group 2 included patients with positive bloodstream cultures but negative catheter tip cultures (CVC-).

Statistical analysis

The RFs for infection among preterm infants with BSIs, both with and without catheter- tip infection, were examined. Quantitative variables are presented as means±standard deviation (SD), while qualitative variables are reported as frequencies. When appropriate, proportions for categorical variables were compared using Fisher's exact test. To analyze continuous variables, a Wilcoxon-Mann-Whitney rank sum test was employed for comparisons between two groups. Multivariable analysis included covariates that had a p-value of ≤ 0.05 in the univariable analysis. The Akaike information criterion (AIC) and the Bayesian information criterion (BIC) were employed to select the appropriate models [26-29].

Results

Table 1 presents the characteristics of the preterm neonates included in this study. Among the 28 preterm neonates, 13 (46.5%) were male and 15 (53.5%) were female, resulting in a sex ratio of 0.86. Of the twenty newborns, 71.4% were delivered vaginally, while eight (28.6%) were delivered via cesarean section. Based on GA at birth, the cohort comprised 10 (35.7%) extremely preterm, 12 (42.8%) very preterm, and 6 (21.5%) moderately preterm newborns.

According to Table 2, 13 newborns (46.5%) had extremely low birth weight (ELBW) ranging from 592 to 995 grams, 9 newborns had (32.2%) had VLBW ranging from 1060 to 1370 grams, and 4 newborns (14.2%) had low birth weight (LBW) ranging from 1720 to 2400. Additional maternal and neonatal characteristics include maternal age at the delivery (mean±SD: 29.7±6.2 years; median: 29.5; range: 19-45), GA (mean±SD: 29.2±3.3 weeks; median: 29; range: 25-36), birth weight (BW) (mean±SD: 1287.1±606.7 g; median: 1075; range: 592-2800), age at infection onset (mean±SD: 20.8±21.1days; median: 13; range: 5-104), catheter length of stay (mean±SD: 12.5±4.5 days; median: 12.4; range: 4.5-20.5) (Table 3). The non-specific markers yielded the following results: CRP at 38.2±43.5 mg/L; median: 23.3; range: 0-178, with an abnormality rate of 67.8% (18/28), range 10-178; serum lactate at 5.2±1.6 mmol/L; median, 5.1; range 2.9-7.9; WBC at 26,418±48,694/mm^3; median: 15,400; range from 5,000 to 271,000. Leukocytosis was observed in 46.4% of cases (13 out of 28), with a range of 18,200 to 271,000/mm^3; PLAT/mm^3 ranged from 12,000 to 447,000, with a median of 154,500 and a mean±SD: 162, 643±98,181.

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Table 1: Characteristics of the 28 children with CoNS included in this study. *WA: weeks of amenorrhea; **CRP: C-reactive protein.

Patient N°	Gestational Age *(WA)	Birth weight (g)	Age at infection onset (days)	Gastrointestinal disorders	Lactates mmol/L	**CRP mg/L	Leukocytes /mm²	Platelets/ mm³
1	26	710	48	yes	7.2	0	9900	70000
2	25	950	47	yes	7.3	5	9800	214000
3	36	2800	8	yes	5.5	53	9900	230000
4	26	700	8	yes	7.0	5.7	34200	173000
5	28	1200	30	yes	6.9	40	19900	65000
6	29	1370	9	yes	6.8	23	18400	200000
7	27	975	11	yes	7.5	62	25100	85000
8	28	960	13	yes	7.7	17	13400	103000
9	30	1060	7	NO	3.5	0	12000	213000
10	31	1720	10	NO	4.5	178	20500	70000
11	11	1730	10	yes	5.8	84	19000	60000
12	27	986	19	NO	4.6	3.4	11800	316000
13	25	700	28	yes	6.5	0	11400	194000
14	35	2371	14	yes	6.8	99	10500	136000
15	26	592	15	yes	7.9	103	16100	72000
16	27	990	8	yes	2.9	89	271000	12000
17	29	1330	3	yes	3.4	58	37000	123000
18	29	755	6	yes	4.2	0	27600	98000
19	32	1090	53	yes	4.3	23.7	9500	298000
20	35	2400	6	yes	5.0	41.5	20400	73000
21	36	2730	104	yes	5.9	15	9100	199000
22	29	949	5	yes	5.3	31	10700	232000
23	34	1340	24	yes	3.5	45	14700	185000
24	30	1250	13	yes	3.7	10	18200	447000
25	29	1320	5	NO	4.1	0	5000	120000
26	28	1192	11	yes	3.0	0	12000	286000
27	26	995	33	yes	3.3	84	36900	75000
28	25	900	9	NO	4.0	0	35700	205000
Mean±SD	29.2±3.38	1288±606.2	19.8±21.5	Y: 82.2% N: 17.8%	38.2±43.5	3.28±1.62	26775±48733.7	162642±98180
Median	29	1075	11		23.3	5.15	15400	54500

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Table 2: Distribution of 28 preterm infants according to their gestational age and their birth weight.

Gestational age (GA-weeks)	Range	N (%)
Extremely preterm (<28)	25-27	10 (35.7)
Very preterm (<32)	21-31	12 (42.8)
Moderate preterm (<37)	32-36	6 (21.5)
Total		28 (100.0)
Birth weight (BW-gram)	Range	N (%)
Extremely low weight (ELBW)<1000	592-995	13 (46.5)
Very low birth weight (VLBW)<1500	1060-1370	9 (32.2)
Low birth weight (LBW)<2500	1720-2400	4 (14.2)
Normal birth weight ≥2500	2730 and 2800	2 (7.1)
Total		28 (100.0)

Note: Based on GA at birth, 42,8% of the cohort comprised was born very preterm and 35.7% was born extremely preterm. ELBW ranged from 592 to 995 g for 46.5% of newborns, while VLBW ranged from 1060 to 1370 g for 32.2%.

Table 3 illustrates the additional maternal and neonatal traits as well as certain clinical conditions among the study participants. Of the 28 preterm neonates, 14 (50%) developed thrombocytopenia, defined as a platelet count of less than 150,000/mm^3. Among these 14 cases, one (7.2%) presented with very severe thrombocytopenia (12,000/mm^3), nine (64.3%) with severe thrombocytopenia (60,000-98,000/mm^3), and four (28.5%) with moderate thrombocytopenia (103,000-136,000/mm^3). Among the 28 preterm newborns, 42.8% (12/28) received lipid emulsion supplementation, 57.1% (16/28) were treated with postnatal antibiotics, 42.8% (12/28) developed premature jaundice, and 50% (14/28) exhibited hemodynamic disorders; 53.5% (15/28) and 35.7% (10/28) of their mothers got antenatal corticosteroid and antenatal antibiotic therapy respectively. The other parameters evaluated included patent ductus arteriosus (57.1%; 16/28), PPI use (60.7%; 17/28), and mode of delivery, with cesarean section accounting for 42.8% (12/28) and vaginal delivery for 57.2% (16/28).

Blood culture and CVC culture results

CRBSIs involve bacteria that are part of the normal skin microbiota. Table 4 presents the CoNS identified in both blood and catheter tip cultures. The primary CoNS strains identified were Staphylococcus haemolyticus, S. epidermidis, and S. saprophyticus. They were detected in 39.3%, 28.6%, and 14.2% of blood cultures, respectively. Catheter tip cultures yielded S. epidermidis and S. haemolyticus in 61.6% and 15.3% of cases, respectively.

Table 3: The other demographic characteristics in these studied subjects.

Variables	Mean±SD	Median	Range
Maternal age at delivery (years)	29.7±6.2	29.5	19-45
Gestational age (GA-weeks)	29.2±3.3	29	25-36
Birth weight (BW-gram)	1287.1±606.7	1075	592-2800
Age at infection onset (days)	20.8±21.1	13	5-104
Catheter length of stay (days)	12.5±4.5	12.4	4.5-20.5
CRP (mg/L)	38.2±43.5	23.3	0-178
WBC/mm^3	26,418±48,694	15,400	5,000-271,000
PLAT/mm^3	162,643±98,181	154,600	12,000-447,000
Lactate (mmol/L)	5.2±1.6	5.1	2.9-7.9

Note: These findings included additional maternal and neonatal traits as well as certain clinical conditions, especially thrombocytopenia, that are linked to platelet count rate.

Antibiotic susceptibility of CoNS isolates results

Tables 5 and 6 present the results of the antibiotic susceptibility testing. In summary, the majority of CoNS spp. isolated from both blood and catheter tip cultures, demonstrated resistance to penicillin and cefoxitin, indicating methicillin-resistance. The isolated demonstrated heterogeneous resistance to aminoglycosides (kanamycin, gentamicin, tobramycin, and netilmicin), erythromycin (a macrolide), ofloxacin (a quinolone), and rifampin. They remain susceptible to glycopeptides (vancomycin), fusidic acid, trimethoprim-sulfamethoxazole, fosfomycin, and to doxycycline. All isolates were categorized into five R-patterns (a, b, c, d, e) for blood culture samples and into three R-patterns (a, c, b) for catheter tip culture samples.

Comparison of phenotypic results obtained from strains isolated in blood cultures versus those from catheter tip cultures.

In this study, 28 venous blood samples and 28 removed catheter tips were analyzed. Among these samples, 28 blood cultures were positive (100%), while catheter cultures were positive in 12 (42.8%) of the preterm infants. The other 16 (57.2%) were negative. Among the 28 CoNS isolates in this series, blood culture results matched catheter tip culture results in 42.8% (12 out of 28) of cases. Twelve concordant strains displayed R-patterns (a), corresponding to six S. haemolyticus isolates and four S. epidermidis isolates,

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Table 4: Neonatal sepsis distribution of coagulase-negative staphylococcus (CoNS) isolates according to the kind of sampling.

CoNS isolates	Blood culture	Central venous catheter (CVC)	Total (%)
	N=28 (%)	Tip culture N=28 (%)	
S.haemolyticus	7 (25.0)	6 (50.0)	13 (32.5)
S.epidermidis	8 (28.5)	4 (33.4)	12 (30.0)
S.saprophyticus	4 (14.1)	1 (8.3)	5 (12.5)
S.hominis	3 (10.8)	1 (8.3)	4 (10.0)
S.warneri	3 (10.8)	0	3 (7.5)
S.capitis	3 (10.8)	0	3 (7.5)
Total	28 (100.0)	12 (42.8)	40 (100.0)

Note: S. haemolyticus, S. epidermidis, and S. saprophyticus were detected in 32.5%, 30%, and 12.5% of the blood and CVC cultures, respectively.

Table 5: Antibiotic susceptibility of coagulase-negative Staphylococcus strains isolated from blood samples.

Antibiotic tested	*S.haemolyticus* N=7	*S.epidermidis* N=8	*S.saprophyticus* N=4	*S.hominis* N=3	*S.capitis* N=3	*S.warneri* N=3
Penicillin	R (%) S (%)	R (%) S (%)	R(%) S(%)	R (%) S(%)	R (%) S(%)	R (%) S(%)
	7 (100) 0	8 (100) 0	4(100) 0	3(100) 0	3 (100) 0	3 (100) 0
Cefoxitin	7 (100) 0	8 (100) 0	4(100) 0	3(100) 0	3 (100) 0	3 (100) 0
Kanamycin	7 (100) 0	8 (100) 0	4(100) 0	3(100) 0	3 (100) 0	3 (100) 0
Gentamicin	7 (100) 0	8 (100) 0	4(100) 0	3(100) 0	3 (100) 0	3 (100) 0
Tobramycin	7 (100) 0	8 (100) 0	4(100) 0	3(100) 0	3 (100) 0	3 (100) 0
Netilmicin	7 (100) 0	8 (100) 0	4(100) 0	3(100) 0	0 3 (100)	3 (100) 0
Erythromycin	7 (100) 0	8 (100) 0	3(75) 1(12.5)	0 3(100)	0 3 (100)	0 3(100)
Lincomycin	1 (14.3) 6(85.7)	2 (25) 6 (75)	0 4(100)	1(33.4) 2(66.4)	0 3(100)	0 3(100)
Pristinamycin	0 7(100)	0 8 (100)	0 4(100)	0 3(100)	0 3 (100)	0 3(100)
Rifampin	6 (85.7) 1(14.3)	7(87.5) 1(12.5)	0 4(100)	1(33.4) 2(66.4)	3 (100) 0	3(100) 0
Ofloxacin	7 (100) 0	8 (100) 0	4(100) 0	3(100) 0	0 3 (100)	0 3(100)
Vancomycin	0 7 (100)	0 8(100)	0 4(100)	0 3(100)	0 3(100)	0 3(100)
Fusidic acid	0 7 (100)	0 8(100)	0 4(100)	0 3(100)	0 3(100)	0 3(100)
*SXT	0 7 (100)	0 8 (100)	0 4(100)	0 3(100)	0 3(100)	0 3(100)
Fosfomycin	0 7 (100)	0 8 (100)	0 4(100)	0 3(100)	0 3 (100)	0 3(100)
Doxycyclin	0 7 (100)	0 8 (100)	0 4(100)	0 3(100)	0 3(100)	0 3(100)
R patterns	a	a	b	c	d	e

Note: *SXT: Trimethoprim-sulfamethoxazole; High resistance: 90.9-100%; Moderate resistance: 75-87.5%; High susceptibility: 90.9-100%; moderate susceptibility: 66.4-75%; R patterns: resistance patterns (a, a, b, c, d, e).

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respectively. The R-pattern (b) was detected in a single strain and matched the S. saprophyticus isolate. The R-pattern (c) was detected in a single strain and matched the S. hominis isolate. Among the eight CoNS strains isolated from blood cultures, comprising one S. haemolyticus (phenotype a), four S. epidermidis (phenotype a), and three S. saprophyticus (phenotype b), none were detected in the corresponding catheter tip cultures. In catheter tip cultures, three S. capitis strains (phenotype d) and three S. warneri (phenotype e) were absent. Table 7 presents the variables assessed in the NICU of UHAP concerning catheter-related bloodstream infections among 28 preterm newborns.

PFGE results

When the same Staphylococcus spp. were recovered from both the CVC tip and peripheral blood cultures, and exhibited identical resistance patterns, they underwent PFGE genotyping to confirm CRBSI. SmaI restriction sites in the chromosomal DNA of 24 Staphylococcus spp. The isolates studied generated seven distinct patterns of 13-17 fragments, ranging in size from 48.5 to 533.5 Kbp, which were arbitrarily designated as PFGE patterns (PFGEp). Five PFGE types (A, B, C, D, and E) were identified. PFGEp A was the predominant type, accounting for 50% (12/24) of the isolates, followed by PFGEp B at 33.4% (8/24), PFGEp D at 8.4% (2/24), PFGEp C and PFGEp E, each representing 4.1% (1/24). PFGEp A identified S. haemolyticus in isolates 1-3 and 16-18 from blood cultures, and in isolates 19-24 from CVC tip cultures. PFGEp B included S. epidermidis isolates 4, 5, 8, and 9 from blood cultures, as well as isolates 11, 13-15 from CVC tip cultures. PFGEp D included S. hominis (isolate 7) from blood culture and (isolate 10) from CVC tip culture. These isolates were closely related to one another within the same genotype. PFGEp C contained S. saprophyticus (isolate 6) from a blood culture, while PFGEp E contained S. saprophyticus (isolate 12) from a CVC tip culture. These final isolates were genotypically distinct. Figure 1 shows the molecular sizes of these PFGE products, which consisted of 16-24 fragments, ranging from 48.5 to 533.5 Kb. PFGEp A was associated with 12 S. haemolyticus isolates (R-pattern a), PFGEp B included eight S. epidermidis isolates (R-pattern a), PFGEp C represented a single S. saprophyticus strain isolated from a catheter tip (R-pattern b), and PFGEp D comprised two S. hominis isolates (R-pattern c).

Table 6: Antibiotic susceptibility of Coagulase-negative Staphylococcus strains isolated from Central Venous Catheter (CVC) tip culture.

Antibiotic tested	***S.haemolyticus*** **N=6**		***S.epidermidis*** **N=4**		***S.hominis*** **N=1**		***S.saprophyticus*** **N=1**	
	R(%)	S (%)	R (%)	S (%)	R	S	R	S
Penicillin	6 (100)	0	4 (100)	0	1	0	1	0
Cefoxitin	6 (100)	0	4 (100)	0	1	0	1	0
Kanamycin	6 (100)	0	4 (100)	0	1	0	1	0
Gentamicin	6 (100)	0	4 (100)	0	1	0	1	0
Tobramycin	6 (100)	0	4 (100)	0	1	0	1	0
Netilmicin	6 (100)	0	4 (100)	0	1	0	1	0
Erythromycin	6 (100)	0	4(100)	0	0	1	1	0
Lincomycin	1(16.6)	5 (83.4)	0	4 (100)	0	1	0	1
Pristinamycin	0	6 (100)	0	4 (100)	0	1	0	1
Rifampin	6 (100)	0	4(100)	0	0	1	0	1
Ofloxacin	6 (100)	0	4 (100)	0	1	0	1	0
Vancomycin	0	6 (100)	0	4 (100)	0	1	0	1
Fusidic acid	0	6 (100)	0	4 (100)	0	1	0	1
*SXT	0	6 (100)	0	4 (100)	0	1	0	1
Fosfomycin	0	6 (100)	0	4 (100)	0	1	0	1
Doxycyclin	0	6 (100)	0	4 (100)	0	1	0	1
R patterns	a		a		c		b	

Note: *SXT: Trimethoprim-sulfamethoxazole; High resistance: 100%; moderate resistance: 87.5% ;High susceptibility: 100%; moderate susceptibility: 75%; R patterns: Resistance patterns (a, a, c, b).

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Table 7: Studied variables associated with catheter-related bloodstream infection in 28 preterm newborns in the neonatal intensive care unit of APUH.

Patient N°	**Positive Blood culture**	**Positive catheter tip culture≥10^3**	**Variable**	**Variable**	**Variable**	**Variable**	**Variable**	**Variable**	**Variable**	**Variable**
N= 28	Group 1	Group 1 CVC+	GA (weeks)	BW (g)	Age at Infection onset (days)	CRP>10 (mg/L)	WBC count 18,000/ mm^3	Platelet count <150,000/mm^3	Lactate (0.88-2.2 mmol/L)	catheter length of stay (days)
2 5 8 10 11 14 17 18 20 21 23 27	+ + + + + + + + + + + +	10^6 10^3 10^4 10^6 10^5 10^3 10^4 10^6 10^5 10^4 10^4 10^5	25 28 28 31 30 35 29 29 35 36 34 26	950 1,200 960 1,720 1,730 2,371 1,330 755 2,400 2,730 1,340 995	47 30 13 10 19 28 20 15 53 104 24 33	— 40 17 178 84 99 58 — 41.5 15 45 84	— 19,900 — 20,500 19,000 — 37,000 27,000 20,400 — — 36,900	— 65,000 103,000 70,000 60,000 136,000 123,000 98,000 73,000 — --- 75,000	7.2 7.3 5.5 7.0 6.9 6.8 7.5 7.7 3.5 4.5 5.8 4.6	5.3 6.2 4.5 7.0 8.4 10.5 12.3 13 9 7 11 17.8
12 (42.8%)			12/28 (42.8%)	12/28 (42.8%)	12/28 (42.8%)	10/28 (35.7%)	7/28 (25%)	8/28 (28.6%)	12/28 (42.8%)	12/28 (42.8%)
Patient N°	Positive blood culture	Negative catheter culture	Variable	Variable	Variable	Variable	Variable	Variable	Variable	Variable
N=28	Group 2	Group 2 (CVC-)	GA (weeks)	BW (g)	Age at Infection onset (days)	CRP≥10 mg/L	WBC >18,000 /mm^3	Platelet Count <150,000 /mm^3	Lactate (mmol/L)	Catheter length of stay (days)
1 3 4 6 7 9 12 13 15 16 19 22 24 25 26 28	+ + + + + + + + + + + + + + + +	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	26 36 26 29 27 30 27 25 26 27 32 29 30 29 28 25	710 2,800 700 1,370 950 1,060 986 700 592 990 1,090 949 1,250 1,320 1,192 900	48 8 8 9 11 7 10 14 15 8 6 5 13 5 11 9	— 53 — 23 62 — — — 103 89 23.7 31 — — — —	— — 34,200 18,400 25,100 — — — — 271,000 — — 18,200 [1]5,000 — 35,700	70,000 — — — 85,000 — — — 72,000 12,000 — — — 120,000 — —	6.5 6.8 7.9 2.9 3.4 4.2 4.3 5.0 5.9 5.3 3.5 3.7 4.1 3.0 3.3 4.0	10 11.6 12.5 18.5 20.5 16.2 17.6 13.4 11.4 10.3 14.7 15.2 12.8 17.2 19.8 18.9
N=16 (57.2%)			16 (57.2%)	16 (57.2%)	16 (57.2%)	7 (25.0%)	7 (25.0%)	5 (17.9%)	16/28 (57.2%)	16/28 (57.2%)

Note: GA: gestational age (weeks); BW: birth weight;WBC: White blood cell; [1]WBC: leukopenia, 5,000/mm^3; *****CRP: C-reactive protein.

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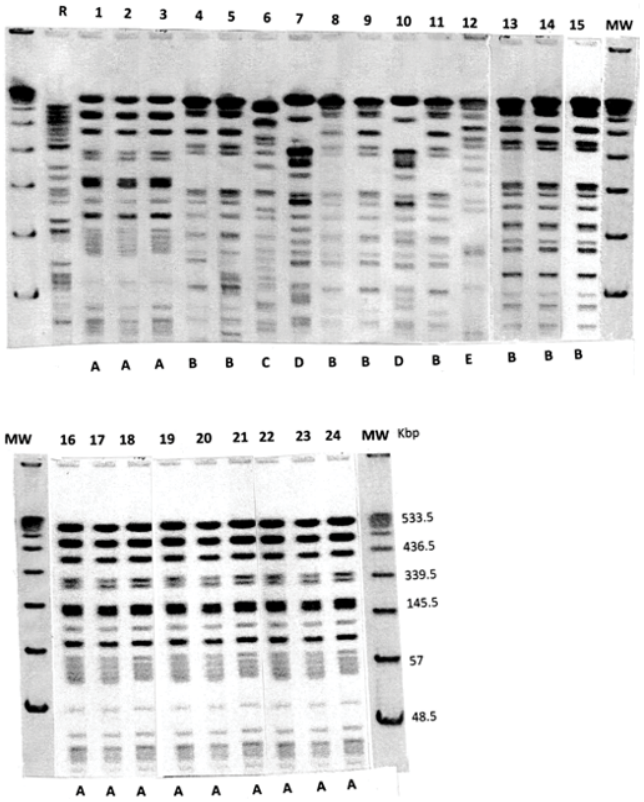


Figure 1: Representative of PFGEps of 24 CoNS *spp.* isolated from blood culture samples (12 isolates), and from CVC tip cultures samples (12 isolates).

Comparing phenotypic procedures with the genotypic method

We confirmed CRBSI by comparing phenotypic procedures with genotypic methods. The phenotype (a) resembled both genotype A of S. haemolyticus and genotype B of S. epidermidis. Phenotype (c) matched genotype D of S. hominis. Phenotype (b) matched genotype C of S. saprophyticus isolated from the blood culture and genotype E of S.

Saprophyticus isolated from the catheter tip culture**.**

The role of genotypic analysis in the investigation of CRBSI episodes

In our study, we identified 74 episodes of suspected CRBSI. They exhibited symptoms resembling CRBSI and had one or more CoNS isolates detected in both blood and catheter tip cultures. During these episodes, the distribution of positive blood cultures was as follows: 16 episodes with 16 positive cultures (100%), 8 episodes with 4 positive cultures (50%), 3 episodes with 1 positive culture (33.3%), 12 episodes with 3 positive cultures (25%), 21 episodes with 3 positive cultures (14.2%), and 14 episodes with 1 positive culture (7.1%). Based on PFGE results, we were able to analyze 26 CoNS isolates following 66 episodes of suspected CRBSI. Among these, 5 distinct PFGEps (A-E) were identified, enabling the detection of 64 episodes of true CRBSI (96.9%). Out of 45 episodes, 12 had positive blood cultures (26.6%), 8 out of 17 episodes (47%) were positive, and 2 out of 2 episodes were positive. Across two episodes, we identified 2 positive blood cultures; in one episode, the positive blood culture matched PFGEp C, and in the other, it matched PFGEp E yet for both instances, no corresponding PFGEp pattern was found between the blood culture and the catheter tip culture. Consequently, they were not classified as CRBSI.

Baseline characteristics

According to the results, 28 preterm infants with BSIs were identified, comprising 12 (42.8%) in the CVC+ group who had positive blood and catheter tip cultures, and 16 (57.2%) in the CVC- group who had positive blood cultures but negative catheter tip cultures. When analyzing the two groups, CVC+ and CVC-, the following results were observed: GA was 30.5± 3.7 weeks; median 29.5; range 25-36 versus 28.2±2.8 weeks; median 27.5; range 25-36, BW was 1360±693 g; median 1265; range 240-2730 versus 1097± 509 g; median 988; range 592-2800), age at onset of infection was 33±26 days; median 26; range 10-104 versus 12±10 days; median 9; range 5-48, CRP 66±48 >10mg/L; median 52.5; range 15-178 versus 55±32; median 53; range 23-103, lactate 6±1.3 <2.2 mmol/L; median 6.8; range 3.5-7.7 versus 4.6±1.4; median 4; range 2.9-7.9, WBC 25,900±8,063/mm^3; median 20,500; range 19,000-37,000 versus 67,100±100,170/mm^3; median 29,650; range 18,200-271,000, PLAT 89,222±27,092/mm^3; median 75,000; range 60,000-136,000 versus 71,800±38,977/ mm^3; median 72,000; range 12,000-120,000, catheter length of stay 15±3.4 days; median 8.7; range 4.5-17.8 versus 9.3±3.8 days; median 15; range 10-20.5 (Table 8).

Univariate analysis of factors associated with CRBSI

Our study identified several variables that are crucial for the clinical and biological diagnosis of CRBSI. When comparing group CVC+ to group CVC-, significantly higher values were observed in the CVC+ group for BW (p=0.03), age at infection onset (p=0.003), PLAT count (p=0.02), catheter-related length of stay (p=0.001), and lactate levels (p=0.008). As shown in Table 8, no significant differences were observed between the CVC+ and CVC- groups for GA (p=0.11), CRP (p=0.06), or WBC count (p=0.39). Additionally, qualitative parameters were analyzed using Fisher's exact test. Significant associations were found with lipid emulsion (p=0.0003), antenatal corticosteroids (p=0.003), antenatal antibiotic therapy (p=0.04), neonatal antibiotic therapy (p=0.02), patent ductus arteriosus (p=0.02), and PPIs (p=0.005). The quantitative parameters were analyzed in parallel using the Wilcoxon-Mann-Whitney test, revealing significant differences for BW (p=0.03), age at infection onset (p=0.0003), lactate levels (p=0.008), PLAT

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Table 8: Univariate analysis of factors associated with CR-BSI.

Variables	Group 1 (CVC+)	Group 2 (CVC-)	p-value
Gestational age (weeks) Mean±SD Median Range	 30.5±3.7 29.5 25-36	 28.2±2.8 27.5 25-36	0.11
Birthweight (g) Mean±SD Median Range	 1360±693 1265 240-2730	 1097±509 988 592-2800	**0.03**
Age at infection onset (days) Mean±SD Median Range	 33±26 26 10-104	 12±10 9 5-48	**0.0003**
CRP mg/L Mean±SD Median Range	 66±48 52.5 15-178	 55±32 53 23-103	0.06
WBC count/mm^3 Mean±SD Median Range	 25900±8063 20500 19000-37000	 67100±100170 29650 18200-271000	0.39
Platelet count/mm^3 Mean±SD Median Range	 89222±27091 75000 60000-136000	 71800±38977 72000 12000-120000	**0.02**
Catheter length of stay (days) Mean±SD Median Range	 15±3.4 8.7 4.5-17.8	 9.3±3.8 15 10-20.5	**0.001**
Serum lactate mmol/L Mean±SD Median Range	 6±1.3 6.8 3.5-7.7	 4.6±1.4 4 2.9-7.9	**0.008**

Note: We found that birth weight (BW) (p=0.03), age at infection onset (p=0.003), platelet count (PLAT) (p=0.02), catheter length of stay (p=0.001), and lactate (p=0.008) were all significantly higher in group CVC+ compared to group CVC-.

(p=0.02), and catheter-related length of stay (p=0.001) as detailed in Table 9. A logistic regression model was employed to incorporate the significant factors identified in this analysis. The age at which the infection onset began remained an independent RF for CRBSI.

Marker selection using the Akaike information criterion (AIC) and the Bayesian information criterion (BIC)

Table 10 summarizes the associations between the risk of CRBSI occurrence and the following variables: GA, BW, age at infection onset (ONSET), CRP, WBC count, and PLAT count. We performed a discriminant analysis using simple logistic regression. This demonstrates the significance of evaluating models with varying parameter counts. The most effective approach for comparing models is to utilize either the AIC [26] or the BIC [27-29]. When AIC and BIC variable selection methods were applied to ONSET, a set of markers was selected that best fit the data. When analyzed using a multivariate approach, the age at infection onset began was the sole factor statistically linked to the risk of CRBSI. In the optimal search for a multivariate model, we use the term

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Table 9: Rates and relative risk factors for catheter-related bloodstream infection caused by coagulase-negative staphylococci.

Analyzed parameters	**Group1 (CVC+)**	**Group2 (CVC-)**	**Wilcoxon-Mann Whitney test (p-value)**	**Fisher's exact test** (p-value)
Gestational age (weeks) mean±SD median (range)	30.5±3.7 29.5 (25-36)	28.25±2.86 27.5 (25-36)	Qobs: 130 P=0.11	
Birthweight (g) mean±SD median (range)	1,360±692.4 1,265 (240-2,730)	1,097.4±508.8 988 (592-2,800)	Qobs: 141.5 **P=0.03**	
Age at infection onset (days) mean±SD median (range)	33±25.8 26 (10-104)	11.6±10.1 9 (5-48)	Qobs: 173.5 **P=0.0003**	
CRP≥10/mm³ **mean**±SD median (range) **Serum lactate mmol/L** mean±SD median (range)	66.1±48.3 51.5 (15-178) 6±1.3 6.8 (3.5-7.7)	54.9±31.8 53 (23-103) 4.6±1.4 4 (2.9-7.9)	Qobs: 135 P=0.06 Qobs: 153 **P=0.008**	
WBC count/mm³ mean±SD median (range)	25,900±8,063.4 20,500 (19,000-37,000)	67,100±100.170.3 29,650 (18,200-271,000)	Qobs: 113.5 P=0.39	
Platelet count/mm³ mean±SD median (range)	89,222.2±27,091.4 75,000 (60,000-136,000)	71,000±38,976.9 72,000 (12,000-120,000)	Qobs: 143 **P=0.02**	
Catheter length of stay (days) mean±SD median (range)	9.3±3.8 8.7 (4.5-17.8)	15.0±3.4 14.9 (10-20.5)	Qobs: 26 **P=0.001**	
Lipid emulsion	10 (83.4%)	2 (12.5%)		**P=0.0003** OR: 28.428 95% CI[3.2095; 476.2275]
Antenatal corticosteroid	11 (91.6%)	4 (25%)		**P=0.003** OR: 27.2597 95% CI [2.7094;1517.2448]
Hemodynamic disorders	3 (25%)	5 (31.2%)		P=0.06 OR: 6.1128 95% CI [0.9744 ;51.6683]
History jaundice	8 (66.6%)	4 (25%)		P=0.06 OR: 5.5744 95% CI [0.9054;42.9234]
Antenatal antibiotic therapy	7 (58.3%)	3 (18.7%)		**P=0.04** OR: 5.5744 95% CI [0.8634;48.4832]
Neonatal antibiotic therapy	10 (83.4%)	6 (37.5%)		**P=0.02** OR: 7.6616 95% CI [1.0876;95.7421]
Patent ductus arteriosus	10 (83.4%)	6 (37.5%)		**P=0.02** OR: 7.6616 95% CI [1.0876; 95.7421]

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Mode of delivery **Cesarean section** **Vaginal**	 8 (66.6%) 4 (33.4)	 4 (25%) 12 (75%)		P=0.06 OR: 5.5744 95% CI [0.9054; 42.9234]
Proton pump inhibitor	11 (91.6%)	6 (37.5%)		**P=0.005** OR: 16.3688 95% CI [1.6493; 860.9408]

Note: For each of the risk factors related to the infection studied, significant differences were observed both by the Wilcoxon-Mann Whitney test and by Fisher's exact test (<0.05) between the two groups. On the other hand, the following parameters: WBC count, hemodynamic disorders and history jaundice are not statistically significant (p>0.05) and therefore do not constitute likely risk factors related to infection in this study. p-values in bold are statistically significant

Table 10: Selection of models with Akaike information criterion (AIC) and Bayesian information criterion (BIC).

0	Parameter Number in the model	ONSET	GA	BW	CRP	PLAT	WBC	AIC	BIC
1	6	V	V	V	V	V	V	30.70215	40.02768
2	5	V	V		V	V	V	28.71205	36.70527
3	5	V	V	V		V	V	29.17177	37.16499
4	5	V	V	V	V		V	28.70611	36.69933
5	5	V	V	V	V	V		33.23517	41.62284
6	5	V	V	V	V	V	V	30.28223	38.27323
7	4	V				V	V	27.41080	34.07183
8	4	V	V		V		V	26.72015	33.38117
9	4	V	V	V			V	27.42134	34.08236
10	4	V	V		V	V		31.27269	37.93371
11	4	V	V	V		V		32.17604	38.83706
12	4	V		V		V	V	28.67476	35.33578
13	3	V		V	V			29.75714	35.08596
14	4	V		V	V		V	28.2936	34.95462
15	4	V	V	V	V			31.44426	38.10528
16	4	V		V	V	V		31.68335	38.34437
17	4	V			V	V	V	30.65144	37.31247
18	3	V	V				V	25.69952	31.02578
19	3	V	V			V		30.39824	35.72706
20	3	V	V		V			29.48198	34.8108
21	3	V		V		V		30.70391	36.03272
22	3	V			V		V	29.25369	34.58251
23	3	V		V			V	26.84445	32.17327
24	3	V			V	V		31.10912	36.43794
25	3	V				V	V	32.40407	36.975
26	3	V	V	V				32.04537	37.37419
27	2	V			V			29.15658	33.15319
28	2	V				V		32.38367	36.35028
29	2	V	V					30.54763	34.54424
30	2	V		V				30.17781	34.17443
31	2	V					V	30.57355	34.57017
32	1	V						31.35667	34.02107

Note: The best model within the meaning of the AIC and BIC criteria is model n° 18 which among all candidates leaves the lowest residual information (AIC=25.7; BIC=31.02) and that satisfies the parsimony criterion, comprising only 3 terms (ONSET, GA, WBC).

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''ONSET'' to align with the other variables (GA, PLAT, and WBC). Among all candidates, model 18 yields the lowest residual information (AIC=25.7; BIC=31.02), and satisfies the parsimony criterion by including only three terms: ONSET, GA, and WBC. Other factors, such as CRP, BW, and PLAT, resulted in weaker merit models (Table 10). At the time of CRBSI diagnosis (ONSET), the age range was 99 days (minimum 5, maximum 104), with a mean of 20.8 days, and a median of 13 days. Based on the CVC culture results, the ONSET analysis yielded an area under the ROC (Receiver Operating Characteristic) curve or Area Under the Curve (AUC) of 0.90 (95% CI [0.73; 0.98], (p<0.001), indicating that two groups (CVC+ and CVC-) can be well distinguished at the critical threshold of 14 days. The study demonstrated a sensitivity of 83.3% and a specificity of 87.5% (Figure 2). The ONSET analysis was performed based on the results of CVC culture. The AUC was 0.90, with a 95% CI [0.73, 0.98]. At the critical threshold of 14 days, this result effectively distinguishes between the two studied groups (CVC+ and CVC-).

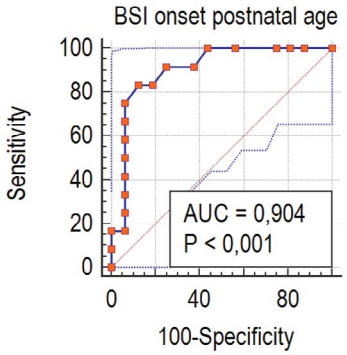


Figure 2: Area Under the Curve (AUC) of the ONSET variable according to the CVC culture results.

Discussion

The results of this study indicate that contamination of the CVC can occur during BSI, although it is not a consistent occurrence. It was observed in fewer than half of the individuals in the study. Although CRBSI is acknowledged as the most common complication of parenteral nutrition (PN), it is challenging to definitively diagnose CRBSI in more than 50% of preterm infants. BSI, particularly CRBSI, are among the most common and severe types of HAIs. In a retrospective analysis of a prospective cohort study conducted by Pijoan et al. [13], analysis of VLBW infants (<1500 g at birth) revealed a significant decrease in the incidence of neonates with ≥ 1 BSI episode (27%) during the study period, corresponding to an 18.7% reduction (p=0.002), including a statistically significant decline in the 500-999 g subgroup (16.5% reduction). BSI rates decreased by 23.5% (p<0.001), while CRBSI rates by 18.4% (p=0.062). Catheter infections occur most frequently when caused by CoNS. A fever is typically observed when an infection is present at the insertion site. Severe sepsis is a rare occurrence. The issue is resolved by removing the catheter after 5-7 days of antibiotic therapy. Assuming no complications arise, we can discuss maintaining the catheter for 7 days and utilizing an antibiotic lock for 10 to 14 days. CoNS are the primary pathogens responsible for CRBSIs, which account for the majority of documented sepsis cases in the NICU. These microorganisms are components of the skin's normal microbiota. They were the most frequently detected on the catheter tip. The definition of CRBSI mandates the isolation of one or more identical CoNS spp. from blood and catheter tips. In this study, CoNS was detected in 42.8% of CRBSI cases. According to Vodianyk, et al. [17] and the European Center for Disease Prevention and Control (ECDC) [12], CoNS were the most frequently isolated microorganisms in BSI, including those microbiologically confirmed CRBSI.

In this study, S. haemolyticus, S. epidermidis, and S. saprophyticus accounted for 32.5%, 30%, and 12.5% of CoNS respectively. In a previous study, we showed that S. haemolyticus and S. epidermidis were the most frequently isolated CoNS spp., with corresponding rates of 41.8% and 17.8% [30]. Depending on Vodianyk, et al. [17], among the Staphylococcus spp. strains isolated from pediatric patients with BSIs, 80% were S. aureus, 10% were S. epidermidis, and 10% were S. haemolyticus. The three most commonly isolated CoNS strains were S. epidermidis (45%), S. hominis (14%), and S. haemolyticus (12.7%) as per Chaieb et al. [31]. Durkin and colleagues [32] and Oliveira et al.[33] reported similar outcomes in 30% and 86.3% of S. epidermidis isolates, respectively. Sahu et al. [8] did a prospective observational study with 258 children under the age of 18 who had a Hickman line or chemoport inserted. They found that Klebsiella and CoNS were common pathogens in 25.6% and 20.2% of 74 episodes of CABSI. A similar finding was reported by Gowin et al. [7], who identified CoNS as the most common pathogens responsible for BSI, accounting for 54.5% of cases, with S. epidermidis specifically present in 39.6% of these infections. In another study, among Staphylococcus spp. strains that were isolated from pediatric patients with BSIs, 80% were S. aureus, 10% were S. epidermidis, and 10% were S. haemolyticus [17]. In 2022, the ECDC found that Staphylococcus spp. were the main cause of CRBSI, with S. epidermidis and S. aureus responsible for 23.6% and 12.0% of cases, respectively [34]. There may also be a big resistance to antimicrobial drugs, considering that many CRBSI retailers are proof against robotically-used antimicrobials. All the CoNS strains isolated in this study were resistant to penicillin and cefoxitin (100% resistance). They demonstrated a high resistance to aminoglycoside, and ofloxacin (100%) and a high susceptibility to vancomycin, pristinamycin, trimethoprim-sulfamethoxazole, fosfomycin, and doxycycline. In any other look performed at the NICU,

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we found the identical results |35]. Additionally, Durkin et al. [27] mentioned comparable findings. Bacteria resistant to conventional antibiotic treatment have been detected in 38.7% of blood samples. The most prevalent pathogens become methicillin-resistant S. epidermidis (30.6%) [7]. Within the pathogenesis of CRBSIs as a result of CoNS, there are fundamental ways wherein CoNS gets into the bloodstream because of CVC insertion. There are routes for contamination of the CVC tip; extraluminal in those short-lasting (<8 days) and endoluminal in those long-lasting (>8 days) infections. In critically ill patients, the bloodstream is the most likely. Our observation revealed that the presence of CoNS at the CVC tip was an independent RF associated with CVC colonization (p=0.001), highlighting the significance of the skin as a reservoir for this microorganism. CoNS typically adhere to the polymer floor of the CVC, forming a slime/glycocalix layer. The role of the glycocalix in the pathogenesis of CRBSI following catheter insertion into the vascular system [14]. As soon as the CoNS gets to the CVC, contamination takes place because bacteria can stick with the catheter surface, colonize it, and make biofilm. Biofilm is made when a microorganism is attached to the external or internal surface of the catheter. The length and location of the CVC biofilm relies on how lengthy the catheter has been in place. If the biofilm is less than 10 days old, it' will shape on the external catheter surface. In the case of lengthy-term indwelling catheters, it'll form at the internal surface [12]. The primary routes and sources for CoNS entering the bloodstream include intravascular catheters (central lines), which represent the single most common pathway for CoNS BSIs and account for a significant proportion of healthcare-associated bacteremia. Bacteria colonizing the patient's skin can migrate down the external surface of the catheter tract from the insertion site into the blood vessel; second, contamination of catheter hubs and access sites occurs when healthcare providers or patients handle needleless connectors, stopcocks, or hubs without proper antiseptic technique, allowing bacteria to enter the lumen of an intravenous or central line; third, biofilm formation on implanted medical devices involves CoNS producing a sticky extracellular matrix that enables firm adhesion to artificial surfaces such as prosthetic. In numerous clinical situations, CoNS do not truly enter the patient's bloodstream; rather, they contaminate the blood sample during skin puncture if skin antisepsis is inadequate.

CVCs used in NICU reveal patients to complications, the principal one being BSI. Prevention is achieved through the detection of RFs. However, additionally, through research of RFs associated with it, just as by means of the identity of the germs. The RFs for CRBSI were determined to be: BW (p=0.03), age at infection onset (p=0.003), PLAT count number (p=0.02), catheter length of stay (p=0.001), lipid emulsion (p=0.0003), antenatal corticosteroid (p=0.003), antenatal antibiotic therapy (p=0.04), neonatal antibiotic therapy (p=0.02), patent ductus arteriosus (p=0.02), and PPI (p=0.005). Group 1 patient had a higher risk of having CRBSI than group 2.

In the meta-analysis study conducted by Wang and colleagues in 2025 [36], the RFs for CRBSI in neonates, ranked from strongest to weakest association, included multi-lumen central venous catheters (≥2), 5-min Apgar score (≤7), number of manipulations (≥2), catheter indwelling time (>14 days), GA (≤32 weeks), PN, maternal disease, BW<1,500 g, catheterization of the upper and lower limbs. All these factors were associated with the risk of CRBSI.

An evidence-based prevention bundle is suggested based on the meta-analysis's identification of the main modifiable RFs for CRBSI in neonates. To reduce the incidence of CRBSI and improve ressource efficiency, this bundle focuses on key factors such as catheter indwelling time, aseptic technique, and nutrition management, especially in high-risk neonates [36]. Another systematic review and meta-analysis focusing on patients aged 18 years or older [37] examined eleven RFs for CRBSI, categorizing them into modifiable and unmodifiable groups [38]. These authors identified the following modifiable RFs: duration of catheterization (≥5, ≥7, and ≥14 days), use of multiple-lumen catheters, duration of tube indwelling, length of ICU stay, and position of indwelling; unmodifiable RFs included age ≥60 years, extensive antibiotic use, diabetes mellitus, total PN, and immunosuppression, all of which were significantly associated with CRBSI. As anticipated, the study by Huang and colleagues [37] supports the view that the duration of catheterization is a modifiable factor that increases the incidence of CRBSI. The authors may conclude that a longer duration of catheterization increases the risk of infection. These authors also conclude that effectively targeting modifiable factors may reduce the risk of developing CRBSI in the ICU and improve patient clinical outcomes. While our study examained risk markers associated with CRBSI, the findings from the literature differ from our results. So that you can have a look at the epidemiology and etiology of CoNS CRBSI, an accurate technique needs to be used to identify strain-relatedness. Regardless of our consequences, it isn't feasible to confirm that every one 24 cases of CoNS presumptive phenotypically CRBSI are responsible for CRBSI. Of those isolates, 22 (91.6%) were genotypically related to CRBSI and constituted authentic motive of CRBSI, and 2 (8.4%) were no longer related to CRBSI and have been not considered to be the cause. Within the gift examine, patients in group 2 were characterized by the absence of evidence of a source of BSI apart from that associated with vascular access. Brief BSI is often asymptomatic. However, it may additionally trigger the onset of clinical signs and symptoms in line with several hypotheses. The probability of getting a false positive blood culture may be associated with

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overfilling pediatric blood culture bottles. A blood culture bottle that is too full might also have enough blood cells to make CO_2 and help the unique detection algorithms inside the incubation module work faster. Because overfilling might lead to a false positive, no microorganisms are cultured [39]. CoNS are the most frequently isolated organisms from blood cultures. They are a significant cause of HAIs but also the most frequent cause of false-positive blood cultures [40]. These CoNS isolates are often regarded as contaminants, which can lead to several potential adverse outcomes, including uncertainty regarding the diagnosis of BSI, inappropriate antibiotic treatment, unnecessary catheter removal, prolonged hospital stays, and increased healthcare costs [41]. In this study, eight of the 16 patients with a blood culture-positive results but negative intravascular catheter tip cultures had their catheters removed five days before the onset of BSI. This could mean that BSI may appear suddenly or persist for an extended period. The optimal therapeutic strategy is to remove the catheter immediately if sepsis is suspected. It is necessary to establish additional central access to maintain PN, manage the umbilical cord in very preterm infants, and administer appropriate antibiotics. Placing a new access line in very preterm infants is not always straightforward, and repositioning a displaced catheter often requires significant effort. Infections such as those caused by genital-urinary catheters, dental procedures, digestive tract interventions, and colonization of indwelling invasive systems are examples of infections that can occur during certain BSIs. In a separate study, we observed that bacterial translocation from the gastrointestinal tract to the circulatory system occurred in 53.5% of preterm infants [26].

Study limitations

Given the small size of the study population, it is probable that some risk factors for contamination were overlooked in the patients' medical records. It is possible that certain variables, such as inadequate preparation of the sampling site, or absent hand disinfection, suboptimal sampling techniques, the use of invasive devices for sampling, sample multiplication, and poor asepsis of blood culture bottle caps, were excluded from the analysis because they had not yet been studied. CoNS are the most frequently isolated microorganisms from blood cultures in newborns. It serves as both a contaminant and a pathogen. It is challenging to differentiate between contaminants and pathogens.

Conclusion

Based on our analysis, the published AIC and BIC criteria best address key statistical considerations. The best approach for comparing models is to use either the AIC or the BIC. After applying AIC and BIC variable selection to ONSET, a set of markers that best fit the data was selected. Identifying CoNS is a critical indicator of infection, given that S. haemolyticus, S. epidermidis, and S. saprophyticus are the most frequent causative agents commonly linked to CRBSI. When microorganisms are isolated from both blood and CVC samples, accurate characterization is essential. The A and B genotypes, comprising 12 and 8 isolates of CoNS respectively, constitute a large significant portion of the epidemic that spread within the NICU. A strong association was identified between major epidemic genotypes and their R-pattern (a), indicating that multidrug resistance is becoming increasingly prevalent. The analysis of CRBSI revealed genotypic implications. Since the catheter is not completely contaminated, the decision is whether to retain it and remove it secondarily shortly before the end of antibiotic therapy if a biofilm is present on its external surface. Then, continue treatment using a new vein line.

Ethical Approval and Consent to Participate

All procedures involving human participants were conducted in accordance with the Declaration of Helsinki and/or the local Research Ethics Committee (Personal Protection Committee-PPC), which granted favorable approval for the study involving preterm infants and their clinical and laboratory data. Since this non-interventional retrospective study relies exclusively on anonymized medical data extracted from existing electronic medical records and involves no direct interaction with human subjects, consent from the legal guardians of the minors was not sought. All study participants were autonomous and independent breastfeeding mothers who had the capacity to decide whether to include their baby's clinical and biological data in the research.

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Author Contributions

AL, GK, and MB contributed to the study conception, design, and drafted the manuscript. All authors participated in the acquisition, analysis and the interpretation of data and also in editing and final revisions. They participated in meetings and follow-up discussions that culminated in the preparation of this manuscript. All authors read and approved the final manuscript.

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Conflict of Interest

The authors declare that they have no conflict of interest.

References

1. Zhang Y, Wang Y, Sheng Z, et al. Incidence rate, pathogens and economic burden of catheter-related bloodstream infection: a single-center, retrospective case-control study. Infect Drug Resist 16 (2023): 3551-3560.
2. Brown R, Burkee D. The hidden cost of catheter-related blood stream infections in patients on parenteral nutrition. Clin Nutr ESPEN 36 (2020): 146-149.
3. Zeng C, Wu A, Li L, et al. Multi-center prospective study on central line-associated bloodstream infections in 79 ICUs of China. BMC Infect Dis 21 (2021): 1208.
4. AI-Shukri RN, AI-Rawajfah OM, AI-Daken L, et al. ICU-acquired central line-associated bloodstream infection and its associated factors in Oman. Am J Infect Control 50 (2022): 1026-1031.
5. MacPhail A, Chraïti M-N, Zanella M-C, et al. Microbiology of catheter-associated bloodstream infection: differences according to catheter type. Int J Infect Dis 148 (2024): 107247
6. National Healthcare Safety Network (NHSH). Bloodstream infection event (central line-associated bloodstream infection and non-central line-associated bloodstream infection): (January 2026): 1-46.
7. Gowin E, Swiatek-Koscielna B, Januszkiewicz-Lewandowska D. The profile of microorganisms responsible for port-related bacteremia in pediatric hemato-oncological patients. Cancer Control 27 (2020): 1-7.
8. Sahu A, Zameer M, Vinay C, et al. Catheter-associated bloodstream infection in children with tunneled central venous catheters: a single-center experience. J Indian Assoc Pediatr Surg 29 (2024): 329-333.
9. Dimopoulou V, Glaser K, Giannoni E. Central line-associated bloodstream infections in niewborns: from vulnerability to prevention. Seminars Fetal Neonat Med 30 (2025): 101665.
10. Strunk T, Molloy EJ, Mishra A, et al. Neonatal bacterial sepsis. Lancet 404 (2024): 277-293.
11. MacPhail A, Chrai¨ti M-N, Nguyen A, et al. Epidemiology of hospital-acquired bloodstream infections in haemato-oncology patients in Geneva, Switzerland. Infect 53 (2025): 1929-1939.
12. European Centre for Disease Prevention and Control (ECDC). Healthcare-associated Infections acquired in intensive care units (ICUs). In: ECDC. Ann Epidem report for 2021. Stockholm: ECDC 2024.
13. Pijoan J, Pérez-Lopez J, Madrid M, et al. Incidence of late onset bloodstream infection and use of preventive practices in very low birth weight infants in Spain: the neokisses cohort surveillance experience. Antimicrob Resist Infect Control 15 (2026): 77.
14. Cai S, Thompson DK, Anderson PJ, et al. Short-and long-term neurodevelopmental outcomes of very preterm infants with neonatal sepsis: a systematic review and meta-analysis. Children (Based) 12 (2019): 131.
15. Zipursky AR, Yoon EW, Emberley J, et al. Central line-associated blood stream Infections and non-central line-associated blood stream infections surveillance in Canadian tertiary care neonatal intensive care units. J Pediatr 208 (2019): 176-182- e6.
16. Bull F, Tavaddod S, Bommer N, et al. Different factors control long-term versus short-term outcomes for bacterial colonisation of urinary catheter. Nat Commun 16 (2025): 3940.
17. Vodianyk A, Poniatovsky V, Shyrobokov V. Molecular characteristics of antimicrobial resistance and biofilm formation of bloodstream infection pathogens Isolated from pediatric patients in Ukraine. IJID Regions 15 (2025): 1006-1046.
18. Awadh H, Chaftari AM, Khalil M, et al. Management enterococcal central-line-associated bloodstream infections in patients with cancer. BMC Infect Dis 21(2021): 643.
19. Rezaei A, Parsa H, Kootahi ZE, et al. Prevalence of bacterial infection in septic neonates in South of Iran. Adv Pediatr Res 9 (2022): 1000036.
20. MacPhail A, Chraïti M-N, Nguen A, et al. Epidemiology of hospital-acquired bloodstream infections in hemato-oncology patients in Geneva, Switzerland. Infect 53 (2025): 1929-1939.
21. Brun-Buisson C, Abrouk F, Legrand P, et al. Diagnosis of central venous catheter- related sepsis. Critical level of quantitative tip cultures. Arch Int Med 147 (1987): 873-877.
22. Böll B, Schalk E, Buchheidt D, et al. Central venous catheter-related infections in hematology and oncology: 2020 updated guidelines on diagnosis, management, and prevention by the Infectious Diseases Working Party (AGIHO) of the German Society of Hematology and Medical Oncology (DGHO). Ann Hematol 100 (2021): 239-259.
23. Stevenson LG, Drake SK, Murray PR. Rapid identification of bacteria in positive blood culture broths by matrix-assisted laser desorption ionization-time of flight mass spectrometry. J Clin Microbiol 8 (2010): 444-447.

Léké A, et al., Arch Clin Biomed Res 2026
DOI:10.26502/acbr.50170543

24. EUCAST (European Committee on Antimicrobial Susceptibility Testing). Staphylococcus spp. Clinical breakpoint tables for interpretation of minimum inhibitor concentrations (MICs) and zone diameters. V15.0, valid from 2025-01-01(p. 1-118).

25. Tonover FC, Arbeit RD, Goering RV, et al. Interpreting chromosomal DNA restriction patterns produced by pulsed-field gel electrophoresis: criteria for bacterial strain typing. J Clin Microbiol 33 (1995): 2233-2239.

26. Akaike H. Information theory and an extension of the maximum likelihood principle. In: Petrov BN, Csaki F (eds). Second International Symposium on Information Theory. Budapest, Hungary: Akademai Kiado (1973) pp. 267-281.

27. Sappani M, Islam S, D'Souza R, et al. Statistical assessment in published dose-reponse meta-analyses is suboptimal: evidence from a methdological review and reanalysis of 242 datasets. J Clin Epidemiol 188 (2025): 11198.

28. Chen Y-J, Chang L-F, Yin M-F, et al. Comparative effectiveness of game-based learning modalities in nursing and medical education: a systematic review and Bayesian network meta-analysis. Nurse Educ today 167 (2026): 107266.

29. Mastrantoni L, Chiaravalli M, Spring A, et al. Comparison of first-live chemotherapy regimens in unresectable locally advanced or metastatic pancreatic cancer: a systematic review and Bayesan network meta-analysis. Lancet Oncology 25 (2024): P1655- 1665.

30. Leke A, Amar G, Elion Dzon B, et al. Coagulase-negative staphylococcal bacteremia by bacterial translocation of gastrointestinal origin in preterm infants: role of molecular analysis. J Clin Pediatr Mother Health 1 (2021): 1-11.

31. Chaieb K, Touati A, Salah AM, et al. DNA fingerprinting of multi-resistant coagulase-negative staphylococci isolated from biomaterials in dialysis services. Arch Med Res 37 (2006): 953-960.

32. Durkin MJ, Dukes JL, Reeds DN, et al. A descriptive study of the risk factors associated with catheter-related bloodstream infections in the home parenteral Nutrition population. JPEN J Parenter Enteral Nutr 40 (2016): 1006-1013.

33. de Oliveira A, Sanches P, Lyra JC, et al. Risk factors for infection with coagulase- negative staphylococci in newborns from the neonatal unit of a Brazilian University Hospital. Clin Med Insights Pediatr 6 (2012): 1-9.

34. Pinto M, Borges V, Nascimento M, et al. Insights on catheter-related bloodstream infections: a prospective observational on the catheter colonization and multidrug resistance. J Hosp Infect 123 (2022): 43-51.

35. Leke A, Amar G, Elion Dzon B, et al. Coagulase-negative Staphylococcus and antibiotic susceptibility patterns in cases of sepsis in the Neonatal Intensive Care Unit of Amiens-Picardie University Hospital (France). J Pediatr Infants 3 (2020): 6-17.

36. Wang S, Chi L, Zhou X. Risk factors for neonatal catheter-related blood stream infections: a systematic review and meta-analysis. Front Public Health 13 (2025): 1719016.

37. Huang H, Chang Q, Zhou Y. Risk factors of central catheter bloodstream infections in intensive care units: a systematic review and meta-analysis. PLOS ONE 19 (2024): e296723.

38. Spelman T, Pilcher DV, Cheng AC, et al. Central line-associated bloodstream infections in Australian ICUs: evaluating modifiable and non-modifiable risks in Victorian healthcare facilities. J Epidemiol Infect 145 (2017): 3047-3055.

39. Van Laser F, Marmans I, Jansen H. Flacons d'hémoculture faussement positifs et sur-remplissage. NOSO INFO 2022. www./nosoinfos/flacon-dhemoculture-faussement-positifs-et-sur-remplissage/.

40 El Hussaini Z, Harrar N, Zerouali K, et al. Prevalence of coagulase-negative staphylococci in blood cultures at the Ibn-Rochd University Hospital in Casablanca. Pan Afr Med J 33 (2019): 193.

41. Simon A. Les prélèvements d'hémoculture. NOS INFO 2022. www.nosoinfo.be/nosoinfos/les-prelevements-dhemoculture/. s

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