Original Article

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Paediatrics Section

Role of Hand Hygiene and Sterile Blood Sampling in Reduction of False Positive Blood Cultures from a Neonatal Intensive Care Unit of a Rural Teaching Hospital: A Quasi-experimental Study

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ABSTRACT

Introduction: Blood culture remains the gold standard for diagnosis of newborn infections. Its contamination not only results in inadvertent use of antimicrobials against the false positives but also causes substantial financial burden and patient safety concerns. There are various ways to reduce blood contamination, of which hand hygiene and sterile blood sampling are most crucial.

Aim: To evaluate and reduce the blood contamination rate and false positive blood cultures from the Neonatal Intensive Care Unit (NICU).

Materials and Methods: The prevalent bacteriology and Blood Culture Contamination Rate (BCCR) at the NICU was assessed by a retrospective study on all the neonates with suspected sepsis who had blood culture at admission. Healthcare workers at NICU were observed for their hand wash and sterile blood sampling technique by dedicated team members. Identified deficiencies among them were intervened by an educational model with regular training and reinforcement on hygienic practices for three months. Postintervention prospective study was done on all the neonates with suspected sepsis who had blood culture at admission. During this period the same educational model continued, to know its efficacy in reduction of blood contamination and change of bacteriology pattern. Data collected was entered into Microsoft excel sheet 2010 version and analysed using software Stata 14.0 version.

Results: Preintervention blood culture reports of 205 neonates screened for sepsis showed 58 (28.3%) samples with positive growth. Of this, 18 were contaminants, 31 were Coagulase Negative Staphylococci (CoNS), three gram negative and six gram positive organisms with blood contamination rate of 8.7%. Blood culture reports of postintervention study on 200 neonates screened for sepsis showed 41 (20.5%) samples positive for growth. Bacteriology showed 12 contaminants, 13 CoNS, eight gram positives, seven gram negatives and one fungal growth with BCCR of 6%. After intervention growth of CoNS was reduced which was statistically significant ($p<0.05$).

Conclusion: Simple inexpensive education programme helps the healthcare workers to follow the standard technique of hand wash and sterile blood sampling which goes a long way in reducing blood culture contamination.

Keywords: Hand wash, Neonatal sepsis, Quality improvement

INTRODUCTION

Neonatal sepsis is an important cause of mortality and morbidity in newborn babies. It contributes approximately 25% of 2.8 million worldwide neonatal deaths annually, of which over 95% of sepsis related neonatal deaths occur in low and middle income countries [1]. The incidence of neonatal sepsis in India is 30 per 1000 live births and contributes to 20.8% of all neonatal death [2]. Diagnosis of sepsis in newborn is challenging due to subtle clinical features, lack of availability of all investigations and difficulty in interpretation of their results. Blood culture is a gold standard for diagnosis of neonatal sepsis [3]. A positive blood culture helps the clinician to initiate definitive cost effective therapy whereas false positive results due to contamination limits its utility causing frustration to both the clinician and laboratory personnel [4]. BCCR varies from 0.6-6% among institutions with a bench mark at 2-3% [4]. High

BCCR is seen among young children and at the emergency department [4,5]. CoNS is a universal commensal of the skin and most common contaminant in 70-80% of contaminated blood cultures, however they can cause true bacteremia in 10-26.4% of cases and may be up to 50% in very low birth babies [4,6]. A simple yet most effective way to prevent this ambiguity is by reducing the growth of CoNS in the blood.

An important environmental source of infections is from the contaminated hands of healthcare workers and hand hygiene is an inexpensive, cost-effective way of preventing neonatal infections [1]. As skin commensals are the commonest source of contamination, BCCR can be reduced by increasing venipuncture sterility [4]. Initial retrospective study included all the neonates with clinically suspected sepsis who had blood cultures at admission to NICU. Their blood culture samples showed CoNS growth which was very frequent among other contaminants which included (*Corynebacterium* spp., *Bacillus* spp. *Propionibacterium acnes*, *Micrococcus* spp.) resulting in high false positives which could have been due to inadequate hand hygiene and unsterile blood sampling at NICU [7]. It was hypothesised that following a standard protocol on hand hygiene and sterile blood sampling technique would reduce the BCCR and growth of false positives and hence this study was aimed to evaluate and reduce the growth of BCCR at the NICU.

MATERIALS AND METHODS

This quasi-experimental study was a follow-up of retrospective observational study, conducted at NICU of PES Medical College, Kuppam, Andhra Pradesh, India. Informed consent was taken from the parents or the care givers of the admitted newborn and the ethical clearance was obtained from the Institutional Human Ethics Committee with no PESIMSR/IHEC/48/2014.

The Our NICU is 20 bedded with 10 incubators, 10 radiant warmers, four ventilators and eight phototherapy units. There is availability of arterial blood gas, pulse oximeters, surfactant therapy and a 24 hour laboratory as well as radiology services. In the NICU there is nurse to patient ratio of 1:1 for ventilated babies and 1:4 for other admitted babies. Other team members include a paediatrician exclusively posted to NICU in addition to a postgraduate resident and an intern.

The CoNS and other contaminants grown from blood culture samples of NICU were frequently received. Hence, a retrospective observational study on 205 single sample blood culture reports of neonates screened for sepsis at NICU from April to September 2014 was done by collecting data from microbiology department data base and analysed for BCCR and bacteriology pattern. The results of this study showed BCCR of 8.7%, which included *Corynebacterium* spp., *Bacillus* spp., *Propionibacterium acnes*, *Micrococcus* spp. reported as contaminants. CoNS grown from single sample blood culture by itself could be a contaminant, but they were reported in the blood culture report as growth and to correlate clinically. Hence, to know the significance of CoNS growth authors correlated retrospectively all positive blood culture reports with the clinical data of neonates from the case notes which were maintained at the medical records department. This clinicobacteriological correlation showed CoNS and other contaminants were false positives except in 13.3% of screened newborns [7]. Hence, the present study was planned to reduce such false positives.

Study Procedure

In view of high BCCR at NICU, all healthcare workers who were involved in blood sample collection were trained as per All India Institute of Medical Sciences protocols (AIIMS) [8]. In this guideline under aseptic precautions 5 cm skin over the venipuncture site was cleaned with alcohol, povidone iodine followed again by alcohol swab and dried for a minute. At least 1 ml of blood was collected by a needle or a new cannula before starting antibiotics using aseptic methods from the peripheral vein of a neonate with suspected sepsis. This was injected into a culture bottle with 10 mL of brain heart infusion broth and 0.025% sodium polyanethole sulfonate anticoagulant. These blood culture bottles were transferred to microbiology laboratory as soon as possible. Bottles were incubated at 37°C for seven days. Subcultures were done on 2nd, 4th and 7th day on MacConkey and chocolate agar. Growths of organisms were identified by colony characteristics and standard biochemical tests. Antibiotic sensitivity testing done by modified Kirby-Bauer disc diffusion method as per Clinical and Laboratory Standards Institute (CLSI) recommendations [7].

Healthcare workers were observed for World Health Organisation (WHO) hand wash technique by a senior staff nurse [9]. The lacunae in hand wash and sterile blood sampling techniques were noted and all the healthcare workers had focused individualised training. Hand wash steps and sterile blood sampling guidelines were displayed in the NICU.

A feasible intervention programme to recall AIIMS and WHO sterile blood sampling and hand wash steps respectively, by pictures and questions were developed by a team consisting of a paediatrician, a microbiologist, and a senior NICU staff nurse. This was constantly practiced by all the healthcare workers who were involved in both blood sampling as well as newborn care and was validated by team members. The observation period lasted for three months from October to December 2014 in order to become familiar with the intervention programme. Regular reinforcement on sterile blood sampling and hand wash technique was done daily during handover shift meetings. Further, intermittent direct observation was done by shift in charge nurse as well as weekly reminder was given by the paediatrician and microbiologist separately throughout the observation and prospective study period.

Inclusion and Exclusion criteria: With continued intervention education programme in place a prospective quasi-experimental study was done for a period of nine months from January to September 2015 which included all the neonates who had clinically suspected sepsis with blood culture at admission. All neonates with clinical sepsis as well as with high risk factors for development of sepsis were excluded from the study if they had no blood culture at admission.

Throughout this study period intervention programme was continued as there was constant change of frontline healthcare workers involved in the care of neonates due to postgraduate student rotation training programme as well as replacement of nursing staff, the intervention education programme had to be constantly rolling to maintain the uniform quality of training and practice. Postintervention data on blood culture reports of screened neonates for sepsis was collected with special reference to blood contaminants and CoNS. Both retrospective and prospective data were compared to evaluate the efficacy of intervention in reducing the growth of CoNS and other contaminants. The flow chart of study method is shown in [Table/Fig-1].

Preintervention
Retrospective data for six months, 205 blood culture reports,
Results: High BCCR and false positive CoNS.

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Intervention
Healthcare workers hand wash and blood sampling method observed
Lacunae identified,
Focused individual training.
Hand wash and sterile blood sampling steps displayed at NICU
Daily recall of these steps during handover meetings. Intermittent observation of hand wash and blood sampling
Daily and weekly reinforcement by supervisors done.

⇩

Postintervention
Prospective data over nine months, 200 blood culture reports collected and analysed for CoNS and Contaminant growth.

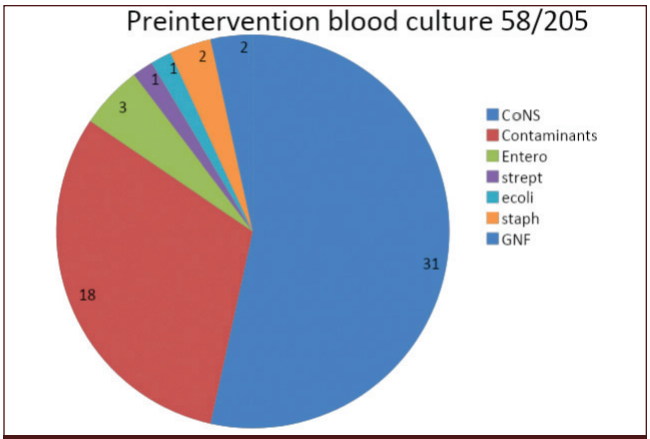
[Table/Fig-1]: Study process.

STATISTICAL ANALYSIS

The pre and postintervention data was entered in a Microsoft excel sheet 2010 version and analysed using software Stata 14.0 version. The descriptive statistics of categorical data were analysed using percentages and frequencies and the continuous data was analysed using mean and standard deviation wherever applicable. For interferential statistics, Chi-square test was used. The p-value <0.05 was taken as statistically significant.

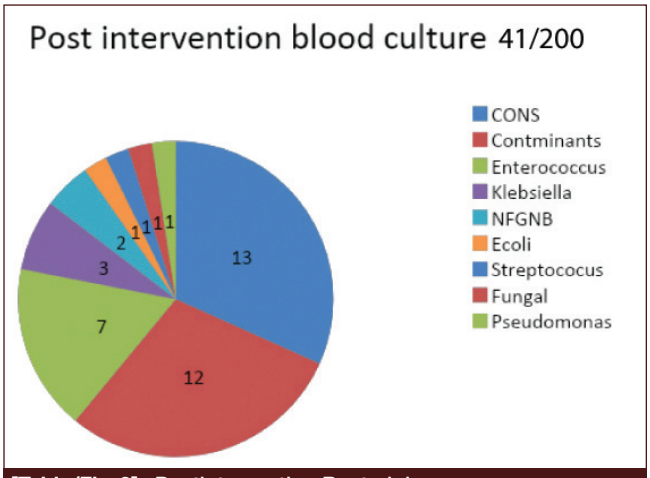
RESULTS

Preintervention data is represented in [Table/Fig-2], of the 205 blood culture samples, 58 (28.3%) had positive growth. Of which CoNS were 31 (53.4%), other contaminants were 18 (31%) with BCCR of 8.7%, Total false positives which included contaminants and CoNS were 49 (84.4%) and true positives, 9 (15.52%).



[Table/Fig-2]: Preintervention bacteriology.

Postintervention data is represented in [Table/Fig-3], of the 200 blood samples cultured, 41 (20.5%) had positive growth. Of this, CoNS were13 (31.7%), other contaminants 12 (29.2%) with BCCR of 6%. Total false positives with contaminants and CoNS were 25 (60.9%) and true positives were 16 (39.02%).



[Table/Fig-3]: Postintervention Bacteriology.

[Table/Fig-4] compares the growth of CoNS, other contaminants, combined CoNS and other contaminants (False positives), true positives with respect to the number of blood samples which did not grow them during pre and postintervention period. When preintervention and postintervention period were compared, growth of CoNS and false positives reduced from 15.12% to 6.5% and from 23.9% to 12.5% respectively among the total cultured blood samples. This was statistically significant (p-value <0.05) and was primarily due to reduction of CoNS growth rather than that of other contaminants. The growth of true positives were increased but was not statistically significant.

Blood culture report	Preintervention (205) N (%)	Postintervention (200) N (%)	p-value*
CoNS			
Present	31 (15.12)	13 (6.50)	0.005*
Absent	174 (84.88)	187 (93.50)	
Contaminants			
Present	18 (8.78)	12 (6.00)	0.285
Absent	187 (91.22)	188 (94.00)	
False positives			
Present	49 (23.90)	25 (12.50)	0.003 *
absent	156 (76.10)	175 (87.50)	
True positives			
Present	9 (4.39)	16 (8.00)	0.131
Absent	196 (91.61)	184 (92)	

[Table/Fig-4]: Comparison of positive blood culture of an organism with respect to their negative cultures during pre and postintervention period.
*p<0.05 significant (Pearson's chi-square test)

[Table/Fig-5] compares growth of CoNS, other contaminants, false and true positives to the total positive blood culture samples between pre and postintervention period. Growth of CoNS reduced and that of true positives increased with respect to false positives between pre to postintervention positive blood culture samples, which was statistically significant (p-value <0.05). Though other blood contaminants also reduced this was not statistically significant.

Blood culture	Preintervention (58) N (%)	Postintervention (41) N (%)	p-value*
CoNS	31 (53.45)	13 (31.71)	0.032*
Other isolates	27 (46.55)	28 (68.29)	
Contaminants	18 (31.03)	12 (29.27)	0.851
Other isolates	40 (68.97)	29 (70.73)	
False positives (CoNS+other contaminants)	49 (84.48)	25 (60.98)	0.008*
True positives	9 (15.52)	16 (39.02)	

[Table/Fig-5]: Comparison of positive blood cultures between pre and postintervention period.
*p<0.05 significant (Pearson's chi-square test)

DISCUSSION

Clinicians face the diagnostic dilemma in neonatal sepsis due to non specific clinical features, paucity of investigations and false positive blood culture reports. Blood culture is a gold standard test to identify the causative organism [4]. In order to obtain an authentic blood culture report various prerequisites are clean hands, sterile blood sample, sample size, proper transport, details of prior antibiotics usage. Apart from this, sterile inoculation into the culture media and their processing at the laboratory are also essential [10]. More than 50% of blood culture reports are contaminated [11]. The bench mark for BCCR rate is 2-3% though varies from 0.6-6% and 0.6-17% in various studies [4,12]. This high variability is due the sampling conditions, rapid staff turnover, lack of ongoing training, settings like teaching hospitals and emergency departments, patient's age and co-morbidities apart from the very definition of contamination itself [12].

Preintervention retrospective study [Table/Fig-2] with 205 blood culture samples had BCCR of 8.7% which was high compared to bench mark. It included 31% of positive blood culture reports documented as contaminants (*Corynebacterium* spp., *Bacillus* spp. *Propionibacterium* acnes, *Micrococcus* spp.) and where resamples were requested. But BCCR would have been much higher (23.9%) if CoNS were also included and which contributed to 53.4% of positive blood culture reports, but they were not included as their significance was not known. The contaminants as cause of true bacteremia are rare except for CoNS which could be a true positive especially in intensive care units [4].

The CoNS are ubiquitous commensals that colonise the skin and gastrointestinal tract of up to 99% of newborn infants by day 3 of life [6]. The most frequently isolated microorganisms are CoNS in 75-88% of contaminated blood cultures, followed by *Bacillus* spp., viridans group streptococci, *Corynebacterium* spp., *Propionibacterium* spp., *Micrococcus* spp. and *Clostridium perfringens* [12]. Hence proper hand hygiene and sterile blood technique act synergistically in reduction of hand commensals mainly CoNS as shown in this study. CoNS represent true bacteremia in 10 to 26.4% of cases and up to 50% in very low birth babies [4,6]. Initial retrospective clinicobacteriological correlation of present study showed that CoNS and other contaminants were clinically significant in 13.3% of high risk neonates admitted to NICU who needed second line antibiotics to improve [7]. This study recommended implementation of quality control strategies on hand wash and blood collection method to reduce blood contamination. Hence, an intervention with a feasible education model was introduced to reduce blood contamination including CoNS.

Postintervention study with an education model on hand wash and sterile blood sampling showed that growth of CoNS reduced from 53.4% to 31.7% of positive blood culture reports and from 15.12% to 6.50% of total blood culture samples both of which are statistically significant testifying the effectiveness of hand hygiene and sterile sampling methods. Contaminants other than CoNS were also reduced from 31% to 29.2% of positive blood culture samples and BCCR reduced from previous 8.7% to 6% both were statistically not significant and BCCR did not reach the bench mark. This shows intervention programme reduced most common skin commensal CoNS

significantly than other contaminants and still it needs to be further addressed to achieve the bench mark. The false positives reduced from 84.48% to 60.98% and from 23.9% to 12.50% with intervention from positive blood cultures and total blood culture samples respectively which were statistically significant and was mainly due to reduced CoNS growth. True positives increased from 15.52% to 39.02% of the positive blood culture reports which is statistically significant and is due to reduction in the false positives thus increasing the utility of blood culture. But the true positives only increased from 4.39% to 8% of the total cultured blood samples and were not statistically significant as it depended on the disease characteristics of the neonate at admission.

"Clean Care is Safer Care" is not a choice but a basic right and hand hygiene is simple action to reduce infection [9]. A study by Sharek P et al., on hand hygiene reported reduction in BCCR and CoNS as false positive growth and not as true positive in NICU [13]. A study by Chraiti MN et al., showed association between hand hygiene and low BCCR in ICU [14]. A study by Bae M et al., showed implementation of phlebotomy team reduced blood contamination from 0.45 to 0.27% and increased true positive growth from 5.01 to 5.87% [15]. Studies by Krajčinović SS et al., and Hall RT et al., revealed implementation of sterile blood culture collection checklist bundle or web based education model reduced BCCR in NICU from 16.4% to7.6%, and in paediatric emergency department from 3.9% to 1.6% respectively [16,17]. In another study by Hamilton LF et al., with sterile blood sampling bundle false positives were reduced from 4.6-0.6% in a NICU [18]. Bottom line of all these studies emphasise very basic fact and that is cleaner the hands as well as blood sampling lesser the blood contamination.

This study strengthens the effectiveness of a simple cost effective educational model, if practiced regularly can reduce blood contamination especially with CoNS there by increasing the usefulness of blood culture among sick high risk neonates in a setting like ours which is a rural teaching hospital. This not only provides quality care but also reduces the cost of treatment.

Limitation(s)

This was a small sample study from a single centre using single blood culture for a short period of time. Hand hygiene and sterile blood sampling were studied together and hence contribution of each cannot be assessed though technically not possible to isolate both. BCCR could have been high, if CoNS were included and as their significance was not known in the initial study they were not included. We intervened with our own practical and feasible education model rather than any particular standard model. In this study hygienic practices of healthcare workers at NICU were objectively observed and this should have also included the hygiene method of the blood sample processing done by microbiology laboratory workers. A further large randomised controlled study is needed to address all these biases.

CONCLUSION(S)

Hand wash and sterile blood sampling are effective synergistically in reduction of predominant skin commensal, CoNS. Reduction in blood contamination enhances quality care, patient safety and cost effective management. Intervention by an education model is a simple strategy to reduce blood contamination but however needs constant perseverance to achieve good compliance.

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