OPEN ACCESS Freely available online

ISSN: 2167-0897
Journal of
Neonatal Biology

Research Article

A Quality Initiative to Improve the Reliability of Blood Cultures Drawn in Neonates with Suspected Sepsis

Pradeep Kumar Velumula[1*], Dhruv Gupta[2], Amit Sharma[3], Basim Asmar[4,5], Sanket Jani[4,7], Nithi Fernandes[4,7], Roopali Bapat[6], Sanjay Chawla[4,7]

[1]Department of Neonatal-Perinatal Medicine, Mercy One Waterloo Medical Center, Waterloo, USA; [2]Department of Pediatrics, Pediatrix Medical Group, El Paso, TX, USA.; [3]Department of Pediatrics, Memorial Hospital of Carbondale, Carbondale, USA; [4]Department of Pediatrics, Hutzel Women's Hospital/Detroit Medical Center, Detroit, USA; [5]Department of Infectious Diseases, Children's Hospital of Michigan, Detroit, USA; [6]Department of Pediatrics, Nationwide Children's Hospital, Columbus, USA; [7]Department of Pediatrics, Central Michigan University, Mount Pleasant, USA

ABSTRACT

Background: A delay or a false negative diagnosis of sepsis in neonates may be associated with serious morbidity and mortality.

Objectives: To improve optimal blood culture volume by 25% from baseline over two months and sustain the improvement for 10 consecutive months.

Methods: Data on blood culture volumes and medical knowledge of the staff on sepsis was collected in the pre-and post-intervention phase. During Intervention phase, we conducted multiple Plan-Do-Study-Act (PDSA) cycles that included education, accountability, feedback, support, and awareness during the intervention phase.

Results: A total of 287 blood culture samples were analyzed; 114 samples during the pre-intervention and 173 samples in the post-intervention phase. The target proportion of BC samples with optimal volume each month was achieved, and the results sustained for 10 consecutive months.

Conclusion: The study emphasizes the importance of simple and realistic interventions to achieve and sustain collection of adequate blood culture volumes in neonates.

Keywords: Neonates, Neonatal sepsis, Blood volume, Blood culture, Quality Initiative

Abbreviations: BC: Blood Culture; PDSA: Plan-Do-Study-Act

INTRODUCTION

Sepsis is one of the leading causes of neonatal deaths worldwide [1,2]. An under-developed immune system predisposes neonates, especially preterm infants; to infections more than children of other ages [2-4]. The incidence of early onset sepsis in neonates is 0.98 per 1000 live births with Group B *Streptococcus* and *Escherichia coli* being the most isolated organisms in term and preterm infants, respectively [3,4]. Blood Culture (BC) is the gold standard diagnostic test for neonatal sepsis. Antepartum exposure to antibiotic prophylaxis along with low blood culture volumes may be associated with a low positivity rate of blood culture samples in neonates with sepsis. Positivity rate of BC depends on multiple factors including, the volume of blood collected, dilution ratio of blood to culture medium, timing of obtaining the culture, level of bacteremia, number of cultures obtained, and technique used to obtain the culture [5].

Studies have shown a low-level of bacteremia (≤ 10 CFU/ml) in 60% of positive pediatric blood cultures [6]. Previous studies have noted an increase in bacterial isolation from blood with increasing blood volume, implying a higher chance of false negative report with insufficient blood volume [7,8]. It is recommended to draw a minimum of 1 ml of blood when using the pediatric blood culture bottle but there are no clear recommendations on minimum amount of blood to be collected when using microbial isolator

Correspondence to: Pradeep Kumar Velumula, Department of Neonatal-Perinatal Medicine, Mercy One Waterloo Medical Center, Waterloo, USA, Tel: +1-319-272-2229; E-mail: pradeep.omc@gmail.com

Received: 29-Jun-2022, Manuscript No. JNB-22-17259; **Editor assigned:** 04-Jul-2022, Pre QC No. JNB-22-17259(PQ); **Reviewed:** 20-Jul-2022, QC No. JNB-22-17259; **Revised:** 25-Jul-2022, Manuscript No. JNB-22-17259(R); **Published:** 02-Aug-2022, DOI: 10.35248/2167-0897.22.11.350.

Citation: Velumula PK, Gupta D, Sharma A, Asmar B, Jani S, Fernandes N, et al. (2022) A Quality Initiative to Improve the Reliability of Blood Cultures Drawn in Neonates with Suspected Sepsis. J Neonatal Biol. 11:350.

tubes [9]. In the setting of suspected clinical sepsis, clinicians often consider treating the infants with antibiotics despite negative blood culture results due to high risk of false negative results.

One of the challenges faced in the neonatal intensive care unit is obtaining an adequate volume of blood, especially in preterm neonates, due to factors including technical difficulty of obtaining blood from small veins, and the need for timely administration of antibiotics [10]. Lack of awareness on optimal blood culture volumes among staff could either result in false negative reports when inadequate volume is collected or can increase the risk for iatrogenic anemia. Often the volumes of blood collected for blood culture are suboptimal and can affect the result and decisions regarding the management [10,11].

At our institute, the Microbiology Department recommends collecting 0.5 ml-1 ml in an Abbott Isolator Microbial Tube or ≥ 1 ml-3 ml while sending in pediatric blood culture bottle (BD BACTEC™ PEDS Plus PRIME Medium Culture Vials). Considering the importance of sending optimal blood volume for culture in optimizing the management of neonatal sepsis, we initiated a quality improvement project to improve the reliability of blood cultures drawn in our unit.

SMART Aim/Objective

We aimed for an improvement of optimal blood culture volume by 25% from baseline of 66% to 82% following our interventions and sustain the improvement for at least 10 months.

METHODOLOGY

The quality improvement initiative was done at Hutzel Women's Hospital, affiliated with Detroit Medical Center, a birthing center with approximately 3,500 deliveries each year. Institutional Review Board approval was obtained from Wayne State University prior to study initiation. Infants are admitted in a Level II or level III NICU. Prior to obtaining the BC, betadine and alcohol swabs are used for skin preparation and blood is drawn in the Microbial Isolator tube for culture. For patients with suspected sepsis, blood test including BC is obtained prior to antibiotic administration. Based on final culture reports and clinical scenario, the clinical team determines the duration of treatment. The outcome measure of our quality initiative was the proportion of BC sent with optimal volume each month. Process measures were a) improvement in knowledge of medical staff compared to the pre-intervention period, assessed through questionnaires and b) availability of adequate support for nursing staff for patients with difficult blood draws. Balancing measures were the number of needle-sticks to obtain the culture, time to complete the blood draw and delay in administration of antibiotics.

Pre-intervention phase (January 2019 to June 2019)

Nurses sent a requisition form along with the BC sample, which included information on time taken, and number of needle sticks required to complete the blood draw. The technician in microbiology department documented the weight of the isolator tube, using a high precision digital weighing scale, Smart Weigh GEM 20, and recorded it on the requisition form. These forms were securely stored at a designated location in the microbiology department and collected weekly by the principal investigator. Data was collected for six consecutive months from January 2019 to June 2019.

Baseline neonatal characteristics of neonates including birth weight, gestational age, respiratory support, source of blood, and sex were obtained (Table 1). Other variables tracked were outcome measures: Volume of blood drawn and percent of samples with optimal volume as previously mentioned; balancing measures: time and number of needle sticks to draw the BC, blood volume, and time taken from order to administration of antibiotics; and process measures: questionnaire scores (Tables 2 and 3). During the pre-intervention phase, 66% of samples had adequate blood volume. In the pre-intervention survey, the correct response rate for the optimal volume of blood culture, time frame to administer antibiotics and adequate support in case of difficult blood draws were noted in 72%, 70% and 63%, respectively.

Table 1: Baseline characteristics of study population before and after intervention.

Parameter	Pre-intervention (n=114)	Post-intervention (n=173)	p-value
Gestation: Weeks, Median (IQR)	37 (6)	37 (7)	0.13
Birth weight: Grams, Mean (SD)	2522 (1005)	2467 (1064)	0.11
Respiratory support, percent	78	84	0.35
Sex, percent: Female	53	48	0.44
Source of blood, percent: Peripheral vein	83	80	0.43

Intervention phase/PDSA cycles, July 2019 to August 2019

Multiple Plan-Do-Study-Act cycles (PDSA) with interventions including education, awareness, feedback, accountability, and support were performed. Morning and evening huddles in the NICU were utilized to implement these interventions.

Education

Through discussion, education on neonatal sepsis management, (subtle signs of neonatal sepsis, importance of adequate blood volume to yield positive blood culture results, timely initiation of antibiotics) was provided to the clinical team.

Awareness: The clinical team was made aware of the hospital policy on obtaining the blood culture, the appropriate tube, and the volume of blood. Paper handouts of the policy were provided.

Feedback: We discussed the baseline data on blood culture volumes and the survey results with the nurses and clinical team.

Accountability: Nurses were instructed to make the physicians aware of insufficient blood culture volume, despite best efforts.

Support: Nurses were encouraged to reach out to other members of clinical team for help with difficult blood draws.

Statistical analysis

Data analysis was performed using IBM SPSS Statistics for Windows, version 28 (IBM Corp., Armonk, N.Y., USA) software. For continuous variables with non-parametric distribution, Wilcoxon rank-sum test was utilized and for parametric distribution

Student's t-test was used. Chi-square/Fisher's exact test is used for categorical variables. A p-value <0.05 was considered significant. Statistical Process control chart were performed using QI Macros © 2020 Know Ware International Inc., version 2020. We used the standard Montgomery rules to identify special cause variation [12].

Post-intervention phase/Results, September 2019 to June 2020

Following the intervention phase, we continued the analysis on BC volumes sent each month and clinical team was updated every month of the results. A total of 173 samples were analyzed in the post-intervention phase. The baseline neonatal characteristics were similar in pre-intervention phase and post-intervention phase (Table 1). In the post-intervention phase following the PDSA cycles, the mean blood volume (SD) improved from 0.52 ml (0.11) to 0.60 ml (0.12), p<0.01, and the proportion of BC's sent with adequate volume improved from 66% (70/114) to 86% (149/173) (Table 2) (Figure 1). The mean blood volumes over time during the quality initiative are shown in the X-Bar chart (Figure 2). The proportion of blood cultures sent each month with adequate volume, primary objective of the quality initiative, was achieved and was sustained during the post-intervention phase (Figure 3). The process measures, medical knowledge of the staff on optimal blood volume to be sent for BC and the time frame for starting antibiotics in neonates with suspected sepsis; and availability of adequate support during difficult blood draws showed improvement in the post-intervention phase (Table 3). The balancing measures, including average time to complete the blood draw and average time from order to administer the antibiotics were similar during both periods. The median (IQR) number of needle sticks needed to complete the blood draw was 2 (1) in the pre- and 1 (1) in the post intervention phase (Table 2). There were no positive blood cultures reported in both pre- and post-intervention phase during the study period.

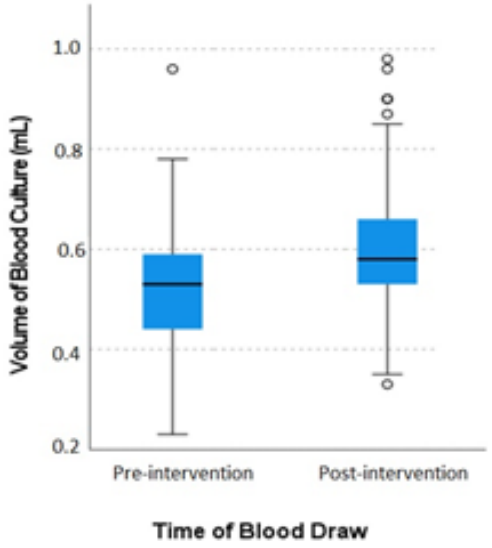

Figure 1: Range of blood culture volumes obtained before and after intervention. There was a significant increase in blood culture volume after education and support of staff.

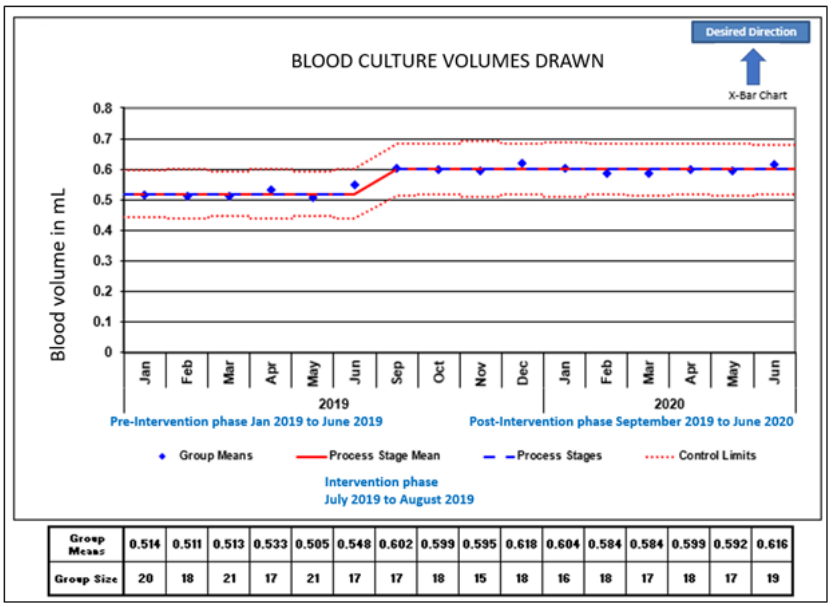

Figure 2: X-Bar chart with average volumes of blood during the study period. Note: (•) Group Means; (——) Process Stage Mean; (– –) Process Stages; (·····) Control Limits.

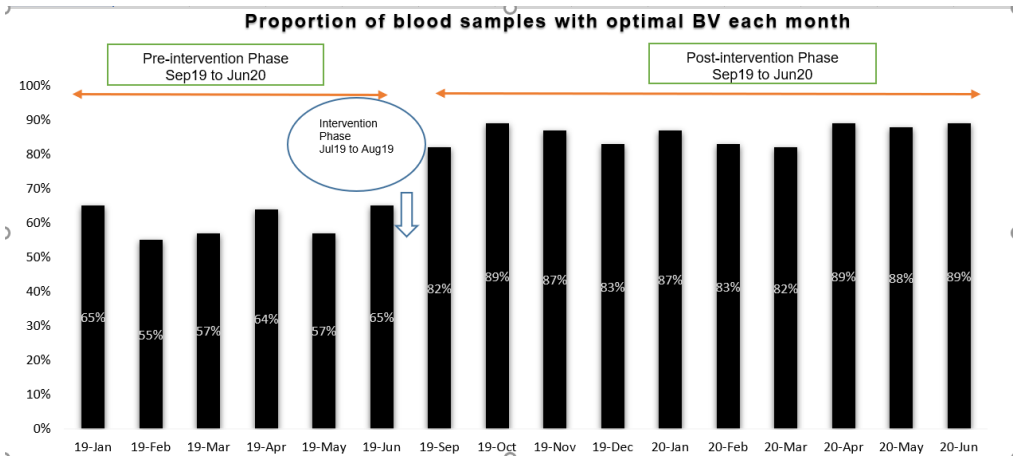

Figure 3: Proportion of BC's sent with optimal BV each month.

Table 2: Outcome measures before and after intervention.

Variable	Pre-intervention n=114	Post-intervention n=173	p-value
Blood volume in ml, mean (SD)	0.52 (0.11)	0.60 (0.12)	<0.01
Samples with optimal blood volume, percent	66	86	<0.001

Table 3: Balancing and Process measures before and after intervention.

Variable	Pre-intervention	Post-intervention
Balancing measures	n=101	n=141
Time to complete blood draw: Minutes, mean (SD)	6.5 (3.7)	5.9 (2.9)
Number of needle-sticks required for blood draw, median (IQR)	2 (1)	1 (1)
Time from physician order to administration of antibiotics, minutes, mean (SD)	50.2 (10.5)	50.5 (11)
Process measures Accuracy of questionnaire	n=35	n=35
Optimal volume of blood needed for culture	72%	100%
Time frame to administer antibiotics after suspicion of sepsis	70%	97%
Having adequate support for difficult blood draws	63%	77%

RESULTS

Prior to this quality initiative performed in our NICU, we noted a high rate of suboptimal BC volumes in the pre-intervention phase. With simple and realistic measures (education, awareness, feedback, accountability, and support), we were able to achieve our target improvement in the BC volumes and sustain the improvement through the entire study period. Similar studies in the past have noted suboptimal BC volumes and difficulty in obtaining optimal blood volume in neonates and its improvement through various quality improvement measures [8,10,11]. Many authors recommend collecting a minimum of 0.5 ml to 1 ml of blood to successfully isolate the organism from two different sites, ideally simultaneously and "The Committee on Fetus and Newborn" suggests collecting a minimum of 1 ml blood while using the pediatric BC bottle [13,9].

In a recent clinical practice improvement project noted 96.9% of BC samples had suboptimal volume in the pre-intervention period. Utilizing measures like developing and implementing a guideline on BC collection technique, education, and documentation of blood volume and reasons for obtaining suboptimal volume, they demonstrated an improvement with suboptimal BC volumes being reduced to 25% in the post-intervention period [10]. A subset of neonates and children has low colony counts of bacteria [14-16]. In an *in-vitro* study, investigated the rate of BC positivity with different bacterial colony counts and volumes of blood inoculated into the pediatric BC bottles. A total of 490 samples were studied. They noted approximately 60% of the BC's had false negative result if less than 0.5 ml blood is collected in neonates with low colony count sepsis and recommended to collect 1 ml-2 ml to improve the positivity rate of BC in neonates [7].

In a similar quality initiative study done in children less than 18 years of age found only 35.4% of BC samples had adequate blood volume and intervention through laminated posters indicating the appropriate volume and BC bottle, increased samples with adequate volume to 63.9%. In their study, ≥ 0.5 ml of blood volume was considered as adequate for neonates [8]. These results are similar to the current study. The current study was not designed to assess the influence of BC volumes on the positivity rate of BCs, or the factors associated with inadequate volume, as the overall incidence of positive BCs in our unit was extremely low. Since most BCs were drawn in the setting of suspected sepsis, we aimed at improving knowledge on sepsis, increase awareness and adherence to the hospital policy while obtaining BCs.

Studies from adult practice have shown that increase in the workload and not having a dedicated phlebotomy team can

influence the volume of blood collected and the contamination rate of BCs [17,18]. One of the interventions in our study was to provide adequate support to the nurses for blood draw in situations with difficult blood draws. Towards the end of study period, there was a subjective improvement in the nursing opinion regarding support during a difficult blood draw. Improved knowledge on importance of adequate blood volume for culture, increased awareness of the hospital policy along with a decreased hesitancy to ask for help could be the reasons for this improvement.

The strengths of our study include a consistent group of caregivers that were evaluated during the pre- and post-intervention phase, and a sustained improvement shown over ten months in the post intervention phase. Limitations of the current study include the possibility of a selection bias due to dependence on nursing staff to send the requisition form with BC. A single-center study with a low incidence of sepsis might impact the generalizability of the study results to other units. To address the selection bias and confirm the practice change we achieved, after the study was completed, all the BCs drawn in our unit were weighed for a period of one month. We found 31 of 32 of these samples had optimal blood volume. This further demonstrated sustained results in optimizing BC volume.

CONCLUSION

Blood culture is the gold standard test in evaluation and management of neonatal sepsis. Suboptimal blood volume for culture in neonates is a frequent problem and may have impact on the reliability of blood culture reports. A delay or a false negative report may be associated with serious morbidity and mortality. In the Quality Initiative conducted in our unit, we achieved and sustained the optimal blood culture volumes in this patient population by implementing simple and realistic interventions such as education, awareness, accountability, feedback, and support. Such quality initiative programs aimed at optimizing the blood culture volume may be helpful in improving the accuracy of the blood culture reports.

RESEARCH FUNDING

No funding received to complete the study.

The authors declare no conflict of interest.

REFERENCES

1. Fottrell E, Osrin D, Alcock G, Azad K, Bapat U, Beard J, et al. Cause-specific neonatal mortality: Analysis of 3772 neonatal deaths in Nepal, Bangladesh, Malawi and India. Arch Dis Child Fetal Neonatal Ed. 2015; 100(5):439-447.
2. Liu L, Johnson HL, Cousens S, Perin J, Scott S, Lawn JE, et al. Global, regional, and national causes of child mortality: An updated systematic analysis for 2010 with time trends since 2000. Lancet. 2012; 379(9832):2151-2161.
3. Stoll BJ, Puopolo KM, Hansen NI, Sánchez PJ, Bell EF, Carlo WA, et al. Early-onset neonatal sepsis 2015 to 2017, the rise of *Escherichia coli*, and the need for novel prevention strategies. JAMA Pediatr. 2020; 174(7):e200593.
4. Stoll BJ, Hansen NI, Sánchez PJ, Faix RG, Poindexter BB, Van Meurs KP, et al. Early onset neonatal sepsis: The burden of group B Streptococcal and E. coli disease continues. Pediatrics. 2011; 127(5):817-826.
5. Buttery JP. Blood cultures in newborns and children: Optimising an everyday test. Arch Dis Child Fetal Neonatal Ed. 2002; 87(1):25-28.
6. Kellogg JA, Manzella JP, Bankert DA. Frequency of low-level bacteremia in children from birth to fifteen years of age. J Clin Microbiol. 2000;38(6):2181-2185.
7. Schelonka RL, Chai MK, Yoder BA, Hensley D, Brockett RM, Ascher DP. Volume of blood required to detect common neonatal pathogens. J Pediatr. 1996; 129(2):275-278.
8. Connell TG, Rele M, Cowley D, Buttery JP, Curtis N. How reliable is a negative blood culture result? Volume of blood submitted for culture in routine practice in a children's hospital. Pediatrics. 2007; 119(5):891-896.
9. Polin RA, Papile LA, Baley JE, Bhutani VK, Carlo WA, Cummings J, et al. Management of neonates with suspected or proven early-onset bacterial sepsis. Pediatrics. 2012; 129(5):1006-1015.
10. Singh MP, Angiti RR. The practice of blood volume submitted for culture in a neonatal intensive care unit. Arch Dis Child Fetal Neonatal Ed. 2020; 105(6):600-604.
11. Neal PR, Kleiman MB, Reynolds JK, Allen SD, Lemons JA, Yu PL. Volume of blood submitted for culture from neonates. J Clin Microbiol. 1986; 24(3):353-356.
12. Montgomery DC. Introduction to statistical quality control. J Am Vet Med Assoc. 2021; 258(7):733-739.
13. Washington JA, Ilstrup DM. Blood cultures: Issues and controversies. Rev Infect Dis. 1986; 8(5):792-802.
14. Dietzman DE, Fischer GW, Schoenknecht FD. Neonatal *Escherichia coli* septicemia—bacterial counts in blood. J Pediatr. 1974; 85(1):128-130.
15. Marshall GS, Bell LM. Correlates of high grade and low grade Haemophilus influenzae bacteremia. Pediatr Infect Dis J. 1988; 7(2):86-90.
16. Durbin WA, Szymczak EG, Goldmann DA. Quantitative blood cultures in childhood bacteremia. J Pediatr. 1978; 92(5):778-780.
17. Halverson S, Malani PN, Newton DW, Habicht A, Vander Have K, Younger JG. Impact of hourly emergency department patient volume on blood culture contamination and diagnostic yield. J Clin Microbiol. 2013; 51(6):1721-1726.
18. Bekeris LG, Tworek JA, Walsh MK, Valenstein PN. Trends in blood culture contamination: A College of American Pathologists Q-Tracks study of 356 institutions. Arch Pathol Lab Med. 2005; 129(10):1222-1225.