Journal of Acute Disease

Original Article

doi: 10.4103/2221-6189.316675 jadweb.org

Effect of exchange blood transfusion on oxygen saturation of neonates with severe neonatal jaundice by pulse oximetry

Abubakar Muhammed Shakur[1]✉, Nuhu Abubakar Garba[2], Ibrahim Ahmadu[1], Daniel Apollos[3], Aminu Wada[4], Safiya Garba Abdullahi[1], Abdulsalam Mohammed[4], Mustafa O. Asani[1], Ibrahim Aliyu[1]

[1]*Department of Pediatrics, Cardiopulmonary Unit Aminu Kano Teaching Hospital, Kano, Nigeria*

[2]*Department of Pediatrics, Federal Medical Centre, Nguru, Nigeria*

[3]*Department of Pediatrics, Federal Teaching Hospital, Gombe, Nigeria*

[4]*Department of Pediatrics, Aminu Kano Teaching Hospital, Kano, Nigeria*

ABSTRACT

Objective: To determine if there was any difference in SpO_2 readings during exchange blood transfusion (EBT).

Methods: A prospective cross-sectional study of neonates with severe neonatal jaundice requiring EBT was conducted. Oxygen saturation was recorded before, immediately and 15 minutes after EBT by using a pulse oximeter.

Results: This study included 30 neonates with 20 males and 10 females. The age ranged from 1 to 12 days with a mean of (5.4 ± 2.9) days. Pre-EBT SpO_2 ranged from 90% to 98% with a mean value of (94.3 ± 2.2)%; SpO_2 in the end of EBT ranged from 85% to 99% with a mean value of (94.1 ± 3.2)%; SpO_2 at 15 minutes after EBT ranged from 77% to 99% with a mean value of (94.8 ± 4.1)%. There was no significant difference between SpO_2 values at onset of EBT and either immediately or 15 minutes after EBT (P=0.770 and 0.422, respectively). SpO_2 showed no significant difference between neonates who were infused with blood of different storage times (<24 h or ⩾24 h) at the onset of EBT (P=0.584), immediately (P>0.999) and 15 minutes after EBT (P=0.887). Besides, SpO_2 values were compariable in neonates with hematocrit <45% or ⩾45% at the onset of EBT (P=0.284), immediately (P=0.118) and 15 minutes after EBT (P=0.868).

Conclusions: EBT does not affect SpO_2 in neonates.

KEYWORDS: Exchange blood transfusion; SpO_2; Neonate; Hypoxia

1. Introduction

Exchange blood transfusion (EBT) is a clinical therapeutic method by which a patient's blood is removed in aliquots while fresh blood is simultaneously infused until a target amount is reached to exchange the patient's blood with the donor's[1]. It is called partial exchange transfusion when the replacement fluid is an isotonic fluid (usually normal saline or occasionally, 0.5% human albumin solution) instead of blood. Partial exchange is commonly done for polycythemia. The commonest indication for EBT worldwide is severe neonatal jaundice (NNJ)[2,3]. Other indications include sickle cell disease crises (acute stroke, secondary prevention of stroke, and severe acute chest syndrome), hyperleukocytosis, severe sepsis, disseminated intravascular coagulopathy, metabolic conditions like galactosemia, other aminoacidopathies and hyperammonaemia, severe fluid and electrolyte imbalance, severe anemia, and cardiac failure[1,4]. The rate of EBT is relatively low among developed countries, while it remains high in developing countries[3,5-7]. Slusher *et al.*[3] reported a significantly higher EBT rate among Africans of 186.5/100 000 live birth. While the Americans,

✉To whom correspondence may be addressed. E-mail: amshakur3@gmail.com

How to cite this article: Shakur AM, Garba NA, Ahmadu I, Apollos D, Wada A, Abdullahi SG, et al. Effect of exchange blood transfusion on oxygen saturation of neonates with severe neonatal jaundice by pulse oximetry. J Acute Dis 2021; 10(3): 112-116.

Article history: Received 23 August 2020; Revision 20 April 2021; Accepted 30 April 2021; Available online 31 May 2021

Europeans, and western pacific regions have rates of 0.38, 0.35, and 0.19 per 100000 live birth, respectively[3]. In Nigeria, Owa *et al.*[8] in 2009 reported an EBT rate of 5% among neonatal admissions in Ile-Ife, Osun State, southwestern Nigeria.

It is a known fact that EBT, although a safe procedure, could be associated with serious complications. Various studies have reported death resulting from EBT either directly or from its complication. Owa *et al.*[8] reported a mortality rate of 10% from a study conducted in Ile-Ife, southwestern Nigeria. Apart from blood-related complications like infections, there are catheter-related complications like air embolism, cardiac arrhythmias, limb gangrene, and necrotizing enterocolitis. Biochemical changes include hypoglycemia, hyponatremia, hyperkalemia, hypocalcaemia, and acidosis[8-13]. These complications, separately or collectively increase the risk of hypoxia which will no doubt lead to the adverse neurologic outcome if the neonate survives[14].

Pulse oximetry is now considered the fifth vital sign. It is a reliable, cheap, and non-invasive method of monitoring oxygen saturation[15]. The pulse oximetry works based on the light emission of different wavelengths from the light emission diode. The machine reads the differences or changes in absorbance which had either be reflected or transmitted through body parts the machine is applied to[15]. The transmission mode uses thin parts of the body like the earlobe and fingertips while the reflectance mode, besides it uses more body parts like the chest wall, toe, forehead, with the fingertip being the commonest site.

EBT is a stressful procedure for the neonate, and most neonate who undergoes EBT are already very sick[2,12,13,16]. These coupled with earlier mentioned complications increases the possibility of hypoxia with a higher risk of injury to the immature/developing neonatal brain. This study, therefore, aims to determine if there is any difference in SpO_2 readings during EBT.

2. Patients and methods

2.1. Ethical approval

Permission to carry out the study was obtained from the Ethical Committee of Aminu Kano Teaching Hospital, AKTH, Kano (NHREC/21/08/2008/AKTH/EC/2538. Dated 4/7/2019).

2.2. Inclusion and exclusion criteria

This was a cross-sectional study involving neonates in our Special Care Baby Unit who undergone EBT between July 2019 and Febuary 2020. The inclusion criterion was all neonates admitted into the Special Care Baby Unit of our hospital and who had met the unit criteria for EBT. Subjects with caregivers who declined consent and subjects who were amputees or had no limb for application of electrode were excluded from the study.

2.3. EBT procedures and data collection

Heat loss was minimized by pre-warming the blood and maintaining a normal ambient temperature. Neonates was restrained properly without jeopardizing their health. Through an umbilical catheter, which was secured directly or *via* cut-down, the EBT was done using the push-pull method in aliquots of 10 mL or 20 mL depending on the gestational age and weight of the neonates. Besides, 1 mL/kg of 10% calcium gluconate in single volume dilution was given slowly after every 100 mL of exchange, *via* the umbilical vein with heart rate monitoring. With the pulse oximeter properly applied to the right index finger of the neonates, the SpO_2 was recorded at the onset, immediately and 15 min after EBT. The subjects' biodata, vital signs among other information, and pulse oximeter readings were recorded.

2.4. Statistical analysis

All data were analyzed using Statistical Package for Social Sciences (SPSS) version 16 (SPSS Inc. Chicago Illinois). Qualitative variables were summarized as frequencies and percentages while quantitative variables such as age, weight were summarized as means and standard deviations (mean ± SD). The independent sample student *t*-test and Whitney Mann *U* test were adopted to determine associations between variables. The significant level of this study was set at α=0.05.

3. Results

A total of 30 neonates were involved in this study with 20 males and 10 females. The age range was from 1 to 12 d with a mean of (5.4 ± 2.9) d. The weight on admission ranged from 1.7 kg to 3.9 kg, with a mean of (2.9 ± 0.6) kg, while the length ranged from 36.3 to 57.0 cm with a mean of (48.4 ± 5.1) cm. The estimated gestational age ranged from 37 to 41 weeks with a mean of (38.1 ± 1.3) weeks.

The pre-EBT hematocrit ranged from 20.3% to 57.0% with a mean of (40.3 ± 8.3)%. Pre-EBT SpO_2 ranged from 90% to 98% with a mean of (94.3 ± 2.2)%. SpO_2 in the end of EBT ranged from 85% to 99% with a mean of (94.1 ± 3.2)%; while SpO_2 15 min after EBT ranged from 77% to 99% with a mean of (94.8 ± 4.1)%. Table 1 showed ABO incompatibility was the commonest underlying disease among those who had exchange transfusion in this study, and most of the neonates were of the blood group B rhesus positive category, while their mothers were blood group O rhesus positive category.

Direct umbilical vein cannulation was performed in 28 (93.3%) neonates, only 2 (6.7%) required cutting down. Only 8 (26.7%) had storage time of the donated blood <24 h, while the majority (22, 73.3%) were ≥24 h.

Table 2 shows no difference in the SpO_2 values at the onset of

EBT, immediately and 15 min after EBT.

Table 3 showed that SpO_2 values were not significantly different between the neonates infused blood with different storage time; however, the median was higher for those with older aged blood at the onset of EBT and in the end of EBT (P=0.584 and P>0.999, respectively).

Table 4 showed that SpO_2 value was compariable in the neonates with PVC <45% or ⩾45% at the onset of EBT (P=0.284), immediately (P=0.118) and 15 minutes after EBT (P=0.868).

Table 1. Pathogenesis and the blood group distributions.

Variables	*N*	Percentage
Pathogenesis		
ABO incompartibility	21	70.0
GPDD	3	10.0
Sepsis	5	16.7
Others	1	3.3
Total	30	100.0
Newborn blood group		
Group O	9	30.0
Group A	8	26.7
Group B	13	43.3
Total	30	100.0
Rh positive	28	93.3
Rh negative	2	6.7
Maternal blood group		
Group O	23	76.7
Group A	3	10.0
Group B	4	13.3
Total	30	100.0
Rh positive	29	96.7
Rh negative	1	3.3

GPDD: Glucose phosphate dehydrogenase deficiency.

Table 2. Comparison of the SpO_2 values at the onset of EBT, immediately and 15 min after EBT.

Time of EBT	SpO_2 (%)	*t*	*df*	*P*
Onset of EBT	94.3 ± 2.2	-	-	-
End of EBT	94.1 ± 3.3	0.295	29	0.770
15 min after EBT	94.9 ± 4.2	−0.815	29	0.422

EBT: Exchange blood transfusion.

Table 3. Comparison of the SpO_2 values of patients infused blood with different storage time.

Time of EBT	STB (h)	*N*	SpO_2 (%)	*U*	*P*
Onset of EBT	<24	8	93.5 (88.5-98.5)	99.5	0.584
	⩾24	22	94.0 (86.0-102.0)		
End of EBT	<24	8	93.5 (85.5-101.5)	88.0	>0.999
	⩾24	22	94.0 (80.0-108.0)		
15 min end of EBT	<24	8	96.0 (88.0-102.0)	85.0	0.887
	⩾24	22	95.5 (73.5-117.5)		

EBT: Exchange blood transfusion; STB: Storage time of blood.

Table 4. Comparison of SpO_2 values between different hematocrits at different stages of EBT.

Time of EBT	Hematocrits	*N*	SpO_2 (%)	*U*	*P*
Onset of EBT	<45%	8	93.5 (85.5-101.5)	65.5	0.284
	⩾45%	22	94.5 (88.5-100.5)		
End of EBT	<45%	8	92.0 (79.0-105.0)	55.0	0.118
	⩾45%	22	94.5 (85.5-103.5)		
15 min after EBT	<45%	8	94.5 (87.5-101.5)	84.5	0.868
	⩾45%	22	96.0 (74.0-118.0)		

EBT: Exchange blood transfusion.

4. Discussion

This study like many other studies on NNJ showed more males are affected than females[11-13,17,18]. The reason could be that glucose phosphate dehydrogenase deficiency, X-linked autosomal recessive condition, and other neonatal conditions are more common among males[19-21]. The commonest cause of NNJ in this study was ABO incompatibility, accounting for 70% of the causes. This finding is similar to many other studies[11,13,17-18]. The reason could be ABO incompatibility which is due to antigen-antibody mediated hemolysis is more likely to be severe and progressive thus requiring EBT, while glucose phosphate dehydrogenase deficiency that is triggered by exposure to substances causing oxidant stress, is usually external, may be self-limiting and usually abate when the trigger is removed[21]. However, a study in Abakaliki, southeastern Nigeria reported low birth weight as the commonest cause followed by ABO incompatibility (30% and 20% respectively)[5]. This is a cross-sectional retrospective study covering 3 year period, and missing data are likely especially when records are kept manually. The mean weight, height, and gestational age were also normal. In ABO incompatibility, hemolysis starts in utero, a paucity of A or B antigenic sites on the fetal erythrocytes, and competitive binding of isoantibody to other antigenic sites in other tissues may explain the mild hemolytic process[22]. In our study, the pre-EBT hematocrit ranged from 20.3% to 57.0% with mean of (40.3 ± 8.3)%. The near-normal mean hematocrit shows the main indication for EBT was severe NNJ, rather than anemia. This is similar to previous studies[23]. Although there is hemolysis leading to jaundice, we expect anemia, but often it is not severe[11]. Also, relatively high hematocrit at birth has been reported among babies in this country. For example, a study on hematologic parameters of apparently healthy babies by Ogundeyi *et al.*[24] in Sagamu, southwestern Nigeria showed that the hematocrit in the majority of normal term neonates on day 3 was between 45% to 54% while that reported by Buseri *et al.*[25] in Port Harcourt showed 40% to 53% among neonates less than 7 d old. Most of subjects in our study were full-term with a mean age at presentation of (5.4 ± 2.9) d. This near-normal hematocrit may also be due to delayed cord clamping, maternal-fetal transfusion, or polycythemia from other causes (which may also be a factor leading to the severe NNJ). Ibekwe *et al.*[5] reported a lower hematocrit of 35.02%, however, prematurity

was found to be the main cause of NNJ. Iatrogenic and frequent sampling are known contributing factors of anemia in preterm babies[26].

From this study, although there was a slight fall in mean SpO_2 (94.1%) at the end of the EBT and a slight rise at 15 min after the EBT (94.9%) compared to the mean SpO_2 at the beginning of the EBT, the differences both were not statistically significant (P=0.770 and 0.422 respectively). Also when the SpO_2 values were compared between neonates infused blood of different storage time, it showed no statistical difference. Although to the best of our knowledge, there is paucity of study to compare the variation of SpO_2 during EBT, there were several studies on adverse effects associated with EBT which has documented several complications including those related to the procedure like cardiac arrest, tachycardia, bradycardia, and seizures, among others[5,11-13,17-21]. Patra *et al.*[12] reported an adverse effect in 74% of the neonates including seizures and cardiac rest and a case of mortality. The serious complications were however found only among the critically ill neonates. The fact that most neonates undergoing this procedure are very sick, the possibility that donors' blood may undergo some biochemical changes like hyperkalaemia and hypocalcaemia, among others. As an extension of the storage time and the manual exchange procedure that employs the push and pull method, it was postulated that EBT may be associated with a possible cardiopulmonary compromise and consequent fall in SpO_2. But it was not found to be so in this study. In another study on the metabolic and cardiorespiratory effect of EBT in neonates by Aliyu *et al.*[17] in the same center, they reported an increase in respiratory and heart rates post-procedure but no record of apnea. Although the sample size of this study is small, it can be inferred that EBT remains a safe procedure when the operational guideline is followed thoroughly. It is preferable to use freshly collected blood, use of blood collected after 24 h was found not to show a significant fall in SpO_2 reading during and after the procedure.

Although EBT is an invasive procedure that may be associated with many complications including cardiorespiratory morbidities; however, our study did not document any significant fall in SpO_2 during the procedure even when blood collected after 24 h was used for the procedure.

Conflict of interest statement

The authors report no conflict of interest.

Authors' contributions

A.M.S., N.A.G. and I.A. contributed in the development of the concept and the write-up of the manuscript; while D.A., A.W., S.G.A., and A.M. contributed in the data collection and analysis; and M.O.A. and I.A. contributed in the development of the concept, data analysis and proof-reading of the manuscript. All authors approved the manuscript before submission.

References

[1] Yal NR. Neonatal exchange transfusion (NET)-what is its current net value? *J Blood Disord Treat* 2018; **1**(2): 9-13.

[2] Kusfa IU, Mamman AI, Ibrahim IN, Benjamin A, Yahaya G, Musa S, et al. Indications and patterns of blood transfusion in neonatal intensive care unit of a tertiary hospital in North West Nigeria. *Ann Trop Paediatr* 2019; **10**(2): 132.

[3] Slusher TM, Zamora TG, Appiah D, Stanke JU, Strand MA, Lee BW, et al. Burden of severe neonatal jaundice: a systematic review and meta-analysis. *BMJ Paediatr Open* 2017; **1**(1): e000105.

[4] Özek E, Soll R, Schimmel MS. Partial exchange transfusion to prevent neurodevelopmental disability in infants with polycythemia. *Cochrane Database Syst Rev* 2010; (1): CD005089.

[5] Pius S, Bello M, Maya Y, Djossi S, Ambe JP. Prevalence of exchange blood transfusion in severe hyperbilirubinaemia and outcome at the University of Maiduguri Teaching Hospital Maiduguri, Northeastern Nigeria. *Niger J Paediatr* 2017; **44**(2): 50-55.

[6] Farouk ZL, Muhammed A, Gambo S, Mukhtar-Yola M, Umar Abdullahi S, Slusher TM. Follow-up of children with kernicterus in Kano, Nigeria. *J Trop Pediatr* 2018; **64**(3): 176-182.

[7] Olusanya BO, Osibanjo FB, Mabogunje CA, Slusher TM, Olowe SA. The burden and management of neonatal jaundice in Nigeria: A scoping review of the literature. *Niger J Clin Pract* 2016; **19**(1): 1-17.

[8] Owa JA, Ogunlesi TA. Why we are still doing so many exchange blood transfusions for neonatal jaundice in Nigeria. *World J Pediatr* 2009; **5**(1): 51-55.

[9] Murki S, Kumar P. Blood exchange transfusion for infants with severe neonatal hyperbilirubinemia. *Semin Perinatol* 2011; **35**(3): 175-184.

[10]Hakan N, Zenciroglu A, Aydin M, Okumus N, Dursun A, Dilli D. Exchange transfusion for neonatal hyperbilirubinemia: an 8-year single center experience at a tertiary neonatal intensive care unit in Turkey. *J Matern Fetal Neonatal Med* 2015; **28**(13): 1537-1541.

[11]Mattie FW, Julie C, Keyaria DG, Caroline C, Mike G, Laila J, et al. Exchange transfusion safety and outcomes in neonatal hyperbilirubinemia. *J Perinatol* 2020; **40**(10): 1506-1512.

[12]Mohammad KS, Behnaz B, Maryam S, Saadat T. Complications of exchange transfusion in hospitalized neonates in two neonatal centers in Hamadan, a five-year experience. *J Compr Ped* 2015; **6**(2): e20587.

[13]Chacham S, Kumar J, Dutta S, Kumar P. Adverse events following blood exchange transfusion for neonatal hyperbilirubinemia: A prospective study. *J Clin Neonatol* 2019; **8**(2): 79-84.

[14]Usman F, Diala UM, Shapiro SM, Pichon JBL, Slusher TM. Acute bilirubin encephalopathy and its progression to kernicterus: current perspectives. *Res Rep Neonatol* 2017; **8**: 33-44.

[15]Chan ED, Chan MM, Chan MM. Pulse oximetry: Understanding its basic

principles facilitates appreciation of its limitations. *Respir Med* 2013; **107**(6): 789-799.

[16]Joel-Medewase VI, Olufemi-Aworinde JK, Alabi AO, Agelebe E, Adebami OJ. Pattern and indications for neonatal blood transfusion in Ogbomoso, Southwestern Nigeria. *Int J Health Sci* 2020; **9**(10): 111.

[17]Aliyu I, Mohammed A, Farouk ZL, Ibrahim ZF. Exchange blood transfusion: Its metabolic and cardiorespiratory effect in newborns. *J Clin Neonatol* 2017; **6**(3): 168-172.

[18]Badiee Z. Exchange transfusion in neonatal hyperbilirubinaemia: Experience in Isfahan, Iran. *Singapore Med J* 2007; **48**(5): 421-423.

[19]Kaplan M, Hammerman C. Severe neonatal hyperbilirubinemia: A potential complication of glucose-6-phosphate dehydrogenase deficiency. *Clin Perinatol* 1998; **25**(3): 575-590.

[20]Farouk ZL, Ibrahim M, Ogala WN. Glucose-6-phosphate dehydrogenase deficiency; the single most important cause of neonatal hyperbilirubinaemia in Kano, Nigeria. *Niger J Paediatr* 2017; **44**(2): 44-49.

[21]Olowe SA, Ransome-Kuti O. The risk of jaundice in glucose-6-phosphate dehydrogenase deficient babies exposed to menthol. *Acta Paediatrica* 1980; **69**(3): 341-345.

[22]Gomella TL, Cunningham MD, Eyal FG, Tuttle DJ. ABO Incompatibility. [Online] Available from: accesspediatrics.mhmedical.com/content.aspx? aid=1107528079. [Accessed on June 24 2020].

[23]Ogunlesi TA, Ogunfowora OB. Pattern and determinants of blood transfusion in a Nigerian neonatal unit. *Niger J Clin Pract* 2011; **14**(3): 354.

[24]Ogundeyi MM, Olarewaju DM, Njokanma OF, Ogunlesi TA. Haematological profile of apparently healthy term babies aged one day, three days and six weeks delivered in Sagamu, Nigeria. *Niger J Clin Pract* 2011; **38**(3): 125-130.

[25]Buseri FI, Siaminabo IJ, Jeremiah ZA. Reference values of hematological indices of infants, children, and adolescents in Port Harcourt, Nigeria. *Pathol Lab Med Int* 2010; **2010**(2): 65-70.

[26]Mokuolu OA, Ernest SK, Ogbonmide BF, Adeniyi A. Packed red cell volume pattern in Nigerian preterm babies. *Ann Trop Paediatr* 2000; **20**(1): 45-49.