Original Article

Indian Journal of Child Health

A quarterly, peer-reviewed, international, open access journal
published by Atharva Scientific Publications, India.

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How to cite this article: Agrawal A, Goyal S. Analysis of phlebotomy blood losses in neonates in a tertiary care hospital. Indian J Child Health. 2014;1(1):7-11.

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Analysis of phlebotomy blood losses in neonates in a tertiary care hospital

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Received – 15 March 2014 Initial Review – 30 March 2014 Published Online – 17 April 2014

Abstract

Introduction: Blood loss due to laboratory testing is greatest for the most premature neonates with very low birth weight who require many weeks of intensive support and monitoring. **Objective:** The purpose of this study was to find out the volume of blood withdrawn for analytical purposes in neonates. **Design:** Retrospective chart analysis **Setting:** Neonatal intensive care unit (NICU) of a tertiary care teaching hospital of central India **Participants:** Neonates admitted to NICU over a period of three months. All medical records of recruited patients were reviewed and amount of blood withdrawn for analytical purposes was recorded. **Intervention:** None **Main Outcome Measures:** The amount of blood overdrawn per test and blood overdrawn per newborn. **Results:** A total of 153 neonates were admitted to the NICU during the study period. A total of 684 samples were performed, corresponding to 4.47±3.36 (range 1-17) per neonate. The mean volume of blood removed was 9.38 ml ± 8.8 ml per newborn (range 1 -51 ml). The amount of blood withdrawn was inversely proportional to the gestational age and birth weight i.e., neonates less than 32 weeks gestation and those with birth weight <1500 gm had statistically significant more phlebotomy loss ($p<0.0001$). The amount of blood withdrawn per test was significantly more than required by laboratory. **Conclusion:** The volume of blood sampled in our NICU was higher in neonates with low birth weight and lesser gestational age. The amount of blood overdrawn per test was much higher than required by laboratory.

Key words: *Newborn, Phlebotomy, Intensive care, Blood loss*

All medical treatments and procedures are associated with potential adverse effects of greater or lesser significance. During the first weeks of life, blood loss attributable to laboratory testing is acknowledged as the primary factor leading to anemia in critically ill infants [1]. The impact of blood loss due to laboratory testing is greatest for the most premature neonates with very low birth weight who require many weeks of intensive support and monitoring [2]. This is a patient population for which the need for frequent and prolonged blood testing is great but circulating blood volume is small. As neonatal blood volume is normally 70ml/kg, the total blood volume of the most premature infants may be as low as 50 ml in which case sampling just 1 ml represents a 2% reduction in blood volume, equivalent to 100 ml blood loss from a healthy adult. The undisputed value of blood testing for diagnosis and monitoring of disease is tempered by recognition that repeated blood sampling can result in blood loss of sufficient magnitude to cause anemia that can contribute to the necessity for red cell transfusion in particular patients. Sick neonates are one of the most heavily transfused groups of patients in modern medicine [3-6]. Phlebotomy overdraw as a causative factor of anemia especially in low birth weight newborns has been reported previously; however, very few studies describing the amount of phlebotomy blood losses in newborns have been done in developing countries. The aim of the present work is to find out the volume of blood removed for analytical purposes in our neonatal unit.

METHODS

This was a retrospective study conducted at a tertiary care neonatal intensive care unit over a period of three months. All medical records of neonates admitted to NICU during that period were reviewed. Newborns with surgical conditions or with major congenital anomalies were excluded from the study. For each patient the following data were collected: gestational age (GA), birth weight (BW), duration of hospitalization, cause of admission and the number and volume of blood sampling.

Blood samples were taken by qualified resident doctors through venous punctures. Heel stick samples were not done due to limitation in facilities. The blood samples were ordered for each neonate by pediatrician only when needed to make diagnostic and therapeutic interventions. For simplicity, blood lost on gauze pads, syringes, bedding and intravenous tubing was not included. The minimum amount of blood needed for a particular test and the amount of blood withdrawn was documented. The amount of blood overdraw per test was recorded. The total amount of blood withdrawn per newborn was recorded.

Data collected was analyzed to find out the volume of phlebotomy in the neonatal unit. Demographic factors were summarized as counts (percentages for categorical variables & as mean±SD for continuous variable like gestational age, and birth weight). Both groups were compared using chi square test for all variables. Statistical analysis was done by using Microsoft Office Excel 2010 and statistical significance was taken as 5%.

RESULTS

A total of 170 newborns were admitted during the study period. Five had surgical conditions and three had major congenital anomalies and were therefore excluded from the study. There was incomplete collection of data in nine newborns so, 153 neonates were included in the study finally. Of these 153 neonates studied, a total of 684 samples were performed, corresponding to 4.47 (range 1-17) samples per neonate. The commonly done tests were a complete blood count, C-reactive protein, blood culture, blood sugar, serum electrolytes, serum bilirubin, renal profile and coagulation profile as required.

Table 1: Distribution of cases according to illness

Variables	Number	%
Prematurity	70	45.75
Perinatal asphyxia	47	30.71
Neonatal Sepsis	22	14.40
Neonatal jaundice	8	5.23
Meconium aspiration syndrome	6	3.91
Total	153	100

The mean gestational age of newborns was 32.39 ± 2.8 weeks and the mean birth weight was 2.14 ± 0.68 kg. The mean duration of stay of study subjects was 4.83 ± 4.25 days. The clinical profile of study subjects is mentioned in Table 1. The total number of samples performed and the volume of blood withdrawn was significantly higher in newborns with birth weight less than 1500 gm (Table 2).

Table 2: Relation between birth weight and sampling

Variables	<1500 gm	1500-2499 gm	>2500 gm
Number of Newborns	28	68	57
Duration of stay (days)	6.20	4.50	4.53
Total number of samples	285	271	128
Blood sampling per newborn	10.17	3.98	2.24
Total volume withdrawn (ml)	439	469	427
Volume per newborn (ml)	15.62	6.81	7.50*
Volume (ml/kg/day)	2.53	1.28	0.78*

***- p value <0.0001**

Similarly, the volume of blood withdrawn was significantly higher in neonates with lower gestational age. The relationship between gestational age and blood sampling is showed in Table 3. When Pearson's correlation was applied between total number of samples withdrawn per newborn and birth weight, an inverse significant correlation (r = -0.172,

P value = 0.032) was found. However, a positive significant correlation (r = 0.896, P value = 0.001) was obtained between total number of samples withdrawn per newborn and total volume of blood withdrawn per newborn.

Table 3: Relation between gestational age and sampling

Variables	<32 weeks	32-37 weeks	>37 weeks
Number of Newborns	31	36	86
Duration of Stay (days)	6.11	4.93	4.30
Total number of samples	175	176	333
Samples per Newborn	5.65	4.89	3.87
Total volume withdrawn (ml)	434	378	624
Volume per newborn (ml)	14	10.50	7.25*
Volume ml /kg/day	2.13	1.45	0.93*

***- p value <0.0001**

Smaller and premature neonates underwent significantly more number of blood tests and more volume of blood was extracted per kilogram of body weight which was statistically highly significant (p<0.0001). The amount of blood overdrawn was 1.5 ml per draw for complete blood count, 1 ml for serum bilirubin, 1 ml for renal profile, 1 ml for serum electrolytes and 1 ml for C- reactive protein than required by laboratory (Table 4).

However, the amount of blood drawn for blood culture and prothrombin time was appropriate (Figure 1). This can be attributed to the use of marked tubes for prothrombin time. The mean (± Standard error of mean) volume of blood withdrawn for the 684 samples drawn exceeded that requested by hospital laboratory by 100% ± 37.79% per test.

DISCUSSION

Preterm infants typically experience heavy phlebotomy losses from frequent laboratory testing in the first few weeks of life. This results in anemia requiring RBC transfusions. The initial and subsequent blood phlebotomies during the first days in the NICU can result in lower hemoglobin concentrations and on that basis can cause some to qualify for and receive an early blood transfusion. For the smallest patients, the initial phlebotomy might equal upto 10% of their blood volume [7-10].

Table 4: Table showing amount of blood withdrawn for various tests

Lab parameter	Volume required (ml)	Volume withdrawn (ml)	Overdraw (ml)	Overdraw (%)
Complete Blood count	0.50	2	1.50	300
C reactive protein	1	2	1	100
Liver function	1	2	1	100
Renal Function	1	2	1	100
Serum electrolytes	1	2	1	100
Blood culture	1	1	Nil	Nil
Prothrombin time	2	2	Nil	Nil

In our study, the mean blood loss due to blood sampling in very low birth weight (<1500gm), low birth weight (1500-2499 gm) and appropriate for birth weight (> 2500 gm) was 2.53ml/kg/day, 1.28 ml/kg/day and 0.78 ml/kg/day respectively. Similarly, the number of samples withdrawn per newborn was significantly (p<0.0001) more in very low birth weight newborns which indicate that blood loss is inversely proportional to birth weight. Several other studies support this finding. In a study by Maier et al, the median cumulative blood loss due to diagnostic tests was 0.74 ml/kg/day inversely related to birth weight: 0.59 ml/kg/day among infants weighing 1250 to 1499 gm, 0.83 ml/kg/day among those weighing 1000 to 1249 gm, 1.27 ml/kg/day among those weighing 750 to 999 gm [10]. Similarly, Lin et al reported that very low birth weight and most critically ill infants experienced the greatest blood overdraw [4].

In our study, we found an inverse relationship between gestational age and blood sampling. The mean blood loss in those ≥ 28 weeks, ≥ 32 weeks, ≥ 37 weeks were 2.13 ml/kg/day, 1.45 ml/kg/day and 0.93 ml/kg/day respectively i.e. newborns with lower gestational age had statistically significant greater blood loss ($p<0.0001$). Kling et al found relation between gestational age, birth weight and mean blood loss. He found out that infants with lower birth weight (971±238 gm versus 1272±144 gm; $p<0.001$) and lower gestational age (27.7±1.6 weeks versus 30.7±2.8 weeks; $p<0.001$) had greater phlebotomy blood loss (3.3±1.6 ml/kg/day versus 1.4±0.5 ml/kg/day; $p< 0.001$) during the first postnatal weeks [11]. Similarly, Madsen et al described phlebotomy blood losses in premature neonates of 24-32 weeks gestation during first four weeks of life. The highest frequencies were found during the first week, in infants with extremely low GA and in critically ill infants. The mean blood loss and transfusion volume values were 13.6 ml/kg and 6.3 ml/kg, respectively [12]. Nexo et al also evaluated blood losses in twenty low birth weight neonates. Blood was sampled one to 13 times per infant per day on 382 of the 435 total days of hospitalization. The average blood loss was 7 to 51 ml/kg of body weight per four weeks i.e. from 5 to 45% of the calculated total blood volume. Of the blood removed, about 25% was in excess of the need for analytical procedures [13].

Despite emergence of high quality automated analyzers which require minimal amount of blood for testing, very few intensive care units practice this for fear of failed results or repeat sampling. Reducing the iatrogenic blood loss associated with laboratory testing has significant potential for reducing red cell transfusion of premature neonates. Avoidance of unnecessary testing, defining and complying with minimum sampling requirements and recording blood loss due to sampling can be effective in minimizing iatrogenic blood loss. Each pediatric laboratory should have a clear-cut recommendation on the amount on blood volume necessary for the requested number of tests [14,15].

Recently, advances in technology have enabled reduction in the sample volume requirements of analytical systems that have had greatest impact in reducing iatrogenic blood loss. In our study, the amount of blood withdrawn for laboratory tests was significantly higher than required by the laboratory. This can be attributed to use of unmarked tubes, unavailability of pediatric phlebotomy vials, lack of awareness amongst staff on adverse effects of overdraw, and overdraw to avoid repeat sample because of insufficient volume. The graph shows the amount of blood withdrawn for analytical purposes in NICU. In another study, phlebotomy resulted in a mean blood volume loss of 2.5±1.4 mL/draw, 7.1±5.3 mL/day, and 34±37 mL per pediatric intensive care unit stay, of which 1.4±1.1 mL/draw, 3.8±3.6 mL/day, and 23±31 mL per pediatric intensive care unit stay were discarded as excess. This excess represents 210%±174% of the volume requested by the laboratory and a 110% overdraw [14]. Same study also showed significantly excess upto two fold higher withdraw than required by the laboratory. Overdraw also occurred the most for one test compared to consolidated draws for 2, 3 and 4 tests. Blood drawn for a chemistry profile had the greatest chances of being overdrawn [14].

Several strategies can be employed to reduce blood testing while preserving optimum patient care including non invasive hemodynamic monitoring, adoption of practice parameters for diagnostic evaluation and point of care testing [15]. Point of care testing has acceptable precision, and can provide valuable diagnostic information while being minimally invasive. It requires very small (i.e. microlitre) blood samples, and in some cases blood is not even removed from the patient because indwelling sensors or a closed circuit extracorporeal sampling device is employed to permit return of sample to the patient after analysis [16-18]. Using umbilical cord blood for the initial blood tests of very low birth weight neonates results in higher haemoglobin and fewer RBC transfusions [19-20].

CONCLUSIONS

Blood testing in neonatal intensive care units is excessive in preterm infants with lower birth weight. Therefore, to avoid excessive phlebotomy losses blood withdrawn from neonates should be in accordance with laboratory requirements. The use of point of care and non invasive monitoring devices and consolidation of tests should be encouraged.

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Funding: None; Conflict of Interest: None Stated

How to cite this article: Agrawal A, Goyal S. Analysis of phlebotomy blood losses in neonates in a tertiary care hospital. Indian J Child Health. 2014;1(1):7-10.