BLOOD VOLUMES OF PAKISTANI MALE DONORS: IMPLICATIONS FOR BLOOD DONATION.

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Background: Safety of blood donors rest on withdrawing only appropriate quantities of blood. Adjusting the volumes drawn according to the average blood volumes of any population can ensure this. This requires knowledge of total blood volume of donors, which should ideally be measured by standard methods or derived by alternate suitable method. This observational, cross sectional study was undertaken to calculate blood volumes of Pakistani male donor using recommended equations and obtain safe donation volume limits for our population. **Methods:** Height and weight of male Pakistani donors reporting to Combined Military Hospital blood bank was recorded by standardized method. Blood volumes were calculated by two different equations using body surface area. The data was entered in SPSS 10.0 version for Windows and statistical analysis done. **Results:** Mean total blood volumes of 625 male donors calculated was 4819.2 ml with first equation and 4566.8 ml with second equation. 95% CI was between 4796.7 and 4841.6 with first equation and 4541.6 and 4591.9 with second equation. The maximum volumes of donation recommended for western population constitutes less than 12 % of calculated total blood volume of our population, with either equation. This is with in safe limits by any standard. **Conclusion:** 450 ml $\pm$ 45 ml including samples in pilot tubes should be the recommended donation volume in Pakistani donors. The maximum volume being collected in other countries constitute safe limits for Pakistani donors as well. Equations showing better correlation with measured volumes should preferably be used to calculate blood volumes. Impact of collecting blood volumes recommended in this study, on blood donors, should be studied.

Key words: Blood volume; blood donor.

INTRODUCTION

Donor selection procedures determine the safety of both the donor and the recipient. This is based on the medical history and limited physical examination of the donor, done on the day of donation[1].

Donor weight is the usual criteria used to roughly indicate the volume of blood that can be safely collected. 10-15% of donor's estimated blood volume is considered to be a safe limit, set by different scientific and regulatory bodies, that can be donated.[1-5]

Prediction of blood volume with weight alone is inaccurate. Many non-invasive methods and calculations using height, weight, body surface area and skin fold thickness have been devised to assess the blood volumes more accurately. These calculated blood volumes form the best approximates to the invasive measured total blood volume (TBV), red cell volume (RCV) and plasma volume (PV). These volumes may vary among population groups. [2]

On account of that, safe limit of blood volume drawn may also vary. Therefore, these should form the basis of practice to collect appropriate and safe volume of blood from donors. However, no studies have been done in Pakistani population either to measure or calculate blood volumes.

Present, prospective study was undertaken to calculate blood volumes of Pakistani blood donors, using different equations, to ascertain safe limits of blood donation volumes, to generate data for evidence-based guidelines and make recommendations.

MATERIAL AND METHODS

Height in feet and inches and weight in kilograms was recorded, with standardized scale, of all male blood donors reporting to blood bank of Combined Military Hospital, Multan, for six months. This was also correlated with the historical weight and height known to the donors themselves.

At the end of study period the data was entered in SPSS 10.0 for Windows for calculations. The variables labeled included unique donation number, age of the donor, height in feet and inches, height in centimeters, weight in kilograms, body surface area (BSA) with equation 1 and equation 2, total blood volume with two equations using BSA, the difference of blood volume obtained from two equations. The two equations used are shown in Table 1 along with the referred source.[6-8]

Analysis of this primary data was generated with SPSS descriptive statistics option, as output sheets showing mean age, mean blood volumes with two equations, their difference, significance of difference, 95% confidence intervals, standard deviation, standard error of mean, mean blood volumes derived for different percentages of TBV.

Table 1- Equations for calculating blood volume

Equation	BSA (m^2) calculation	RCV (ml) calculation	PV (ml) calculation	TBV (ml) calculation
Equation 1 [6,7]	$\sqrt{Ht \text{ (cms x wt (kg) / 3600}}$	-	-	Males 2740 ml/m^2
Equation 2 [8]	$Wt^{0.425} x H^{0.725} x\ 0.007184$	(1486xBSA)-825	1578xBSA	RCV+PV

Table 2- One sample statistics and paired sample Test

Parameter	Range	Mean	SD	SEM	95%CI	Correlation	Sig
Age (years)	17-58	27.4	6.8				
Weight (kg)	50-110	66.3	7.3				
Height (cms)	144.7-200.6	169.4	5.4				
BSA(m^2)equation 1	1.51-2.30	1.75	.104				
BSA(m^2)equation 2	1.50-2.29	1.74	.102				
TBV(ml)equation 1	4137.4- 6302.0	4819.2	285.7	11.4	Lower 4796.7 Upper 4841.6		
TBV(ml)equation 2	3739.5-6222.2	4566.8	319.5	12.7	Lower 4541.6 Upper 4591.9		
Difference Equation 1-equation 2	248.4-802.8	252.4	64.6				
Pair (TBV by equation 1 and TBV by equation 2)		252.4	64.6	2.5	Lower 247.3 Upper 257.5 (95% CI of difference)	.983	.00

Table 3- Percentage of TBV in Pakistani donors as function of volumes of blood donations in other countries

Country	Volume of donation	Percentage of Pakistani donors blood volumes/absolute volumes	
		Equation 1	Equation 2
UK average volume [2]	450 ml	9.3%	9.8%
Maximum volume [2]	450 ml + 45 ml=495 ml	10.2%	10.8%
Maximum volume with pilot tube sampling volume [2]	495 ml + 30 ml= 525 ml	10.8%	11.4%
Turkey, Greece, Italy [2]	350-400 ml	7.2%-8.3%	7.6%-8.7%
UK guidelines [3,5]	13% (max)	626.4 ml	593.6 ml
USA [4]	15% (max)	722.8 ml	685.0 ml

Paired sample t-test was applied to compare the means of these two variables (Blood volume with equations 1 and 2) for a single donor group. It calculated the difference between values for each case and tested whether the average differed from zero. Different percentages and absolute blood volumes of our donors as function of blood volume recommendations of other countries were also calculated.

RESULTS

Complete data regarding age, height and weight was available for 625 donors (Table 2). The difference of BSA with two types of calculations showed a negligible difference of 0.01m^2. The mean difference of blood volume with the two equations was 252.4 ml and the rest of the means for the other parameters calculated are shown in Table 2.

However, it could not be ascertained, whether the difference in TBV by the two equations was due to difference in the PV or RCV because the equation 1 used whole blood volume for calculation while equation 2 calculated the RCV and PV separately (Table 1) and these were later summed to give TBV. The volume difference calculated by the two equations was significant (*p* value .000).

The mean blood volumes of our donors as function of different percentages of blood volume being used in different countries are shown in Table

3. The percentage and these translated into absolute volumes based on our donor data are also shown.

The recommended volume of collection in the United Kingdom (UK) and Europe[2,5] is 450 ml ± 45 ml, which is equivalent to 9.3 % ± 0.93 % of TBV with equation 1 and 9.8 ± 0.98 % of TBV with equation 2, of our donors. If maximum volume recommended i.e. 495 ml is collected it will constitute 10.2% and 10.8% with the two equations respectively. The additional volume of 20-30 ml collected in pilot tubes for donor testing will make maximum volume of 525 ml i.e. 10.8% and 11.4 % of TBV with two equations respectively.

DISCUSSION

It is the basic responsibility of blood banks to ensure safety of the blood donors. Blood donation process is one of the safest procedures provided all the standards and guidelines are strictly followed and nothing is left to individual or institutional whims and assumptions, casual approach and faulty procedures.

Blood donor population's physical characteristics may also vary in different regions and countries. Therefore it is more appropriate to develop guidelines/ standards for indigenous population based on local data or data pertaining to the differences of our population from the western population where the guidelines have been made according to their data. These differences should be translated into local guidelines/standards.

One of the key areas where the local population physical characteristics can have effect is the volume of blood drawn for donation. The blood volume donated should not cause any adverse effects and at the same time provide adequate quantities of components like platelets, plasma etc to meet the standards. Because of these considerations this safe limit of blood volume at donation has been spelt out in terms of percentage of TBV. This has variably ranged between 10-15 % from different sources [1,2,3,4,5]. In absolute quantities this varies from 250 ml in some Asian countries, 350-400 ml in Turkey, Greece and Italy, 450 ml in UK and United States of America (USA) [2,3] to a maximum of 525 ml in USA [4]. The lower volumes in Asian countries are due to population who are smaller.

The national guidelines for blood transfusion services of Pakistan, compiled by public health division of National Institute of Health, [9] does not differ from UK guidelines in the red book but it does not refer to any local data, therefore there was need to generate objective local data so that evidence based guidelines can be made or revised.

The exact RCV and PV can only be estimated using standardized methods like ^{51}Cr. ^{99}mTc and ^{111} in labeling of red cells and albumin respectively such as those drawn up by the radionuclide panel of the International Committee for Standardization in Haematology (ICSH) [10]. These methods have been widely used and provide within method accuracy of 2-3 %. The limitation of this method is that these measurements are invasive and need radionuclide labeling and so far no such study is available on Pakistani population. These studies need to be done in healthy volunteers so that their accurate data can be extrapolated on to other population groups like blood donors. Also, ideally, this data should be used to validate the application-derived equations that have been used to calculate the TBV, RCV or PV by other workers.

It has been established that equations based on both height and weight provide more accurate estimates of erythrocytes and plasma volume than those based on height or weight alone[11]. These are almost as accurate as equations utilizing lean body mass or skin fold thickness and are simple to use. Therefore, RCV or PV standards should be based on height, weight regression equations or surface area ratio equation for clinical purposes[7].

We calculated the TBV of donors using at least two equations. We selected these equations as they have been recommended in transfusion medicine text. Pearson et al, derived equations from direct measurement of RCV and PV from selected published papers[8]. Approximately 99 % of the measured values were within ± 25% of the predicted mean normal values. We used recommended equations to find out whether the difference in predicted volumes was significant and what implications it would have for donation volumes in our population.

The BSA calculated by equations showed difference of only .01 m^2 but when RCV and PV were calculated separately and then added, the difference of means of TBV by two equations was 252.4 ml. When the two means were compared with t-tests for paired sample statistics the difference was significant therefore the parts of equations calculating blood volume cannot be used interchangeably. Predictive value of equation 1 is not known as it was not compared with the actual measured values therefore equation 2 is more appropriate to be applied in our population because it was more closely correlated with the actual estimations in other populations [8].

The difference of TBV with these two equations is significant therefore the one giving larger volumes can overestimate collection volume

and hence recommendation of collecting larger volumes can compromise safety. Since equation 2 is better correlated with actual measured values[8] and also it has wider safety margin because of TBV calculated being smaller therefore it was taken to be closer to the actual volumes and should be preferred for calculation blood volumes in our population. The percentage volumes of the TBV calculated by either equation, however, do not exceed the 13 % limit by UK guidelines [3] and 15 % limit by AABB (American Association of Blood Banks), USA [4].

The recommendation for blood donation volume for male Pakistani donors are, therefore, same as for the donors in UK i.e. 450 ml $\pm$ 45 ml with additional volume of 20-30 ml in pilot tubes. This will meet the safety standards for donors and quality control parameters of component prepared. However, the final verdict on this to be truly being 11.4 % of measured volumes can be done after measurements of RCV and PV by radionuclide methods in our population.

Lack of this information has prevented us from properly correlating the calculated values from equations with the measured values in our donor population.

The safety impact of recommended volumes in our study can only be validated after documenting number and nature of adverse effects of blood donation, which should be made reportable to a centralized authority. The guidelines then need to be revised according to the information collected from these reported adverse effects. This data also cannot be extrapolated to female donors who constituted less than 1% of our donor population. For them, separate equations should be applied and recommendations developed based on that.

The volumes of blood collected should be measured by using automatic weight sensitive devices and not left to non standardized visual check for the adequacy of volume as is being done by majority of local blood banks. It is also recommended that impact of collection of this quantity of blood on iron stores of volunteer donors be also studied and that data be utilized to make guidelines and recommendations for frequency of blood donations and volumes collected per year, for Pakistani donors.

CONCLUSION

Maximum collection volumes for donors stated in standards for other countries also constitute safe volume limits for our donors as well, based on the calculations of total blood volumes by different recommended equations. However, there is need to measure the exact blood volumes by radionuclide methods in Pakistani population and results of this study should be correlated with these.

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