Iron Stores in Thai Blood Donors

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Abstract

A high number of blood donations may cause iron depletion. In order to evaluate iron stores in volunteer Thai blood donors, 82 male and 72 female donors were studied. All were tested for serum ferritin (SF), hemoglobin (Hb) level and asked for detailed histories of donations and iron supplementation. Mean SF in first-time donors was 161.12 ng/mL in men (n=16) and 53.92 ng/mL in women (n=23). Mean SF in multiple-time donors was 52.72 ng/mL in men (n=66) and 25.72 ng/mL in women (n=49). Depleted iron stores (SF $\leq$ 15 ng/mL) were found in 8.7 per cent of first-time female donors, 21.21 per cent and 32.65 per cent of multiple-time male and female donors, respectively. The mean numbers of total donation were 51.42$\pm$30.8 in men and 8.22$\pm$6.97 in women. The estimation of depleted iron stores from Hb level could be determined in 57.14 per cent of male and 88.89 per cent of female donors. In conclusion, iron supplementation will benefit female donors and multiple-time male donors. The frequency of donations per year was more predictive of decreased iron stores than the number of total donations.

Key word : Blood Donor, Serum Ferritin, Iron Store, Iron Depletion

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Blood donation results in a substantial loss of iron which is primarily more of a problem in actively menstruating women than in nonmenstruating women[1,2] and men[3]. Men are able to maintain adequate iron status while donating up to 5 units of blood annually, but women are at risk of iron deficiency if they donate more than 1 unit per year[4]. Iron deficiency was found in 18-50 per cent

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of menstruating women accepted for blood donation who had given blood repeatedly[4-6]. Donor screening for hemoglobin (Hb) level using copper sulfate test (CST) is designed to prevent iron deficiency anemia but does not necessarily protect against the development of iron depletion[4-8]. Regular blood donors may develop varying degrees of nonanemic iron depletion such as fatigue, decreased mental performance, reduced exercise tolerance and defective host defense against infection[7].

Previous studies[1-10] have demonstrated that the serum ferritin (SF) level appears to be a reliable indicator of mobilizable body iron status and bone marrow hemosiderin iron in healthy subjects and is suitable for large scale investigation of iron status. Because of the significant differences in iron status between the sexes[4], it is necessary to consider male and female donors separately. The aim of this study was to evaluate iron stores in male and female Thai blood donors by measurement of SF. The relationships between SF and number of phlebotomies, donation frequency and Hb level in eligible donors screening by CST were also analyzed.

MATERIAL AND METHOD

The study was comprised of 82 male and 72 female volunteer blood donors, fulfilling the general health criteria for donations. Each donor answered questions, providing information on age, time of last donation, donation frequency per annum, number of previous donations, and iron supplement. Women were asked additional questions regarding menstrual and hysterectomy status. More information was also taken from the individual donor records.

The predonation screen included a copper sulfate gravity test for Hb values, set for 12.5 g/dl in women and 13.5 g/dl in men. Approximately 450 $\pm$ 10 per cent ml of blood was drawn from eligible donors. Blood samples were collected at the end of donation and analyzed for complete blood count by Technicon H3 RTX (Bayer Diagnostic) or Cell Dyn 3500 (Abbott Diagnosis) and sera were stored at -20°C for determination of serum ferritin level. The sera were thawed on the day of the assay and serum ferritin was measured by an automated microparticle enzyme immunoassay (MEIA) Axsym system, Abbott Laboratories, Abbott Park, IL. Iron stores were considered depleted when serum ferritin was less than 15 ng/ml according to WHO cut-off levels.

The comparison among the mean of different groups was calculated by one way ANOVA. The association between hemoglobin and serum ferritin was calculated by correlation coefficient. The p value of less than 0.05 was considered significant.

RESULT

Multiple-time donors developed significantly lower iron stores. Mean SF (ng/ml) in the first time donors was 161.12$\pm$108.15 in men and 53.92 $\pm$ 62.62 in women. Mean SF in multiple-time donors was 52.72$\pm$54.94 in men and 25.72$\pm$17.20 in women. Depleted iron store (SF$\leq$15) was absent in the first time male donors, but was found in 21.21 per cent of multiple-time male donors. By contrast, 9.52 per cent and 35.71 per cent of the first time and multiple-time menstruating female donors had depleted iron stores (as shown in Table 1 and 2).

Table 1. Distribution of serum ferritin levels in male and female blood donors.

Serum ferritin (ng/ml)	First-time				Multiple-time			
	Male		Female		Male		Female	
	No.	%	No.	%	No.	%	No.	%
<10	0	0	1	4.35	10	15.15	12	24.49
10-14	0	0	1	4.35	4	6.06	4	8.16
15-30	1	6.25	7	30.43	15	22.73	16	32.65
31-90	4	25	10	43.48	27	40.91	17	34.69
>90	11	68.75	4	17.39	10	15.15	0	0
Total	16		23		66		49	

The mean numbers of total donation were 51.42±30.8 in men and 8.22±6.97 in women. The influence of the total number of donations on SF was not impressive. The prevalence of iron depletion was related to the frequency of blood donations rather than to the cumulative total number of donations (as shown in Table 3 and 4). The donation frequency had an influence on SF. An increase in

Table 2. Distribution of serum ferritin levels in menstruating and nonmenstruating female donors.

Donor	Serum ferritin (ng/ml)					Total
	<10	10-14	15-30	31-90	>90	
Menstruating						
First-time						
Number	1	1	7	8	4	21
Per cent	4.76	4.76	33.33	38.09	19.05	
Multiple-time						
Number	11	4	16	11	0	42
Per cent	26.19	9.52	38.09	26.19		
Nonmenstruating						
First-time						
Number	0	0	0	2	0	2
Per cent				100		
Multiple-time						
Number	1	0	0	6	0	7
Per cent	14.29			85.71		

Table 3. Relation between serum ferritin levels and mean number ± SD (range) of blood donations in male and female donors.

Serum ferritin (ng/ml)	No. of donations		No. of donors	
	Male	Female	Male	Female
<15	51.42±30.8 (7-110)	8.22±6.97 (1-28)	14	18
≥15	17.97±23.97 (1-101)	9.01±13.49 (1-62)	68	54
			82	72

Table 4. Relation between donation frequency and serum ferritin level (mean ± SD) in male and female blood donors.

Donations per year	Serum ferritin (ng/ml)			
	Male donors		Female Donors	
0	161.12±108.15	(n=16)	53.92±62.62	(n=23)
1	85.59±72.96	(n=12)	32.07±17.97	(n=14)
2	70.79±63.98	(n=20)	22.76±15.75	(n=18)
3	31.03±27.94	(n=21)	20.67±16.44	(n=13)
4	27.70±19.89	(n=12)	33.27±22.50	(n=4)
	$p < 0.0001$		$p < 0.05$	

Table 5. Relation between serum ferritin and distribution of Hb values in blood donors.

Serum Ferritin (ng/ml)	Hemoglobin (g/l) <130 M	<130 F	130-140 M	130-140 F	>140 M	>140 F	No. of Donors M	No. of Donors F
<10	6	13	2	0	2	0	10	13
10-14	0	3	0	2	4	0	4	5
15-30	2	17	5	5	8	1	15	23
31-90	4	20	9	7	18	0	31	27
>90	3	2	6	2	13	0	22	4
No. of donors	15	55	22	16	45	1	82	72

the annual number of phlebotomies was accompanied by a significant decrease in mean SF levels ($p < 0.0001$ in male and $p < 0.05$ in female donors). The relationship between SF and Hb is shown in Table 5. Donors with SF levels less than 15 ng/ml had lower Hb than donors with SF>15 ng/ml ($p < 0.0001$). An increase in SF levels was accompanied by an increase in Hb levels ($r = 0.385$). However, the estimation of depleted iron stores from Hb levels could be determined in only 57.14 per cent of male and 88.89 per cent of female donors.

DISCUSSION

Depleted iron store is not uncommon in regular donors due to several reasons. Hb levels alone are inadequate to distinguish between normal and depleted iron stores because Hb declines after stores are completely exhausted. Hb level screening by CST does not provide an adequate assessment of venous Hb[3,7,8]. Moreover, there is a marked overlap in the frequency distribution between normal and anemic individuals resulting in a high number of false positive and negative results. In this study, 45.1 per cent of male donors who had Hb $\leq$ 13.5 g/dl and 76.4 per cent of female donors who had Hb $\leq$ 12.5 g/dl could not be identified by CST.

Serum ferritin level is known as the most informative assessment in estimating the amount of storage iron[11,12]. SF has been widely used to access iron status, but it hasn't been used for screening purposes because of the higher cost, time consuming and complexity of the test. It also identifies even the mild iron deficiency group. This study showed that iron depletion (SF $\leq$ 15) was found in male donors who had Hb > 13.5 g/dl and in female donors who had Hb > 12.5 g/dl. The dependency of iron status on the donation frequency rather than total donation was also observed.

Prevention of iron depletion can be done by several approaches. Should the frequency of donation be reduced?[8]. The disadvantage is that it will reduce the already scarce blood supply. Iron supplement is another approach[2,4,7,13], but the gastrointestinal side effect, the risk of iron poisoning in donors[14] and the risk of masking conditions associated with blood loss in donors have made iron supplement program difficult to implement and maintain. The last approach is whether the Hb rejection criteria should be reduced to optimize the predictive value of SF or blood donation standards should include monitoring of SF in order to identify iron depleted donors, but this would also result in a larger number of donor deferrals.

SUMMARY

This study showed that depletion of iron stores occurred gradually with increased donation frequency. The prevalence is higher in menstruating women. Iron depletion (SF $\leq$ 15 ng/ml) was absent in the first time male donors, but was found in 21.21 per cent of multiple-time male donors, 8.7 per cent and 32.65 per cent of the first time and multiple-time female donors, respectively. The conventional CST screening for Hb level which is more practical and less expensive, compared to SF, is inadequate to prevent iron depletion. Until a better screening test can be implemented, efforts to reduce the prevalence of iron depletion should be done by limiting the donation frequency of menstruating

women. Iron supplement is also another approach in donors who are likely to be highly motivated especially in menstruating women and multiple-time male donors.

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จำนวนเหล็กสะสมในผู้บริจาคโลหิตคนไทย

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จำนวนเหล็กสะสมในร่างกายอาจลดลงได้ในผู้บริจาคโลหิตประจำ การตรวจหาระดับ serum ferritin เป็นวิธีที่แม่นยำวิธีหนึ่งในการบอกถึงภาวะดังกล่าว ผู้ดำเนินการวิจัยได้ทำการตรวจหาระดับ serum ferritin ในผู้บริจาคโลหิตชาย 82 คน และหญิง 72 คน โดยเปรียบเทียบกับระดับฮีโมโกลบิน และการตรวจกรองก่อนให้โลหิต โดยวิธี copper sulfate เพื่อดูปริมาณธาตุเหล็กของผู้บริจาค

ผลการวิจัยพบว่าค่าเฉลี่ยของ serum ferritin ในผู้บริจาคโลหิตชายและหญิงที่มาบริจาคโลหิตเป็นครั้งแรก = 161.12 ng/mL และ 53.92 ng/mL ตามลำดับ ในขณะที่ค่าเฉลี่ยของ serum ferritin ในผู้บริจาคโลหิตชายและหญิงที่บริจาคประจำ (1–4 ครั้ง/ปี) = 52.72 ng/mL และ 25.72 ng/mL ตามลำดับ พบว่ามีภาวะขาดเหล็ก (serum ferritin $\leq$ 15 ng/mL) ในผู้บริจาคโลหิตหญิง ซึ่งบริจาคเป็นครั้งแรกคิดเป็นร้อยละ 8.7 และมีภาวะขาดเหล็กในผู้บริจาคประจำ โดยคิดเป็นร้อยละ 21.21 ในเพศชาย และ 32.65 ในเพศหญิง การตรวจค่าฮีโมโกลบิน ที่พบว่าต่ำกว่าปกติ จะบอกถึงภาวะจำนวนเหล็กสะสมลดลงได้เพียงร้อยละ 57.14 และ 88.89 ในผู้บริจาคโลหิตชายและหญิงตามลำดับ โดยสรุปผู้บริจาคโลหิตที่บริจาคเป็นประจำมีโอกาสที่จะเกิดภาวะจำนวนเหล็กสะสมลดลง ถึงแม้จะตรวจกรองค่าฮีโมโกลบิน ก่อนรับบริจาค และควรให้ธาตุเหล็กเสริมแก่ผู้บริจาคโลหิตหญิงทุกราย และผู้บริจาคโลหิตชายเฉพาะที่เป็นผู้บริจาคประจำ

คำสำคัญ : จำนวนเหล็กสะสม, ผู้บริจาคโลหิต, ภาวะขาดเหล็ก

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