Anemia and Iron Depletion among Blood Donors

Nutchanart   Nonsee, B.Sc. (Medical Technology)*,

Somchai   Insiripong, M.D.**

Abstract:

Objective: The blood donation can cause the iron depletion or even iron deficiency anemia. This study is aimed to find the iron depletion and anemia among blood donors and to test the validity of hemoglobinometer for blood donor anemia screening. **Participants and Methods:** This cross-sectional study recruits the blood donors who are investigated for Hb concentration using hemoglobinometer for blood donor screening and automated hematology analyzer and serum ferritin during September-December 2013, at blood donation center, Maharat Nakhon Ratchasima Hospital. **Results:** Only 203 from 249 can donate blood and they are classified into 4 groups, i) the first donation, ii) 2-5 donations, iii) 6-10 donations, iv) >10 donations. Only 57 donors (28.1%) have hypoferritinemia that is more common in group iv (9.1% in group i vs. 34.6% in group iv). And 63 donors (31.0%) have anemia that is more common in group i (45.4% in group i vs. 26.9% in group iv). As compared with the automated analyzer, the sensitivity, specificity, positive and negative predictive values, positive and negative likelihood ratios of hemoglobinometer for detecting anemia are 40.0%, 97.2%, 91.3%, 69.0%, 14.4 and 0.62, respectively. **Conclusion:** Hypoferritinemia and anemia are very common among blood donors. But the hemoglobinometer for blood donor screening has very low sensitivity to detect the anemia, so it seems rather harmful if it is used to screen the donors.

บทคัดย่อ: **ภาวะโลหิตจาง และการขาดธาตุเหล็กในผู้บริจาคโลหิต**

นุชนาถ นนทรีย์, ว.ทบ.(เทคนิคการแพทย์)*, สมชาย อินทรศิริพงษ์, พ.บ.**

* กลุ่มงานเทคนิคการแพทย์, โรงพยาบาลมหาราชนครราชสีมา จ.นครราชสีมา 30000

** กลุ่มงานอายุรกรรม โรงพยาบาลมหาราชนครราชสีมา จ.นครราชสีมา 30000

เวชสาร โรงพยาบาลมหาราชนครราชสีมา 2558; 37: 155-60.

* Department of Medical Technology, Maharat Nakhon Ratchasima Hospital, Nakhon Ratchasima, 30000

**Department of Medicine, Maharat Nakhon Ratchasima Hospital, Nakhon Ratchasima, 30000

วัตถุประสงค์: การบริจาคเลือดสามารถทำให้ขาดธาตุเหล็ก หรือถึงกับทำให้เป็นโลหิตจางจากการขาดธาตุเหล็กได้ วัตถุประสงค์ของการศึกษานี้ คือ ศึกษาภาวะขาดธาตุเหล็ก และภาวะโลหิตจางในผู้บริจาคเลือดคนไทย และศึกษาคุณค่าของเครื่องตรวจวัดฮีโมโกลบินขนาดเล็ก (hemoglobinometer for blood donor screening) ในการคัดกรองโลหิตจาง **ผู้ป่วยและวิธีการ:** เป็นการศึกษาภาคตัดขวาง โดยรวบรวมผู้บริจาคที่หน่วยบริจาคเลือด โรงพยาบาลมหาราชนครราชสีมา ระหว่างเดือนกันยายน - ธันวาคม 2556 ทุกรายจะได้รับการตรวจความเข้มข้นเลือด (hemoglobin concentration) ด้วยเครื่องตรวจวัดฮีโมโกลบินขนาดเล็ก (hemoglobinometer for blood donor screening) และเครื่องวิเคราะห์เลือดอัตโนมัติ และตรวจระดับ ferritin ด้วย **ผลการศึกษา:** มีผู้ที่บริจาคเลือดได้ 203 ราย จากทั้งหมด 249 ราย และแบ่งออกเป็น 4 กลุ่ม, i) กลุ่มบริจาคครั้งแรก, ii) บริจาค 2-5 ครั้ง, iii) บริจาค 6-10 ครั้ง, iv) บริจาคมากกว่า 10 ครั้ง มีผู้บริจาค 57 ราย (ร้อยละ 28.1) ที่มีระดับเหล็กต่ำ และพบมากในกลุ่มที่ iv (ร้อยละ 9.1 ในกลุ่มที่ i เทียบกับร้อยละ 34.6 ในกลุ่มที่ iv) และผู้บริจาค 63 ราย (ร้อยละ 31.0) มีภาวะโลหิตจาง ซึ่งพบได้บ่อยในกลุ่มที่ i (ร้อยละ 45.4 ในกลุ่มที่ i เทียบกับร้อยละ 26.9 ในกลุ่มที่ iv) โดยการเปรียบเทียบ กับเครื่องวิเคราะห์เลือดอัตโนมัติพบว่าความไว ความจำเพาะค่าทำนายผลบวกค่าทำนายผลลบ positive and negative likelihood ratios ของเครื่องตรวจวัดฮีโมโกลบินขนาดเล็ก ในการตรวจภาวะโลหิตจางคือร้อยละ 40.0, 97.2, 91.3, 69.0, 14.4 และ 0.62 ตามลำดับ **สรุป:** ภาวะเหล็กต่ำและภาวะโลหิตจางพบได้บ่อยในผู้บริจาคโลหิต แต่การใช้เครื่องตรวจวัดฮีโมโกลบินขนาดเล็ก เป็นเครื่องคัดกรองที่มีความไวต่ำในการตรวจหาภาวะ โลหิตจางนั้น อาจจะเป็นอันตรายต่อผู้บริจาคโลหิตได้

Introduction

Actually anemia is highly prevalent in Thailand, and two major causes are iron deficiency and thalassemia. In the 3rd and 4th national survey by the ministry of public health, the prevalence of anemia is found to increase from 11.4 to 15.8 in males and from 22.2 to 29.8% in females[1] whereas about 30-40% of the Thai people are affected by at least one of the abnormal genes of thalassemia and/or hemoglobinopathies[2].

The common causes of iron deficiency anemia among adults are iron loss via either the gastrointestinal and genital tract in females. Blood donation can also be the cause of iron deficiency as well as iron deficiency anemia because every 1 milliliter of the whole blood containing half milligram of the elementary iron and each time of donation of 450 ml of the whole blood, leading to the loss of iron of 242 ± 17 mg for male and of 217 ± 11 mg for female donors[3]. In one large study from India, the percentage of anemia (Hb <12.5 g%) and of iron depletion (serum ferritin <15 ng/mL) increasingly correlate with the more numbers of blood donation, viz., anemia is found in 3%, 12%, 16% and 25% of males who donate <10, 11-20, 21-50 and >50 times, respectively and in 26.7% of females who donate <10 times while the iron depletion is found in 10% of males who donate >20 times and in 16.7% of females who donate <10 times[4].

With the high prevalence of anemia from iron deficiency as well as thalassemia as the background and the possibility of the iron depletion with or without anemia due to the frequent donations, this study was aimed to study the prevalence of anemia and the iron depletion among the blood donors in Maharat Nakhon Ratchasima Regional Hospital.

Participants and Methods

This cross-sectional study prospectively recruited the volunteer donors, both males and females during September-December 2013, at the blood donation unit, Maharat Nakhon Ratchasima Hospital. Every donor would be screened for the hemoglobin (Hb) concentration using hemoglobinometer, HemoCue®, Hb 301, CBC using the automated hematology analyzer, Beckman Coulter, "LH-750"®, and serum ferritin level using the chemiluminescent method by the automated chemistry analyzer, Beckman Coulter, UniCel DxI 800.

By HemoCue, if the Hb level was less than 12.5 g% for females and less than 13.0 g% for males, the donors would be deferred because of the anemia and they would be recommended to see the hematologists for the further investigations and the proper management. And if the serum ferritin was less than 20 ng/mL, it would be considered the hypoferritinemia or the depletion of iron storage. On the same day, the Hb concentration from CBC performed by the automated hematology analyzer would be used as the gold standard to calculate the validity of the HemoCue for the detection of anemia among the blood donors.

At the end of each donation, 30 tablets of ferrous sulfate would be prescribed to every donor. The general recommendation for the interval between each donation for the frequent donors was every three months. And the ages of the donors were between 18 and 60 years.

This study did not include the pregnant donors.

This study was approved by the ethic committee of Maharat Nakhon Ratchasima Hospital.

Results

There were 249 participants, voluntarily desiring to donate the whole blood. Of these, only 203 participants (81.5%) were allowed to donate the blood, consisting of 134 males and 69 females, and their ages ranged from 18 to 60 years, mean 37 ± 11.7 years while 46 were deferred because of anemia screened by Hemo Cue. And from 203 donors, they were classified into four groups, according to the number of donations, group i) for the first time donation, group ii) 2-5 donations, group iii) 6-10 donations and group iv) >10 donations. The numbers of male and female donors in each group were shown in the table 1.

From 203 donors, there were 57 ones (28.1%) having hypoferritinemia (serum ferritin level less than 20 ng/mL). They were distributed in different groups as shown in the table 2 and 3

From 203 donors, there were 63 (31.0%) having anemia, using the automated hematology analyzer, ie., Hb concentration less than 12.5 g% for females and less than 13 g% for males which were distributed in different groups as shown in the table 4 and 5.

From 249 participants, by using the HemoCue, 46 were found to have anemia, but only 42 of them were confirmed to have true anemia by using the automated hematology analyzer. And 203 were allowed to donate the blood because the HemoCue found them to have the normal Hb concentration. Among them, 63 of 203 were demonstrated to have anemia using the automated hematology analyzer. With all these figures, the ability of HemoCue for detecting the anemia among donors could be verified as shown in the table 6.

Table 1 The numbers of donors in each group according to gender

	Male	**Female**	**Total (%)**
Group i	11	11	22 (10.8%)
Group ii	30	28	58 (28.6%)
Group iii	14	5	19 (9.4%)
Group iv	79	25	104 (51.2%)
Total	134	69	203 (100%)

Table 2 The prevalence of hypoferritinemia among donors in each group

	Male	**Female**	**Total (%)**
Group i (N=22)	1	1	2 (9.1)
Group ii (N=58)	1	14	15 (25.9)
Group iii (N=19)	2	2	4 (21.0)
Group iv (N=104)	24	12	36 (34.6)
Total (N=203)	28	29	57 (28.1)

By using the automated analyzer as the gold standard, the sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio and negative likelihood ratios of the HemoCue for detecting the anemia could be calculated to be 40.0% (95% CI: 30.56-50.02%), 97.2% (95% CI: 93.03-99.22%), 91.3% (95% CI: 79.19-97.53%), 69.0% (95% CI: 62.11-75.26%), 14.4 (95% CI: 5.33-38.92) and 0.62 (95% CI: 0.53-0.72), respectively.

Discussion

Around half of our donors (51.2%) are the regular donors, and the more donations they perform, the more hypoferritinemia they access (34.6% in the more than ten donations group vs. 9.1% in the first donation group). The more times of the blood donation can cause the more prevalence of iron depletion. At the first donation, the prevalence of iron depletion is equally 9.1% for both sexes but it is gradually increased in males up to 20.9% in the group iv while it is suddenly increased in females up to 50% in the group ii and 48% in the group iv. Our findings used to be established by Finch et al since 1977[5] and later confirmed by many studies[6,7] because to donate one unit of whole blood (472 mL) is to lose the iron of 236 mg for males and 213 mg for females[5] while the absorption of the iron from food via gastrointestinal tract is around 1 to 2 mg a day[8]. Our findings should

Table 3 The prevalence of hypoferritinemia among donors according to genders in each group

		Hypoferritinemia	**Total**	**Percentage**
Group i	Male	1	11	9.1
	Female	1	11	9.1
Group ii	Male	1	30	3.3
	Female	14	28	50.0
Group iii	Male	2	14	14.3
	Female	2	5	40.0
Group iv	Male	24	79	30.4
	Female	12	25	48.0
Total	Male	28	134	20.9
	Female	29	69	42.0

Table 4 The prevalence of anemia among donors in each group

	Male	Female	Total (%)
Group i (N=22)	2	8	10 (45.4)
Group ii (N=58)	3	16	19 (32.8)
Group iii (N=19)	3	3	6 (31.6)
Group iv (N=104)	11	17	28 (26.9)
Total (N=203)	19	44	63 (31.0

Table 5 The prevalence of anemia among donors in each group according to gender

		Anemia	Total	Percentage
Group i	Male	2	11	18.2
	Female	8	11	72.7
Group ii	Male	3	30	10.0
	Female	16	28	57.1
Group iii	Male	3	14	21.4
	Female	3	5	60.0
Group iv	Male	11	79	13.9
	Female	17	25	68.0
Total	Male	19	134	14.2
	Female	44	69	63.8

encourage the daily iron supplement as the routine practice until the due date of new donation comes for any regular donor particularly the Thai females.

Likewise, the prevalence of anemia is very high in our donors, 46 of 249 individuals (18.5%) using the HemoCue, are deferred because of the anemia but when using the automated analyzer, the anemia is found in 105 from 249 ones (42.2%). These figures are much higher than 5.6% of the donors who are deferred because of the low Hb concentration in Malaysia[9]. In general, the prevalence of anemia in Nakhon Ratchasima province is found to 18.7% in males and 13.4% in females[10]. The prevalences of anemia in both sexes are much higher than that of the general population and they do not increase according to the number of donations. On contrary, they gradually decrease according to the more numbers of donations.

The efficiency of the HemoCue for detecting the anemic donors is very limited because its sensitivity and negative predictive value are very low (40.0% and 69%, respectively). The HemoCue is found to provide consistently higher Hb value in comparison to CBC by a margin of 0.5 g/dl until the author recommend to subtract 0.5 g/dl from the Hb estimates achieved by HemoCue[11] and also the capillary Hb values (Hemo Cue) are significantly greater than venous Hb values (HemoCue), which in turn are significantly greater than venous Hb values by Cell-Dyn (mean+SD: 14.05±1.51, 13.89±1.31, 13.62±1.23, respectively; $P < 0.01$ for all comparisons among groups)[12]. And it is recommended not to use HemoCue to determine the level of Hb in critically ill patients, especially when capillary blood samples are used and/or in the presence of edema[13]. Moreover, in the study of pregnant women, the Hb levels determination using HemoCue® venous sample and HemoCue® capillary sample are found to be higher than that determined by the automated hematology analyzer (12.70±1.77, 12.87±2.04 and 11.53±1.63 g%, respec-tively)[14]. The use of HemoCue for screening the blood donors seems to be harmful because about one-third (63 of 203 or 31.0%) of the donors will be allowed to donate the blood in spite of suffering from anemia.

Table 6 The prevalence of anemia detected by the HemoCue vs. by the automated analyzer

	Anemia	Normal	Total
Anemia by Haemocue	42	4	46
Normal by Haemocue	63	140	203
Total	105	144	249

Summary: The study recruits 249 blood donors but 46 are deferred due to anemia screened by HemoCue. Using the automated analyzer, the prevalence of anemia among donors is high (14.2% for males, 63.8% for females) while the rate of hypoferritinemia is higher in the groups of more donations (9.1% in the first donation vs. 28.1% in the >10 donations group). The sensitivity, specificity, positive predictive value and negative predictive value for HemoCue to detect anemia compared with the automated analyzer are 40.0%, 97.2%, 91.3% and 69.0%, respectively, so it seems harmful for the donors if they are screened negative for anemia by using HemoCue.

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