Effect of pre-storage gamma irradiation on red blood cells


Department of Transfusion Medicine, Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow, India

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Background & objectives: The irradiation of blood components has received increased attention due to increasing categories of patients eligible to receive such blood to prevent transfusion-associated graft versus host disease. Irradiation leads to enhancement of storage lesions, which could have deleterious effects when such blood is transfused. The aim of the present study was to assess the biochemical changes during conventional preservation of irradiated and non-irradiated whole blood.

Methods: Ten units of whole blood were taken from healthy donors and divided into two parts. One aliquot was subjected to gamma irradiation and then stored under conventional blood banking conditions. Sampling was done from these irradiated and non-irradiated blood bags and tests for free plasma haemoglobin, plasma potassium and lactate dehydrogenase (LDH) were performed.

Results: A progressive increase in the mean values of plasma Hb, K+ and LDH was seen in both the groups. The increase was statistically significant.

Interpretation & conclusion: Our findings indicated that the gamma irradiation of blood resulted in increased plasma haemoglobin, potassium and LDH. These biochemical changes might not have clinical significance when irradiated blood is transfused to a select group of patients. There is a need for further in vivo studies to follow up the consequences of transfusion of irradiated blood in patients.

Key words Gamma irradiation - storage lesions - whole blood

Transfusion-associated graft-versus-host disease (TAGVHD) is a devastating, usually fatal complication of blood transfusion that results from the engraftment and clonal expansion of allogenic donor white cells. It is the donor cell, which engrafts, multiplies and mounts an immune response against susceptibles. Gamma irradiation prevents TAGVHD but also damages red blood cells (RBCs) and reduces their survival. Pre-existing immunocompromised status of patient, difficulties in diagnosis and typically fatal outcome of the disease make it important to irradiate the blood components being transfused in high risk groups. The major documented effects for damage to RBCs include leakage of intracellular potassium and haemoglobin. There have been various studies with contrasting results and more research and studies in this area are needed. The present study was therefore undertaken to assess the storage lesions during conventional preservation of whole blood after gamma irradiation.
Material & Methods

The study was performed from November 2000 to January 2001 at the Department of Transfusion Medicine, Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow. Written consent was taken from donors prior to blood collection to be a part of the study. The study protocol was approved by the ethics committee of the institute. One unit (350 ml) of whole blood was taken and divided into two aliquots of 175 ml each, 10 such units were thus divided into 20 aliquots. One aliquot (175 ml) from each unit of blood was subjected to gamma irradiation of 25 Gy by a self contained gamma cell irradiator (Nordion, Canada) and then stored at 4°C under conventional blood banking conditions. Sampling was done from these 10 irradiated and 10 non-irradiated blood bags on days 0, 7, 14, and 21 with the help of sampling site coupler (Fenwal, USA).

Tests for free plasma Hb, plasma K+ and lactate dehydrogenase by using a kit from Bayer, India were performed on each of these samples.

Paired t-test was used for statistical analysis and \( P<0.05 \) was considered significant.

Results & Discussion

There was a progressive statistically significant increase in the mean values of all parameters in both the groups (Table).

We have demonstrated that irradiation with 25 Gy damaged RBCs. Other studies have also demonstrated significant rise in plasma Hb, potassium and LDH in irradiated blood units. Gamma irradiation causes an increase in sodium and potassium permeability of the RBC membrane during cold storage, which is reversible when the RBCs are warmed to 37°C. However, there have been reports of possible clinical effects after use of irradiated blood in intravascular foetal transfusions.

The demand for irradiated blood products is increasing. This increased demand has taxed the resources, especially in the third world countries where the demand has exceeded resources by huge margins. Irradiators are expensive and cannot be justified for every transfusion set up. Anderson et al found that 87.7 per cent of the blood banks and transfusion services did not have irradiators and obtained irradiated blood from regional blood centers or hospital transfusion services. It thus becomes empirical for the blood banks to maintain an inventory of irradiated blood components.

In the present study blood was irradiated just after collection i.e., pre-storage irradiation. However, most centres in our country do not maintain an inventory of irradiated blood components, which would be valuable in planning for mass casualty situations where a large number of patients suddenly become immunosuppressed from inadvertent exposure to toxic chemicals or nuclear radiation. Irradiation of blood immediately before infusion may not be practical in a mass casualty situation as irradiation equipment may not be available, and time to irradiate the red cells would be at a premium. If red cells were irradiated pre-storage, they would be ready immediately, at any location for infusion into victims.

References


| Table. Changes in irradiated and non-irradiated whole blood over a 21-day period |
| Days stored | Plasma Hb (mg/l) | K+(mmol/l) | LDH (U/l) |
| Non-irradiated: (n=10) | | | |
| 0 | 42 ± 21 | 7.00 ± 2.53 | 416.3 ± 159.9 |
| 7 | 91 ± 28 | 12.28 ± 3.50 | 740.5 ± 306.9 |
| 14 | 119 ± 21 | 15.96 ± 6.33 | 1096 ± 394.9 |
| 21 | 196 ± 49 | 21.00 ± 8.23 | 1313 ± 268.7 |
| Irradiated: (n=10) | | | |
| 0 | 112 ± 112 | 9.88 ± 7.2 | 502.2 ± 301.5 |
| 7 | 135 ± 49 | 16.82 ± 7.2 | 1044 ± 430.3 |
| 14 | 154 ± 70 | 21.88 ± 9.2 | 1330.8 ± 459.1 |
| 21 | 210 ± 119 | 29.92 ± 12.5 | 1477.4 ± 396.4 |

Values are mean ± SD; LDH, lactate dehydrogenase; \( P<0.05 \) for each parameter within a group at different days of storage (Paired t-test)


