

Clinical Workshop

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Some Factors Determining Rate of Microaggregate Formation in Stored Blood

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WITH THE TECHNICAL ASSISTANCE OF STEPHEN DE FEO

Microaggregates consisting of platelets, leukocytes, fibrin strands and other debris develop in whole blood stored under standard blood bank conditions.¹ Some of these microaggregates are small enough ($< 170 \mu$) to pass through standard transfusion filters and thereby enter the venous circulation. If they are filtered out in the pulmonary circulation, they may produce pulmonary vascular disturbances and capillary endothelial damage.^{2,3} While several studies have documented the presence of microaggregates and debris in bank blood, the time of appearance of these materials has not been determined. A survey of screen filtration pressures of bank blood, an index of the amount of microaggregates and debris present,⁴ was undertaken to obtain information correlating the storage age of blood with the appearance of microaggregates and debris.

METHOD

Samples were collected distal to standard transfusion filters from 99 units of bank blood

in the Hospital of the University of Pennsylvania operating rooms during September, October, and November 1972. The blood had been stored one to 21 days in ACD solution under standard blood bank conditions. Screen filtration pressure was measured in duplicate using a modification of the Swank technique.⁴ Blood was forced through a 2.54 sq mm area of a nickel screen (pore size $20 \times 20 \mu$)§ at a rate of 2.2 ± 0.08 ml/10 sec (mean \pm SD) by means of a heavy-duty Harvard Apparatus infusion pump. Pressure required to force blood through the screen was recorded on a Texas Galvanometer via a Statham Microdot transducer calibrated to 1,700 torr. Screen filtration pressure was recorded as the pressure maximum at the end of 10 seconds and is expressed in the results as the mean value and standard error of the mean. Duplicate measurements had a coefficient of variation of 8.9 per cent. Significance of difference of means was determined by analysis of variance (*f* test).

RESULTS

Values for screen filtration pressure remained low during the first five days of storage, the mean being 70 ± 11 torr (fig. 1). During the second five days, the mean pressure increased markedly to 509 ± 81 torr. Thereafter pressure values increased gradually with storage time. Mean values for screen filtration pressure for days one

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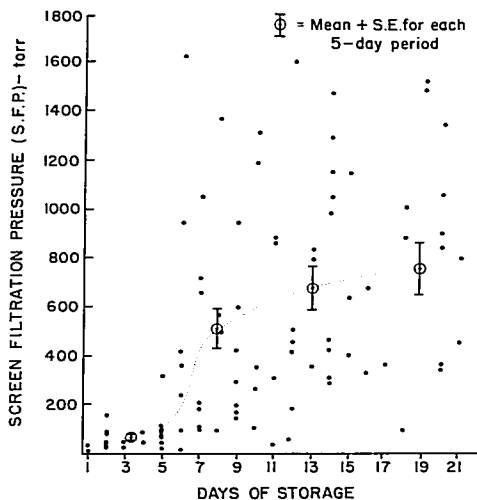
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§ Buckbee Mears Company, 245 E. 6th Street, St. Paul, Minnesota 55101.

FIG. 1. Screen filtration pressures during 21 days of storage.



through five differed significantly from the overall mean and from all other five-day means ($P < 0.05$).

In the first five days of storage, blood from donors 35 years of age and older had higher screen filtration pressures ($\bar{X} = 117 \pm 26$ torr) than blood from donors younger than 35 years ($\bar{X} = 46 \pm 6$ torr) (table 1). With storage longer than six days, differences related to donor age disappeared.

Blood from female donors had lower mean values for pressure than blood from male donors during the first ten days of storage (table 1).

DISCUSSION

Screen filtration pressure has been shown to correlate with the size of platelet aggregates in blood.⁵ Abnormally high pressures for stored blood are restored to normal by

TABLE 1. Other Factors Affecting Increases in Screen Filtration Pressure (S.F.P.)*

Time Group	Factor	S.F.P. (torr)	Storage Age (Days)	S.F.P. (torr)	Storage Age (Days)
	Donor Age	Less Than 35 Years		35 Years and Over	
Days 1-5		46 ± 6	2.8 ± 1.5	117 ± 26	3.7 ± 1.6
Days 6-10		527 ± 115	8.1 ± 0.4	601 ± 12	7.6 ± 0.4
Days 11-15		681 ± 113	14.7 ± 0.3	618 ± 267	12.9 ± 0.3
Days 16-21		877 ± 169	19 ± 0.7	858 ± 209	19 ± 2.3
	Donor Sex	Male	Female		
Days 1-5		83 ± 18	3.1 ± 0.4	52 ± 9	3.5 ± 0.5
Days 6-10		601 ± 90	7.9 ± 0.3	207 ± 63	7.6 ± 0.5
Days 11-15		603 ± 122	13.4 ± 0.4	787 ± 184	12.8 ± 0.4
Days 16-21		820 ± 145	19 ± 0.5	568 ± 218	19.3 ± 0.7

* Values are means ± SE.

small-pore (20 μ) filtration of aggregates of platelets, leukocytes, fibrin strands, and other debris.¹

While dose-response data relating amount of microaggregate infusion to pulmonary damage have not been obtained, Connell and Swank have shown pulmonary microembolism with platelet-leukocyte microaggregates after blood transfusion using standard transfusion filters.³ These microemboli were associated with pulmonary capillary endothelial damage. Both the microemboli and the capillary damage were prevented by use of 20- μ -pore filtration. This survey suggests that blood stored less than five days contains much less potentially obstructive materials than older blood.

Our data indicate that at about the sixth day of storage some process producing a relatively sudden increase in screen filtration pressure occurs in blood. Further studies are under way to determine whether this process is fibrin formation. In addition, the survey suggests that studies of the effects of age and

sex of the donor on pressure might help clarify the processes involved in the development of microaggregates and thus alter blood banking techniques to reduce the amounts of microaggregates and debris formed during storage.

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Insulin Adsorption by Glass Infusion Bottles, Polyvinylchloride Infusion Containers, and Intravenous Tubing

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The addition of insulin to intravenous fluids has been suggested for intraoperative management of the diabetic patient.^{1,2} This practice, however, has been precluded by the finding that insulin is adsorbed by glass and

plastic.^{3,4} Adsorption of insulin to glass infusion bottles and plastic intravenous tubing at slow rates of infusion (two-hour period) has been documented.³ Adsorption ranged from 5 per cent for 20 units to 3.1 per cent for 40 units of insulin added to 500 ml isotonic saline solution, while plastic intravenous tubing adsorbed 30 per cent of 20 units and 26 per cent of 40 units of insulin added to the same infusion bottles. Rapid infusion of Ringer's lactated solution or dextrose, 5 per cent, in Ringer's lactate solution during the first hour of surgery is commonplace. The purpose of this study was to determine the amount of insulin adsorption during rapid infusion from glass bottles (1,000 ml), polyvinylchloride infusion containers, and intravenous tubing.

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