the experiment the animal's circulating blood volume as measured was 1,057 cc., with plasma volume of 624 cc. and a cell mass of 433 cc. Before the fourth bleeding, after 70 per cent. removal of blood, although the plasma volume had remained constant, the cell mass had fallen to 160 cc., about 37 per cent. of the original. The circulating cell mass at the conclusion of the experiment was much lower than the latter figure. Yet after such extensive removal of blood and depletion of red blood cells the dog was relatively strong and well, not acidotic and apparently little disturbed by his extreme anemia, for the pulse had increased only from 96 to 142 per minute. This experiment illustrates not only the restorative effect of serum but also the exceptional vitality of some dogs. . . .

REACTIONS

"The nature of the serum 'reaction' mentioned, which was encountered in about 25 per cent. of serum infusions, was of unusual character. The only constant sign of reaction was a moderate and transient drop of blood pressure, from which the animals always recovered spontaneously within the one half hour post infusion period. Further infusions of the same serum into the same animal never brought a repetition of this effect. Occasionally there were additional symptoms, such as chilling, growling, vomiting and defecation, which likewise were of transitory nature and did not recur on subsequent serum infusions. The same pool of serum would cause reactions in one animal and not in others. Compatibilities were performed in all instances, and only compatible serum was used. We were unable to establish a common causative factor, and this subject is now being further investigated with reference to sensitivity and other factors. . . .

COMMENT

"Our experiments have demonstrated that serum overcomes all the effects of hemorrhage in dogs except the loss of red blood cells. . . . If serum is as effective in overcoming the effects of hemorrhage in man as it appears to be in dogs, then certainly it would provide the ideal substitute at the battle front. Since serum requires no particular care in handling and no preliminary testing and may be preserved for a long time, it can be processed in ample quantities from the blood of noncombatants in civilian centers far removed from the war front, prepared in proper containers ready for use and distributed directly to the front, where it can be stored until used. . . . We have had the opportunity to employ pooled human serum in a limited number of cases of hemorrhage or shock. The effects from immediate human serum infusion on the blood pressure and general condition in these cases paralleled the beneficial results observed in our animal experiments." Bibliography—25 references.

J. C. M. C.

E. L. DEGOWIN, J. E. HARRIS and E. D. PLASS. *Studies on Preserved Human Blood. I. Various Factors Influencing Hemolysis.* J. A. M. A. 114: 850–855 (March 9), 1940.

"The current interest in the use of preserved human blood for transfusions has been especially motivated by economic pressure in the United States and by military necessity in Europe. Hence the empirical clinical use of transfusions of preserved blood has tended to precede rather than to follow fundamental objective biologic and chemical studies in the laboratory. A review of the literature reveals few data from which the clinician can establish satisfactory criteria for the use or rejection of preserved blood. . . .

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There is considerable evidence that the intravenous injection of a large amount of hemolyzed blood may result in death, but the exact relation of hemoglobin to the production of severe transfusion reactions has not been determined. . . . The object of the studies here reported was to determine the rates of hemolysis occurring in human blood in various preservatives and stored under a variety of conditions. . . .

"In the majority of the experiments the general procedure was the same. Erlenmeyer flasks or pyrex glass of from 1,000 to 1,500 cc. capacity were autoclaved with appropriate amounts of the preservative to be studied. When dextrose solutions were to be combined with other chemicals, the former were heated separately to avoid caramelization and later combined with the latter aseptically. Blood was drawn into the flasks from the median basilic veins of healthy men in quantities of from 400 to 600 cc. The blood was mixed with the preservative by gentle rotation of the receiving flasks. A 16-gage needle was used and connected to the flask by a 15-inch section of gum rubber tubing. Before the cells settled, the entire mixture was apportioned in 50 cc. quantities into 250 cc. Erlenmeyer flasks closed with cotton plugs. The entire lot was stored under identical conditions, and when an analysis was to be made the entire contents of one small flask were thoroughly shaken and the cells were centrifuged out. The supernatant plasma was then pipetted off and analyzed for hemoglobin. This procedure insured a uniform dilution of blood and preservative throughout the entire experiment and obviated the difficulties attendant on sampling the same flask repeatedly.

"The refrigerator used was a room cooled by open coils of salt brine. The temperature was maintained at from 3° to 5° C. by an electrically controlled thermostat. Continuous records of the temperature were kept. The frost on the open refrigeration coils insured a high relative humidity and thus a minimum of evaporation.

"Special precautions were taken to keep the blood away from sunlight or from prolonged exposure to artificial light. . . .

"The following solutions were used in preservatives: 5.4 per cent. anhydrous dextrose U.S.P. (Merck & Co., Inc.) in distilled water, 5.4 per cent. anhydrous dextrose (Eastman Kodak Company) in distilled water, 3.2 per cent. sodium citrate (Merck reagent grade, $Na_3C_6H_5O_7\ 2H_2O$) in distilled water (sterilized by Berkefeld filtration).

"Several methods of estimation of small amounts of hemoglobin were tried before final adoption of the method of Wu. This is a quantitative application of the benzidine test for hemoglobin in which a brown compound is compared in the colorimeter with a similar color developed in a standard hemoglobin solution. . . .

"Many of the facts demonstrated in the laboratory have been applied in the routine operation of the blood bank in the University Hospitals. . . . Criteria for determining when preserved blood becomes unfit for use cannot be presented accurately. From experience we have adopted the arbitrary rule that citrated blood should be discarded after ten days of storage and blood in the dextrose-citrate mixture is considered unfit for transfusion after thirty days. With this practice there have been no unusual reactions which could be ascribed to distintegrated blood and no hemoglobinuria. The oldest blood used was transfused after storage in dextrose-citrate mixture for thirty-eight days. The recipient suffered no reaction, and no hemoglobin appeared in the urine. In the operation of a blood bank where the daily number of transfusions is large the need for a preserva-

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tive in which blood can be stored for more than seven days is not urgent. If the number of transfusions is not large, however, a proportionately larger loss is incurred among bloods belonging to the rarer groups AB and B. In a blood bank which averages four transfusions daily the mathematical probability that a blood of group AB or B will be required within seven to ten days is not great. Therefore any preservative which can prolong the period of potential usefulness of such a blood results in smaller losses.

". . . Progressive hemolysis occurs in human blood stored in any of the preservatives studied. . . . The rate of hemolysis is much greater when blood is stored at 20° C. than at 5° C. . . . The addition of large quantities of isotonic dextrose solution to blood slows considerably the rate of hemolysis as compared with that in blood stored with little or no added dextrose. . . . The Rous-Turner blood-dextrose-citrate mixture has been so modified that it can safely be given intravenously without discarding the plasma. This modification consists of ten volumes of blood, thirteen volumes of 5.4 per cent. aqueous solution of anhydrous dextrose and two volumes of 3.2 per cent. dihydric sodium citrate in water. . . . Blood stored in the modified blood-dextrose-citrate mixture will hemolyze only one twenty-fifth to one fiftieth as much in thirty days at 5° C. as will blood in sodium citrate alone or in sodium citrate plus sodium chloride. . . . The blood-dextrose-citrate mixture has proved safe and practical for human transfusions and is of distinct advantage in the operation of blood banks with a small volume of transfusions. . . . Hemolysis is less in blood stored in sealed flasks from which the air is completely displaced by the blood mixture than when the blood is exposed to the air. . . . Blood stored in flasks containing air trapped by rubber stoppers hemolyzes no faster than blood exposed to the air in cotton-plugged flasks. . . . Erythrocytes stored in the dextrose-citrate mixture resist destruction by shaking better than do those stored in sodium citrate alone or in citrate-saline mixtures. . . . The initial hemolysis encountered when blood is drawn into large volumes of preservatives can be prevented if the blood is cooled rapidly and uniformly by mixing it with preservatives which have been previously cooled to about 5° C. Bibliography—12 references.

J. C. M. C.

E. L. DEGOWIN, J. E. HARRIS and E. D. PLASS. *Studies on Preserved Human Blood. II. Diffusion of Potassium from the Erythrocytes During Storage.* J. A. M. A. 114: 855–857 (March 9), 1940.

"The concentration of potassium in the human erythrocyte is normally from seventeen to twenty times that in the serum. Any change in this ratio occurring during the storage of blood is of clinical interest in view of the well known toxicity of potassium salts injected intravenously. . . . The studies here recorded were undertaken with the hope that the increase in plasma potassium might serve as an index of corpuscular deterioration. . . . For each analysis a flask containing 50 cc. of blood mixture was withdrawn from storage, the contents were thoroughly shaken and centrifuged, and the plasma was pipetted off for analysis. This procedure insured a constant proportion of cells and plasma in all specimens of a series derived from any initial blood mixture. Estimations of the plasma potassium were made by the silver cobaltinitrite method of Truszkowski and Zwemer. Analyses were made in triplicate and were compared with duplicate standards. The deviation from the mean in these determinations was generally less than 2 per cent. The

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