A Survey

Hematologic Complications

of extra-corporeal by-pass

PART IV CONCLUSION

Management of Abnormal Bleeding:

The approach to the patient who is bleeding to a degree not anticipated following the usual heart-lung bypass is outlined in *Table 11*. In such instances it will be important to ensure that heparin has been completely neutralized. A simplified protamine titration technic has already been described. Platelet counts, prothrombin times and partial thromboplastin times should be obtainable at all times through the hospital laboratory.

More useful, and often forgotten, is the simple clot observation test. If no clot forms within a resonable period a drop of full strength surgical thrombin should be added. Absence of an immediate clot suggests depletion of fibrinogen. This can be confirmed by adding normal blood or plasma. If a clot then appears, it proves the thrombin was active and confirms the absence of fibrinogen in the patient's sample. The clot formed in the mixture of patient and normal plasma can be observed for lysis.

As far as possible the therapeutic approach should be specific, based on the laboratory findings and the events during surgery which may have resulted in abnormal hemostasis. Protamine should be administered if proof is obtained that heparin remains in the circulation. Platelet concentrates and fibrinogen are rarely indicated; the latter carries with it a high risk of serum hepatitis. In most instances the primary requirement is restoration of blood volume, replacing volume and the missing hemostatic factors with blood collected as recently as possible, certainly within the previous 24 hours.

If replacement fails to correct the low platelet count and abnormal clotting tests, despite adequate volume restoration, the possibility of continuing intravascular coagulation may have to be considered. Logical therapy would appear to be reintroduction of heparin. The risks of this are obvious, and one would need to be certain that more conservative measures were not succeeding and that the evidence for intravascular coagulation was quite definite.

In most instances the results of hemostatic tests in the bleeding patient will be within the range of minor deviations usually encountered after open heart surgery. A local cause for excessive blood loss should then be assumed, and the chest re-explored to find vessels which can be ligated. This almost always results in control of hemostasis.

Hemolysis:

A rise in plasma hemoglobin is expected during heart-lung bypass. The plasma hemoglobin level of the donor blood used to prime the pump-oxygenator will be somewhat elevated, especially if collected in heparin. Mechanical injury of red cells is an unavoidable event during bypass, but ever effort should be made to minimize this. The level of hemoglobin in the plasma of the patient is the net effect of mechanical hemolysis countered by removal of hemoglobin by the patient.

Hemoglobin removal is accomplished primarily by binding to the plasma globulin haptoglobin. It is unusual for hemolysis to be sufficiently excessive to exceed the binding capacity of the haptoglobin of the patient and of the transfused donor blood; gross hemoglobinuria is thus rare. The pump-oxygenator circuit should be designed to minimize areas of turbulent flow or sudden changes in diameters of tubing.

Hemolysis is usually greatest with bubble oxygenators, less with filming oxygenators and least with well-designed membrane oxygenators. The level of hemoglobin reached in the plasma is, on the other hand, reduced with hemodilution. The greatest source of hemolysis due to mechanical trauma occurs at the site of suction of blood from the interior of the heart. This can be minimized by gentle aspiration with as little interruption of the blood column by air bubbles as possible.

Blood aspirated from the pericardial sac or pleural spaces is even more likely to be hemolyzed, and most teams discard this blood. It has been suggested that red cells may be recovered from this blood and washed by a continuous flow centrifuge, thus minimizing the amount of foreign blood which has to be administered, a highly praiseworthy object (31).

Emboli:

Despite the placement of a filter in the arterial line returning blood from the oxygenator to the patient, emboli have been noted in multiple organs following bypass (32). Antifoam agents are employed, especially in bubble oxygenators, to remove bubbles from the blood returning to the patient. Microscopic air emboli have occurred nonetheless, and emboli of the silicone antifoam agent have also been noted.

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TABLE 11

MANAGEMENT OF ABNORMAL BLEEDING

I. Tests
   A. Rule out heparin
      1. Whole blood clotting time, or
      2. Protamine titration
   B. Check platelet count, or
      1. Estimate platelets on blood smear
      2. Observe clot retraction
   C. Prothrombin time
   D. Partial thromboplastin time
   E. Clot observation—most important
      1. Retraction
      2. Lysis
      3. Low fibrinogen
      4. If no clot, add thrombin
         If no clot, add normal blood or plasma

II. Treatment
   A. Specific, according to above findings
   B. Fresh whole blood
   C. Re-explore

The latter can be minimized by applying an appropriately thin coating of this agent. Platelet and fibrin emboli have also been seen.

Most frequent have been microscopic fat emboli; in part these appear to enter from the cut surfaces of the heart. Denaturation of proteins in blood during storage and during its exposure to the trauma and gas phase of the external circuit has also been implicated. Swank has suggested that these embolic materials may be removed by passage through a filter of dacron fibers (33), but the overall safety and practicality of such filtration procedure remains to be more completely explored.

Anemia

A progessive fall in the whole blood hemoglobin level generally occurs in the first week following surgery (Table 12). Some of this may result from diffusion of fluid from the extravascular spaces back into the circulation. Some of the early drop results from continuing post-operative hemorrhage. A proportion of the red cells remaining in the circulation at the end of bypass have been mechanically injured to the extent that their survival is shortened. Continuing mechanical hemolysis occurs in some patients who have had artificial heart valves inserted. Finally, an occasional patient will have a rapid rise in the titer of a previously undetectable red cell isoantibody. If this reacts with a large proportion of the donor cells remaining in the circulation, massive hemolysis may rapidly occur (34).

Isoantibodies Following Open Heart Surgery

Patients subjected to heart-lung bypass are exposed to a large quantity and variety of foreign antigens in the many units of donor blood which are usually administered. New red cell isoantibodies may develop, but most reports indicate that the frequency of clinically significant red cell isoantibodies is little greater than are encountered after routine transfusions (35).

In contrast, white cell isoantibodies occur in high frequency, almost approximating their occurrence following repeated series of transfusions (35).

In contrast, white cell isoantibodies occur in high frequency, almost approximating their occurrence following repeated series of transfusions (35). Platelet isoantibodies are far less often detectable. Antibodies to foreign IgG (36) and IgA globulins (37) occur in an appreciable number. The clinical importance of these numerous antibodies is largely inapparent as yet, but an occasional patient subjected to open heart surgery more than once will develop red cell antibodies to the point where it is difficult to find compatible blood, and anti-IgA antibodies have been associated with severe urticarial and even anaphylactoid transfusion reactions (38).

Febrile Lymphocytic Splenomegaly:

This syndrome, manifested by fever, splenomegaly and atypical lymphocytes in the peripheral blood, occurs 20 to 40 days after surgery in a variable number of patients (39). Early speculation that it might be the result of a graft-versus-host syndrome has not yet been supported by objective data. Increasing evidence has been presented implicating transfusion of organisms in the large volume of fresh blood.

It appears quite likely that most of these syndromes are due to the cytomegalic virus (40). A few cases have had a positive heterophile agglutination test, and may represent transfusion-induced infectious monomucleosis. The syndrome of febrile lymphocytic splenomegaly is benign; its chief importance comes from its possible confusion with bacterial endocarditis.

Serum Hetatitis:

A more serious sequel of open-heart surgery is serum hepatitis. This may occur 30 to 180 days after surgery. A serious illness may occur and many deaths have resulted. The frequency with which this occurs following open heart surgery appears to vary with the blood donor population. Studies at the Clinical Center of the National Institutes of Health have shown an incidence as high as 12% when blood from commercial banks was used (41).

In San Francisco, the reported patient rate of involvement has been 0.7%. The frequency of hepatitis is not in proportion to the number of units transfused, raising the possibility that some of the transfused blood contains protective antibodies. Efforts to abort

TABLE 12

CAUSES OF LATE FALLS IN RED CELL COUNT

A. Increase in plasma volume
B. Continuing hemorrhage
C. Shortened life span of injured red cells
D. Mechanical hemolysis
E. Isoantibodies

hepatitis by injection of pooled normal gamma globulin have led to conflicting results (42). A current national study involving a number of centers with carefully planned protocols (including controls) may help to settle this question.

Conclusion

Many of the important complications of open heart surgery are hematologic. A large proportion of these are related to the massive amounts of donor blood generally transfused. Every effort should be made to minimize the amount of donor blood utilized during these procedures.

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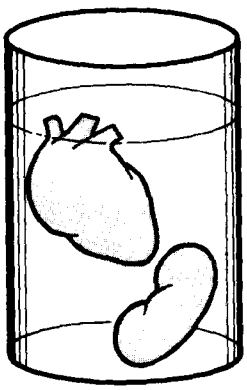

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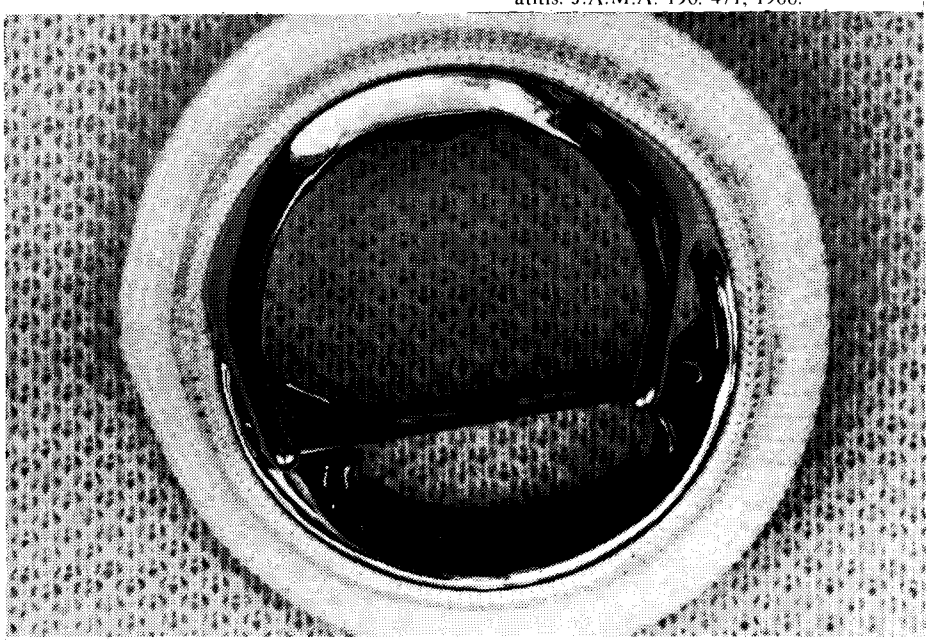

LTI Carbon, known commercially as Pyrolite, a product of Gulf General Atomic, Inc., may be the greatest material for prosthetic heart valves since Dr. Albert Starr first popped a Silastic ball into a bird-cage. Its full name is Low-Temperature Isotropic carbon and recent studies by Bokros, Gott, et al. reached some interesting conclusions. Pyrolite-coated surfaces that had been polished and from which all absorbed gases had been removed were found to be significantly thromboresistant by virtue of their basic physical and chemical properties. The two prosthetic heart valves that have been recently made available in limited clinical trials are the DeBakey aortic valve with a Pyrolite-coated ball and the Lillehei-Kaster tilting disc valve with a Pyrolite disc.

Clinical trials have been initiated utilizing the Kaster-Lillehei pivoting disc prosthesis with the Pyrolite disc. Manufactured by Washington Scientific Industries, Inc., the valve will be available for both aortic and mitral placement in six sizes from 14 to 25 mm. internal orifice diameter. For more information concerning this prothesis, circle Number 37 on the Reader Service Card.

A recent merger has made the entire line of Surgitool's valvular prosthetics available from your Artificial Organs specialist from Travenol Laboratories. A member of this line is the DeBakey Aortic prosthesis with the Pyrolite coated ball occluder. This ball will withstand a crushing force in excess of 300 pounds and have been hydro-statically tested to 15,000 psi without failure. The Pyrolite coating wears at the rate of 0.00004 inches per year giving it a wear life of about 500 years. For data on this interesting medical engineering concept, circle Number 36 on the Reader Service Card.