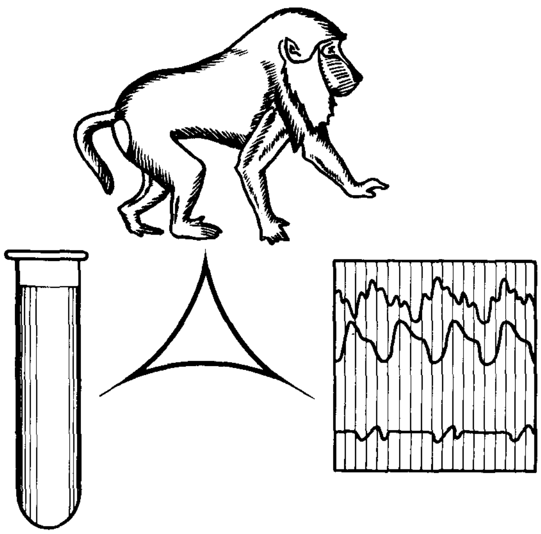


Research Notes

Studies of Roller Pump Induced Hemolysis

*Notes from Lawrence R. Gleason and Eugene F. Bernstein, M.D., Ph.D.**

In recent years, the roller pump has won increasing clinical popularity. Refinements in pump design and construction presently permit spring-loading and accurate occlusive settings, monitoring flow rates with electromagnetic flow meters, gear take-up devices, and the use of varying tubing materials. It therefore appeared appropriate to re-evaluate the contributions of occlusion, tubing material, pump design and construction, flow rate and duration of the test period, to the amount of blood destruction observed following exposure to a roller pump circuit. Additional mechanical considerations in roller pump construction which may effect hemolysis include the radius of the roller, the number of rollers, roller and race geometry and speed, and the stiffness and elasticity of the tubing compressed by the rollers.

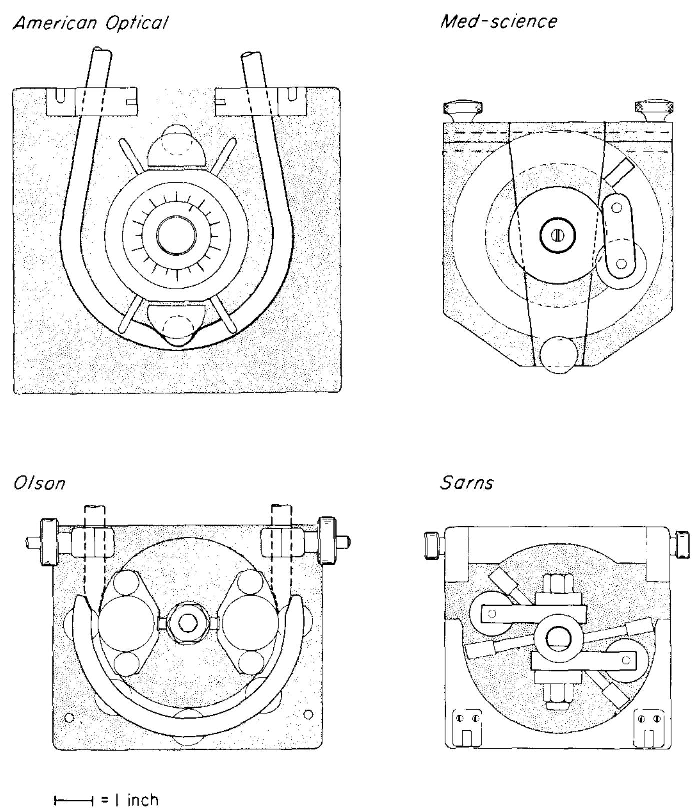
A non-occlusive setting of the roller pump permitted a 60 cm. column of blood to fall approximately 2 cm. in 5 seconds with the pump rollers stationary. An occlusive setting was obtained by gradually tightening the rollers to the point where a 60 cm. column of blood was supported indefinitely.

The flow rate used was 2 liters per minute and the duration of the experiments was 2 hours. Control samples were taken after 3 to 5 minutes of pumping and then every 30 minutes.

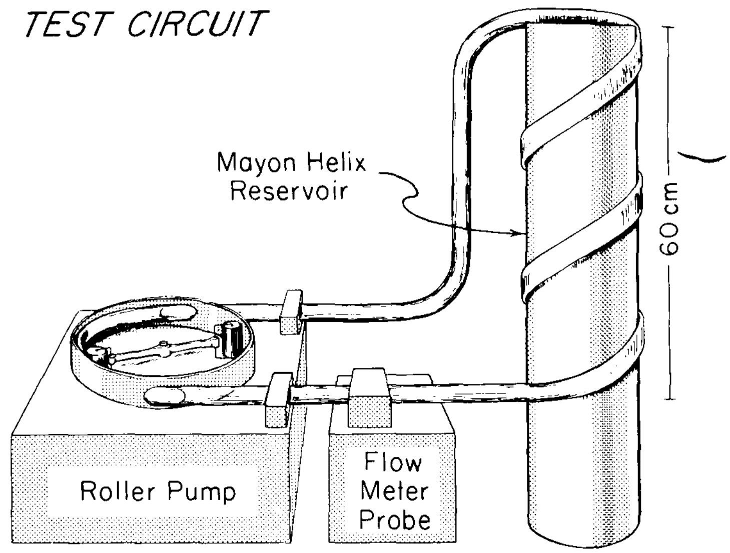
In these experiments, canine blood was circulated through tubing systems with identical dimensions and surface areas. The flow rate, and therefore the average velocity of the flowing blood, was kept constant. The major differences in the test systems were, therefore, in the mechanical and chemical properties of the four materials tested, and in the detailed geometry of the rollers, the number of rollers, the length of the arc of roller occlusion, and the radius of the pump heads.

Roller diameter or arc could not be correlated with hemolysis. The number of rollers did not appear to effect

Comparative Geometry of Roller Pump Heads



TEST CIRCUIT



hemolysis either; a single roller with a 360° arc is likely to be, and proved to be, the equivalent of two rollers, each with a 180° arc.

The effect of occlusion on the four tubing materials tested was somewhat surprising. With all but silastic, occlusion resulted in a considerable increase in hemolysis. With silastic, little difference was noted—and an actual decrease in hemolysis was recorded. Such differences must be ascribed to chemical or physical aspects of the materials. Stiffness, elasticity, surface roughness and wettability are some of the tubing properties which may be involved and should be studied. The damage due to occlusion may also be a result of turbulent flow created in front of the roller, or the negative pressure area just behind the advancing roller. The present data suggest that the small leak present with a barely non-occlusive setting is not harmful under the conditions of our experiments, but do not necessarily imply that larger leaks, associated with greater degrees of roller incompetence, would be as benign.

CONCLUSIONS

The data in this study appear to permit several conclusions:

1) Additional evidence has been presented to justify using the concept of the Index of Hemolysis to characterize the immediate blood damaging capacity of pumps of various types, using varying flow rates and varying durations of pumping.

2) Of the materials tested, silastic appears to be the best presently available surface for conduit tubing with a roller pump. Further, it would appear that silastic tubing may be used in a roller pump with occlusive settings without the additional damage observed with other materials.

3) Occlusive pump settings resulted in considerably higher rates of hemolysis than the non-occlusive settings with all materials tested, except silastic.

4) The use of GBH coating on polyvinyl chloride tubing did not decrease, and in fact increased, the immediate hemolysis observed with polyvinyl tubing.

5) The importance of the physical and chemical nature of the surface of materials in contact with blood in causing blood cellular destruction is emphasized and further work in this area is suggested. Mechanical and geometric considerations of pump rollers and tubing stiffness and elasticity may also be important contributing factors.