VENOUS PRESSURE IN RELATION TO BLOOD VOLUME IN MAN

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IN the state of shock, the effective volume of the circulating blood is reduced. This may be due to actual loss of blood volume (as whole blood or plasma), to pooling of the blood in the venous reservoirs of the body or to other factors such as heart failure. When the effective blood volume of the body is reduced, there is a measurable drop in the blood pressure, often greater on the venous than on the arterial side. As the patient recovers from shock, his arterial and venous pressures approach more nearly normal limits.

It is an easy matter to make frequent observations of the arterial blood pressure and much reliance is placed on these determinations in evaluating the efficacy of management of the patient in shock. It is unfortunate that a record of the venous pressure is not so easy to obtain, for the venous pressure also reflects the disparity between the capacity of the circulatory bed and the volume of the circulating fluid within the vascular system. A drop in the venous pressure may be an earlier warning of impending shock than is a fall in the arterial pressure.

Since it has been found that the effective blood volume drops in shock and is restored toward normal as this condition is overcome by replacement of the lost fluid, two series of observations were made to determine whether measurement of the relative venous pressure could be used as a method of measuring this change. In the first series, the change in venous pressure was measured on 25 human donors after removal of 500 cc. of blood. In the second series, the change in venous pressure was determined in 20 patients after the infusion of 500 cc. of whole blood. As a corollary to this latter series of observations, the change in venous pressure was determined in a group of 20 postoperative patients after infusion of varying amounts of saline solution at a constant rate.

Venous pressures were determined in an antebrachial vein by means of a stationary glass manometer with an internal bore of 3 mm. (fig. 1). The manometer was connected by a T tube to the phlebotomy tubing and to a reservoir containing saline solution. Frequent determinations

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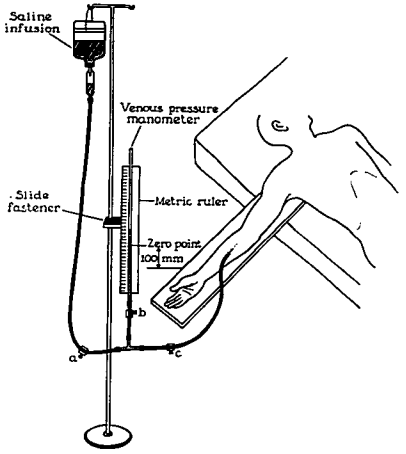

FIG. 1. The direct method of recording venous pressures.

of the venous pressure could be obtained without disturbing the subject's position. The venous pressure is recorded on the metric ruler (fig. 1) by noting the level to which the saline solution falls in the glass manometer when stopcock *a* is temporarily closed and stopcock *b* is opened. A point 100 mm. above the surface of the table or bed on which the patient lay supine was selected as the zero point for the venous pressure readings (1).

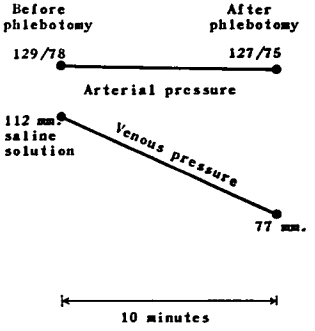

FIG. 2. Withdrawal of 500 cc. of blood caused a decrease of venous pressure of 31 per cent (average for 25 donors).

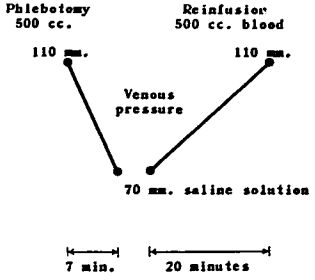

FIG. 3. Rapid withdrawal of 500 cc. of blood caused drop in venous pressure. Reinfusion of 500 cc. of blood into same subject restored venous pressure to former level.

After the rapid withdrawal of 500 cc. of blood from each of 25 transfusion donors, it was found that the venous pressure had fallen from an average resting value of 112 mm. of saline solution to 77 mm., a drop of 31 per cent (fig. 2). No marked change was observed in arterial pressure, pulse or respirations. In one subject, rapid withdrawal of 500 cc. of blood produced a drop in venous pressure from 110 mm. to 70 mm. After the same 500 cc. of blood had been rapidly reinfused, it was found that his venous pressure had returned to its former level of 110 mm. (fig. 3).

The average venous pressure for 20 patients requiring transfusion of 500 cc. of whole blood rose from 64 mm. of saline solution before transfusion to 92 mm. after transfusion. No constant or marked change occurred in their arterial pressures or pulse rates (fig. 4).

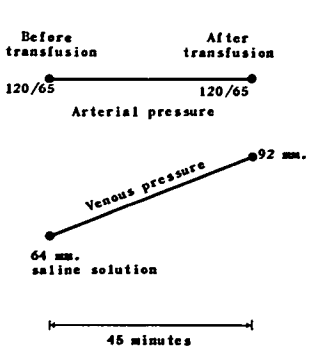

FIG. 4. Transfusion of 500 cc. of whole blood caused a rise of venous pressure of 44 per cent (average for 20 recipients).

In these observations, the venous pressure was found to vary directly with increments and decrements of blood volume produced by transfusion or phlebotomy. Furthermore, the measurable change was more pronounced in the venous pressure than in the arterial pressure, probably as a result of the multiplicity of factors which control the arterial pressure as contrasted with the more passive role of the venous circulation. This result leads to the conclusion that measurement of the venous pressure in man reflects rapid changes in blood volume.

In certain instances in which rapid changes in the blood volume are anticipated, as in shock resulting from hemorrhage, serial estimation

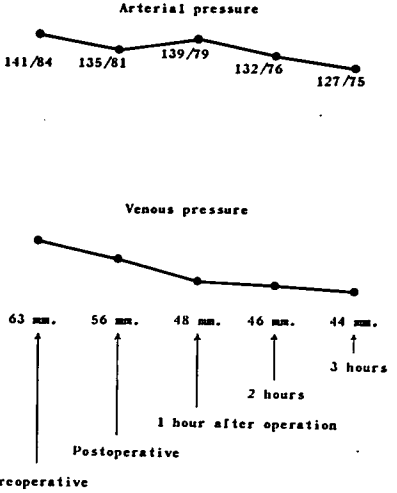

FIG. 5. Intravenous infusion of 1,500 to 2,000 cc. of physiologic saline solution failed to raise venous pressure in 20 patients after prostatic resection.

of the venous pressure during the administration of infusion mediums may serve as a useful adjunct in determining the necessity for replacement therapy and the efficacy of the measures employed to restore blood volume to normal. Abnormally high values of the venous pressure should warn of impending congestive failure and should indicate that fluids are being administered too rapidly or in too great an amount.

By use of the method outlined in previous paragraphs, venous pressures were measured in 20 elderly patients before they underwent transurethral prostatic resection under spinal anesthesia. Postoperatively, determinations of venous pressure were obtained at intervals during

the course of intravenous administration of physiologic saline solution at the rate of 10 to 17 cc. per minute for a total of 1,500 to 2,000 cc. in two to three hours. Although a considerable amount of bleeding attends this operation, the clinical picture of shock was not seen in any of these patients.

The average arterial pressure was 141 mm. systolic and 84 mm. diastolic preoperatively and 135 mm. systolic and 81 mm. diastolic postoperatively. The average venous pressure was 63 mm. of saline solution preoperatively and 56 mm. postoperatively. Three hours after operation and at the completion of the infusion, the average arterial pressure was 127 mm. systolic and 75 mm. diastolic and the average venous pressure was 44 mm. (fig. 5).

The degree of fall in the arterial and venous blood pressures found in these patients was slight. The preoperative medication, condition of the patients, anesthesia and the skill of the surgeon are all factors which influence the interpretation of the data obtained. However, a drop in the arterial pressure was usually present and a greater percentage fall was found in the venous pressure in almost every instance.

The intravenous administration of saline solution by fast drip did not restore the arterial or venous pressures to the preoperative level. This is in striking contrast to the results obtained in the transfusion experiment described previously in which the venous pressure was found to rise after the infusion of whole blood by fast drip. Hill, McMichael and Sharpey-Schaefer (2) have shown that infused crystalloid solutions are lost from the blood stream within thirty minutes, whereas the injection of plasma and whole blood causes an increase in blood volume which may be measured for a period of days. The results obtained would indicate that saline solution by infusion does not serve as a satisfactory replacement for lost blood, whereas transfusions of whole blood do produce a significant rise in venous pressure.

CONCLUSIONS

It is a simple matter to obtain venous pressure determinations when intravenous therapy is in progress by attaching to the intravenous tubing a venous pressure manometer with its saline reservoir. It is believed that determinations of venous pressure accurately reflect changes in the total blood volume which are more difficult to discover by other methods. The procedure has a limited usefulness in guiding the intravenous therapy of patients in surgical shock and might also be of value when solutions are to be administered intravenously to patients with a variety of conditions in which further increase in venous pressure is to be avoided, such as congestive heart failure, constrictive pericarditis, ascites and Banti's disease.

SUMMARY

Rapid withdrawal of 500 cc. of blood from each of 25 donors produced a fall of venous pressure from an average resting value of 112

mm. of saline solution to 77 mm. Transfusion of 500 cc. of whole blood into 20 patients produced a rise of venous pressure from 64 mm. to 92 mm. Infusion of physiologic saline solution did not restore the venous or arterial pressure to the preoperative level.

REFERENCES

1. Lyons, R. H.; Kennedy, A. J., and Burwell, C. S.: The Measurement of Venous Pressure by the Direct Method, Am. Heart J. 16: 675–693 (Dec.) 1938.
2. Hill, D. K.; McMichael, J., and Sharpey-Schaefer, E. P.: Effects of Serum and Saline Infusions. Quantitative Studies in Man, Lancet 2: 774–776 (Dec. 21) 1940.

The Pittsburgh Society of Anesthesiologists elected the following officers for 1949:

President—George J. Thomas, M.D.
Vice President—Ira W. Flamberg, M.D.
Secretary-Treasurer—William D. Stewart, M.D.

Plans are being discussed for the meeting of the State Society, to be held in Pittsburgh late in September.

On March 31, Dr. T. S. Danowski, Research Professor of Medicine, University of Pittsburgh Medical School, will speak on "Fluid and Electrolyte Balance in Anesthesia."

On April 25, Dr. Richard Hamilton will speak on "Bronchoscopy in Anesthesia."

All of the above meetings will be held at the Pittsburgh Academy of Medicine.

In May, the annual combined meeting with the Cleveland Society will be held in Youngstown, Ohio.