VENOUS PRESSURE DURING SURGICAL ANESTHESIA

A PRELIMINARY REPORT * †

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The circulatory status of the patient is a prime concern of the anesthesiologist. It is self-evident that left-sided cardiac output depends on blood return to, and output by, the right heart. This observation led to a study of variations in venous pressure, as indicative of the patient's status and a guide to management during surgical anesthesia. Specifically, speed and quantity of intravenous blood and fluid therapy, the use of vasopressors, tolerance to unusual positioning and surgical trauma, choice and dosage of anesthetic drugs, technical management in regard to airway and assisted or controlled respiration, function of the right heart and adequacy of pulmonary circulation—all of these considerations may be reflected in changes in venous pressure.

Blood circulates at a progressively lessened pressure in its circuit from the left to the right heart. This gradient is provided on the venous side by: (1) an increment of energy transmitted through the capillary bed and arteriovenous shunts from the arterial side, (2) skeletal muscular activity combined with the venous valvular system, (3) venous smooth muscle activity under autonomic (homeostatic) control and (4) the respiratory pump. This latter factor creates an alternating negative and positive intrapulmonary pressure synchronized with compression and relaxation of the splanchnic pool or venous reservoir (1, 2).

Metabolic requirements, within the extensive variations of physiologic state, and physical environment normally govern the content and dynamic status of the central venous reservoir. The autonomic correlation is complicated, as evidenced by Bainbridge, McDowell, Lovén and Luckhardt reflexes. Under surgical anesthesia, the skeletal muscular pump is inactivated; hemorrhage, hypoxia and capillary permeability may constitute leaks in the conduit system; anesthesia and trauma obtund reflex homeostatic function; abnormal positions impair channels of flow; an open abdomen or thorax alters the normal support of the intact

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torso; assisted or controlled respiration nullifies the negative pressure phase of the respiratory cycle, all of which make for an added burden on the right heart.

Venous pressure readings are an established aid in the clinical evaluation of the function of the right heart and of pulmonary function. A search of the literature reveals a dearth of information regarding

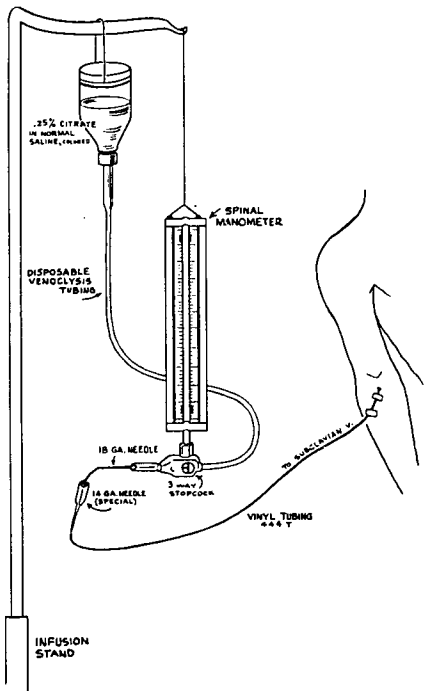

FIG. 1.

means of appraisal during the conduct of a surgical procedure. There are no established norms or considerations of the varying circumstances incident to anesthesia and operative procedures. However, ideas derived from several sources have gradually resulted in the evolution of a practical plan for continuing measurement during operation (3, 4, 5).

A glass spinal manometer (fig. 1) is attached to a substantial supporting board and suspended from an infusion standard. On the op-

posite side and at a slightly higher level is suspended a flask of saline solution to which has been added 50 cc. of 2.5 per cent sodium citrate solution, as an anticoagulant, and one of the common dyes to facilitate the manometric readings. Glucose solution is unsatisfactory because its large molecule causes air pocketing in the manometer. Disposable tubing leads to the inlet side of a three way stopcock, the side inlet of which is attached to the bottom of the manometer. To the outlet side of the manometer is fitted an 18 gauge needle which is threaded snugly into vinyl plastic tubing.§ The vinyl tubing is threaded through a special 14 gauge, large bore needle § into a convenient vein in the upper arm, and is advanced the required distance so that the end is placed in the subclavian vein. The 14 gauge needle is withdrawn and the vinyl tubing is fixed securely with adhesive tape. Aseptic precautions, of course, are followed.

By means of the stopcock, flow from the infusion bottle is directed through the tubing to insure its patency. The manometer is then primed by turning the stopcock for a moment to direct the flow from the flask into the manometer, and then from the manometer toward the vein. The meniscus comes to rest when the manometric pressure approximates the venous pressure. It is important that the vinyl tubing be kept continually flushed except when readings are being made, to avoid coagulation of any blood back flow. The base of the manometer must always be adjusted to the heart level, and this adjustment maintained with changes in position of the patient.

The placement of the intravenous catheter in the subclavian vein is chosen arbitrarily to secure a standard which is constant under varying surgical and anesthetic conditions. Peripheral readings, using either needle or catheter, are subject to local variables, such as temperature changes, venospasm, pressure and displacement by drapes and surgeons, and are slow to reflect changes in central venous pressure. Significant repeated readings throughout lengthy major surgical procedures have been achieved only recently, and after considerable experimentation with and study of physiologic, physical and environmental factors.

The purpose of this presentation is to stimulate the interest of colleagues in an easily applied and maintained apparatus, and to offer some conjectures which eventually may be proved valid. These conjectures are as follows:

(1) Given a healthy circulatory and respiratory status, the immediately extrathoracic venous pressure, under resting inhalation anesthesia, with a closed system, approximates 5 to 15 cm. of water. Fluctuations of venous pressure closely follow the planes of anesthesia, in correlation with arterial pressure.

(2) Depletion of blood volume by hemorrhage or peripheral vascular relaxation by spinal anesthesia (6) results in a fall in venous pres-

§ No. 444T, Becton, Dickinson and Company, Rutherford, New Jersey.

sure preceding a fall in arterial pressure. There may be a transient early rise in central venous pressure when hemorrhage is arterial. Adequate blood replacement is reflected by a reversal of a falling venous pressure, or by its maintenance with no decrease.

(3) An increase in intrathoracic pressure is reflected by increased venous pressure. This is additive when the intrapulmonary pressure is increased. It seems paradoxical to find that the intravascular venous pressure is increased when the chest is open. A rational explanation is the fact that the extravascular intrapleural pressure is negative.

(4) Visceral traction often results in marked decrease in arterial pressure. This decrease does not seem to be paralleled on the venous side. The converse has been the usual observation.

TABLE 1

VENOUS PRESSURE VALUES

I. Normal individuals (age and sex groups)
  1. Positioning effects
     Supine, prone, lateral, head down, head up
  2. Anesthetic drug effects—various planes
     Inhalation, intravenous, conduction
  3. Technic effects
     Hypoxia and/or accumulation of carbon dioxide
     Airway—(1) laryngeal function intact
           (2) endotracheal airway
     Open, closed, circle, to and fro
     Assisted and controlled respiration,
       monophasic and biphasic
  4. Surgical effects
     Open chest } combined procedures
     Open abdomen }
II. Abnormal (pathologic) individuals
  1. Pulmonary deficiencies
  2. Cardiac deficiencies
  3. Vascular deficiencies
III. Correlations
  1. Arterial blood pressure
  2. Blood volume
  3. Electrocardiogram

(5) Extremes of positions may result in increased venous pressure in the presence of falling arterial pressure and may be indicative of central venous pooling. This has been noted in Trendelenburg, perhaps combined with lithotomy, positions, and in the lateral kidney position.

(6) Impairment of the pulmonary vascular bed by emphysema or, acutely, by bronchospasm or lung resection, or too great positive pressure results in increased venous pressure, especially in the presence of inadequate function of the right heart. It may be that this is an early and most significant indication of right heart failure.

It is evident that many clinical observations must be made before venous pressure readings can be evaluated. Table 1 is a superficial out-

line of the scope of this work. With the acquiring of knowledge it may be that venous pressure recordings will be an essential guide in the management of patients who have protracted surgical procedures.

SUMMARY

The physiology of venous pressure is considered together with the potential effects of anesthesia and surgery.

A practical plan for minute to minute measurement of venous pressure in the operating room is presented.

Some hypothetical deductions, drawn from clinical observations, are recorded, together with an outline of projected further study.

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AUSTRALIAN SOCIETY OF ANAESTHETISTS

The next Annual General Meeting of the Australian Society of Anaesthetists will be held in Melbourne, Victoria between August 25 and 29, according to the announcement by Dr. S. V. Marshall, President of the Society. A special invitation has been extended by the group to any Americans who can attend.