POLYCYTHEMIA IN RELATION TO ANESTHESIA
AND SURGERY *

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The purpose of this paper is to emphasize the hazards which accompany performance of anesthetic and surgical procedures for patients who have polycythemia, and to suggest the use of simple laboratory technics which will serve as guides to intelligent intravenous therapy. It is common practice for internists and members of surgical teams to stress the hazards involved in performance of surgical procedures for patients who have anemia. We should be equally cognizant of inherent dangers which accompany and follow performance of anesthetic and surgical procedures for patients who have polycythemia. Management of these patients, irrespective of whether their polycythemia is of the relative, transient, or absolute variety, † demands meticulous attention.

Because avoidance of hypoxia is a fundamental requisite of good anesthesia, it is essential that we recognize every possible cause of inadequate oxygenation. Pathologic processes characterized by increased viscosity of the blood constitute a common cause of hypoxia. Although polycythemia vera is not a common entity, relative polycythemia (1), that variety characterized by increased viscosity owing to loss of circulating plasma, is a common finding among surgical patients. This fact is emphasized when we recall that burns, dehydration, shock, intestinal fistulas, peritonitis, pancreatitis, mesenteric thrombosis, intestinal obstruction and improperly managed Wangensteen drainage are common causes of relative polycythemia. Surgeons and anesthesiologists are frequently confronted with these acutely ill patients whose ability to tolerate operation is complicated by the presence of this blood abnormality. Internists who are called upon to manage treatment of polycythemia vera are not influenced by the time factor. They, therefore, can resort to therapeutic procedures which

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‡ Relative Polycythemia—concentration of erythrocytes greater than normal due to loss of circulating plasma.

Transient Polycythemia—greater than normal concentration of erythrocytes due to shunting of red cells into circulating blood from a storehouse such as the spleen.
Absolute Polycythemia (Polycythemia Vera)—abnormal increase in number of erythrocytes and an associated hypervolemia.
require prolonged therapy, such as spray irradiation or the use of radioactive phosphorus (2). The surgical team, however, must employ a method of treatment which is effective immediately. Proponents of spray irradiation argue that bleeding stimulates hematopoiesis and is, therefore, an unsound therapeutic procedure. In spite of this, "bleeding" remains an effective method to be employed for the control of polycythemia vera. In emergency, this procedure must be resorted to in order to avoid the serious complications which result because of retardation of circulation, partial or complete vascular occlusion and hypoxia. Otherwise optimal safety cannot be achieved for these patients during the operative procedure and convalescence. Provided polycythemia is of the absolute variety, sufficient blood must be removed at daily intervals to reduce the hematocrit to a normal level.

Early recognition of all varieties of polycythemia is of major importance to anesthetists and surgeons. This frequently makes the difference between success and failure in management of anesthesia and performance of surgical procedures. Recognition of polycythemia vera is of particular importance because this variety is characterized not only by absolute increase in the number of erythrocytes but also by increased blood volume (1). Administration of any type of intravenous therapy is, therefore, harmful. Repeated venesection is the only method of preparing patients who have polycythemia vera for elective operation. Prompt detection of relative polycythemia is essential for two reasons: first, because the diagnosis of polycythemia vera must be excluded; and second, whereas administration of solutions containing crystalloids or plasma is of decided value, transfusion of whole blood increases the existing hemococoncentration.

The pathologic changes in polycythemia are the result of increased viscosity, retardation of circulation, hypoxia, increased permeability of endothelial tissues and intravascular coagulation. Increased viscosity of blood initiates a series of pathologic changes which may prove detrimental to convalescence of surgical patients. Retardation of circulation in smaller arterioles and capillaries results in inadequate oxygenation of tissues, accumulation of carbon dioxide and other metabolites such as lactic acid (3). There is also edema owing to passage of water and plasma into the tissues. Capillary congestion is responsible for increased bleeding into incised areas. Partial or complete vascular occlusion results when thrombosis occurs. These changes are likely to produce faulty healing of wounds and may be responsible for formation of extensive hematomas. Since blood is an excellent medium for growth of bacteria, the onset of infection may lead to tissue breakdown and dehiscence.

Accumulation of end products of metabolism favors production of acidosis. Retention of carbon dioxide owing to impairment of respiratory exchange in the presence of pulmonary emphysema, pulmonary fibrosis or bronchiectasis causes acidosis, as does accumulation of
carbon dioxide and lactic acid in the tissues because of inadequate circulation. The most dangerous complication which is likely to develop in patients who have polycythemia is formation of thrombus. This alone contributes largely to production of the above mentioned pathologic changes, and introduces the added hazard of embolic phenomena. Pulmonary edema, edema of the tissues of the brain and congestive failure are also potential complicating factors. Polycythemic individuals are prone to develop failure of the right side of the heart for the same reason that patients having hypertensive heart disease develop myocardial failure. They are even more likely to develop thrombosis of major vessels than are patients who have arteriosclerosis. Other complicating factors include oliguria and renal insufficiency (4). Their susceptibility to onset of intercurrent infections, especially those of the respiratory tract, makes these individuals poor operative risks.

It, therefore, behooves the anesthesiologist to be aware of the possible presence of polycythemia when he encounters patients who present signs such as a ruddy, plethoric complexion, conjunctival suffusion, cyanosis, venous engorgement, varicosities, hypertension and evidence of severe degrees of dehydration. Existence of these signs should prompt him to obtain a more detailed history with regard to headache, vertigo, cardiac decompensation, abdominal pain, paresthesias and peripheral paralysis. It is equally as important that anesthesiologists be aware of the possibility that polycythemia vera may be co-existent with such pathologic conditions as emphysema, pulmonary fibrosis, chronic bronchitis, bronchiectasis, mitral stenosis, pulmonary stenosis, congenital heart disease, asthma and dilatation and hypertrrophy of the right auricle and ventricle. The best anesthesiologist is the man who possesses the widest knowledge of medicine applied in reference to each of his patients.

Intelligent management of surgical patients includes intravenous administration of solutions of crystalloids, plasma, plasma fractions, synthetic proteins and whole blood. Performance of this duty requires sound clinical judgment as well as a thorough understanding of the significance of laboratory findings. Numerous laboratory procedures provide useful information, but determinations of total blood and total plasma volumes are the most useful guides to judicious fluid therapy (5). Because of the time factor involved, however, application of data obtained from performance of this test is limited to preoperative and postoperative periods. During actual performance of surgical procedures anesthesiologists frequently encounter problems in intravenous therapy which demand immediate and accurate decision. Serial recordings of pulse rate, respiratory rate and blood pressure now form the basis of anesthetic records. They serve as reliable guides to follow in determining when intravenous therapy should be instituted, but do not assist in deciding what type of therapy is needed. There is, there-
fore, a need for the performance of some simple, accurate laboratory procedure in the operating room which can be employed in conjunction with other clinical data to guide intravenous therapy.

Barbour and Hamilton developed the first accurate method of determining specific gravity of blood by the falling drop technic. When Phillips and Van Slyke suggested employment of solutions of copper sulfate (table 1) for this test anesthesiologists were provided a simple, practical method which could be employed in the operating room. Because of its extreme simplicity, reasonable accuracy and remarkable reproducibility, it is an excellent test to employ during the management of surgical patients who are likely to lose large amounts of plasma or blood, as well as those in whom we suspect the existence of hemoconcentration. To facilitate serial determination of the specific gravity of whole blood during performance of anesthetic procedures we recommend employment of copper sulfate in concentrations ranging from a specific gravity of 1.045 to 1.070. A battery of seven 4 ounce bottles is set up in series with each containing 100 cc. of copper sulfate whose specific gravities are graduated in units of three. This quantity is sufficient to provide accurate determinations of the specific gravity of 100 drops of blood. When collecting samples of venous blood, tourniquets should not be applied for longer than one minute. Longer application may result in passage of enough fluid into the tissues to increase measurably the concentration of blood. In the presence of shock I employ samples of venous blood rather than capillary blood because capillary blood may contain 30 to 40 per cent more cells and a corresponding increase in value for hemoglobin than exist in venous or arterial blood (6). The technic consists of dispensing droplets of blood from a syringe whose needle point is held at a height of 1 cm. above the solution. This provides each droplet with sufficient striking force to penetrate the surface film of the solution. Within three to five seconds the momentum of the fall is lost. The gravity of the droplet relative to the solution does not change appreciably till it has been immersed in copper sulfate for another ten to fifteen seconds (6). The droplet will do one of three things: (1) it will fall directly to the bottom; (2) after losing the momentum of fall into the solution it will rise toward the surface, and (3) it will remain stationary for approximately 10 seconds before falling to the bottom. The latter is the end point we seek.
Determination of gravities of blood during the progress of anesthesia and surgical procedures provides a simple practical physiologic guide to govern intravenous therapy. If the value for plasma protein is known by preoperative determination, line charts of Phillips and Van Slyke may be employed for the conversion of whole blood gravities to hemoglobin concentration and hematocrit percentages. Calculations are made by placing a straight edge on the points determined. Knowing the number of grams of plasma protein per 100 cc. together with the specific gravity of whole blood, one can readily determine the hematocrit as well as the number of grams of hemoglobin per 100 cc. During management of patients admitted because of burns received at the circus disaster in Hartford in 1944, the copper sulfate falling drop technic proved to be of real value in estimating degrees of shock and in directing administration of plasma, whole blood and protein therapy (7).

Since becoming interested in the problems of hemoconcentration in relation to anesthesia we have been impressed by the number of patients discovered to have polycythemia. As expected, polycythemia of the relative variety is most commonly encountered. Since relative polycythemia is produced by loss of water, electrolytes or plasma from the blood, judicious administration of solutions containing crystalloids or plasma promptly removes hazards which would otherwise be encountered during administration of anesthesia and performance of surgical procedures. Administration of whole blood to patients whose hematocrit reading is elevated is definitely contraindicated. An example of hemoconcentration which resulted from the loss of a copious amount of blood-tinged serum into the peritoneal cavity is presented.

A 62-year-old man was admitted complaining of severe cramplike pain in the upper abdomen. Pain was most marked on the right side, and was described as being constant but undulating in character. Although morphine sulfate, ½ grain, had been administered in fractional doses during the three-hour period immediately before performance of laparotomy, the patient continued to have severe pain. During this interval cutaneous surfaces were pale, cold and moist. Spasm of the muscles of the upper abdomen was marked, the degree of rigidity being most pronounced on the right side. Blood pressure after admission was recorded to be 128 mm. systolic and 72 mm. diastolic. Following administration of 1500 cc. of normal saline solution it rose to 140 mm. systolic and 80 mm. diastolic. Vomiting had been copious. The attending surgeon’s diagnosis was mesenteric thrombosis. One thousand cubic centimeters of whole blood was ordered for administration in the operating room. Bilateral intercostal block was performed. Immediately before the operative procedure was started two venipunctures were performed. Infusions of normal saline solution were started, but before administering whole blood it was considered advisable to determine the specific gravity of the patient’s blood. Because the calcu
lated hematocrit was discovered to be well above the normal range, whole blood was not administered. Cause of the hemoco

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before the hematocrit was reduced to 47.5. Debridement of the right elbow was performed, and subsequently two plastic procedures were required to correct the cutaneous defect which resulted from destruction of the cutaneous surface overlying the extensive hematoma. Brachial plexus blocks were employed for performance of the first two procedures. No complications were encountered. The third and final operation was performed at a subsequent admission. Because the anesthesiologist failed to note that the patient had polycythemia vera inhalation anesthesia was employed. Induction and maintenance were most difficult even though muscular relaxation was not required.

Internists may minimize the significance of hematocrit readings of 50 and above, but to anesthesiologists and surgeons they are of major importance. Because maintenance of optimal levels of anesthesia without cyanosis is rendered most difficult, and because of the increased incidence of complications resulting from altered respiratory and circulatory physiology, it is our belief that in the presence of hemoconcentration the choice of anesthesia is limited to regional techniques whenever possible. When inhalation techniques are employed for these patients the anesthesiologist soon becomes aware that his patient is not doing well. Attention is attracted to the patient’s ruddy complexion, varying degrees of cyanosis, unexplained elevation of blood pressure and existence of marked venous engorgement. He, therefore, suspects that the airway may be inadequate. Careful examination of its patency, however, reveals no evidence of respiratory obstruction. Increasing the concentration of oxygen in the gaseous mixture fails to relieve the disturbing persistence of cyanosis, as do all maneuvers he may attempt including introduction of an endotracheal catheter. The degree of discoloration usually increases till a characteristic cape-like distribution of cyanosis appears which involves the head, neck, shoulders and all dependent tissues (case report 1 and 2). Conjunctival suffusion

**Case Report 1.**

R.G. Admission Diagnosis: Recurrent hernia—ventral.
Operation: Repair of Recurrent hernia—ventral.
Maintenance: Cape-like distribution of cyanosis even after endotracheal intubation and administration of high concentration of oxygen.
Specific Gravity of Blood: Start of operation .......................... 1.082
                          Completion ........................................ 1.058
Fluid Therapy: 1700 cc. of 5 percent glucose in distilled water.

**Case Report 2.**

Mr. C. Preoperative Diagnosis: Small bowel obstruction, peritonitis arteriosclerotic heart disease.
Anesthesia: Abdominal field block, cyclopropane-oxygen (endotracheal).
Maintenance: Difficult. Persistent cyanosis in spite of vigorous fluid therapy and administration of high concentration of oxygen.
Distribution of cyanosis: Cape-like and dependent tissues.
Final Diagnosis: Peritonitis (generalized); paralytic ileus; relative polycythemia; irreversible shock.
focuses attention upon the eyes, examination of which reveals the presence of marked capillary and venous congestion. Such a sequence of events and findings should make us cognizant of the possible presence of hemoconcentration. Experience has led some (8) to believe that this cape-like distribution of cyanosis is pathognomonic of polycythemia.

That loss of effective circulation, which is characteristic of polycythemia, produces disturbances which jeopardize successful convalescence is illustrated by the following report.

An elderly patient whose acute onset of intestinal obstruction was complicated by polycythemia vera was admitted for performance of exploratory laparotomy in emergency. The diagnosis of polycythemia was not made until after the surgical procedure had been performed and a transfusion of whole blood has been administered. Because of the onset of cyanosis during administration of the blood a member of the Department of Anesthesiology saw the patient in consultation. After a diagnosis of polycythemia vera had been definitely established by excluding the possible presence of relative polycythemia it was suggested that daily phlebotomy be performed to reduce the hematocrit reading from 58 to a normal level. This was not performed. When the patient returned to the operating room for repair of a dehiscence, members of the section were of the opinion that hemoconcentration and hypervolemia had contributed to the production of this postoperative complication.

Efficiently managed blood banks are a necessity, but when whole blood is readily available there is a tendency to administer it when indications for its use do not exist. An artificially induced polycythemia with hypervolemia is reported.

A 63-year-old man was admitted in a state of profound shock. The referring physician’s diagnosis was perforated peptic ulcer. The abdominal wall was boardlike in rigidity. Coffee groundlike material was removed from the stomach by means of a Levin tube. Stools were tarry black in color. A total of 5000 cc. of whole blood together with a minimal quantity of saline solution was administered between 2 a.m. and 11 a.m. Hematocrit reading made during the morning revealed a level of 52. Upon the patient’s arrival in the operating theater for surgical repair of a perforated peptic ulcer the anesthesiologist became suspicious of the presence of polycythemia. Hypertension was pronounced. Superficial veins and venules were engorged. Cyanosis of the head, neck, shoulders and dependent tissues was marked. Administration of 100 per cent oxygen brought about improvement of color but cyanosis remained. Administration of the anesthetic and performance of surgical exploration were postponed until the second hematocrit reading was reported following removal of 600 cc. of whole blood. Performance of the surgical procedure was accomplished, employing continuous spinal anesthesia. An otherwise difficult procedure was successfully completed without incident.
Conclusions

Serial determination of the specific gravity of whole blood and adoption of methods for the rapid determination of hematocrit and hemoglobin readings during actual performance of surgical procedures are valuable aids to the anesthesiologist. They not only provide him with a means of detecting hemoconcentration, but enable him to administer intravenous fluids upon a reasonably sound physiologic basis. Until a technic is devised which will permit calculation of the total plasma and total blood volumes during performance of operative procedures, this method should prove helpful.

References

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