Management of Massive Blood Losses in Small Infants—Incremental Transfusion of Fresh Unanticoagulated Adult Blood

K. M. JANIS, M.D., AND J. W. MCBRIDE, M.D.*

Extensive surgical operations on neonates and small infants often necessitate replacement of massive blood losses. Bank blood, regardless of how fresh, may allow metabolic or hematologic complications to develop following multi-blood-volume replacement in a newborn infant whose liver is immature or in an older infant undergoing massive hepatic resection. The two cases in this report describe replacement of multi-blood-volume losses which utilized incremental transfusion of warm, unanticoagulated, fresh, whole adult blood drawn directly from donors present in the operating room.

REPORT OF TWO CASES

Patient 1. A six-hour-old 3.14-kg newborn male infant was brought to the operating room for resection of a large abdominal tumor. Anesthesia was induced with halothane and nitrous oxide in oxygen. The trachea was intubated and anesthesia maintained with nitrous oxide–oxygen and *d*-tubocurarine via a Jackson-Rees T-piece apparatus. Two 16-gauge intravenous catheters were placed in the arms. Electrocardiogram, central venous pressure, arterial blood pressure, rectal temperature, and renal output were monitored. Transfusion was begun simultaneously with the incision and, after approximately ¾ of the infant's estimated blood volume had been replaced with fresh bank blood, sudden massive blood loss occurred. The blood pressure signal could not be detected with the Doppler † ultrasound transducer, and no pulse could be palpated. Calcium chloride, 30 mg, and mannitol, 1.25 g, were administered intravenously. Surgical control of the bleeding was obtained. Subsequently, incremental transfusion of fresh blood from crossmatched donors brought to the operating room was begun. There was also a second episode of severe hypotension following sudden blood loss, which responded to rapid incremental administration of fresh unanticoagulated blood. Total replacement of six and a half times the estimated blood volume was administered: 1,280 ml fresh bank blood; 700 ml fresh adult blood by incremental transfusion; 775 ml 5 per cent dextrose in Ringer's lactate solution. Throughout the procedure all blood was warmed, and the temperature of the infant was maintained between 96 and 99 F. At the conclusion of the surgical operation nitrous oxide was discontinued and then effects of *d*-tubocurarine were reversed with atropine and neostigmine. The trachea was extubated and the infant cried vigorously in the operating room. The postoperative course was uneventful.

Patient 2. An 18-month-old 11.8-kg female infant was brought to the operating room for resection of a hepatic tumor. Two hundred and fifty ml of fresh bank blood had been administered the night before to correct preoperative anemia (hemoglobin = 9.1 g/100 ml). After premedication with scopolamine, 0.1 mg, and morphine, 1 mg, intramuscularly, anesthesia was induced and maintained with halothane–nitrous oxide and oxygen via a Jackson-Rees T-piece apparatus. *d*-Tubocurarine was added intravenously for muscle relaxation. Two 16-gauge catheters were placed in the arms. Rectal temperature, arterial blood pressure, electrocardiogram, central venous pressure, and urinary output were monitored. Early in the procedure massive blood loss occurred, and hypotension which ensued responded to rapid administration of warm fresh bank blood (1,250 ml). Sodium bicarbonate, 15 ml, and calcium, 100 mg, were also administered. Subsequently, incremental transfusion of warm, fresh adult blood from previously crossmatched donors (650 ml) was begun. Fresh frozen plasma (250 ml), Ringer's lactate solution (700 ml) and an additional 500 ml fresh bank blood were administered during the procedure. The rectal temperature was maintained between 98 and 99 F throughout the procedure, and urinary output was adequate. After reversal of the effects of the muscle relaxant with atropine and neostigmine, the trachea was extubated. The patient cried vigorously in the op-

* Present address: Director, Department of Pathology, Porter Memorial Hospital, Valparaiso, Indiana.

Received from the Anesthesiology and Clinical Pathology Services, Wilford Hall USAF Medical Center, and the Department of Anesthesiology, University of Florida College of Medicine, Gainesville, Florida 32601.

Reprint requests should be addressed to Doctor Janis, Department of Anesthesiology, University of Florida College of Medicine, Gainesville, Florida 32601.

† Parks 802 Doppler Unit, Parks Laboratories, Beaverton, Oregon.

Downloaded from anesthesiology.pubs.asahq.org by guest on 11/18/2019

erating room. Clotting values (partial thromboplastin time, prothrombin time, and platelets), measured pre-, intra-, and postoperatively, remained within normal limits. The postoperative course was uneventful.

Discussion

Transfusion of blood from donor to patient by syringe was first performed by James Blundel in 1818.[1] In 1881, William Halsted used a syringe to transfer blood directly from himself to his sister.[1] Lindemann, in 1913, developed a multiple-syringe technique for the transfer of blood directly from the donor to the patient.[1] Without the benefit of cross-matching procedures or anticoagulants, the transfusion of unanticoagulated blood remained difficult and dangerous until experience with citrated blood was gained.

Through analysis of experience with massive transfusions given to battle casualties, Miller found that fresh blood often was necessary to completely correct the bleeding diathesis which developed during massive blood replacement.[2] The technique of incremental transfusion described here supplies warm fresh blood without anticoagulants in situations where bank blood containing anticoagulants might allow development of the metabolic and/or hematologic complications of massive transfusion. The "storage lesion" of banked blood is well-documented.[3] In addition, recent evidence has shown that bank blood may be deficient in erythrocyte content of 2,3-diphosphoglyceric acid[4] and that fetal hemoglobin may be unable to bind 2,3-DPG adequately.[5] Incrementally transfused fresh adult blood without anticoagulants is available, and it is kept warm and metabolically normal by the body, which serves as a "tonometer" until the moment it is withdrawn from the donor. With this technique, very little biochemical change in the transfused blood will have occurred. In this manner, blood at normal body temperature containing adequate levels of labile clotting factors, platelets, 2,3-DPG and adult hemoglobin, with normal *p*H and electrolyte content, will be transfused, rather than blood subjected to the alterations associated with blood bank processing and storage.

The newborn infant's immature liver may be unable to transform citrate anticoagulant metabolically. Fresh bank blood, regardless of the nature of the anticoagulant and preservative used, may overwhelm the compensatory mechanisms of the immature newborn liver. In addition, the infant may be deficient in labile clotting factors. Bank blood will be unable to supply adequate quantities of labile clotting factors or platelets. Patient 2 was an older infant whose hepatic metabolism was more mature, but might have been limited preoperatively by invasion of tumor mass and further limited postoperatively as a result of surgical excision of a large portion of the remaining functional hepatic tissue. Massive resection of hepatic tissue may impair hepatic metabolism of anticoagulants and production of labile clotting factors in the intra- and postoperative periods.

Successful utilization of this technique requires teamwork. A clinical pathologist will evaluate the patient preoperatively and obtain laboratory determinations relevant to the patient's hemostatic state, including family history, prothrombin time, activated partial thromboplastin time, platelet count, and examination of smear for platelet clumps, quantitative fibrinogen, and clot formation, and retraction times. The blood bank is alerted, and donors of the appropriate type are contacted and crossmatched prior to surgery. Blood replacement is begun with fresh bank blood and, after three-quarters of one estimated blood volume has been administered, fresh frozen plasma (5–10 ml/kg) is given and the pathologist brings the donors to the operating room suite. A large-bore catheter is placed in the donor's antecubital vein. Blood is withdrawn in 10-ml syringes and administered to the patient immediately. Experience has shown that use of larger syringes may result in the donor's blood's clotting in the syringe before it can be successfully transfused to the patient. Various types of blood filters have been used, and the platelet filter seems to be the best available for this procedure, although it is not totally satisfactory. After 400 ml of blood are removed, the procedure is continued with subsequent donors. On three other occasions this system was organized and ready to be placed in immediate operation, but it was not necessary because surgical blood loss did not exceed three-quarters of one estimated blood volume.

Downloaded from anesthesiology.pubs.asahq.org by guest on 11/18/2019

Conclusion

This technique allows warm fresh unanticoagulated adult whole blood to be rapidly transfused in situations requiring massive blood replacement. Blood transfused by means of incremental transfusion of warm unanticoagulated adult blood is as nearly normal, in terms of metabolic physiology and factors necessary for normal clotting, as it is possible to obtain. Therefore, it is effective in preventing (or treating) complications associated with massive transfusion of bank blood in small infants.

References

1. Hutchin P: History of blood transfusion: A tercentennial look. Surgery 64:685–700, 1968
2. Miller RD, Pong MJ, Robbins TO: Coagulation Defects Associated with Massive Transfusion. Presented at the ASA Meeting, October 1969, San Francisco.
3. Bunker JP: Metabolic effects of blood transfusion. Anesthesiology 27:446–455, 1966
4. Bunn HF, May MH, Kocholaty WF, *et al.*: Hemoglobin function in stored blood. J Clin Invest 48:311–321, 1969
5. Bunn HF, Jandl JH: Control of hemoglobin function within the red cell. New Eng J Med 282:1414–1420, 1970

Surgery

MEDIASTINOSCOPY Positive diagnostic results were obtained in 13 of 32 patients who underwent mediastinoscopy. Although local anesthesia may be used, general anesthesia with tracheal intubation improves the accuracy and safety of the procedure. Any severe systemic disease or any disease that would preclude anesthesia is a contraindication to mediastinoscopy. Complications of mediastinoscopy include hemorrhage, air embolsm, vocal-cord paralysis, pneumothorax, mediastinitis and tracheal injury. (*Cooley, J. E., and Houseworth, J. H.: Mediastinoscopy: Indication, Technique and Results, Papers of Carle Clinic and Foundation 23: 3 (Jan.) 1970.*)

FUTURE OPERATING ROOMS In the new surgical complex at Illinois Masonic Medical Center in Chicago, a patient scheduled for elective surgery will have routine preoperative preparation as an outpatient and will be admitted directly to one of the preoperative beds the night before operation, rather than being assigned to a regular bed in the hospital. The day of operation, the patient will be transported to a holding area, from which he will subsequently enter the operating suite through the "front" access door. The staff—surgeons, surgical nurses, anesthesiologists, and orderlies—will enter their shower–locker–lounge area on the third floor, dress for surgery, exit to a common vestibule and then to a staircase which serves the third- and second-floor clean core only, and finally will enter the operating suite through its "back" door. Ten of the operating rooms will be fitted with floor pedestals located close to the table, eliminating the usual tangle of cords and hoses. These pedestals will contain nonflammable gases, physiologic monitoring devices with leads to a remote master screen, electrocautery equipment with remote control, water, compressed air, and electrical power with standard voltage. None of these rooms will require conductive flooring or explosion-proof outlets, since no flammable gases will be used in them. The few remaining rooms will be fitted in the conventional manner for teaching and research purposes. At the end of each work day, all large equipment such as tables, tray stands, etc., will be disinfected in the operating room and moved to a station in the outer-ring corridor, where the equipment will be washed with decontaminant. Detailed planning has gone into the systems for ventilation, equipment supply, waste disposal, and communications and into the design for the recovery room and intensive care units. (*Hix, A. M., and Beck, R. M.: Surgeries for the 1970's, Mod. Hosp. 114: 85 (Jan.) 1970.*)

Downloaded from anesthesiology.pubs.asahq.org by guest on 11/18/2019