

# SERIAL MICROHEMATOCRIT DETERMINATIONS IN ANESTHESIA

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PRECISE blood, water, and electrolyte replacement in infants and children may be difficult at any time, and is often temporized in the operating room, at a time when the greatest precision is needed.

In a previous report,<sup>1</sup> we have mentioned the use of microhematocrits in the management of fluid replacement. To date, serial microhematocrits have been obtained in 25 cases where it seemed likely that there would be excessive blood loss or some other problem in fluid therapy. Therefore, it seemed appropriate to describe the technique in detail. A hematological evaluation of microhematocrits has been reported.<sup>2</sup>

## METHODS

The principle of the method is that blood rises readily into a capillary tube, and that the hematocrit of blood obtained by skin puncture faithfully reflects the venous hematocrit.

The essential equipment consisted of 75 mm. by 1.5 mm. heparinized capillary tubes,\* and a centrifuge made for use with these tubes.† An alcohol lamp was usually available for heat-sealing one end of each filled tube, but in emergencies any flame, even ordinary matches, could be used. Centrifuged tubes were read on a spiral device,<sup>2</sup> which was re-

placed recently by an improved (illuminated magnifying) reader.‡

The puncture sites were exposed fingers, toes or heels, care being taken to avoid previously punctured sites, as well as intravenous infusions. A variety of instruments were used for the punctures, including hypodermic needles, commercial stylets, and finally size 11 Bard Parker blades. Accurate readings required free flow of blood, rather than a few drops obtained by pressure. Whenever possible, 30 tubes of blood (each tube about two-thirds full) were obtained from each puncture. This blood loss was small, since the volume of each tube was less than 0.05 ml. Each tube was read twice after centrifugation, resulting in 60 readings per specimen. This added little time

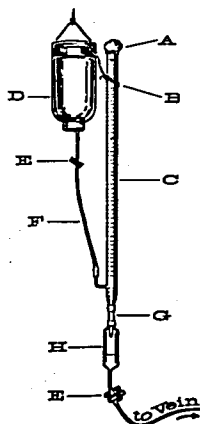


FIG. 1. Apparatus for careful measurement of intravenous fluids. A, cotton plug. B, supporting string. C, cylinder graduated in 0.1 ml. D, reservoir bottle. E, clips for regulation of flow; the lower one was always a screw-clamp. F, intra-venous extension tube, used to connect reservoir and cylinder. G, rubber tube over end of cylinder. H, drip chamber.

TABLE 1

SIMULTANEOUS VENOUS AND SKIN MICROHEMATOCRITS

	Venous	Skin
Observations	16	14
Mean	32.2%	32.2%
Standard error	±1.7%	±1.8%

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\* Capillary tubes, no. 3018-H, Arthur H. Thomas Co.

† Micro-capillary centrifuge, model MB, International Equipment Co.

‡ Micro-capillary reader, model CR, International Equipment Co.

to the procedure, compensated for errors, and provided the hematocrit if one, or even two, of the fragile tubes were broken.

Centrifugation at 10,000 r.p.m. was done as soon as possible, depending on the urgency, and usually in the anesthesia or other room adjoining the operating theater. A cover of foam rubber reduced the noise of the centrifuge. The readings obtained after 4 minutes were unchanged by 8 minutes centrifugation, so that the former period was accepted.

The tubes were read to the nearest tenth per cent, with reproducibility falling within 1.0 per cent. Some specimens were obtained simultaneously with venous blood samples; these microhematocrits were not significantly different (table 1), in agreement with the large series of comparisons reported by McGovern, Jones and Steinberg.<sup>2</sup>

All fluids administered intravenously were measured to 0.1 ml. by means of a graduated cylinder (fig. 1). A side arm at the lower

end connected the cylinder to a reservoir bottle through a sterile, plastic, extension tube. This permitted refilling without manipulation and without contamination of the cotton plug in the upper end of the cylinder. Also, in the event of massive hemorrhage, it permitted immediate, direct, connection to the patient of the entire blood reservoir. It did not matter whether the blood reservoir was of plastic or of glass, since pumping pressure if needed had to be applied below the graduated cylinder. For this purpose, the ordinary intravenous infusion set connected to the lower end of the cylinder could be of the type equipped with a ball valve for use as a pump. Alternatively, a syringe connected at the patient end of the infusion set, by a three-way stopcock, could be used for pumping.

Urine was not collected routinely except when a bladder catheter was indicated, or, in the case of older children, when bladder control was present. However, periodical not-

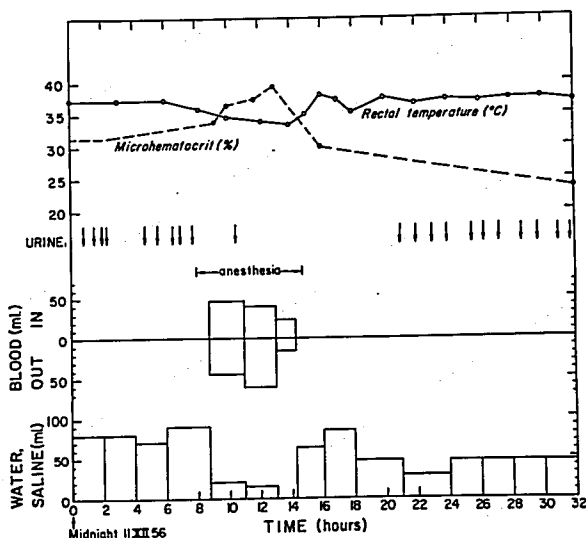


FIG. 2. Some aspects of fluid balance in Case 1. The intravenous infusion consisted of 0.3 per cent sodium chloride and 5 per cent dextrose in water. Micturition at times indicated by arrows.

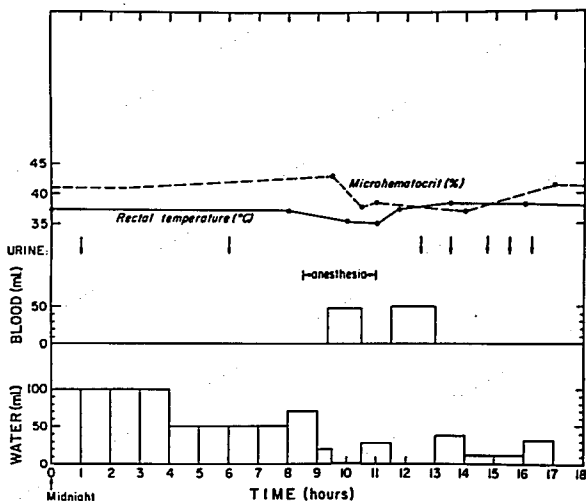


FIG. 3. Case 2. The infusion of water contained 5 per cent dextrose. Micturition at times indicated by arrows.

were made regarding the state of the diapers. Other output, such as ventricular or gastric drainage, was measured at regular intervals.

#### CASE REPORTS

**Case 1.** This patient was born joined to her Siamese twin sister by a bony connection 24 cm. in circumference between the frontal regions (craniopagus; cephalopagus frontalis), which necessitated that one twin be facing down while the other was facing up.<sup>1</sup> Other articles have dealt in detail with anesthetic,<sup>1</sup> surgical, and developmental<sup>4</sup> aspects of this case. One-hundred and twenty-five days after birth anesthesia was induced with intravenous thiopental, supplemented with nitrous oxide. The infants were uncovered, except for diapers and surgical drapes; with the operating room temperature at 23 C., the rectal temperature fell from 37.5 to 33.3 C. during the operation. The separation was performed and one twin moved to another table, so that both closures could be performed simultaneously by two surgical teams. Both twins survived the operations, are well at the present time, and seem to be developing normally.

Figure 2 depicts replacement therapy in this twin at the time of this operation. Her length was 52 cm. but her weight could only be estimated; the preoperative combined weight was 8.05 kg., and

immediately after surgery she weighed (including head dressing) 4.11 kg., while after 1 week she weighed (without dressing) 4.30 kg. When operative blood loss began, the single venous catheter was devoted largely to blood replacement; the microhematocrit rose and urinary output decreased. (The level of anesthesia was kept as light as possible and urination of about 20 ml. did occur once, 2.5 hours after induction.) The total blood loss of 122 ml. was calculated by weighing sponges and was replaced by only 111 ml., because of the elevated microhematocrit. Subsequently, the patient was given a solution consisting of 0.3 per cent sodium chloride with 5 per cent dextrose; urination resumed after 240 ml., and the microhematocrit fell rapidly to the preoperative level. However, despite frequent urination during the night, the microhematocrit was 23 per cent the next morning. Later that day (not shown in figure 2) an additional 45 ml. of blood was replaced, and the microhematocrit rose to 31.8 per cent, a level which was maintained.

**COMMENT:** It seems likely that the total blood loss was approximately 155 ml., between one-third and one-half the initial blood volume. Since a third of this loss was not replaced until the next day, the nearly-normal microhematocrit at 16 hours must have reflected dehydra-

tion. Two causes of this are apparent: decreased water replacement, and loss of an unknown (but probably large) quantity of cerebrospinal fluid during craniotomy.

**Case 2.** This infant seemed entirely normal until the age of 3 months. At that time, his parents first noticed diminished activity, and at the age of 4 months the head was enlarged. Cerebral air and dye studies indicated a communicating type of hydrocephalus. When admitted to the hospital he had generalized hypotonia, retarded mental development, head circumference 52.6 cm., and chest circumference 37.4 cm. A ventriculoperitoneal shunt was planned, but instead subdural drainage was instituted when a right subdural hematoma was encountered. This drained 440 ml. in 3 days, then stopped; he failed to improve, and his weight fell from 9.5 kg. to 8.6 kg. Extensive bilateral subdural membranes were then excised in 3 stages.

Figure 3 shows some aspects of the fluid and blood replacement problem during biparietal craniotomy at 15½ months, weight 8.6 kg., length 77 cm. Anesthesia was induced with thiopental and supplemented with nitrous oxide. He was uncovered except for diaper and surgical drapes (room temperature, 23 C.) resulting in a fall of rectal temperature from 37.2 C. to 35.0 C. during the procedure. Near the end of the operation, the microhematocrit fell to 38 per cent and remained near this level despite replacement of an additional 50 ml. of blood. While this blood was being administered, the patient began to void large quantities of nearly colorless urine. Water replacement was reduced, resulting in a normal microhematocrit at 17 hours.

**COMMENT:** This case is cited to illustrate that microhematocrit determinations must be evaluated in conjunction with the other evidence available. The minimum parenteral water requirement for this child was estimated from his surface area as 300 ml. per day,<sup>5</sup> or 12.5 ml. per hour. Though this rate was grossly exceeded for many hours, urination was infrequent. The microhematocrit also rose, as though he had undergone an increase in extravascular, extracellular fluid volume. However, the microhematocrit elevation might have been due to hypothermia.<sup>6,7</sup> A diuresis seemed to take place shortly after the operation, perhaps in relation to awakening from anesthesia.

#### DISCUSSION

Our purpose is to call attention to a rather simple technique of value in some operative situations. Serial microhematocrit determina-

tions may also have a place in studies of water balance, but our experience has not been extensive enough in this respect.

Variation in microhematocrits could be rather large, when blood flow was not free and pressure was applied. It was not uncommon to find a value of, for example, 30 increase to 35 per cent under such conditions, presumably due to venous stasis. Decreases of equal magnitude were found less often, and were attributed to dilution of blood by "tissue juice." In our experience, specimens should be obtained carefully if the readings are to be accurate. However, McGovern, Jones and Steinburg<sup>2</sup> did not emphasize this point.

Hypothermia did not appear to alter microhematocrit results qualitatively. The intense skin vasoconstriction impeded a free flow of blood when specimens were obtained, and there was usually a rise in microhematocrit,<sup>8</sup> but no delay occurred in recording changes such as that due to blood loss. In experiments on dogs performed in this laboratory,<sup>9</sup> a marked rise in vena caval microhematocrits (e.g., from 45 to 60 per cent) was associated with severe anoxia due to respiratory depression. Thus the fluid shifts described in hypothermia might also result from tissue anoxia, which should be recalled when evaluating microhematocrits of anesthetized patients.

#### SUMMARY

Serial microhematocrit determinations seemed to be of value in estimating water and blood replacement in infants and children during major surgery. Two illustrative cases of the technique are presented.

The authors are indebted to Drs. Clarence Hebert and Gilbert Christenson, who were in charge of some of the cases and obtained specimens, and to Dr. Guy McKhan for criticism of the manuscript.

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**OBSTETRIC ANESTHESIA** The need for good obstetric anesthesia and a suggested method for providing it are described in this review article from the M. D. Anderson Hospital. (Wilber, S. A.: *Anesthesiologist's Contribution to Modern Obstetric Management*, *South. M. J.* 52: 871 (July) 1959.)

**CAUDAL ANESTHESIA** On reviewing the cervical dilatation time curves of 605 patients who received caudal anesthesia during a three-year period it was demonstrated that caudal anesthesia does not necessarily affect the course of labor in the absence of complicating factors. Included among these factors were cephalopelvic disproportion, excessive preanesthetic medication and malposition. Untoward effects on the course of labor may be readily reversed by allowing the anesthesia to wear

off, by administering oxytocin infusion, and (in select cases) by amniotomy. (Friedman, E. A., and Sachtleben, M. R.: *Caudal Anesthesia*, *Obst. & Gynec.* 13: 442 (April) 1959.)

**APOMORPHINE** A dilute solution of apomorphine hydrochloride was administered very slowly to 75 obstetric patients before the administration of anesthesia. The amount of apomorphine required to produce emesis varied from 2 to 6.5 mg. Seven patients did not vomit after receiving the maximum dose of 6.5 mg. The anesthesia used was cyclopropane and oxygen or nitrous oxide, oxygen and ether. This method proved effective and safe in the present study. (White, R. T.: *Apomorphine as Emetic prior to Obstetric Anesthesia*, *Obst. & Gynec.* 14: 111 (July) 1959.)