THE IMMEDIATE EFFECTS OF SPINAL PONTOCAINE ANESTHESIA ON BLOOD VOLUME IN MAN *

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THE present trend in surgery is to keep the patient in a normal physiologic state before, during and after a surgical procedure. In this respect, blood volume plays a large role. Patients whose blood volume deficit is corrected with blood tolerate operations well (1, 2). The blood volume is kept at normal levels by shifts of fluid between the intravascular and extravascular spaces, renal adjustment, sweating and contraction of the spleen. Blood volume is reduced in hemorrhage, anemia, dehydration, exposure to cold, change in posture from recumbency to upright, obesity, myxedema, acute shock and chronic shock (oligemia). Blood volume is increased with high temperatures, muscular exercise, excitement, splenomegaly, liver disease, leukemia, hyperthyroidism, pregnancy, administration of intravenous glucose or saline solution, transfusions of blood or plasma, experimental chordotomy, bilateral lumbodorsal sympathectomy, arteriovenous fistula, congestive failure, primary and secondary polycythemia (3, 4).

There has been little experimental work on the relationship of various anesthetic agents to blood volume. Ether anesthesia in dogs caused a decrease in plasma volume, increase in cell volume and plasma protein concentration (5, 6), however, in cats the plasma volume was not reduced (7). Humans anesthetized with ether have a decrease in plasma volume (8, 9). Barbiturate anesthesia caused an increase in plasma volume in cats and dogs (10, 11). In the dog, atropine had no effect on blood volume; the volume of red cells and of total blood increased with morphine; blood volume increased with cyclopropane, nitrous oxide and oxygen, and plasma volume increased with sodium pentothal (6, 10, 12, 13).

The flaccid relaxation of the abdominal muscles and the strong intestinal contractions produced by spinal anesthesia have a fascinating and legitimate appeal to many surgeons. We have employed spinal anesthesia in many of our cases with great success and minimal compli-

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cations. From our clinical observations, we have been of the opinion that blood volume changes with spinal anesthesia were not significant. A search of the literature failed to reveal any studies on blood volume and spinal anesthesia in man. However, Adriani (14) stated that there are only slight changes in blood composition and blood volume during spinal anesthesia. We have, therefore, undertaken the present study.

TECHNIC AND METHODS

We have routinely used barbiturate premedication. Seconal, 1½ grains, two hours before operation was our choice. Morphine sulfate, 10 mg., and scopolamine, 0.4 mg., were administered one hour before surgery. The effects of barbiturates on blood volume have been variable (14). Blood volume is diminished in cats receiving morphine. The effect of scopolamine on blood volume is not known.

The spinal anesthetic agent was administered with the patient in the lateral recumbent position on the operating room table. The head was elevated 1 or 2 inches above the level by utilizing a pillow. The skin over the lower vertebrae was prepared with tincture of zephiran. After the fourth lumbar interspace was identified, a skin wheal was made with a mixture of 1 per cent procaine and 15 to 25 mg. of ephedrine sulfate. Spinal puncture was then performed in the usual manner in the fourth lumbar interspace with a number 22 gauge needle.

The anesthetic used in this series of 25 patients was 8 to 10 mg. of pontocaine diluted with equal parts of 10 per cent glucose to which was added 25 mg. of ephedrine. One patient received 6 mg. of pontocaine; each of 12 patients received 8 mg. and the remaining 12 received 10 mg. each. This solution, after being shaken thoroughly, was infiltrated into the spinal canal in a period of from fifteen to eighteen seconds. The patient was turned on his back immediately following the injection of the anesthetic agent. The sensory level was determined by means of pin pricks. An attempt was made to keep the level of skin anesthesia below the umbilicus (tenth thoracic), but frequently it rose to the ensiform cartilage and even to the nipple line. In 7 patients the level attained was the fourth thoracic; in 3 the fifth thoracic; in 11 the sixth thoracic; in 1 the eight thoracic, and in the remaining 3 the tenth thoracic segment.

Blood volume studies were performed several days before surgery and again ten to fifteen minutes after the spinal anesthetic was administered. The procedure utilized has been based on the work of Gibson and Evans (15, 16), Gibson and Evelyn (17), Gregersen, Gibson and Stead (18), Gregersen (19), and Clark, Nelson, Lyons, Mayerson and DeCamp (1, 2, 3). It was essentially the same as that utilized by the latter group, with slight modifications. The patients were in the fasting state and had been lying quietly for ten minutes prior to the test. Thirty cubic centimeters of blood was withdrawn from the antecubital vein without tourniquet compression. Evans Blue dye (T-1824),

5 cc., which had previously been measured in a calibrated syringe was injected into the same vein. The syringe was rinsed three times with blood which was reinjected. Ten minutes after the dye had been injected, another 30 cc. blood sample was drawn from the opposite antecubital vein without tourniquet compression. The syringes utilized for withdrawing the blood were heparinized prior to use. An hematocrit tube was filled and the remainder of the blood transferred to parafinized tubes. The Wintrobe hematocrit tube and the tubes containing the blood samples were centrifuged for thirty minutes at 3000 revolutions per minute. The optical density of the plasma was determined with a Lumetron photoelectric colorimeter, employing a 620 mu filter. The optical density of a standard was also determined. The plasma volume was calculated by multiplying a ratio (of the optical density of the standard to the optical density of the unknown) by 2500. The blood volume was then determined from the following formula:

$$\frac{\text{Plasma volume} \times 100}{100 - \text{Hematocrit}}$$

GENERAL DATA

In our series of 25 cases, the patients underwent the following operations: arthrotomy, bunionectomy, osteotomy, lumbar sympathectomy (4), fusion of knee, inguinal herniorrhaphy (11), incision and drainage of foot, saphenous ligation (2), appendectomy, skin graft (pinch), and pilonidal cystectomy. The average age of the patients was 37.5 years. Eleven cases were in the 20 to 30 year age group, 4 in the 30 to 40 year group, 3 in the 40 to 50 age group, and 6 in the 50 to 60 year group. One case was in the 60 to 70 year age group. Twelve patients received 80 mg. of glucose with 8 mg. of pontocaine, each. Twelve patients received 100 mg. of glucose with 10 mg. of pontocaine, respectively, and the remaining patient was given 6 mg. of pontocaine in 60 Gm. of glucose. The average amount of pontocaine used was 8.9 mg. in 89 mg. of glucose. The figures are reported in table 1.

PLASMA VOLUME AFTER ANESTHESIA

The average plasma volume before anesthesia was 2652 cc. After the anesthetic was administered the average plasma volume was 2750 cc. The total average rise was 98 cc. which was within the limit of error. Fifteen of our 25 patients showed a rise in plasma volume after being anesthetized; however, only 6 of these had significant rises. The average plasma volume increase among these latter 15 cases was 320 cc. In 2 cases the plasma volume remained the same, but in 8 cases it was depressed insignificantly following anesthesia. The average depression in this group was 170 cc., which was within the limit of error. These results are expressed in table 1. In the majority of cases (19, or 76 per cent) studied, the plasma volume was unaffected by spinal

TABLE 1

BLOOD VOLUME STUDIES BEFORE AND AFTER SPINAL PONTOCAINE ANESTHESIA

Case Number	Plasma Volume before Anesthesia	Plasma Volume after Anesthesia	Plasma Volume Elevated after Anesthesia	Plasma Volume Depressed after Anesthesia	Blood Volume before Anesthesia	Blood Volume after Anesthesia	Blood Volume Elevated after Anesthesia	Blood Volume Depressed after Anesthesia	Amount of Glucose Administered, mg.	Amount of Pontocaine Administered, mg.	Thoracic Level of Anesthesia Attained	Age of Patient, years	Type of Operation	Increase in Blood Cells after Spinal Anesthesia, cc.	Decrease in Blood Cells following Spinal Anesthesia, cc.
28390	2500	3175	675		5310	6350	1040		80	8	4	26	Arthrotomy	365	
28441	2175	2328	153		4531	5060	529		80	8	6	26	Bunionectomy	376	
28354	2400	2500	100		4615	5052	337		80	8	6	24	Osteotomy	237	
28129	2775	2677		98	5336	5249		87	100	10	5	68	Lumbar sympathectomy	11	
28348	3000	3075	75		6250	6406	156		80	8	5	35	Fusion of knee	81	
28345	3000	4500	1500		6122	8490	2368		100	10	8	25	Inguinal herniorrhaphy	868	
28127	3250	3500	250		5603	6250	647		60	6	10	54	Incision and drainage of abscess of foot	397	
28453	2300	2325	25		5348	5407	59		100	10	4	56	Lumbar sympathectomy	34	
28565	3125	3085		40	6127	6049		78	100	10	6	35	Inguinal herniorrhaphy		38
28634	2725	2812	87		5677	6248	571		80	8	5	28	Inguinal herniorrhaphy	484	
28671	2406	2175		231	4719	4627		92	100	10	6	50	Inguinal herniorrhaphy	139	
28691	2700	2500		200	6428	6410		18	80	8	4	31	Saphenous ligation	182	
28727	2625	2625			6104	6104			100	10	4	32	Appendectomy		
27876	2850	2525		325	4750	4855	105		100	10	4	53	Lumbar sympathectomy	430	
28756	3000	3675	675		5769	7500	1731		80	8	4	20	Saphenous ligation	1056	
28777	2500	2500			4807	5208	401		100	10	4	23	Lumbar sympathectomy	401	
28964	3125	2800		325	5712	5957	245		100	10	6	23	Inguinal herniorrhaphy and circumcision	570	
28987	2750	2700		50	5392	5510	118		100	10	6	50	Inguinal herniorrhaphy	108	
28933	2500	2500		90	5255	5102		183	100	10	6	56	Inguinal herniorrhaphy		93
28406	2000	2325	325		4444	4558	114		80	8	10	54	Skin graft (pinch)		261
29027	2575	3050	475		5597	6630	1033		80	8	6	27	Pilonidal cystectomy	558	
29044	2283	2328	45		4221	4476	255		100	10	10	53	Inguinal herniorrhaphy	210	
29088	2300	2625	325		4240	5048	808		80	8	6	24	Inguinal herniorrhaphy	483	
29105	2250	2265	15		4243	4530	287		80	8	6	41	Inguinal herniorrhaphy	272	
29141	2100	2175	75		4285	4182		103	80	8	6	25	Inguinal herniorrhaphy		178
Total Average	2652	2750	320	170	5236	5686	600	94	89	8.9	6	37.5		366	143

pontocaine ephedrine anesthesia. The minority of cases (6, or 24 per cent) showed a rise in plasma volume following spinal anesthesia (table 1).

BLOOD VOLUME AFTER ANESTHESIA

The average blood volume before anesthesia was 5236 cc. and after anesthesia was 5686 cc., with an average rise after anesthesia of 450 cc. This rise was within the limits of error of the method. Eighteen of the patients showed a rise in blood volume after being anesthetized, but in only 6 was the rise significant (24 per cent of the total). The average increase of blood volume in the cases in which an elevation occurred was 600 cc. Six patients had a depression of blood volume following anesthesia, but this depression was insignificant and within the limits of error of the method. The average depression was 94 cc. In the majority of cases the blood volume remained unchanged following spinal pontocaine ephedrine anesthesia with seconal, morphine and scopolamine premedication. The blood volume was elevated in 6 cases. Nine of the patients showed increases in both the plasma volume and cell volume. In 20 of our patients an increase in cell volume occurred. The average increase in cell volume following spinal anesthesia was 366 cc.; however, these figures were significant in only 7 cases as the remainder fell within the limits of error of the method. Four patients showed an insignificant depression in cell volume. These results are expressed in table 1.

SUMMARY

Blood volume studies were performed on 25 patients undergoing a variety of operations for which spinal pontocaine ephedrine anesthesia was utilized, with seconal, morphine and scopolamine premedication. Determinations were made several days before the patients were anesthetized and again ten to fifteen minutes after the anesthetic was administered. In the majority of cases the blood volume and plasma volume showed insignificant changes. In a small percentage of cases there was a rise in plasma volume and blood volume, respectively, following spinal anesthesia with the aforementioned technic.

CONCLUSIONS

There was no significant change in plasma or blood volume in the majority of patients receiving spinal pontocaine ephedrine anesthesia, with seconal, morphine and scopolamine premedication.

A small percentage of patients showed an elevation of plasma volume and of blood volume, following spinal pontocaine ephedrine anesthesia, with seconal, morphine and scopolamine premedication.

REFERENCES

1. Clark, J. H.; Nelson, W.; Lyons, C.; Mayerson, H. S., and DeCamp, P.: Chronic Shock: The Problem of Reduced Blood Volume in the Chronically Ill Patient, Ann. Surg. 125: 618–646 (May) 1947.

2. Lyons, C., and Mayerson, H. S.: The Surgical Significance of Hemoglobin Deficiency in Protein Depletion, J. A. M. A. **135**: 9–10 (Sept. 6) 1947.
3. Nelson, W.; Mayerson, H. S.; Clark, J. H., and Lyons, C.: The Blood Volume in Health and Disease, Mod. Med. **16**: 35–40, 97–108 (Feb. 1) 1948.
4. Best, C. H., and Taylor, N. B.: The Physiological Basis of Medical Practice, Baltimore, The Williams & Wilkins Company, 1945, pp. 14–26.
5. McAllister, F. F.: The Effect of Ether Anesthesia on Plasma and Extracellular Fluid, Am. J. Physiol. **124**: 391–399 (Nov.) 1938.
6. Bonnycastle, D. D.: The Effect of Some Anesthetic Agents on the Volume of Body Fluid, J. Pharm. & Exper. Therap. **75**: 18–29 (May) 1942.
7. Conley, C. L.: The Effect of Ether Anesthesia on the Plasma Volume of Cats, Am. J. Physiol. **132**: 796–800 (Apr.) 1941.
8. Stewart, J. D., and Rourke, G. M.: Changes in Blood and Interstitial Fluid Resulting from Surgical Operation and Ether Anesthesia, J. Clin. Investigation **17**: 413–416 (July) 1938.
9. Gibson, John H., and Branch, Charles D.: Blood Volume Changes during Surgical Procedures, Surg., Gynec. & Obst. **65**: 741–747 (Dec.) 1937.
10. Bollman, J. L.; Svirbely, J. L., and Mann, F. C.: Blood Concentration Influenced by Ether and Amytal Anesthesia, Surgery **4**: 881–886 (Dec.) 1938.
11. Hamlin, Edward, and Gregersen, Magnus I.: The Effect of Adrenaline, Nembutal and Sympathectomy on the Plasma Volume of the Cat, Am. J. Physiol. **125**: 713–721 (Apr.) 1939.
12. Searles, P. W.: The Effect of Ether and Sodium Amytal Anesthesia on the Blood, Am. J. Surg. **41**: 399–404 (Sept.) 1938.
13. Searles, P. W., and Essex, H. E.: Changes in Blood in the Course of Ether Anesthesia and Sodium Amytal Anesthesia, Proc. Staff Meet., Mayo Clin. **11**: 481–483 (July) 1936.
14. Adriani, J.: The Chemistry of Anesthesia, Springfield, Illinois, Charles C. Thomas, 1946, p. 333.
15. Gibson, J. G., 2nd, and Evans, W. A., Jr.: Clinical Studies of the Blood Volume. I. Clinical Application of a Method Employing the Azo Dye "Evans Blue" and the Spectrophotometer, J. Clin. Investigation **16**: 301–315 (May) 1937.
16. Gibson, J. G., 2nd, and Evans, W. A. Jr.: Clinical Studies of the Blood Volume. II. The Relation of Plasma and Total Blood Volume to Venous Pressure, Blood Velocity Rate, Physical Measurements, Age, and Sex in Ninety Normal Humans, J. Clin. Investigation **16**: 317–328 (Jan.) 1937.
17. Gibson, J. G., 2nd, and Evelyn, K. A.: Clinical Studies of the Blood Volume. IV. Adaptation of the Method to the Photoelectric Colorimeter, J. Clin. Investigation **17**: 153–158 (Mar.) 1938.
18. Gregerson, M. I.; Gibson, J. G., 2nd, and Stead, E. A.: Plasma Volume Determination with Dyes; Errors in Colorimetry; Use of the Blue Dye T-1824, Am. J. Physiol. **113**: 54–55 (Sept.) 1935.
19. Gregersen, M. I.: A Practical Method for the Determination of Blood Volume with the Dye T-1824, J. Lab. & Clin. Med. **29**: 1266–1286 (Dec.) 1944.