

RENAL FUNCTION DURING ANESTHESIA FOR CARDIOVASCULAR SURGERY

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MORE than half a century ago it was found that ether anesthesia in man produced oliguria with depression in sodium and nitrogen excretion.¹⁹ Since then, both clinical and laboratory observations on the effects of general anesthetic agents on kidney function have indicated only small variation in this theme of renal suppression. In recent years, however, techniques and concepts in anesthesiology have altered as a result of the introduction of the muscle relaxants. These drugs have made possible the achievement of a quiet operative field with lighter planes of anesthesia. Another innovation leading to the use of reduced quantities of anesthetic agents has been the concept of "balanced anesthesia" in which multiple anesthetic agents are employed in the same patient, but each in small quantities. A clinical appraisal of the effects on renal function of these newer anesthetic techniques which we have employed during cardiovascular operations would appear valuable. In this study, renal hemodynamics, together with water and electrolyte excretion, were determined before and after induction of anesthesia, but prior to the commencement of major cardiovascular operations.

METHODS

The subjects of this study were 24 male and female patients, ranging in age from 11 to 66 years. Nine of these patients subsequently underwent open cardiac surgery for repair of congenital or acquired intracardiac defects and 15 underwent resection of thoracic aneurysms with graft replacement. Each patient was studied during two periods: (1) a control period prior to induction of anesthesia, but 30 to 45 minutes following administration of premedicating drugs, and (2) an anesthesia period which began approximately 30 minutes

after induction of anesthesia. During the control period, measurements were made over three separate 10-minute intervals and during the anesthesia period measurements were made over two 10-minute intervals. Measurements included mean blood pressure, glomerular filtration rate, renal blood flow, and excretion of water and electrolytes. Mean blood pressure was calculated from the auscultatory determination by adding one-third the pulse pressure to the diastolic pressure. Inulin clearance was used to determine glomerular filtration rate and para-aminohippurate to obtain renal plasma flow. Renal blood flow was derived from renal plasma flow with the hematocrit. Plasma and urine determination of sodium and potassium were made using a Beckman Flame Photometer. Methods and techniques have been described previously.¹⁵

Premedication for all patients consisted of the following drugs and doses for the 150 pound patient: promethazine 25 mg., meperidine 50 mg., and scopolamine 0.4 mg. Premedication for individual patients was adjusted for body size and decreased in those debilitated by their disease. By the design of this study the effects of these drugs were present during both observation periods. In nineteen of the 24 patients anesthesia was induced with 100 to 200 mg. of 2 per cent thiopental intravenously followed by 50 per cent cyclopropane in oxygen. In five anesthesia was induced with 50 per cent cyclopropane. When consciousness was lost, 0.1 per cent succinylcholine was administered by intravenous drip. When respiration became inadequate the patient's lungs were manually ventilated with cyclopropane in oxygen and tracheal intubation accomplished when apnea developed. The time required from induction to tracheal intubation was usually 5 to 10 minutes. Following tracheal intubation, cyclopropane was discontinued, the rebreathing bag was emptied, and ether added to the system with an oxygen flow rate of 1 to 2 liters per

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TABLE 1
THE EFFECT OF ANESTHESIA ON RENAL HEMODYNAMICS AND WATER AND ELECTROLYTE EXCRETION

Patient	Age	Sex	Mean Blood Pressure (mm. Hg.)		Glomerular Filtration Rate (ml./minute)		Renal Blood Flow (ml./minute)		Hematocrit		Urine Volume (ml./minute)		Na Plasma (mEq./l.)		K Plasma (mEq./l.)		Na Urine (mEq./minute)		K Urine (mEq./minute)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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Key: C: Control observations—average of three 10 minute periods. An: Observations during anesthesia—average of two 10 minute periods.

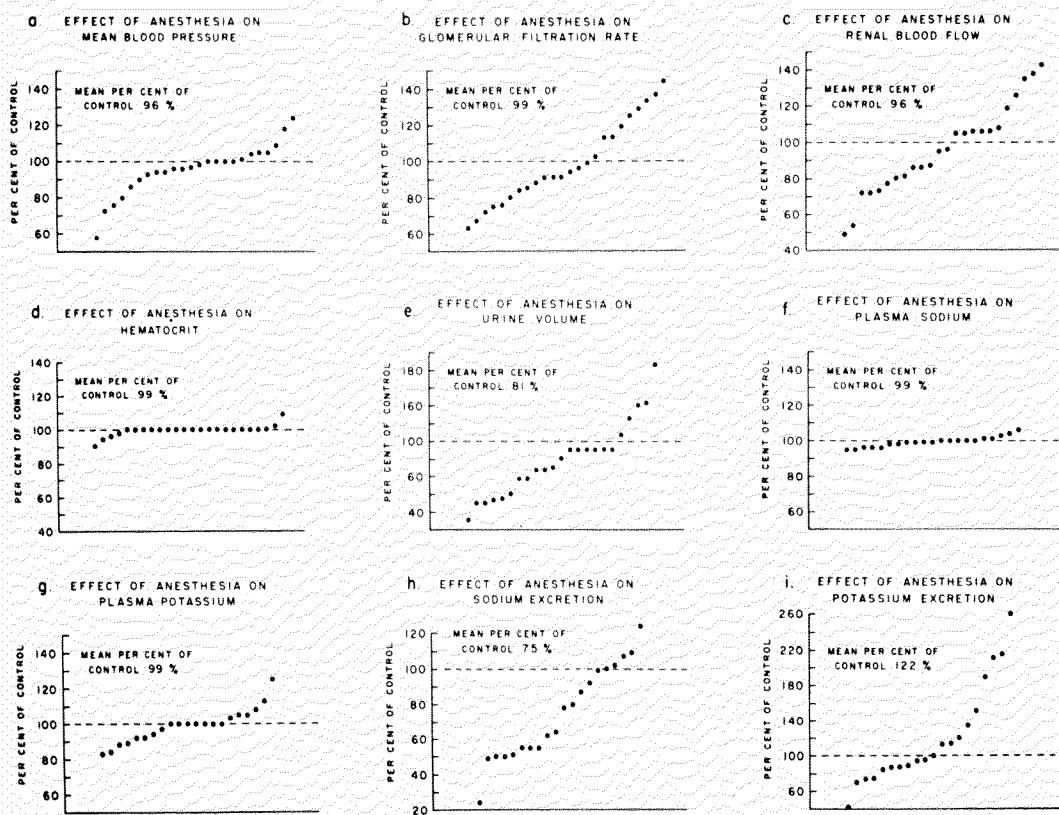


FIG. 1. Graphs *a* through *i* illustrate range of effects of light general anesthesia on renal hemodynamics in 24 patients before major cardiovascular operations. The per cent change for each patient has been plotted and the mean indicated.

minute and the Heidbrink ether vaporizer set between 4 and 6. The administration of ether-oxygen with succinylcholine and with frequent emptying of the rebreathing bag to eliminate cyclopropane was continued for an additional 20 minutes. Respiration was controlled in all patients. A Jefferson Ventilator was used in two-thirds of the patients. Ether was decreased, discontinued or removed when hypotension or cardiac arrhythmia appeared. Vaso-pressor agents were avoided during this study. Approximately 30 minutes following induction of anesthesia and after at least 20 minutes of ether-oxygen, the patient was assumed to be in a reasonably steady anesthetic state. Ether administration was reduced (Heidbrink vaporizer reading 2-3) and the anesthesia measurement period begun. A total of 100-300 mg. of succinylcholine was administered from in-

duction of anesthesia to the end of the anesthesia period.

The anesthetic being studied here was essentially light ether-oxygen supplemented with succinylcholine, a technique which we have used in more than 3,000 cardiac and vascular surgical procedures. No measurement was made of the arterial ether concentration in these patients. However, in a group of 14 female patients less than 40 years of age who were anesthetized by an identical technique for a variety of gynecological procedures, the mean arterial ether concentration 30 minutes after induction was found to be 49.7 ± 1.27 mg. per cent (range 19.7-85.3).¹¹ It is likely that the mean arterial ether concentration in the patients in this study was significantly less than this since many were older and all suffered from cardiac or vascular disease. The administration of ether in these patients

was often discontinued or performed intermittently because of the development of hypotension. The data collected were considered as a unit since no significant differences were found when analyzed for age, sex, or type of surgical procedure subsequently performed.

RESULTS

The data are summarized in table 1. The mean age for the 24 patients was 44 years with a range from 11 to 67 years. The average mean blood pressure before operation was 101 mm. of mercury, reflecting the frequency of preoperative hypertension in this group. During anesthesia blood pressure was maintained at 96 per cent of the control level (fig. 1a). Glomerular filtration rate averaged 78 ml. per minute before induction of anesthesia and was sustained at 99 per cent during anesthesia (fig. 1b). The mean control renal blood flow for the group was 847 ml. per minute and remained at 96 per cent during anesthesia (fig. 1c). Urine volume showed a slight reduction (81 per cent) during anesthesia, which was not statistically significant (fig. 1e). Plasma sodium and potassium were unaltered (fig. 1f and 1g). Urine sodium excretion was reduced 25 per cent but this was not statistically significant ($p > 0.4$) (fig. 1h). Potassium excretion rose 22 per cent but this also was not statistically significant ($p > 0.4$) (fig. 1i).

EFFECT OF ANESTHESIA ON RENAL HEMODYNAMICS AND WATER AND ELECTROLYTE EXCRETION

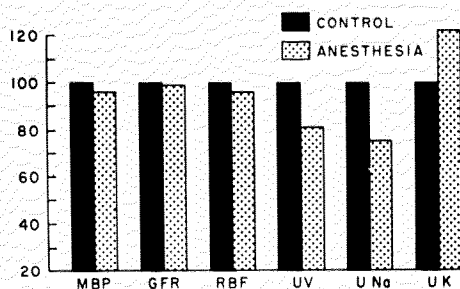


FIG. 2. Graphs illustrate mean effects of light general anesthesia on renal hemodynamics and water and electrolyte excretion in 24 patients. Changes in blood pressure (MBP), glomerular filtration rate (GFR), and renal blood flow (RBF) were not significant. Moderate depression in water (UV), and sodium excretion (UNa) with an elevation in potassium excretion (UK) suggest adrenal cortical activity although these alterations were not statistically significant.

Although the moderate depression in sodium and water excretion and elevation in potassium excretion had no statistical significance, some adrenal cortical activity is suggested (fig. 2).

COMMENT

Some previously reported studies indicating suppression of renal function during general anesthesia may not be entirely valid because operative procedures preceded or were concomitant with the period of observation.^{3, 4, 8} Despite this, evidence suggests that any general anesthetic sufficient to maintain third stage anesthesia significantly reduces renal blood flow, glomerular filtration and urine volume.^{1, 2, 7, 14, 17-20} On the other hand, it has been demonstrated in the dog that light anesthesia with ether or cyclopropane produced no depression in renal plasma flow and glomerular filtration rate⁴ and that thiopental, even in large doses, did not depress renal function.¹ The effects of narcotics used for premedication are similar. The antidiuretic effect of morphine is well documented.^{5, 6, 9, 10} The renal effects of meperidine used in this study have not been as thoroughly evaluated as those of morphine but suggest a similar action.^{8, 13}

Considering the renal depressant effect of drugs for premedication and anesthesia together with the water and salt retention associated with any major surgical procedure, it is not surprising that many anesthesiologists and surgeons tend to restrain the administration of intravenous fluids during operation. The data presented here showing that light anesthesia with the liberal use of muscle relaxants permits nearly normal renal function are most significant in this regard. Evidence continues to accumulate that an adequate urinary output protects the kidney when it is exposed to insult.^{12, 15, 21} Such insults are likely during operations which may be associated with hemorrhage, transfusions, tissue trauma, dehydration and hypotension. Therefore it is important that urinary output be maintained during such operations. In addition to protecting the kidney, an adequate renal function can serve to help maintain acid-base balance during anesthesia and operation.

The observations in this study were made between 30 and 60 minutes following induc-

tion of anesthesia and the changes in renal function were found to be minimal. One can infer that no greater change would have been observed if the study could have been prolonged.

SUMMARY

The renal depressant effect of deep general anesthesia has been observed clinically and experimentally. With the availability of muscle relaxants there has been a trend in clinical anesthesia toward the use of minimal quantities of general anesthetic agents and increasing quantities of muscle relaxants. With such anesthesia, no significant alteration in renal function was found in a study of 24 patients prepared for major cardiovascular operations.

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