# ANASTHESIA FOR SIMULTANEOUS BILATERAL NEPHRECTOMY

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## INTRODUCTION

BILATERAL SIMULTANEOUS NEPHRECTOMY is a important surgical procedure prior to renal transplant. Any anaesthetist may be asked to anaesthetize for this operation, as these procedures may be carried out in centres other than those where the renal transplant may be performed at a later date The anaesthetic problems in bilateral nephrectomy are not unlike those associated with renal transplantation. Although the change to cadaveric donors has widened the scope of renal transplantation, there are advocates of a return to living donor transplants, on the basis that the risks involved in nephrectomy in a healthy adult are now so minimal that this approach is justified.[1] This places more emphasis on the necessity for a clear understanding of the problems associated with simultaneous bilateral nephrectomy.

Although undoubtedly the primary indication for simultaneous bilateral nephrectomy is to prepare for cadaveric renal transplantation, some authors have advocated this procedure for the control of malignant hypertension.[2]

Many authors have described the possible serious complications of standard anaesthetic techniques in uraemic patients. Complicated approaches to the problem have been suggested and several agents in common use have been condemned. The main controversy has centred around the use of muscle relaxants. However, improvement in the preparation of patients for renal transplantation by efficient haemodialysis and recent new knowledge of the pharmacology of muscle relaxants have rendered many of these arguments invalid.

The common denominator in bilateral nephrectomy and kidney transplantation is terminal renal failure, which often is exacerbated by concomitant disease. Despite the fact that patients are nowadays much better prepared by haemodialysis, yet by the standards of normal anaesthetic practice they remain extremely poor risks. Nevertheless, the anaesthetic techniques usually employed for abdominal surgery, with specific consideration of the unique problems of these patients, have proved safe and effective.

This paper describes 126 consecutive operations for simultaneous bilateral nephrectomy in preparation for cadaver transplantations. There were no deaths in this series.

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PRE-OPERATIVE CONSIDERATIONS: ASSESSMENT AND PREPARATION

During the years from 1967 to 1970, 126 patients have had simultaneous bilateral nephrectomy performed at the Vancouver General Hospital.

A. *Indications and Advantages*

The following indications were considered *absolute* for bilateral nephrectomy:

(1) *Conditions which threaten the survival of the patient or a future transplanted kidney*:

(*a*) *Severe hypertension (as reflected in organ damage)*: In the past few years some patients with malignant hypertension of renal origin have been subjected to bilateral nephrectomy as a life-saving measure when all conservative treatment had failed. Emergency bilateral nephrectomy in a patient with uncontrolled hypertension, hypertensive encephalopathy, congestive heart failure, hydrothorax, pericarditis and the acid-base and electrolyte abnormalities which accompany renal failure, is one of the most challenging problems for the anaesthetist. In this series two of the twelve patients with malignant hypertension presented in this manner. To prepare these patients for nephrectomy, an arterio-venous shunt is established and haemodialysis is instituted. Heart failure is brought under control. Electrolyte imbalance is corrected as well as possible. During anaesthesia these patients may develop either hypotension or hypertension. Blood volume replacement becomes a matter of exquisite judgment, to balance between over-loading and under-replacement. In this connection Davidov *et al.*[3] found that the immediate decreases in blood pressure in 17 hypertensive patients treated with furosemide (Lasix®) were associated with decreases in plasma volume, cardiac output and extracellular fluid volume and with increased urinary sodium excretion. The depression of blood pressure could be reversed by the administration of glucose solution alone, suggesting that the changes in arterial pressure were largely related to changes in extracellular fluid volume.[4]

(*b*) *Infection of the urinary tract*, past or present.

(*c*) *Gross reflux* which predisposes to infection.

(2) *Large polycystic kidneys* which might interfere with renal transplantation by virtue of their size.

(3) *Symptomatic or bleeding kidneys*, generally polycystic.

(4) Grossly *abnormal urinary sediment* which might make assessment of function of the transplanted kidney difficult.

*Relative indications of a more controversial nature include*:

(1) *Mild or benign hypertension despite adequate dialysis*: any degree of hypertension is probably an unnecessary stress on a future transplanted kidney.

(2) *Removal of antigen*: in those cases where the original renal disease is due to endogenous production of antibodies directed at the kidney basement membrane. This refers to those cases described by Dixon[5] as having linear intraglomerular deposition on the subendothelial side of the basement membrane.

(3) Ability to use recipient's ureter in the subsequent transplant.

(4) Transplant specificity of the urine sediment, facilitating assessment of the transplanted kidney's function.
(5) Relief of peripheral neuropathy associated with terminal renal failure.

B. *Disadvantages of Bilateral Nephrectomy*

(1) *Decrease in haemoglobin*: This may have a two-pronged effect:
  (*a*) Cardiac work is increased, which may lead to angina and/or marked fatigue in some patients.
  (*b*) An increased number of blood transfusions are required to overcome the symptoms associated with the severe anaemia. These in turn produce problems in their own right:
    (i) *Hepatitis*: although blood negative for Australian antigen is used, there are reports in the literature[6] that hepatitis has followed transfusions with such blood in from 6 per cent to 30 per cent of cases.
    (ii) Sensitization to transplant antigens may develop from leukocytes in the transfused blood. Although the cells be washed, about 10 per cent of leukocytes remain.
    (iii) The increased iron load may become a problem in a patient requiring numerous transfusions, leading to haemosiderosis.
(2) Elective bilateral nephrectomy is an additional surgical procedure of some magnitude. For example, in Schwartz's series[7] six of 26 patients died. In our series of 126 patients there has been no death associated with anaesthesia within a four-month post-operative follow-up period.
(3) Turcotte[8] has recently reported oliguria in homografts associated with patients who had undergone nephrectomy 25 days or less before transplantation. Further investigation might reveal a definite relationship to nephrectomy, although it is difficult to imagine what that relationship might be.

C. *Composition of the Group of Patients Reported*

This series included 126 patients who were subjected to bilateral nephrectomy in preparation for cadaver renal transplantation. The distribution of disease types is summarized in Table I.

There were 76 males and 50 females. The average age was 33 years, the range being 14 to 55 years.

The pathophysiological effects of terminal renal failure are summarized in Table II. A good representation of these defects were noted in every patient without dialysis. In most instances, however, the defects were corrected as much as possible in an attempt to bring patients to an optimum state prior to bilateral nephrectomy. Thirty-one patients in the series had other conditions, both related and unrelated to their kidney disease, as for example bronchial asthma, bronchitis, hepatitis, and sickle cell anaemia.

D. *Preparation of the Patient*

(*a*) *Panendoscopy, cystoscopy, cystogram* and *intravenous pyelogram* (I.V.P.) were performed to assess the status of the lower urinary tract and to exclude

TABLE I

PRIMARY RENAL PATHOLOGY LEADING TO TERMINAL RENAL FAILURE

| Disease | Number of Patients |
|---|---|
| Glomerulonephritis | 64 |
| Pyelonephritis (chronic) | 33 |
| Polycystic Disease | 12 |
| Hypoplastic kidneys | 2 |
| Neurogenic bladder and bilateral hydronephrosis | 1 |
| Gout | 1 |
| Malignant hypertension | 12 |
| Amyloid Disease | 1 |

TABLE II

PATHOPHYSIOLOGICAL EFFECTS OF TERMINAL RENAL FAILURE

| | |
|---|---|
| Blood urea | increased |
| Blood creatinine | increased |
| Creatinine clearance | decreased below 5 ml/min |
| Urinary pH | decreased below 6.0 |
| Bicarbonate | decreased |
| Sodium chloride retention | oedema—increased tendency to hypertension |
| Serum potassium | increased |
| Rbc and haemoglobin | decreased |

any abnormalities which might contraindicate transplantation in the future. A retrograde pyelogram was performed, if this was judged to be indicated.

(*b*) *Correction of Clotting Abnormalities*: Many of these patients are heparinized to prevent shunt clotting. In most instances a six-hour period was allowed between the preceding dialysis and nephrectomy, to allow destruction of the heparin used in the dialysis. Dicoumarins were discontinued four days pre-operatively and if bleeding tendencies were suspected, coagulograms were done.

(*c*) *Assessment of Blood Volume*: Deficiencies in blood volume were judged by postural changes in blood pressure following pre-nephrectomy dialysis, and replacement was done with 0.25 per cent saline, 5 per cent dextrose, lactated Ringer's solution or 2.5 per cent dextrose at a rate of 10 ml/kg per 24 hours.

(*d*) *Hypertension*: For purposes of this series hypertension is defined as a state of raised diastolic blood pressure associated with left ventricular enlargement and retinal changes. The majority of patients in the series qualified under these criteria. Twelve patients presented with malignant hypertension, and 80 per cent of them were receiving one or more antihypertensive drugs. It was a matter of clinical judgment as to whether antihypertensive agents such as methyldopa (Aldomet®) or guanethidine (Ismelin®) were discontinued prior to bilateral nephrectomy, or whether they might be replaced by less potent antihypertensive drugs. If the decision was to discontinue these drugs, a five-day pre-operative waiting period was instituted in the case of methyldopa and fourteen days in the case of guanethidine. In several instances patients who were given general anaesthesia during continued treatment with methyldopa or guanethidine had marked cardiovascular instability during and immediately after operation.

(*e*) *Antibiotics and Neuromuscular Block*: It is well known that intraperitoneal

or intrapleural streptomycin, neomycin and polymixin may produce prolonged apnoea by enhancing the effects of non-depolarizing muscle relaxants.[9] Although these antibiotic preparations were used by injection or by the oral route, these patients do not metabolize such drugs well, so that administration of a standard dose carries a greatly increased risk of potentiating or causing neuromuscular block. One of our patients with bilateral nephrectomy underwent laparotomy for intestinal obstruction. He had three mega units of kanamycin (Kaptrex®) daily and a single dose of 1 gm of Streptomycin and following a standard curarizing dose of d-tubocurare during operation he required mechanical ventilation for 36 hours post-operatively. In three other instances kanamycin was administered by intravenous drip in the immediate post-operative period and produced respiratory insufficiency six, nine and ten hours later, in patients in whom it was considered that curarization had been completely reversed. Return to normal ventilation followed intravenous atropine and prostigmine.

(*f*) *Haemodialysis*: Haemodialysis was carried out in all patients on the day preceding nephrectomy or at least six hours before operation. There is no doubt that this is the most effective way of correcting the effects of chronic renal failure.[10] It removes urea, corrects electrolyte imbalance, and restores normal fluid balance. All patients in this series were on dialysis, some on haemodialysis and some on peritoneal dialysis.

(*g*) *Shunt Care*: Care of the dialysis shunt was emphasized pre-operatively to ensure its proper function in the pre-nephrectomy phase. The limb was splinted to prevent damage to the shunt and we avoided the use of a blood pressure cuff on that limb.

(*h*) *Site for Intravenous Infusion*: The forearm veins were avoided in intravenous therapy in order not to jeopardize future shunt sites.

(*i*) *Assessment of Anaemia*: These patients are invariably anaemic. Anaemia develops gradually *pari passu* with expansion of plasma volume. The anaemia is normocytic, normochromic and is refractory to usual therapy. Both blood transfusions and anaemia increase the potential hazard of development of pulmonary oedema. Blood transfusions also increase the possibility of stimulation of antibody formation. Washed pack cells were most commonly used to raise the haemoglobin level to 7 gm per cent, a level which was found to be adequate for anaesthesia and operation in these patients. The average haemoglobin and serum electrolyte levels of the patients included in this series at the time of anaesthesia are shown in Table III.

In most instances, adequate preparation produced nearly normal serum electrolytes, but the BUN remained elevated and the anaemia was profound.

## Operative Considerations

### A. *Operative Approaches*

Transabdominal, flank, thoraco-abdominal and prone approaches were used for the operation. The choice of approach was influenced by the size and site of the kidneys to be removed, by the presence of perirenal disease which might necessitate

TABLE III

PRE-ANAESTHETIC HAEMOGLOBIN AND SERUM ELECTROLYTES IN PATIENTS FOR SIMULTANEOUS BILATERAL NEPHRECTOMY

| Investigations | Average | Range | |
|---|---|---|---|
| | | Low | High |
| Haemoglobin (gm%) | 7.6 | 4.3 | 11.8 |
| Blood urea (mg%) | 111 | 15 | 256 |
| Serum Sodium (mEq/litre) | 129 | 117 | 156 |
| Serum potassium (mEq/litre) | 4.4 | 3 | 7.2 |
| Serum bicarbonate (mEq/litre) | 24 | 13 | 32 |

TABLE IV

DISEASE AND SURGICAL APPROACH FOR NEPHRECTOMY

| Disease | | Surgical Approach |
|---|---|---|
| Atrophic | Polycystic | |
| 19 | | Transabdominal |
| 91 | | Simultaneous prone |
| | 12 | Transabdominal |
| | 4 | Lateral thoracoabdominal (1)<br>11th rib removed (3) |

TABLE V

BLOOD LOSS DURING SURGERY (IN THE 110 ATROPHIC DISEASE CASES)

| Surgical Approach | Blood Loss |
|---|---|
| Transabdominal | 440 cc |
| Simultaneous prone | 500 cc |

a larger area of exposure, or by the presence of gross reflux, necessitating ureterectomy (Table IV).

Blood loss during operation in the 110 atrophic cases was comparable in the transabdominal and simultaneous prone approaches. Blood loss was attributed mainly to impaired haemostasis rather than to gross bleeding. The amount of blood lost was also a factor of the operating time which averaged two- to two-and-one-half hours. A summary of the blood lost during operations is presented in Table V.

B. *Conduct of the Anaesthesia*

The choice of agents is not critical, provided they are used judiciously and that there is thorough familiarity with their potential side-effects.

(*a*) *Premedication* was usually minimal. Either none was given at all or promethazine 10 mg to 25 mg, or diazepam 10 mg was administered one hour pre-operatively. Atropine was usually administered intravenously at the time of induction.

(*b*) *Induction*

The lack of superficial veins for intravenous induction and for transfusion may be a major problem in these patients. Many of them have had several

shunts and have had numerous samples of blood removed for biochemical analysis. Meticulous care must be exercised to safeguard the shunt. The patient's life may depend upon it in the first few weeks post-nephrectomy. The shunt area is wrapped in cotton gauze to prevent trauma leading to stasis and clotting. The arm is placed by the side. The shunt is not used for the administration of drugs, although, if an arterial line is not established, samples of blood for blood gas determinations may be taken from the shunt. The veins on the back of the hand are used whenever possible, to avoid damaging valuable forearm veins. A central venous pressure line (CVP) is established when possible.

A five-minute period of pre-oxygenation was allowed. Induction of anaesthesia was usually with intravenous thiopentone. Oro-tracheal intubation followed succinylcholine and relaxation during maintenance was achieved with d-tubocurare. In a number of patients tracheal intubation was done with d-tubocurare relaxation. Sterile tracheal tubes, connectors, catheter mounts and laryngoscope blades were used because of the danger of infection.

(*c*) *Maintenance of anaesthesia*

In the majority of instances a technique was used for maintenance which incorporated d-tubocurare, nitrous oxide, oxygen and intermittent positive pressure breathing. In 90 patients anaesthesia was supplemented with halothane. Halothane was never used in more than a 1 per cent concentration and usually at 0.5 per cent. In 12 patients, nitrous oxide was supplemented with intravenous narcotic drugs, using minimal injections of morphine (3 mg increments), meperidine (10 mg increments), or alphaprodine (6 mg increments).

Controlled ventilation is necessitated by the prone position or the thoracic approach. Many of these patients had large kidneys which hampered movement of the diaphragm and tended to impede ventilation under general anaesthesia. Controlled ventilation was regulated to maintain blood gases at near normal values. I.P.P.B. is particularly recommended if there is evidence of incipient pulmonary oedema.

Antihypertensive drugs were usually no problem because the patients had been weaned off them and drugs which are not a hazard to cardiovascular stability had been substituted for the more potent ones. No vasopressors were used. Hypotension was usually due to blood loss and was treated by transfusion, often using packed cells in the first instance. The supine hypotensive syndrome occurred on more than one occasion, usually in association with a large polycystic kidney. It tended to occur when the large kidney was displaced onto the inferior vena cava in the course of dissection of the renal pedicle.

Per-operative hypertension was noticed by Strunin,[12] particularly when the clamps were released from the renal pedicle. This was not a common problem in this series, nor in that reported by Samuel and Powell.[10] Hexamethonium or chlorpromazine were used for control of the blood pressure in the latter series. We have found that with halothane per-operative hyper-

tension is no problem and the blood pressure can be controlled by adjusting the concentration of halothane. At termination of general anaesthesia all patients who had received curare were given neostigmine 2.5 mg and atropine 0.6 mg to 1.2 mg intravenously. Reversal always appeared satisfactory despite occasional elevation of serum potassium levels.

(*d*) *Discussion of Agents and Techniques*

*Regional Techniques*: Vandam in 1962[13] and Wyant in 1967[14] have advocated regional anaesthesia, particularly for renal transplantation. However, in some instances a general anaesthetic supplement was used as well. Since in this series the patients were most commonly in the prone position or a thoracoabdominal approach was used, it was felt that oro-tracheal general anaesthesia was preferable. However, three of our patients received continuous peridural anaesthesia, with light general anaesthetic supplement and tracheal intubation.

*Inhalation Agents*

*Halothane*: Strunin[12] used halothane in concentrations high enough to act as the sole or the main agent, but this led to unpredictable hypotension in patients with abnormal plasma volumes following dialysis. In this series halothane was used as an intermittent supplement to nitrous oxide-oxygen anaesthesia, and served secondarily as an easily controllable antihypertensive agent. Profound muscle relaxation was not possible with halothane alone in the concentrations used, so that muscle relaxants were added.

*Methoxyflurane*: Crandell[15] first suggested that methoxyflurane had direct nephrotoxic properties. Subsequent reports appear to substantiate this. However, this need not be a matter for concern in an already damaged kidney for nephrectomy and some patients did receive this agent. There were no particular problems when it was used in the concentrations administered, which were always below 0.5 per cent.

*Muscle Relaxants*

*Succinylcholine*: Strunin[12] advocated the intermittent use of intermittent succinylcholine. Theoretically there are disadvantages to this approach. Patients with chronic renal failure, unless recently and effectively dialyzed, are often hyperkalaemic.[16] A significant rise in the serum potassium level has been shown in patients given succinylcholine, and this reaches its peak 60 minutes after injection.[17,18] However, this rise is less after induction with thiopentone than with halothane. Intravenous atropine (0.6 mg) does not fully protect the patient from cardiac arrhythmias following subsequent doses of succinylcholine.[19] We have not demonstrated prolonged apnoea from a single dose of succinylcholine in any of our cases. Desmond[20] has shown that pseudocholinesterase levels are in fact not reduced following haemodialysis, although some workers[21,14] had previously described low plasma pseudocholinesterase levels following dialysis.

*Gallamine*: In dogs gallamine is excreted entirely by the kidneys.[22] In the absence of renal function, a sustained level of gallamine was obtained in

these experiments. Clinically, Churchill-Davidson[23] quoted a case in which a boy was mistakenly given 380 mg of gallamine during an operation for exploration of a kidney transplant. He remained apnoeic for three days until the situation was reversed by dialysis. One of our patients was inadvertently given gallamine and had prolonged apnoea for six hours, despite what was felt to have been adequate reversal with prostigmine-atropine. By current consensus gallamine is not considered a suitable agent for patients with reduced renal function.

*D-tubocurare*: The basis of our technique was the use of d-tubocurare with intermittent positive pressure, intermittent halothane and, on occasion, intermittent narcotic analgesics. D-tubocurare had been used cautiously, if at all, by workers in this field and this may have been because the mechanism of its excretion was thought to be mostly renal, although some had been shown to be metabolized in the liver.[12,21,24–26]

Cohen,[27] using titriated d-tubocurare, has now demonstrated in dogs that, in the absence of renal function, the liver was able to excrete up to 40 per cent of a given dose of curare in the bile within a few hours. This alternative route of excretion explains the absence of a prolonged effect in the anuric patient.

Dhuner and his colleagues in 1968[28] described a series of 56 renal transplants in which recipients received essentially the same anaesthesia as that reported in this series. They noted that when the same patients returned to operation for bilateral nephrectomy at a later date and when their transplanted kidneys were working well, that their requirement for curare was the same as it had been when they had no renal function. Experience in this series has been similar. There has been no case of prolonged action of curare nor of difficulty in reversing its effect at the end of the operation.

(*e*) *Recovery*

Following P.A.R. care, further recovery usually takes place on a general urological ward with specially experienced nurses in attendance. If isolation is required the patient is transferred directly to the Intensive Care area. In either case, the patient is transferred to the dialysis unit of the renal ward as soon as it is convenient.

## RESULTS: POST-OPERATIVE CONSIDERATIONS

There were no deaths associated with anaesthesia in the 126 consecutive patients in this series during a four-month follow-up period after simultaneous bilateral nephrectomy.

A. *Surgical Complications*

There were no intra-operative surgical complications. However, several complications were seen in the early post-operative period.

(1) *Pneumothorax* occurred once in association with a thoraco-abdominal nephrectomy as the result of faulty chest suction.

(2) *Acute haemorrhage* requiring re-exploration occurred in one patient on the fifth post-operative day. It was due to heparinization, necessitated by the

revision of a shunt. This underlines the importance of meticulous pre-operative care of the shunt.

(3) In two patients *recurarization* occurred in the post-anaesthetic period at eight and ten hours respectively. This was believed to be related to the introduction of intravenous kanamycin in the early post-operative period. It was promptly recognized and treated with tracheal re-intubation, mechanical ventilation and reversal with prostigmine and atropine.

(4) *Significant ileus* requiring nasogastric suction, occurred in three patients who had nephrectomy by the trans-abdominal approach.

(5) *Chest infection* requiring antibiotic therapy occurred in three patients; one had a thoraco-abdominal incision and the other two had been operated by a trans-abdominal approach. Anaesthesia may have been contributory to these problems.

(6) *Psychosis* was a problem in one patient. She required psychiatric treatment.

(7) *Pelvic abscess* occurred in one patient who, during nephrectomy by trans-abdominal approach had an incidental appendectomy, a procedure with which we strongly disagree.

(8) *Shunt clotting* occurred in six patients and revision of the shunt was necessary in three of these.

B. *Anaesthetic Complications*

(*a*) *Major Complications*

In only five patients was there a major problem, and in only one was there a long-term sequel.

(1) *Pulmonary oedema* occurred in two patients; one of these was severe and acute.

(2) *Cardiac arrest* occurred at the end of the operation in one case. This was reversed immediately by external cardiac compression. In one series, reported by Lunding in 1964,[29] 58 anaesthetics were given to uraemic patients. Sixteen suffered cardiac arrest, and eight of these were associated with tracheal suctioning. It was believed that the arrest was due to a reflex inhibition in lightly anaesthetized patients. However, the possibility of the use of prostigmine for reversal of curarization in the presence of increased potassium concentration was also considered.[17,18] Neither could oxygen desaturation be ruled out.

(3) *Vomiting*: Silent regurgitation may occur. These patients are particularly liable to develop chest infection from any cause. Three patients regurgitated on extubation. One was a problem because there was inhalation of gastric secretions despite extubation in the lateral head-down position. Pneumonitis developed and subsequently a lung abscess in the right lower lobe was resected successfully.

(4) *Post-operative metabolic acidosis*: One patient developed respiratory distress following a satisfactory reversal of d-tubocurare. The only abnormality detected was metabolic acidosis. The patient was managed with oro-tracheal intubation, intermittent positive pressure breathing and sodium bicarbonate therapy. Recovery was complete within 12 hours.

(*b*) *Minor complications* are summarized in Table VI. These were not much

TABLE VI

MINOR COMPLICATIONS RELATED TO ANAESTHESIA

| At Operation | Number of Patients |
|---|---|
| Hypotension | 5 |
| Hypertension | 4 |
| Post-Operative | |
| Hypotension | 3 |
| Hypertension | 5 |
| Pulmonary oedema (mild) | 2 |
| Lung infection | 3 |
| Coagulation defect (needing laparotomy) | 1 |
| Total | 23 |

TABLE VII

HAEMOGLOBIN AND BLOOD TRANSFUSION REQUIREMENTS

| | Pre-Nephrectomy | Post-Nephrectomy |
|---|---|---|
| Haemoglobin | 6.75 gm | 5.25 gm |
| Transfusions (packed cells) | 125 cc/3 mos | 500 cc/3 mos |
| Patients requiring transfusions | 1/3 | all except 1 |

more frequent or different from those which might be expected to occur in any series of 126 poor-risk patients.

C. *Some Effects of Bilateral Nephrectomy on Physio-Pathology*

It is interesting to note that post-nephrectomy changes occur in haemoglobin levels, transfusion requirements and in arterial blood pressure. These observations were made over a three-month period, excluding the four immediate post-operative weeks. A comparison was made with pre-nephrectomy values assessed over a similar three-month period.

(*a*) *Haemoglobin and Blood Transfusion Requirements*

Alterations in pre-nephrectomy and post-nephrectomy haemoglobin levels and blood transfusion requirements are summarized in Table VII. The average pre-nephrectomy haemoglobin was 6.75 gm per cent, as compared to a post-nephrectomy average of 5.25 gm per cent. This drop of 1.5 gm per cent becomes much more significant when the simultaneous increase in post-nephrectomy blood transfusion requirements are taken into account. This increased need for transfusion could not be attributed to a higher BUN nor to a change in dialysis or in medications, such as iron supplements or treatment with androgens; nor could it be attributed to a change in the indications for transfusion requirements. In our renal unit transfusions are considered to be indicated only when the haemoglobin has fallen to less than 4.5 gm per cent. Nor is the increased transfusion requirement due to the emergence of symptoms caused or aggravated by the anaemia as, for example, angina pectoris, excessive fatigue, shortness of breath or a lack of erythropoietin response. This marked increase in transfusion requirements following bilateral nephrectomy is contrary to the observations of Lind-

TABLE VIII

CHANGES IN PRE-DIALYSIS RECUMBENT ARTERIAL BLOOD PRESSURES

| Number of Patients | Pre-nephrectomy (on Aldomet) | Post-nephrectomy (off Aldomet) |
|---|---|---|
| 12 (malignant hypertension) | 205/125 | 143/70 |
| 10 | 160/100 | 145/80 |
| 5 | 133/107 | 133/80 |
| 12 | — | no change |

holm,[30] who noted no change in requirements and of Shaldon,[31] who reported haematocrits above 30 per cent post-nephrectomy without any blood transfusion. Our decrease appears to be more than the transient 30-day drop in haemoglobin levels reported by Naets.[32] Although some investigators[31,33] have reported increased normoblastic proliferation if the haemoglobin is allowed to fall to 5 gm per cent, which has been our custom, we have failed to note the subsequent rise in haemoglobin and decrease in transfusion requirements which these authors have observed.

(*b*) *Changes in Recumbent Arterial Blood Pressure*

The blood pressure changes following bilateral nephrectomy were quite significant and are summarized in Table VIII. Of the 12 patients undergoing nephrectomy for malignant hypertension, nine have been normotensive and off antihypertensive medication for over 12 months since the operation. One patient who had nephrectomy for hypertension had been transplanted before nephrectomy. The transplanted kidney had ceased to function over a four-week period and biopsy showed only hypertensive vascular changes with no signs of rejection. This patient was subsequently subjected to nephrectomy and has been easily controlled by dialysis, remaining normotensive for ten weeks without antihypertensive medications. Of the 22 patients with severe hypertension before nephrectomy, ten had a fall in diastolic pressure greater than 10 mm Hg. Twelve patients had no significant change in their blood pressure. These results are similar to those reported by Kolff,[34] who noted six patients with hypertension not responsive to fluid and water restriction who, following bilateral nephrectomy, were more readily controlled. Others[35–37] have reported similar decreases in blood pressure. This change in blood pressure could not be attributed to decreased dialysis, change in diet or medication.

(*c*) *Uraemic Neuropathy*

The question whether improvement of polyneuropathy follows dialysis, bilateral nephrectomy or renal transplantation is controversial. The weight of evidence seems to indicate that neuropathy which resolves following bilateral nephrectomy was related to the blood pressure elevation,[38] and secondary to vasculitis associated with hyptertension. Schupak[39] cites four cases supporting this argument. However, bilateral nephrectomy cannot be expected to relieve all cases of the so-called uraemic neuropathy, since Versaci[40] reported one case with onset of neuropathy following bilateral nephrectomy and studies of the nerve changes in this condition did

not demonstrate any vascular changes.[41] Our own experience in this area is based on evidence from 94 of the patients who had bilateral nephrectomy and were studied for nerve conduction times. In every instance there was a defect in nerve conduction times. It is interesting to note that if haemodialysis is started in the early stages of this defect, it is followed by improvement. In the late stages haemodialysis produces no improvement. Fifty per cent of the patients who subsequently went on to have renal transplantation showed improvement of conduction time, even in the late stages. One striking case demonstrated a defect indicative of complete denervation. Following bilateral nephrectomy and transplantation there was a demonstrable increase in strength by functional testing and a return to normal conduction times in the median and popliteal nerves. The defect associated with these patients is believed to be due to degenerative (Wallerian) change and not to demyelinization.

## Summary

This paper reviews the anaesthetics given for a series of 126 consecutive bilateral nephrectomies. The special problems presented by these patients are described and they include primarily low haemoglobin, electrolyte imbalance and lack of useable veins following repeated dialysis and venipuncture for biochemical investigation. Many of these patients present with severe hypertension and an unstable cardiovascular system. A thiopentone, succinylcholine, d-tubocurare, nitrous oxide, oxygen and halothane anaesthetic sequence was used by preference. The results and complications of this technique are considered. There were no deaths associated with anaesthesia in this series in a four-month follow-up period.

Major and minor complications were reviewed. There were only a few complications directly attributable to anaesthesia. Changes following simultaneous bilateral nephrectomy are pointed out as they affect haemoglobin levels, transfusion requirements, blood pressure changes, and neuropathy. Experience in this series is compared to others reported.

## Résumé

Cet article fait une revue des anesthésies donnnées pour une série de 126 anesthésies consécutives données pour des néphrectomies bilatérales. Nous décrivons les problèmes spéciaux que posent ces malades dont: une hémoglobine basse, un déséquilibre électrolytique et une absence de veine utilisable à cause des dialyses répétées et des ponctions veineuses pour étude biochimique. Plusieurs de ces malades sont porteurs d'hypertension grave et d'un système cardiovasculaire instable. De préférence il a été utilisé dans l'ordre: du pentothal, de la succinylcholine, de la d-tubocurarine, du protoxyde d'azote, de l'oxygène et de l'halothane. Nous analysons les résultats et les complications de cette technique. Aucune mortalité n'est reliée à l'anesthésie dans cette série sur une période de quatre mois de surveillance.

Nous avons étudié les complications mineures et majeures. Il n'y a eu que peu de complications directement attribuables à l'anesthésie. Les changements qui sur-

viennent à la duite d'une néphrectomie bilatérale simultanée sont signalés car ils touchent le taux d'hémoglobine, l'exigence de transfusions, les modifications de la pression sanguine et les neuropathies. Nous comparons l'expérience de cette série à celle que rapportant les autres.

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