Anesthesia for the anephric patient undergoing major urological surgery

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The anephric patient presents to the anesthetist with a myriad of problems. This article considers the general problems associated with uremia, and also deals with some of the specific anesthetic problems and surgical procedures that may be presented to the clinician. The author reviews the consequences of uremia, the generalized approach to the anephric patient, and the anesthetic considerations for specific major urological surgeries that these patients may undergo.

When considering the anephric patient, a discussion of uremia and its consequences is in order. Because uremia brings about these pathophysiological problems, it is first necessary to understand what is happening to the anephric patient at the cellular and organ levels.

Renal failure and damage occurs in four distinct stages:
I. Decreased renal reserve. Progressive nephron damage due to underlying pathology.
II. Renal insufficiency. Mild azotemia with impaired concentrating ability.
III. Frank renal failure. Anemia, hypocalcemia, hyperkalemia with acidosis becoming apparent; dialysis is required.
IV. Uremia. All the consequences of failure become overt.¹

Clinical considerations

Metabolic and vascular derangement. The uremic patient has derangements in many organ systems as well as changes at the cellular level affecting metabolism and metabolic rate. Of the metabolic disturbances, the relative glucose intolerance and insulin metabolism are perhaps the most important. These patients have decreased utilization of glucose in response to insulin production. They are hyperlipidemic and develop atherosclerosis with all the implied sequelae. Percutaneous vascular therapy is often difficult due to collapsed veins and hardened skin due to uremic deposits. On the cellular level, there are derangements in ion transport with resultant imbalances in sodium, potassium, magnesium, and calcium.

Gastrointestinal disturbances. Gastrointestinal sequelae include increased gastrin production with a predisposition towards peptic ulcer disease.¹ These patients experience nausea, vomiting and, not surprisingly, anorexia. They are often in a poor nutritional state with very little energy reserve.

Endocrine disturbances. These include impaired growth, gonadal dysfunction and secondary hyperparathyroidism. There may be an adrenal insufficiency and hyperaldosteronism further disrupting delicate electrolyte balance.¹

Hematologic changes. Hematologic changes pose severe consequences for the uremic patient. There are decreased erythropoieten levels.¹,² Erythropoieten acts on the bone marrow to regulate red blood cell production. The resulting anemia...
is normochromic and normocytic, yet there is decreased red cell survival due to widespread hemolysis of increasingly fragile red blood cells. Platelets are normal in appearance, but do not aggregate properly and there are resultant clotting abnormalities. The resultant compensatory shift of the oxygen-hemoglobin dissociation curve to the right decreases hemoglobin affinity for oxygen in an effort to deliver more oxygen to the tissues. As a result, these patients are generally tachycardic.

*Neurologic sequelae.* These consist of generalized encephalopathy with depression and fatigue. The patient will also have progressive peripheral neuropathies that worsen with time. Dialysis may halt or even improve this condition minimally, but if severe damage has been sustained, some permanent impairment will remain. The toxic wastes damage nerve endings and their blood vessels. Some spontaneous recovery occurs in the renal transplant patient; however, severe, long-standing damage is often permanent.

*Renin-angiotensin-aldosterone axis.* In some patients, the severe atherosclerosis and progressive death of the kidney results in activation of the renin-angiotensin-aldosterone axis. The obvious result is hypertension. Along with concurrent hypervolemia, this renin-angiotensin activated hypertension can be quite severe and hard to treat.

As one considers the uremic patient’s candidacy for major surgery, a clinical picture begins to emerge. These patients are quite ill, with damage to all organ systems. They are labile with respect to electrolyte balance, fluid volume, and nutritional status as well as difficult to manage anesthetically due to impaired metabolism and excretion of all drugs given.

**Preoperative anesthetic evaluation**

The anephric patient usually presents with a compensated anemia. It is not uncommon to find a hemoglobin of 5 to 8.5 gm%. These patients seem to be well adapted to this decreased hemoglobin and compensate quite well. Blood transfusion is rarely needed preoperatively, and is actually avoided intraoperatively because further bone marrow depression is undesirable in the already depressed patient. Recently, however, new evidence has been reported by Opelz and Terasaki dealing with the transfusion of large amounts of whole blood to pre-transplant patients. These researchers suggest that with preoperative transfusion of more than 20 units of whole blood, there seemed to be greater graft survival than with those patients who received no transfusions. It is unknown if these transfusions benefit the anephric patient undergoing non-transplant surgery.

Generally, if the hemoglobin is less than 5 gm%, elective surgery should be delayed and the patient transfused with leukocyte-poor packed cells or whole blood.

**Fluid and electrolyte considerations**

Electrolyte derangement, particularly potassium and magnesium imbalance, is quite common. Hypermagnesemia manifests itself with neuromuscular depression. Magnesium induces a neuromuscular blockade and potentiates all neuromuscular blockers. With higher levels, there is progressive cardiorespiratory depression and eventual arrest. If serum magnesium values exceed 4 meq/L, elective surgery should be delayed. Hyperkalemia becomes a grave problem with the uremic patient due to hemolysis and inability to excrete potassium. Hyperkalemia causes nausea, vomiting, colic, diarrhea, and conduction problems that eventually lead to life-threatening arrhythmias.

If the patient’s potassium level is in excess of 6 meq/L, elective surgery should be cancelled and the patient dialyzed. Values for serum potassium should be obtained within four hours of the procedure, and ideally should be drawn just prior to induction. If the patient is not on dialysis, or an emergency procedure must be performed, a “hypokalemic cocktail” may be administered. The cocktail consists of dextrose 3.6 gm/L extracellular fluid (ECF) and regular insulin 1.5 units/L ECF to reduce the serum potassium by 1 meq/L ECF; CaCl or calcium gluconate is then added to counteract the action potassium has on the cell membrane, and sodium lactate is added to combat acidosis. This cocktail effectively drives the potassium intracellularly and serves as a temporary solution until the patient may be dialyzed.

**Preoperative dialysis**

If the patient is undergoing dialysis, the date and time of last dialysis must be ascertained. The weight loss must be noted in an attempt to establish the volemic status of the patient. These individuals can arrive in the operating room quite “dry,” and can experience a precipitous drop in blood pressure when anesthesia is implemented. A disaster is also possible when a patient in failure is given even a small amount of volume. These patients walk a fine line between hypovolemia and failure.

Dialysis can often prolong protime and partial thromboplastin time and clotting may be impaired. The chart should also be checked for the
presence of hepatitis non-A and non-B, as these are often present in the patient on long-term dialysis. If the patient does have some form of hepatitis, the anesthetist should take proper precautions in handling the patient and starting intravenous and arterial lines. It is also advisable to warn the other operating room personnel who may not be aware of the hepatitis history.

If the patient has an arteriovenous fistula or arterial shunt, it should be palpated and the bruit checked. This arm is untouchable and must be padded, protected, and accessible to the anesthetist during the procedure. This lifeline to the patient must be preserved; not all transplant surgeries are successful ones.

**Medication**

Most functionally anephric patients are on a multitude of drugs, and the interactions of these drugs with anesthetic agents must be anticipated. Many of these patients are on antihypertensives and diuretics of all varieties, as well as beta-blockers to control blood pressure and heart rate. These can further increase electrolyte and fluid derangements as well as increase blood pressure lability when the patient is stressed with surgery. The anesthetist should anticipate these blood pressure exacerbations that result from surgical stress and postoperative pain, and treat them with alpha and beta blockers and analgesics, if needed.

Premedication in these individuals can be quite varied. Narcotics such as meperidine (Demerol®), fentanyl and morphine sulfate are good choices as are non-butyrophenone tranquilizers like diazepam. The doses of these premedicants should be decreased 50% in the anephric patient due to his diminished ability to excrete these drugs as well as his chronically acidic and anemic state.

All patient drugs should be continued up to the day of surgery and should be resumed postoperatively as soon as possible. Like any hypertensive vascular patient, the renal patient cannot tolerate long bouts of hypotension or hypertension. The anesthetist should strive to keep these patients within 20% of their normal blood pressure.

In an effort to alter the underlying pathology, the primary physician often places a renal patient on corticosteroid therapy. As a result, some long-term patients have adrenocortical suppression and must have exogenous steroids. A steroid prep is necessary preoperatively and may be required intraoperatively and postoperatively as well.

Because many of these patients are often in mild to severe cardiac failure, they may be on digitalis. Digitalis levels should be checked preoperatively and especially post-dialysis. The patient should be continued on the drug up to the day of surgery, and potassium levels should be closely and frequently monitored. For example, in the renal transplant patient, there may be a brisk diuresis after transplant with a subsequent hypokalemia.

Transplant patients are given immunosuppressants in an effort to make them more amenable to transplant. Strict aseptic technique is warranted, and antibiotic therapy must be implemented to protect the patient from his environment.

Lastly, mention must be made of the anephric patient's often poor nutritional status. Nausea and vomiting set the stage for the anorexia most of these patients experience. They are also often mildly depressed, and as a result are poorly nourished with little energy reserve. Their psychological states of depression have roots not only in electrolyte imbalances, but also in the patient's realization that the disease carries a grave and progressive prognosis.

All these factors must be considered in the preoperative evaluation of the anephric patient. The individual patient's place on the continuum must be determined so that the optimum anesthetic plan can be determined.

**Anesthetic technique**

Choice of anesthetic technique is certainly altered in the anephric patient. The shunt or fistula should be protected and kept warm. Its viability should be monitored either through periodic palpation or with a small doppler. When using the doppler, care must be taken that there is negligible pressure on the fistula.

Since most if not all these patients are immunosuppressed, a strict aseptic technique for starting lines, laryngoscopy and handling the patient must be used. Gloves are mandatory for the protection of the patient as well as the anesthetist.

If an arterial line is needed, as in the unstable and/or very ill patient, the dorsalis pedis artery is the ideal artery to cannulate. The brachial and radial arteries in the arms should be preserved for eventual fistula and shunt construction. The arterial line is also a good choice in the patient undergoing a surgery that may result in rapid and extensive blood loss. It not only provides minute-to-minute readings but also a source of arterial blood for blood gases.

Because the anephric patient is chronically anemic, generous preoxygenation for 3 to 5 min-
utes preinduction should be performed. Anesthesia may be induced with thiopental 4 mg/kg or diazepam 0.2 mg/kg. The patient’s apprehension usually makes inhalation induction difficult unless he is quite well premedicated. Innovar® is also a good choice in these people who are usually apprehensive, hypertensive, and tachycardic, but it should be titrated in slowly while the arterial pressure is closely monitored.

Endotracheal intubation may be done with either succinylcholine or a nondepolarizing neuromuscular blocker, according to the choice of the practitioner. It is important to note that the use of succinylcholine can exacerbate elevated serum potassium levels. Pseudocholinesterase levels are often low in the anephric patient, and the chances of getting a phase II block are increased. Of the nondepolarizing neuromuscular blockers, only gallamine is contraindicated due to its 100% renal excretion. Tubocurarine, pancuronium, and metocurine have all been used with relative success, and all have a biliary route of excretion.

For maintenance of anesthesia, enflurane should be avoided due to the incidence of free-fluoride ion excretion. Halothane and isoflurane can be used with success, provided the patient’s clinical history will allow it. Neurulept anesthesia with Innovar® and fentanyl supplements is also a good choice, due to the alpha blocking effect of the droperidol component.

The choice of monitoring varies, but all major renal cases should have the following monitoring devices in place: ECG, BP, CVP or Swan-Ganz® catheter, temperature, precordial or esophageal stethoscope, respirimeter, peripheral nerve stimulator, serial electrolytes and hematocrits, serial colloidal osmotic pressures, and in the case of the diabetic patient, serial blood sugars. If the patient is unstable or massive blood loss is anticipated, an arterial line should be inserted and serial blood gases should be monitored. All IVs should be infused through minidrips or controlled measuring devices to minimize intake unless a large blood loss is anticipated.

Of major importance is fluid and electrolyte management. Sodium, potassium and hematocrit are drawn serially during the procedure. As a guideline for fluid replacement, the time of the last dialysis is noted along with weight loss. BP and CVP are monitored for changes from baseline, and after a transplant, urine is monitored if there is any. After the transplant, the electrolytes should change along with the changing composition of the serum, and exogenous potassium may need to be given. The patient should be extubated at the end of the case if clinical evidence permits. If kidney function (that is, urine production), is good, the neuromuscular relaxants should be eliminated more quickly and reversal will be successful. If there is little or no urine production, reversal may be more difficult and the degree of spontaneous recovery from relaxants must be ascertained by observation, titration of drugs and the peripheral nerve stimulator. These patients are monitored carefully in an intensive care area for 24 to 48 hours, and then transferred to an extended care floor for 5 to 6 weeks to protect the transplant. The fewer drugs used on these patients the better, and meticulous care in terms of antibiotic therapy and aseptic technique is mandatory.

**Specific procedures**

Major urological procedures are performed with some frequency on the anephric patient in many institutions. What follows is a protocol of sorts for five common urological procedures that are often done on the anephric patient.

**Renal transplant.** Of the major procedures, renal transplant is perhaps the most challenging. It is becoming more prevalent with the advent of new drugs and therapies. The preoperative evaluation is the same as that for any anephric patient, with the exception of a preoperative blood transfusion. This is still quite controversial, so many will come to the operating room in their usual state of anemia. The monitoring devices chosen include those used for any anephric patient, as previously mentioned.

The anesthetist may choose an agent for premedication. Barbiturates, neuroleptic agents or tranquilizers are all good choices for induction of anesthesia. Muscle relaxants that may be used include all those currently available with the exception of gallamine. Maintenance of anesthesia may be accomplished with either narcotic agents, neuroleptic agents, or inhalational technique using halothane or isoflurane. All drugs should be titrated carefully due to the patient’s diminished capacity to excrete them. Serial electrolytes, hematocrits and colloidal osmotic pressures should be measured frequently throughout the case to determine changes in the plasma concentration. Many of these patients have cardiovascular problems, blood pressure instability and disorders in carbohydrate metabolism — some of which are the causative factors in their renal failure. In these cases, an arterial line should be inserted and serial arterial blood gases and blood sugars should be monitored throughout the case.
Osmotic diuresis. During a transplant, a “cocktail” is given to promote osmotic diuresis of the kidney as soon as arterial flow is restored. This consists of 12.5 gm salt-poor albumin, 12.5 gm mannitol and 40 mg furosemide (Lasix®). These figures apply to an average sized adult patient. The dosage can vary with patient requirements (for example, a child might receive 1/2 to 1/4 of this mixture).7,10

Open renal biopsy. An open renal biopsy is performed to establish a diagnosis in functionally anephric patients. The procedure is usually of short duration, with the patient placed in a prone position to better facilitate surgical exposure. During the preoperative evaluation, the anesthetist makes those considerations that are necessary in the anephric patient, and premedication is the same. Basic monitoring includes ECG, BP, esophageal stethoscope, temperature and careful fistula protection if one has been constructed. One large peripheral IV should be used in case of blood loss.

Overall, the anesthetist must find the balance between adequate anesthesia and maintaining normovolemia. This can be a challenge when the patient is in the prone position. Maintenance of anesthesia is as with any anephric patient, and muscle relaxants may or may not be used depending upon the needs for relaxation. If relaxants have been titrated carefully, the patient can be extubated at the end of the procedure with little trouble.

Transplant biopsy/nephrectomy. A transplant biopsy and/or nephrectomy is performed on the post-transplant patient who is rejecting the kidney so that the surgeon can determine the cause of the rejection. These patients usually present with fever, tachycardia, and hypertension, and generally appear to be quite ill. This is a challenge for the anesthetist, in that the patient must be managed and stabilized and adequate oxygen and nutrients for metabolic needs must be provided while volume overload and strain on an already failing kidney are avoided. In general, preoperative evaluation and premedication are the same as in the anephric patient.

A rapid sequence induction is suggested because of the patient’s poor physiological status. These people have often been getting progressively sicker, and now must be operated on to find out what’s wrong and/or drain abscesses. The choice for maintenance of anesthesia is often limited to short-acting narcotics or tranquilizers due to the unstable nature of these patients. Monitoring includes ECG, BP, esophageal stethoscope and CVP if the patient is very ill and unstable. If a CVP is used, serial electrolytes, venous blood gases and hematocrits should be monitored. Emergence, extubation and transport to the unit are entirely dependent upon patient parameters. If the kidney has been removed, volume and electrolyte administration is especially important. Postoperative management is much the same as intraoperative care.

Polycystic kidney disease. Perhaps one of the most interesting major urological procedures done on the functionally anephric patient is the bilateral nephrectomy for polycystic kidney disease. The simple bilateral nephrectomy is handled in much the same way any anephric patient is handled. Aside from possible blood loss, it is a fairly straightforward and uncomplicated procedure. Polycystic kidney disease, on the other hand, presents a real challenge to the anesthetist.

Polycystic disease has embryological origins and has an unknown etiology. There is progressive loss of nephron function, and these nephrons are replaced with fluid-filled cysts. The kidneys become quite large and grotesque in appearance, some weighing 5-7 kg apiece. Manipulation of the kidneys in surgery can result in caval compression and bouts of hypotension. Removal of the kidneys can trigger a toxic reaction with anaphylactic-like sequelae. The anesthetist must be prepared to support the blood pressure with volume as well as vasopressors quite rapidly.

Blood loss can also be subtle; the kidneys themselves can contain anywhere from 300 to 500 cc of blood, and this is not readily apparent when one is viewing the surgery from the head of the table.4 Once the kidneys are out and the blood pressure stabilized, the case proceeds as with any anephric patient. Monitoring includes ECG, BP, arterial line, CVP or Swan-Ganz® catheter, temperature and serial arterial blood gases, hematocrits, colloidal osmotic pressures and electrolytes. The choice and management of anesthesia is as for any anephric patient.

Radical nephrectomy. The radical unilateral or bilateral nephrectomy is often done for renal carcinoma. These are challenging, in that the potential for massive blood loss and transfusion is very real. The anesthetist must strive to maintain normovolemia and oxygen-carrying capacity in the soon-to-be anephric patient. Monitoring is the same as for the transplant patient. Serial blood gases, hematocrits, electrolytes and colloidal osmotic pressures are mandatory. The choice of anesthesia and technique is as for any anephric patient.

Autotransplantation. Lastly, a word must be said about the autotransplant patient. Autotrans-
planted is surgery that is done on a kidney that is considered viable. There is usually an associated renal artery aneurysm, arteriovenous malformation or even a carcinoma. The aim of the surgery is to resect the defective or cancerous portion and then return the kidney to the patient. Technically, this is a meticulous and difficult surgery with the kidney being operated upon at a separate sterile table under a microscope. It is also a lengthy procedure, lasting anywhere from 6 to 8 hours. The patient is premedicated and evaluated according to procedures for any anephric patient. If the basic problem is of a vascular nature, adequate blood must be ordered to handle massive blood loss. Choice of anesthetic technique and monitoring devices is the same as that for polycystic and radical nephrectomy patients.

If the patient has a solitary or horseshoe kidney—and many of them do—remember that when the kidney is removed, cooled and perfused with a dialysate solution and then operated upon for anywhere from 30 minutes to 4 hours, the patient is anephric. The anesthetist must keep the patient well hydrated with mannitol and albumin prior to removal of the kidney to ensure diuresis and good perfusion. The transplant “cocktail” may be given prior to vessel anastomosis so the kidney will have a good osmotic load once the vessels are unclamped and the kidney perfused.

Summary

Although it is not within the scope of this article to discuss every conceivable type of surgery done on the anephric patient, the general care of the anephric patient can apply for most of these surgical procedures. The inevitable conclusion would seem to be that, due to the physiological damage they suffer as a result of their uremia, these patients are at risk in almost all areas pertaining to anesthesia. They have fluid and electrolyte problems, poor nutritional status, psychological problems and systemic problems as well as cardiovascular, endocrine and organ disease due to their underlying pathology and the cause of their renal failure. They are plagued by a host of clotting and hemolytic disorders precipitated by long-term dialysis, and are immunosuppressed and anemic. Their ability to fight infection is quite diminished, and they may have one of several forms of chronic hepatitis. They ingest a host of prescribed medications, and their ability to metabolize and excrete these drugs is certainly altered.

With the advent of more sophisticated medications and surgical techniques, these patients are living longer. In the future, the anesthetist will be faced with increased numbers of these patients presenting for a myriad of surgical procedures. As transplant techniques and drugs become more sophisticated, the anesthetist will also be faced with the successfully transplanted patient presenting for surgery unrelated to his renal disease.

It is important to understand renal disease and its consequences as well as the effects that anesthetics and drugs have upon the healthy and the failing kidney. The final goal is to provide the best anesthesia for the individual patient while providing the surgeon with the optimum operating environment. This goal is achieved only with adequate knowledge, preparation and understanding of this rapidly changing and advancing field.

REFERENCES


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