none of a group of patients with polyethylene catheters left in the pulmonary artery was symptomatic. Attempts to retrieve the fragments were more traumatic and dangerous than leaving harmless segments *in situ*. He claims that the presence of a broken catheter in the vascular system is not harmful. Our epidural catheter was made of Teflon, which is recognized as being the least reactive plastic in implantation tests.

We believe the patient must be informed of such an incident and be reassured that no damage results from the presence of Teflon in the body. Attempted removal is far more traumatic and potentially harmful than a policy of reassurance and noninterference.

We conclude that: 1) epidural needles should be inspected for possible barbs on the bevel; 2) epidural catheters should be inspected for possible defects; 3) an epidural catheter must not be pulled back while the Tuohy needle is in place; 4) epidural catheters made of Teflon labelled radiopaque are not visible roentgenographically when in the epidural space; 5) complications from the broken segment are unlikely to occur unless infection supervenes; attention to sterile technique when performing epidural block cannot be overemphasized; 6) breaking off the catheter is not necessarily malpractice, but the vigorous pursuit of the broken segment into deep recesses of the body certainly could be imprudent.

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50:262–265, 1979

Early Recognition of Renal Insufficiency in Post-anesthetic Trauma Victims

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Acute renal failure continues to be a major complication following trauma. Reported mortality rates for acute renal failure in trauma victims range from 50 to 90 per cent.[1–4] Aggressive fluid infusion has been our main thrust in the prevention of ARF; however, respiratory failure is not uncommon in posttraumatic patients, and aggressive fluid therapy in the presence of limited renal functional may aggravate such failure.[3]

Early detection of renal dysfunction is difficult. It has been customary to monitor patients by serial determinations of blood urea nitrogen (BUN), serum

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0003-3022/79/0300/0262 $00.65

creatinine, urinary sodium, and urinary output. These determinations have serious limitations in the early detection of renal dysfunction.[5] Significant increases in BUN and serum creatinine may not be apparent until several days following trauma and operation, although renal function may be less than 25 per cent of normal. Urinary sodium is frequently higher than 40 mEq/l in patients who receive salt-containing fluids. Oliguria alone is unreliable to assess renal function.

It has been reported that when postoperative free water clearance (C_{H_2O}) was close to or above zero, acute renal failure followed in two to three days.[5–7] Administration of furosemide and fluid restriction in anticipation of acute renal failure have been recommended for patients with postoperative C_{H_2O} of more than −20 ml/hour.

Both of these studies were based on C_{H_2O} measurements in selected groups of patients. It has been our observation that not all postoperative patients who have C_{H_2O} of more than −20 ml/hour experience acute renal failure. We therefore re-examined retrospectively the predictive value of C_{H_2O} in postoperative trauma victims.

Methods and Materials

The medical records of 675 consecutive trauma victims admitted during the 12 month period July 1976–June 1977 were reviewed. There were 580 high-speed automobile-accident victims, 80 gunshot victims, and 16 victims of other trauma. All received general anesthesia on the day of admission and survived longer than 24 hours. There were 539 male and 136 female patients in the group. Mean age of the patients was 30.6 years (SD ± 10.1). Fluid administration during operation was dictated by vital signs, central venous pressures and hourly urinary output. When a patient had normal blood pressure and a central venous pressure higher than 15 cm H_2O, with oliguria (urinary output <20 ml/hour), plasma protein fraction was infused by use of a volume-loading technique.[8] The mean fluid volume administered, including blood transfused during operation (average duration 4.1 hours), was 4,800 ml (SD ± 4,612).

Immediately on admission, samples of serum and urine were obtained for determinations of urea nitrogen, creatinine, and osmolality. Twelve to 24 hours after anesthesia, samples of serum and urine were obtained for determinations of creatinine and osmolality. Urine samples were obtained from the urine collected during the above-mentioned period. Endogenous creatinine clearance (C_{cr}) and C_{H_2O} were calculated from these values and urine volume according to standard formulas:

$$C_x = \frac{U_x x \dot{V}}{P_x},$$

and

$$C_{H_2O} = \dot{V} - C_{osm}$$

where C_x is clearance for a substance; U_x, the urinary concentration of a substance in mg/dl or mOsm/l; P_x, the plasma concentration of a substance in the same unit; $\dot{V}$, the urinary flow in ml/min; C_{osm}, osmolar clearance. Blood urea nitrogen, serum creatinine, and urinary output were monitored daily in all patients for the next five days. When a patient had abnormal renal function, C_{cr} and C_{H_2O} were monitored until they became normal.

Patients were arbitrarily divided into four groups: Group I, with C_{H_2O} greater than −20 ml/hour and C_{cr} less than 25 ml/min; Group II, with C_{H_2O} greater than −20 ml/hour and C_{cr} greater than 25 ml/min; Group III, with C_{H_2O} less than −20 ml/hour and C_{cr} less than 25 ml/min; Group IV, with C_{H_2O} less than −20 ml/hour and C_{cr} greater than 25 ml/min. The greatest values of BUN and the incidence of acute renal failure of each group for the first five days were compared using the t test for unpaired data and the chi-square test.

The criteria used for the diagnosis of acute renal failure were 1) BUN above 40 mg/dl; 2) creatinine urine/plasma ratio less than 10; 3) osmolality urine/plasma ratio less than 1.1. Renal dysfunction during the terminal stage of coagulopathy, septicemia, and severe heart failure was also included in the acute renal failure category when the above criteria were met.

Results

In Group I, the greatest BUN values found during the first five days and the incidence of acute renal failure were significantly higher than those in the other groups (table 1). The values of BUN and the incidences of acute renal failure in Group II and Group III were not significantly different from those of Group IV.

Renal function of the patients in Group I for the first five days is illustrated in figure 1. None of these patients was treated by dialysis during this period. Eleven of 26 patients in Group I experienced acute renal failure within five days of sustaining trauma. In 15 of 26 patients, renal function began to improve from the second day of admission; however, acute renal failure developed in two of 15, 16 and 45 days after admission, respectively. Both instances were associated with septicemia and complications of trauma and operation. Nine patients, one in Group II and eight in Group IV, experienced acute renal failure a

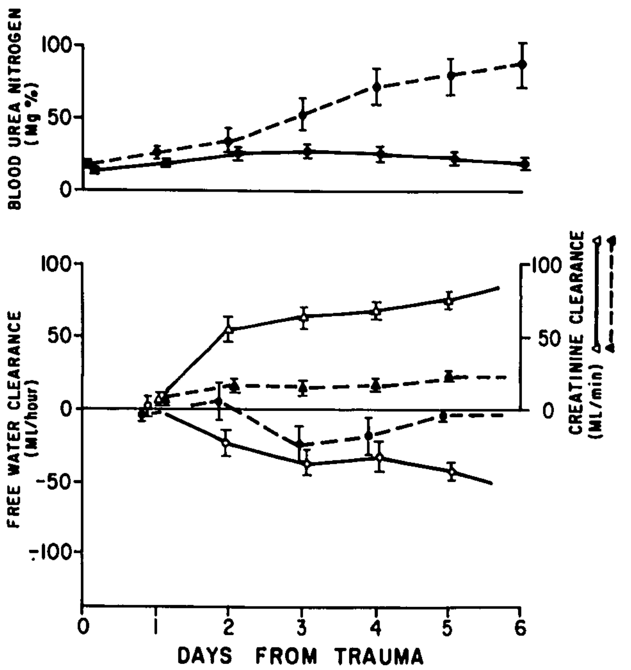

FIG. 1. Daily renal function of patients in Group I. Acute renal failure developed in 11 patients (------); 15 patients (——) did not have acute renal failure. Values are means ± SE.

week or more after trauma in association with multiple organ failure and septicemia. In these patients acute renal failure was not directly related to initial resuscitation.

Of 20 patients in Group II, ten had high serum osmolalities, and three were receiving mannitol for head injuries. The ten who had high serum osmolalities also had high blood alcohol levels on admission. In the remaining seven cases, etiology could not be established. The cause of the low C_{cr} in Group III is not clear.

Blood pressure on admission, values of blood gases, and patient age were compared. There was no significant correlation between these and the incidence of acute renal failure. The mean fluid volume requirement of patients of Group I during anesthesia was 6,870 ml (4,880 ± SD). Although this volume seems greater than volumes needed by patients of the other three groups, the difference was not statistically significant.

None of the 22 patients who had acute renal failure in this study was oliguric. The average daily urinary volume was approximately 2,000 ml, with a range of 1,050–5,010 ml. Eight patients, five in Group I and three in Group IV, needed dialysis an average of 2.5 times. Ten of 22 patients in this study who had acute renal failure died, seven during acute renal failure and three after recovery. The overall mortality rate was 45.5 per cent.

DISCUSSION

In contrast to previous reports,[5–7] these data suggest that C_{H_2O} by itself is not a good predictor of acute renal failure. A transient increase in C_{H_2O} to or above zero can be seen in hypotensive patients.[5] During hypotension, renal blood flow to the inner cortex may increase and wash out the medullary osmolal gradient, resulting in positive C_{H_2O}. This positive C_{H_2O} may be reversed when hypotension is corrected rapidly. Other factors, such as diuretics, hyperosmolar agents, vigorous fluid infusion, and possibly head injury, also appear to influence C_{H_2O}. Therefore, C_{H_2O} alone probably should not be used to evaluate renal function in trauma victims or critically ill patients. C_{H_2O} of more than −20 ml/hour in association with C_{cr} of less than 25 ml/min did appear to be a good predictor of acute renal failure. C_{cr}, a rough clinical estimate of glomerular filtration rate, is not influenced by the factors influencing C_{H_2O}, but by filtration pressure and renal blood flow. Since the primary renal response in hemorrhagic shock is a decrease in glomerular filtration rate and tubular function,[9] measurement of both C_{cr} and C_{H_2O} could be useful for a routine clinical evaluation of renal function.

The early prediction of acute renal failure is of little value unless it is then possible to prevent its development. Although inconclusive in this retrospective study, the steady improvement of renal function in half of the patients in Group I suggests that intra-

TABLE 1. Renal Function and Incidence of Acute Renal Failure

	Number of Patients	Water Clearance* (ml/hr)	Endogenous Creatinine Clearance* (ml/min)	Peak Values of BUN for the First 5 Days (mg/dl)	Number of Patients with Acute Renal Failure
Group I	26	−4.1 ± 27.4	11.4 ± 5.5	55.2 ± 33.2	13
Group II	20	16.5 ± 35.5	52.4 ± 27.8	22.7 ± 18.3	1
Group III	11	−52.0 ± 17.5	9.8 ± 5.8	33.8 ± 25.8	0
Group IV	618	−60.2 ± 50.1	70.3 ± 30.4	18.8 ± 10.1	8

* Values of 12–24-hour renal clearance.
Values are means ± 1 SD.

operative and postoperative renal dysfunction may be reversible. In cases of patients who have C_{cr} of less than 25 ml/min and C_{H_2O} of more than −20 ml/hour, the cause of renal blood flow should be identified and corrected to prevent further deterioration of renal function. Fluid restriction and furosemide administration in anticipation of acute renal failure[7] may not be wise. A volume-loading technique[8] has been used not only to restore plasma volume, but to evaluate myocardial contractility in patients who have borderline heart failure. When aggressive fluid management is indicated for patients who have abnormal renal function, blood volume should be restored using a volume-loading technique. In management of patients who have both heart failure and renal dysfunction, dopamine, nitroprusside or diuretic may be used, depending on the individual patient's condition.

The reported incidence of nonoliguric renal failure has been less than 50 per cent.[1,3,10] We are unable to explain the high incidence of nonoliguric renal failure in this study. It has been reported that an adequate urinary output could be maintained with early administration of a potent diuretic,[11] aggressive fluid infusion,[10] and hypothermic treatment of the kidney.[12] Regardless, acute nonoliguric renal failure is known as a benign form of acute renal failure. Further study is needed to determine whether oliguria can be avoided in acute renal failure when renal dysfunction is detected early and treated.

There are pitfalls in measuring C_{cr} and C_{H_2O} from a single 24-hour urine sample. With more frequent determinations it may be possible to detect acute changes of renal dysfunction not detectable by a single determination from a 12–24-hour collection.

In conclusion, C_{H_2O} alone should not be used for the prediction of acute renal failure. It is suggested that impending renal failure can be recognized early by monitoring both C_{cr} and C_{H_2O} in the postoperative period. In management of patients who have a high risk of developing renal failure, C_{cr} and C_{H_2O} should be included for routine clinical monitoring.

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50:265–267, 1979

Does "Self-taming" with Succinylcholine Prevent Postoperative Myalgia?

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Muscle fasciculations associated with succinylcholine can be decreased or eliminated by administering a small dose (10 mg) of succinylcholine before giving the full paralyzing dose.[1] Does this "self-taming" technique prevent post-succinylcholine muscle pains?

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Accepted for publication July 23, 1978.

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Methods

Forty adult patients, ASA classes 1–3, undergoing major surgical procedures were randomly divided into two groups. Premedication with a narcotic and an anticholinergic drug was essentially the same for all patients. In both groups, following preoxygenation, anesthesia was induced by a slow injection of thiopental, 4 mg/kg, iv, followed by succinylcholine, 1.5 mg/kg, iv, to facilitate endotracheal intubation. Patients in Group I received the entire amount of

