local anesthetics owing to a progressive increase in size and number of arachnoid villi, providing a larger area through which local anesthetic can diffuse into the subarachnoid space.

Only 29 sensory dermatomes can be anesthetized (excluding coccgeal and cranial nerves) by epidural anesthesia. Thus, a point at which an additional volume of local anesthetic ceases to provide further anesthesia must exist. In the elderly this may occur in the upper thoracic region, as doubling the volume in certain patients did not provide further anesthesia. Such a transition was not observed in this study in patients aged 20 to 40 years utilizing volumes of as much as 27 ml, but might have been observed if volumes approaching 40 ml had been injected.

The author thanks Drs. R. Boas, K. Korten, L. D. Vandam, and D. R. Waald for assistance with the preparation of the manuscript.

Anesthesiology
49:428–430, 1978

Nitroprusside Toxicity in a Renal Transplant Patient

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In most previously reported cases of sodium nitroprusside (SNP) toxicity the patients have died.1-6 There has been no report of SNP toxicity in a patient with a transplanted kidney, although these patients often need acute antihypertensive therapy.7,8 We describe the occurrence of SNP toxicity in a patient with a single transplanted kidney who showed tachypy-

laxis to the drug and needed large doses to control hypertension.

REPORT OF A CASE

A 27-year-old 88-kg woman, who had received a cadaveric renal allograft two years previously, had had abdominal pain, nausea, vomiting, and fever for four days. Her immunosuppressive regimen included azothiourine, 150 mg, daily, and prednisone, 35 mg, on alternate days; renal hypertension was controlled with spironolac
tone, 150 mg, furosemide, 40 mg, hydralazine, 400 mg, propranolol, 120 mg, and methyldopa, 2,000 mg, daily. Four months previous to admission she had undergone exploratory laparotomy and repair of a hepatic laceration.

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Received from the University of California Medical Center, 225 Dickinson Street, San Diego, California 92103. Accepted for publication March 9, 1978.

The patient appeared acutely ill and was febrile (temperature 38.7°C orally). Heart rate was 88/min, blood pressure 160/120 mm Hg, and respiratory rate 20/min. The abdomen was moderately distended, and there was acute tenderness and guarding in the right upper quadrant, where a 10–15 cm mass continuous with the lower edge of the liver was palpable. The remainder of the physical examination was unremarkable. Pertinent laboratory data included hematocrit 29 per cent, leukocyte count 28,800, with a shift to the left, serum creatinine, 141 μmol/l (1.6 mg/100 ml), bilirubin 50 μmol/l (2.8 mg/100 ml), lactate dehydrogenase 392 IU, serum glutamic oxaloacetic transaminase (SGOT) 24 IU, alkaline phosphatase 99 IU, amylase 127 U/100 ml; serum electrolytes were normal. Abdominal echography confirmed the presence of a 10-cm solid mass inferior to the right lobe of the liver. Exploratory laparotomy on that day revealed rupture of the gallbladder with a large intraperitoneal hematoma. Cholecystectomy was performed.

In the perioperatve period, despite reintroduction of the prooperative antihypertensive therapy, hypertension became difficult to control, with arterial pressures as high as 200/120 mm Hg. SNP was started at a dose of 4.0 μg/kg/min, and control of hypertension was achieved only with progressive increases in the SNP dosage. Two days postoperatively, the requirement had reached 12.5 μg/kg/min, a total of 1,120 mg of SNP in 48 hours with progressive oliguria (100 ml/8 h). After an hour at this high dose level, the level of consciousness became variable, ranging from hyperscrr-

ibility and combativesness to coma, without any localizing neurologic signs. Within another hour, her hemodynamic status was unstable, and she showed large fluctuations of blood pressure and heart rate. Blood-gas analysis at this time showed PaO2 90 torr, Pco2 30 torr, hydrogen ion concentration 63.1 mmol/l (pH 7.20), base excess –16 mmol/l. Electrolytes were normal. The patient

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0003-3029/78/1200/0428 800.65 © The American Society of Anesthesiologists, Inc.
became hypotensive and, despite withdrawal of SNP, volume augmentation and administration of dopamine, her hemodynamic status deteriorated over the next 30 minutes, and cardiac arrest in asystole occurred.

Prompt, vigorous cardiopulmonary resuscitation, including tracheal intubation and correction of acidosis with bicarbonate, was successful in restoring normal sinus rhythm and a normal blood pressure, although the patient remained comatose for four hours. At the end of this time she awoke, the trachea was extubated, and neurologic examination showed no abnormality. The patient remembered nothing of the events of the previous five hours, and thereafter had no major hypertensive or metabolic problem.

Anuria followed the episode, and radiotopic studies demonstrated that there was no blood flow to the transplanted kidney. An arteriovenous shunt was created, and hemodialysis was started. The remainder of the hospital course was uncomplicated, and the patient was discharged on the tenth postoperative day. The patient is currently alive and doing well on hemodialysis. She has not had a further renal transplant.

**DISCUSSION**

This case demonstrates the development of acute neurologic, metabolic and hemodynamic collapse following 48 hours of increasing SNP therapy in a renal hypertensive patient who had been the recipient of a renal allograft two years previously. There are several reasons a cause-and-effect relationship between the administration of SNP and the deterioration of the patient's condition was highly likely.

First, it is possible that the detoxification and excretion of cyanide was impaired. Cyanide is released from the SNP molecule and transformed for the most part into thiocyanate by the action of hepatic and renal rhodanase. In this patient a combination of abnormal hepatic function and failing renal function may have reduced the transformation of cyanide into the much less toxic thiocyanate; indeed, a thiocyanate level measured at the time was only 3.3 mg/100 ml. With the transformation pathway reduced, and excretion of SNP and cyanide itself reduced by the single failing renal allograft, it is much more likely that high cellular cyanide levels occurred, with consequent intracellular acidosis. Evidence of the failing kidney is apparent from the progressive oliguria in the period before the collapse of the patient, and also by the fact that after the acute hypoxic event, actual infarction of the kidney occurred. Renal hypertension may be refractory to conventional antihypertensives, and use of SNP may increase renin production, a situation likely to lead to refractoriness. The patient did show "tolerance" to the antihypertensive effects of SNP, and dosage requirements progressively increased over a 48-hour period. Tolerance to the hypertensive effect of SNP has a notorious association with toxicity.

Second, the recommended dosage range for SNP is 0.5–1.5 μg/kg/min, with a maximum dose of 3.0 to 3.5 mg/kg. This patient received an excessive dose of SNP, and she may not have been able to excrete the drug or its metabolites.

Third, the patient showed signs of cellular hypoxia with very severe metabolic acidosis in the presence of normal blood-gas tensions and electrolytes. There is widespread agreement that the signs of cyanide toxicity in animals and man are those of severe metabolic acidosis with elevated lactate–pyruvate ratios and severe interference with oxygen utilization, particularly in patients or animals that appear "tolerant" to the hypertensive effects of SNP.

Fourth, there was clearly a temporal relationship between the progressive increase in SNP administration and the development of a toxic episode. The extremely rapid recovery from acute toxicity is also consistent with cyanide toxicity; in animals the recovery half-life for cytochrome oxidase activity after cyanide administration and withdrawal is 30 minutes to 1 hour. The patient in this case had fully recovered five hours after the cessation of SNP administration.

Fifth, it is likely that some interreaction between SNP and the other potent medications occurred. It has been observed that the responses of occasional patients to SNP may change, especially when concurrent therapy with other antihypertensive agents is employed. This patient was receiving immunosuppressive therapy, as well as large doses of spironolactone, hydralazine, propranolol, and methyl dopa.

In summary, we have described a patient in whom excessively large doses of SNP were needed to control renovascular hypertension arising from a compromised transplanted kidney following an abdominal operation for infection. The patient showed "tolerance" to the hypertensive effects of SNP. She manifested acute severe signs of toxicity, including cardiac arrest, but recovered rapidly and completely following withdrawal of the drug and correction of the acidosis. This case illustrates that SNP must be used with extreme caution in patients who are concurrently receiving other potent antihypertensive agents, and that patients who have renal disease may have abnormal responses to SNP. It also suggests that the total dose of SNP administered is more important than the blood pressure response obtained, and that total dose should be monitored on an hour-by-hour basis. Should an inadequate blood pressure response be obtained, then the use of other less evanescent and less toxic agents should be preferred. All the previously published case reports of cardiovascular collapse following SNP administration have followed overdosage with SNP.

In addition to the prompt detection of toxicity by serial acid–base studies, prevention or modification
Postoperative Sore Throat—Importance of Endotracheal Tube Conformity Versus Cuff Design

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Recent investigations have suggested that both conformity of an endotracheal tube to the anatomic contour of the pharynx¹ and the design of the cuff² may have profound effects on the incidence and magnitude of postoperative sore throat. In this study, endotracheal tube anatomic conformity was evaluated and compared with cuff design as a factor in the occurrence of postoperative sore throat.

METHODS

Postoperative sore throat was evaluated in 250 patients who had undergone abdominal or extremity operations. Patients had their tracheas intubated with 7.0–8.5-mm ID National Catheter Company "Lindholm" pharyngeal molded endotracheal tubes with high-residual-volume, high-tracheal-contact, low-pressure cuffs or low-residual-volume, low-tracheal-contact, higher-pressure cuffs. National Catheter Company standard, unmolded endotracheal tubes with both of the above types of cuffs, as well as Bivona Surgical Instruments Company "Kamen-Wilkinson" foam-filled cuffs (which are not actively inflated) were also studied.³ Fifty patients were randomly selected to be intubated with each of the five varieties of tubes and cuffs.

All patients were similarly premedicated. Anesthesia was induced with thiopental, 3–4 mg/kg, and maintained with halothane, 1–2 per cent, or enflurane, 1.5–3 per cent and nitrous oxide, 60 per cent, in oxygen. Following administration of succinylcholine, 1.5 mg/kg, the tracheas wereatraumatically intubated in the usual fashion. The endotracheal tubes were lubricated with lidocaine ointment, 5 per cent, and each had a plastic aluminum stylet in place during intubation. With the exception of the foam-filled cuffs, all cuffs were filled with air until the trachea was just

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0003-3022/78/1200/0430 $00.65 © The American Society of Anesthesiologists, Inc.