minimize the risk of barotrauma, the following precautions are recommended.

1. The patient must be adequately preoxygenated and hyperventilated by the original endotracheal tube using 100% oxygen.
2. An exchange catheter must be selected that is proportional to the size of the endotracheal tube. If the catheter meets resistance, it should be withdrawn slightly.
3. The clinician should consider maintaining oxygenation by administering a low flow of oxygen (1 or 2 l/min) *via* the lumen of the exchange catheter. This can provide adequate apneic diffusion oxygenation, because oxygen consumption in adults is only approximately 250 ml/min. Jet ventilation may not be necessary during the brief period of tube exchange, because the carbon dioxide tension increases during apnea at a rate of only 3 mmHg/min.
4. Whenever jet ventilation is used, the incidence of complicating barotrauma may be decreased by minimizing airway pressure, providing a long expiratory time, and selecting a properly sized exchange catheter, all of which prevent air trapping. A catheter with multiple distal side holes also may decrease the pressure delivered at the distal end, minimize the catheter whip, and center the catheter within the trachea during jet ventilation.[3]

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Blood Pressure Control with Fenoldopam during Excision of a Pheochromocytoma

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WE report the use of fenoldopam for perioperative blood pressure control during excision of a pheochromocytoma in two patients. Fenoldopam was chosen because of its vasodilatory effects and its efficacy in increasing renal blood flow in patients with renal compromise.

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Key words: Adrenalectomy; antihypertensive; catecholamine; dopamine 1 receptor; renal disease.

Case Reports

Case 1

A 64-yr-old woman experienced cardiorespiratory arrest and multisystem organ failure (subendocardial myocardial infarction, renal failure, hepatic dysfunction, quadraparesis, and pulmonary edema) after knee arthroscopy. While in the intensive care unit, a 6-cm left adrenal pheochromocytoma was diagnosed by ultrasound, computed tomographic scan, and plasma (epinephrine: 56,778 pgm/ml, normal: 10-200 pgm/ml; norepinephrine: 123,052 pgm/ml, normal: 80-520 pgm/ml) and urine catecholamine assays (vanillylmandelic acid: 82.9 mg/

day, normal: 0–7 mg/day; metanephrine: 8.6 mg/day; normal <0.35 mg/day; normetanephrine: 5.4 mg/day, normal: <0.65 mg/day). After the diagnosis was established, therapy with phenoxybenzamine and metoprolol was started. She slowly recovered, but because of renal insufficiency (blood urea nitrogen–creatinine: peak, 98–5.3 mg/dl, discharge, 65–2.7 mg/dl) surgery was postponed for 3 months.

At the time of readmission for surgery, her blood pressure was well controlled with medication (phenoxybenzamine, 20 mg/day; metoprolol, 25 mg/day) and her renal function had improved (blood urea nitrogen–creatinine, 22–1.1 mg/dl). After sedation with fentanyl, invasive monitoring (arterial–pulmonary arterial catheterization) was established. General anesthesia was induced with thiopental and isoflurane, and paralysis was achieved using vecuronium. A transesophageal echocardiography transducer was placed for additional cardiac monitoring. During anesthesia, the patient's hemodynamic values were stable (mean arterial pressure [MAP], 80 mmHg; heart rate [HR], 70 beats/min) until the adrenal mass was manipulated (MAP, 108 mmHg; HR, 75 beats/min). A fenoldopam infusion was begun at 0.2 $\mu g \cdot kg^{-1} \cdot min^{-1}$ to control hypertension and titrated to 0.4 $\mu g \cdot kg^{-1} \cdot min^{-1}$. After the tumor was removed, her MAP returned to 80 mmHg and HR increased to 80 beats/min and were stable for the rest of the operation. Fenoldopam was infused for a total of 50 min and was stopped just before tumor excision. No other antihypertensive agents were used. The patient was hydrated aggressively during the procedure with 1 l 5% albumin, 3 l normal saline, and 1 unit packed erythrocytes to obviate hypotension after tumor removal. Her perioperative urine output was 100 ml/h, with no observed increase during the fenoldopam infusion. The patient's renal function remained normal after operation.

Case 2

A 50-yr-old man with a 4-yr history of severe headaches and episodic hypertension and an 8-month history of hot flashes, sweating, and tachycardia had a blood pressure value of 170/90 mmHg. A computed tomography scan showed a 3 × 5 cm right adrenal mass and incidentally revealed a 5 × 5 cm mass in the left lower renal pole. The urine catecholamine assays (vanillylmandelic acid: 25.3 mg/day, normal: 2–10 mg/day; metanephrine: 7.2 mg/day, normal: <1.3 mg/day; normetanephrine: 6.4 mg/day, normal: < 0.9 mg/day) were consistent with a pheochromocytoma. The results of a workup for Von Hippel-Lindau syndrome were negative. A right adrenalectomy and left nephrectomy were performed after 6 weeks of treatment (phenoxybenzamine, 100 mg/day).

Anesthesia and monitoring for this patient were similar to those for case 1, with the addition of Dilaudid (Knoll Pharmaceuticals, Whippany, NJ) epidural anesthesia. Under anesthesia, the patient's hemodynamic values were controlled but varied (MAP, 55–85 mmHg; HR, 55–80 beats/min) until the adrenal mass was manipulated (MAP, 120 mmHg; HR, 68 beats/min). A fenoldopam infusion was begun at 0.2 $\mu g \cdot kg^{-1} \cdot min^{-1}$ and rapidly increased to 0.4 $\mu g \cdot kg^{-1} \cdot min^{-1}$. Esmolol was titrated to 150 $\mu g \cdot kg^{-1} \cdot min^{-1}$ for HR control. During this time, transient hypertension occurred (MAP peaked transiently to 140 mmHg and HR increased to 103 beats/min with esmolol). The fenoldopam dose was increased to 0.8 $\mu g \cdot kg^{-1} \cdot min^{-1}$ and sodium nitroprusside was titrated to 0.8 $\mu g \cdot kg^{-1} \cdot min^{-1}$. Good blood pressure control was achieved (MAP 85 mmHg) with a somewhat labile HR (95–135 beats/min) until the tumor was removed, when all three drugs were stopped. The nephrectomy was uncomplicated and hemodynamics were stable (MAP, 70–100 mmHg; HR, 90–110 beats/min). Fenoldopam was infused for a total of 100 min. The patient was hydrated aggressively during the procedure with 7 l normal saline to prevent hypotension after tumor removal. The perioperative urine output was 100 ml/h, with no observed increase during the fenoldopam infusion. After operation, the patient's renal function deteriorated slightly, with a peak blood urea nitrogen–creatinine value of 15–2.8 mg/dl, but values returned to normal in 10 days.

Table 1. Parenteral Drugs for Hypertension in Pheochromocytoma

Drug	Class	Onset	Duration
Na nitroprusside	NO donor	1 min	3–5 min
Nitroglycerin	NO donor	2–5 min	5–10 min
Fenoldopam	DA_1 agonist	4–5 min	<10 min
Phentolamine	α_1 α_2 blocker	15 min	1 h
Nicardipine	Ca channel blocker	1–5 min	3–6 h
Labetalol	α_1 β_1 β_2 blocker	≤5 min	3–6 h

NO = nitric oxide.

Discussion

Fenoldopam causes peripheral vasodilation *via* selective stimulation of dopamine 1 receptors.[1,2] It has been compared favorably with nitroprusside in several clinical studies of hypertensive patients.[3–5] The activity profile (onset and duration) of fenoldopam would place it well on the list of useful intravenous antihypertensive agents for intraoperative management (table 1).[6] Its short duration of action makes it a desirable agent during pheochromocytoma resection because of the possibility of hypotension and shock after tumor removal.[7] Unlike sodium nitroprusside, fenoldopam also increases renal blood flow and can cause diuresis and natriuresis.[8,9] Although augmented renal blood flow is a desirable action of this agent, drug-induced diuresis would be undesirable in these patients, because volume expansion is an important part of their treatment.[10,11]

The adverse effects (flushing, hypotension, dizziness, headache, tachycardia) of fenoldopam are related directly to its hemodynamic actions. Compared with nitroprusside, which has toxic metabolites (cyanide, thiocyanate), fenoldopam appears to be a safer drug; when used in combination with nitroprusside, it may help prevent the excessive infusion rates of nitroprusside associated with toxicity.

Our first patient needed only fenoldopam, whereas patient 2 also required sodium nitroprusside and esmolol for blood pressure and HR control. Both of these patients had epinephrine-secreting tumors, but patient 2 was not treated before operation with a beta-blocker. Using fenoldopam allowed us to de-

crease the amount of sodium nitroprusside needed to control blood pressure in this patient. These two case reports document the successful use of fenoldopam in patients with renal impairment during pheochromocytoma resection.

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The Case of the Missing Fragment: Detection and Retrieval of a Portion of Broken Valve as It Was Ejected from the Heart

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EMBOLISM of air and small particles during cardiac valve surgery is seen often, but the embolism of large valve fragments is uncommon. We report a case in which a prosthetic valve fractured during its removal, and a large portion of it could not be found. After cardiopulmonary bypass, transesophageal echocardiography (TEE) revealed a broken fragment as it was ejected from the heart, and it was retrieved immediately.

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Key Words: Embolism; mitral valve; prosthetic valve dysfunction; transesophageal echocardiography.

Case Report

A 61-yr-old woman with a prosthetic mitral valve who was taking warfarin for anticoagulation therapy was admitted to the hospital after episodes of visual disturbances and slurred speech. Her mitral valve had been replaced twice: first in 1983 for mitral stenosis, and then 10 yr later for deterioration of the bioprosthetic valve. A 29-mm bileaflet mechanical valve (St. Jude Medical Heart Valve, St. Paul, MN) was implanted at that time and she had received warfarin since then, maintaining an international normalized ratio of ≥ 2.5. She also had atrial fibrillation-flutter, and 2 yr before the current admission had undergone an atrioventricular node ablation and placement of a permanent pacemaker. A TEE was done to evaluate a possible source of embolus as the cause of her current symptoms. The TEE revealed spontaneous echo contrast in the left atrium, a prosthetic mitral valve with normal movement of its leaflets, and a mobile small mass attached to the prosthetic mitral valve, suggestive of a clot.

Two days later, the patient underwent a mitral valve replacement. She was anesthetized with fentanyl, midazolam, and thiopental, and her trachea was intubated without complication. Arterial and pulmonary artery catheters were placed for hemodynamic monitoring, and TEE (Multiplane TEE probe, Hewlett Packard, Andover, MA) was used during the surgery to evaluate contractility and valve function and to