Skin Blood Flow and Plasma Catecholamines during Removal of Pheochromocytoma

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Case Reports

Case 1

A 50-yr-old, 47-kg man with a 3-month history of headache, nausea, palpitation, hypertension, renal failure secondary to glomerulonephritis, and an episode of cerebral hemorrhage was referred to us. The 24-h urinary catecholamines and the metabolites levels were markedly increased (table 1). Computed axial tomography showed a left adrenal mass of 5.0 cm in diameter, confirming the diagnosis of pheochromocytoma. The patient received 7 mg doxazosin mesylate, 1.5 mg prazosin hydrochloride, and 50 mg atenolol orally for 3 weeks before the operation.

Pretreatment consisted of 100 mg pentobarbital orally; 10 mg diazepam orally, and 0.3 mg scopolamine subcutaneously. After cannulation of a peripheral vein, a radial artery, and the pulmonary artery, an epidural catheter was inserted through the T9–T10 interspace, and T3–L1 analgesia was achieved 5 min after injection of 15 ml of 2% mepivacaine. Anesthesia was induced with 100 µg fentanyl, 10 µg midazolam, and 200 µg thiopental, intravenously. Tracheal intubation was facilitated by vecuronium. Anesthesia was maintained with 66% nitrous oxide in oxygen, fentanyl, and epidural mepivacaine. Prostaglandin E1 was titrated intravenously to maintain systolic arterial pressure between 100 and 130 mmHg. Skin blood flow was monitored at the tip of the right first toe by a laser Doppler flowmeter. The probe, with optic fiber separation of 0.7 mm, was secured to the toe, using double-faced adhesive tape.

Blood pressure (BP) and heart rate increased to 220–250/120–125 mmHg and 130 beats per minute, respectively, during manipulation of the tumor. Hypertension and tachycardia were treated by increasing the infusion rate of prostaglandin E1, boluses of 0.2–0.4 mg propranolol, and boluses of 1–2 µg phentolamine. Immediately before removal of the tumor, prostaglandin E1 was discontinued, and 11 dextan 40 was infused rapidly. However, BP decreased to 80/60 mmHg and then stabilized near 100/70 mmHg. No vasoactive drugs were used. Blood loss was estimated at 640 ml, and blood was not

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transfused. The postoperative course was uneventful. The diagnosis was confirmed histologically.

Skin blood flow decreased from 9.12 ml/100 g tissue/min to 3-5 ml during tumor manipulation. Skin blood flow increased promptly after each intravenous bolus of phenolamine. Ligation of veins draining the adrenal gland resulted in some increase in SBF. Within 1 min after removal of the tumor, SBF increased rapidly, from 6.8 ml to 14.17 ml, then continued to increase during the rest of the operation (fig. 1). There were relations between plasma norepinephrine concentration and SBF, as well as BP (SBF = −16.8 × norepinephrine [log ng/ml] + 28.7, r = −0.95, P = 0.0002 [fig. 2] and mean BP [mmHg] = 180 × norepinephrine [log ng/ml] − 23, r = 0.86, P < 0.001).

**Case 2**

A 42-yr-old, 64-kg woman with a 6-month history of headache, nausea and vomiting, excessive sweating, palpitation, and hypertension was scheduled for removal of phaeochromocytoma. Plasma and 24-h urinary epinephrine and norepinephrine levels were markedly increased. Computed axial tomography showed a right adrenal mass of 3.0 cm in diameter. The patient had been given 2 mg bunazosin hydrochloride orally for 7 weeks before admission. Anesthetic management was essentially identical to that in case 1. Skin blood flow was measured at the right first toe. Blood loss was estimated at 318 ml. Vasoactive drugs were not administered. Blood was not transfused. The postoperative course was uneventful. The diagnosis was confirmed histologically.

There were relations between SBF and plasma norepinephrine and epinephrine (−9.8 × norepinephrine [log ng/ml] + 25, r = −0.95, P < 0.0001 and −9.8 × epinephrine [log ng/ml] + 22.8, r = −0.94, P < 0.0001) (fig. 2). The relation of mean BP to plasma norepinephrine was +4 × norepinephrine [log ng/ml] + 47, r = 0.84, P = 0.006.

**Case 3**

A 64-yr-old, 56-kg woman with a 3-yr history of headache and palpitation was scheduled for removal of phaeochromocytoma. The 24-h urinary catecholamines level was increased. Computed axial tomography showed a right adrenal mass of 3.0 cm in diameter and a cyst in the left kidney of 2.5 cm in diameter. The patient had received 1 mg prazosin hydrochloride orally three times a day for 2 weeks.

Anesthesia management was similar to the previous two cases. An SBF probe was secured to the left first toe. Blood loss was estimated at 1,249 ml. Erythrocytes were transfused. Vasoactive drugs were not used. The procedures performed were removal of right adrenal mass, left radical nephrectomy, and dissection of retroperitoneal lymph nodes. The postoperative course was uneventful. The diagnoses of phaeochromocytoma and renal cell carcinoma were confirmed histologically.

There were relations between SBF and plasma catecholamines (−15.2 × norepinephrine [log ng/ml] + 31.5, r = −0.98, P = 0.0014 and −18.5 × epinephrine [log ng/ml] + 21.2, r = −0.98, P = 0.0007) (fig. 2). There was no relation between mean BP and plasma norepinephrine (mean BP = 28 × norepinephrine [log ng/ml] + 82, r = 0.54, P = 0.3917).

**Discussion**

We found that SBF in the first toe increased after epidural block; markedly decreased during manipulation of phaeochromocytoma; increased, although transiently, with administration of phenolamine; and increased again after removal of the tumor in all three patients. The SBF increase that followed the removal of phaeochromocytoma lasted until the operation was completed. The SBF responses to these interventions

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Skin blood flow (ml/100g of tissue/min)

![Graphs showing skin blood flow](image)

Plasma norepinephrine concentration (log ng/ml)

![Graph showing plasma norepinephrine concentration](image)

Fig. 2. Relations between skin blood flow in the great toe measured by Doppler flowmetry and plasma norepinephrine concentration during operation.

were rapid. Plasma norepinephrine concentrations from blood samples withdrawn before and after epidural block, immediately before phentolamine administration, and after removal of the tumor correlated more closely with SBF than with mean blood pressure in all patients.

The vascular anatomy of the skin in the fingers and toes is characterized by a highly developed system of arteriovenous anastomoses that regulate body temperaturc. Surface skin temperature of the finger has been shown to correlate with total digital blood flow. It was shown that laser Doppler flowmetry, using a probe with an optic fiber separation between the exciting and receiving fibers of 0.3 mm, detects capillary flow primarily in the outer 0.6-0.8 mm of the skin, but not blood flow through arteriovenous anastomoses located in deeper layers of the skin. However, Hira et al. showed that a probe with optic fiber separation of 0.7 mm can detect blood flow through both the capillaries and arteriovenous anastomoses in the outer 1.2 mm of the skin. In their study, a close correlation (r = 0.919) was found between blood flow in the human finger measured by venous occlusion plethysmography and that measured by laser Doppler flowmetry with an optic fiber separation of 0.7 mm. Because the probe used in our patients had an optic fiber separation of 0.7 mm, the values obtained in our patients may have reflected blood flow through capillaries and arteriovenous anastomoses in the skin of the toe.

Blood flow through arteriovenous anastomoses ranges from negligible to 80% of the total flow. The diameter of arteriovenous anastomoses may be 10 μm at vasoconstriction but 100 μm at vasodilatation, and blood flow through a unit length of an arteriovenous anastomosis with a diameter of 100 μm at vasodilatation is estimated to be 10,000 times greater than that through a capillary of 10 μm in diameter. Subsequently, Ujima and Tagawa showed that, in the rabbit's ear, thick-walled intermediate sections of arteriovenous anastomoses had dense adrenergic innervation; small arteries and arterial segments had moderate adrenergic innervation; and small veins and venous segments had only a few innervations. The increase in the total SBF in the toe that occurred soon after epidural block in our patients suggests that the increase was due largely to dilatation of arteriovenous anastomoses secondary to sympathetic nerve blockage. The marked decrease in the total SBF in the toe observed during manipulation of the tumor was interrupted by phentolamine. The decrease in the blood flow during tumor manipulation and the rapid increase in SBF after removal of the tumor were inversely and linearly related to the plasma norepinephrine levels in all patients and to the epinephrine levels in two patients.

Our finding suggests that the changes in SBF, measured in the big toe of our patients under epidural anesthesia, appear to reflect the changes in circulating catecholamine concentrations. Skin blood flow measurement may be a useful marker for the changes that occur in the concentrations of plasma catecholamines during removal of pheno-
Asystole during Temporomandibular Joint Arthroscopy

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MOST anesthesiologists are aware that compression of the eye or traction on the extraocular muscles can cause ocular cardiac reflex. Perhaps less well known is that noxious stimulation of trigeminal divisions other than the ophthalmic division (V₁) can also trigger life-threatening dysrhythmia and asystole. We present a case of asystole after stimulation of the mandibular division of the trigeminal nerve (V₃).

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