Irreversible electroporation treatment of pheochromocytoma at a complex site: A case report

Zhiyuan Wu, Tingwei Su, Fukang Sun, Fujun Zhang, Zhongmin Wang, Wei Huang, Qin Liu, Xiaoyi Ding

Department of Interventional Radiology, Ruijin Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China

A 24-year-old man was seen 2 years prior for hematuria, hypertension (165/120 mmHg), and palpitations. The plasma normetanephrine (NMN) level was elevated (9812.4 pg/mL). Computed tomography (CT) showed bilateral adrenal tumors (Fig. 1). Of the two tumors on the left adrenal gland, the lesion on the head aspect was relatively large, while that on the feet aspect (arrow) was relatively small and adjacent to the left renal artery. There was one lesion on the right adrenal gland. Positron emission tomography (PET)-CT showed increased radioactive tracer uptake in the regions of the bilateral adrenal tumors (Fig. 2). The clinical diagnosis was pheochromocytoma.

Subsequently, the large bilateral adrenal tumors were resected over two surgeries. After resection of the large tumor on the left adrenal gland during the first surgery, the patient’s blood pressure decreased to 130/90 mmHg and NMN decreased to 8724.3 pg/mL. After resection of the tumor on the right adrenal gland during the second surgery, his blood pressure further decreased to 112/80 mmHg and NMN decreased to 472.7 pg/mL. Due to the significant improvement in symptoms, the remaining small nodular lesion on the feet aspect of the left adrenal gland was not surgically treated to preserve adrenal function. Postoperative pathology confirmed pheochromocytoma, necrosis in the center of the lesion, partially encapsulated vascular invasion, and indeterminate biological activity.

At 15 months after the second surgery, the patient reported fatigue and lower back pain. His blood pressure was slightly elevated (117/89 mmHg), and palpitations. The plasma normetanephrine (NMN) level was elevated (9812.4 pg/mL). Computed tomography (CT) showed bilateral adrenal tumors. PET-CT results were consistent with the diagnosis of pheochromocytoma.

The IRE surgery was performed under CT guidance in the interventional operating room. The patient was placed under general anesthesia and arterial blood pressure monitoring. First, CT scanning was performed, and IRE probe distribution and insertion routes (Fig. 5A, B, 5C) were devised according to the CT images. A percutaneous puncture from the posterior approach was performed under CT guidance. When the probe was placed in the specified site, the tumor was treated by ablation with IRE at a voltage of 2220–2975 kV with three sets of ablations at 90 pulses per set. After ablation, the current was increased and the impedance was decreased, indicating that IRE was achieved. The probes were withdrawn after ablation and immediate enhanced CT scanning showed no enhancement in tumor tissue, indicating complete ablation. Part of the left renal artery did not appear. There was no contrast spillage from the renal artery or vein, indicating no bleeding or arterial rupture. Intraoperative guiding images and immediate postoperative CT images are shown in Fig. 5.

Intraoperative current stimulation induced significant NMN release. The patient’s blood pressure increased to 184/95 mmHg, and the real-time NMN level was 275.7 pg/mL. Nicardipine HCl (2 mg) and labetalol HCl (5 mg) were administered to return the blood pressure to normal.

After IRE treatment, the phentolamine dosage was gradually reduced over 2 weeks. A circulating tumor cell (CTC) examination on postoperative day 2 did not reveal isolated CTC or microemboli. A repeated CT on postoperative day 6 (Fig. 6) showed reduced density in the primary lesion without enhancement. The renal artery and vein were revealed clearly without stenosis or rupture. The patient’s blood pressure was 97/78 mmHg and the NMN level decreased to 47.7 pg/mL.

At 3 months postoperative, the patient’s blood pressure was 118/80 mmHg and NMN level was 70.5 pg/mL. An abdominal magnetic resonance imaging (MRI) scan showed complete ablation of the adrenal lesion. At 6 months postoperative, the patient reported no symptoms and the NMN level was below 10 pg/mL.

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Corresponding author. Department of Interventional Radiology, Ruijin Hospital, Shanghai Jiao Tong University School of Medicine, No. 197, The Ruijin Er Road, Shanghai, 200025, PR China.

E-mail addresses: wzhiyuan@shsmu.edu.cn (Z. Wu), stw11102@rjh.com.cn (T. Su), sunfukang6@126.com (F. Sun), zfj11283@rjh.com.cn (F. Zhang), wzmt0722@hotmail.com (Z. Wang), bw11475@rjh.com.cn (W. Huang), dxy10456@rjh.com.cn (X. Ding).

Zhiyuan Wu and Tingwei Su equally contributed to this work.
resonance imaging examination (Fig. 7) showed clear shrinkage of the primary lesion, reduced $T_1$-weighted imaging, $T_2$-weighted imaging, and diffusion-weighted imaging signals but no enhancement after contrast injection, indicating complete ablation.

The changes in the patient’s blood pressure and NMN level over the entire course are shown in Figs. 8 and 9.

The present case study shows that IRE can safely and effectively ablate pheochromocytoma lesions adjacent to blood vessels. Safety was demonstrated in 2 respects: (1) pheochromocytoma cells release catecholamines upon intraoperative stimulation, but through preoperative oral $\alpha$-adrenergic antagonists and intraoperative intravenous nicardipine HCl and labetalol HCl, the acute hypertension was adequately controlled.

Fig. 1. Abdominal computed tomography images showing bilateral adrenal tumors. There were two lesions on the left adrenal gland: that on the head aspect measured approximately $4.7 \times 3.8 \times 4.5$ cm, while that on the feet aspect (arrow) was relatively small, measuring $1.2 \times 1.1 \times 1.1$ cm and adjacent to the left renal artery. The lesion on the right adrenal gland measured approximately $4.0 \times 3.3 \times 4.3$ cm.

Fig. 2. Positron emission tomography–computed tomography showed increased radioactive tracer uptake in the regions of the bilateral adrenal tumors. The left SUVmax was 6.3–10.4, while the right SUVmax was 7.9–11.6. SUVmax, maximum standardized uptake value.
IRE did not damage any vascular structures adjacent to the tumor and did not induce rupture or bleeding. Efficacy was demonstrated by blood pressure returning to normal levels postoperatively, NMN decreasing to within the normal range, and the achievement of complete response on imaging evaluation. Based on this experience, we recommend that IRE serve as a substitute to surgical resection, radiofrequency ablation, chemotherapy, or radiotherapy for treatment of pheochromocytoma primary or metastatic lesions adjacent to blood vessels.

Fig. 3. Re-examination by abdominal CT showed proliferation of the residual lesion in the left adrenal region to approximately 1.8 cm × 1.5 cm × 1.6 cm. PET-CT showed partially increased metabolism (arrow), and the SUVmax was 4.8. CT, computed tomography; PET-CT, positron emission tomography–CT; SUVmax, maximum standardized uptake value.

Fig. 4. The residual lesion in the left adrenal region gradually increased in size over the follow-up period. Figures A, B, and C show computed tomography images taken on April 8, 2015, July 5, 2016, and Feb 16, 2017, respectively.
Fig. 5. Intraoperative guiding images and immediate postoperative computed tomography (CT) images. Irreversible electroporation probes avoided the left renal artery, left renal vein, and other important structures. The three probes triangularly surrounded all tumor tissues. The probes were parallel to each other and separated by 12.0 mm, 16.4 mm, and 17.3 mm, respectively. A 1.5-cm section of each probe tip was exposed. A, one probe in the superior position; B, two probes in the inferior position; C, coronal reconstruction image showing separation of the three probes; D, immediate postoperative enhanced CT images showing no enhancement in tumor tissue.

Fig. 6. Images from computed tomography re-examination on postoperative day 6. A decreased density in the primary lesion was seen (0.8 cm × 0.9 cm × 0.9 cm) without enhancement. No stenosis or rupture was seen in the renal artery or vein.

Fig. 7. Images from abdominal magnetic resonance imaging examination performed at 3 months postoperative. Clear shrinkage of the primary lesion, reduced T1WI, T2WI, and diffusion-weighted imaging signals, and no enhancement after contrast injection indicated complete ablation.
Patient consent

Written informed consent was obtained from patients for publication of this case report and any accompanying images.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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