The incidence of renal cell carcinoma has recently increased worldwide. Advanced imaging modalities have led to the increased accidental discovery of renal tumors; however, patients with comorbidities may not be good candidates for surgical resection. Ablative treatment is used for various types of malignancies. Percutaneous cryoablation (PCA) is one of the nonsurgical therapeutic options for renal tumors, with reports of promising results [1, 2]. Although bowel injury after PCA is a well-known complication, it is extremely rare [2–5]. We present a case of acute bowel injury due to PCA that was managed with an emergency surgery. The computed tomography (CT) findings were well correlated with those of both macroscopic and microscopic evaluations.

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An 87-year-old Japanese man underwent percutaneous cryoablation (PCA) therapy for his renal cell tumor. We displaced the colon from the tumor using hydrodissection. Computed tomography (CT) immediately after PCA was indicative of iceball extension to the colon wall, and a discontinuous enhancement of the colon wall was observed. We therefore performed an emergency surgery. On laparotomy, we observed a dark-purple area on the affected area of the colon, and the resected specimen showed focal, deep ulceration on the mucosal surface. Photomicrography revealed mucosal necrosis, submucosal hemorrhage, and necrotic foci in the muscularis propria, corresponding to the discontinuous colon wall enhancement on CT and the deep ulceration and dark-purple area on laparotomy. He recovered from surgery and was discharged without any complications.

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An 87-year-old Japanese man was referred to our hospital for the treatment of a left renal tumor that was detected incidentally (Fig. 1A). His medical history was unremarkable. Other than a decreased estimated glomerular filtration rate (36.7 mL/min/1.73 m²), the results of all other laboratory tests were normal. The renal tumor was diagnosed as renal cell carcinoma on percutaneous CT-guided biopsy. With the patient in the prone position, three 17-gauge cryoprobes (Ice-Rod; Galil Medical, Yokneam, Israel) were placed at planned sites under CT fluoroscopy guidance. To avoid bowel injury, a 21-gauge Chiba needle (Cook, Bloomington, IN, USA) was placed between the renal tumor and the adjacent descending colon, and a diluted (4%) iodine contrast medium (Iohexol;
300 mg/mL; Daiichi-Sankyo, Tokyo, Japan) was injected to displace the colon away from the renal tumor (i.e., hydrodissection was performed).

After confirming colon displacement on CT, we performed PCA using a cryoablation system (Cryo-Hit; Galil Medical) using the Joule-Thomson effect with high-pressure argon gas in two 15-min freeze cycles separated by 2 min of thawing (Fig. 2). During the freezing, intermittent monitoring was performed using CT fluoroscopy; in addition, a conventional CT scan was performed immediately after each freezing. The CT images obtained after the first freezing showed a low-attenuated iceball on the target tumor, indicating no iceball extension to the colon; however, the images obtained after the second freezing showed iceball extension to the medial colon wall (Fig. 1B). Four hours after PCA, the patient’s creatinine kinase and lactate dehydrogenase levels increased to 362 IU/L (normal range, 41–258 IU/L) and 459 IU/L (normal range, 120–240 IU/L), respectively.

The next morning, dynamic contrast-enhanced CT showed a marked thickening in the affected colon wall as well as focal discontinuity in the mucosa and muscle layer enhancement (Fig. 1C). The patient complained

Fig. 1  (A) Pre-treatment contrast-enhanced CT shows the left renal tumor.  (B) A CT image obtained immediately after the second freezing shows the inner margin of the iceball (arrow), and the outer margin, which expands to the colon wall (arrowhead).  (C) Contrast-enhanced CT shows discontinuity of both the mucosal and muscle layer enhancements (arrowhead).

Fig. 2  An iceball was formed around the cryoprobe by using the Joule-Thomson effect with high-pressure argon gas.
of tenderness in the upper left quadrant but showed no signs of peritoneal irritation. Colonoscopy was ruled out because of the risk of colonic perforation. We scheduled an emergency surgery (25 h after PCA) because of the high mortality risk due to perforation given his advanced age. On laparotomy, displacement of the colon revealed a coin-sized dark-purple area on the posteromedial side of the edematous colon (Fig. 3A).

Partial colectomy and end-to-end anastomosis were performed. The mucosal surface of the resected specimen showed deep ulceration (Fig. 3B). The patient recovered soon after the surgery and was discharged without any complications. On microscopic evaluation, necrosis and hemorrhage were seen in all layers of the colon (Fig. 3C), which corresponded to the discontinuous enhancement in the mucosal and muscle layers. The patient did not exhibit any overt symptoms upon periodic follow-up, and a CT scan 3 months after PCA demonstrated no local tumor progression. The patient provided written informed consent for publication of this case report.

**Discussion**

Freezing injury to adjacent organs, such as the colon, duodenum, or ureter, can be a serious complication of PCA in the treatment of a renal tumor. To avoid freezing injury to adjacent organs, various techniques including a change in patient position, manual displacement, and hydrodissection have been reported [6].

Hydrodissection is a widely accepted technique associated with PCA treatment [1,2,6]. Although the visibility of the iceball is the most evident feature of PCA under image guidance, several factors disturbed the visibility of the iceball in the present case, leading to an injury to the large bowel. First, the high concentration (4%) of the diluted contrast medium made it difficult for us to recognize the iceball margin during the procedure. Campbell et al. reported that a concentration of 2% iohexol in saline is an optimal concentration for visibility without artifacts [7].

Second, the injected fluid in the present case contained microbubbles, which was similar to stool in the colon. Indeed, the contracted colon with stool and the fluid with microbubbles were indistinguishable in several sections. Hence, care should be taken not to inject air during a hydrodissection. Although magnetic resonance imaging (MRI) guidance has several advantages over CT guidance, including high tissue contrast and the feasibility of manual displacement without the operator being exposed to radiation, MRI will typically demonstrate considerable artifacts resulting from air, motion, and the metallic cryoprobe. Unfortunately, MRI-guided cryoablation was not practicable in our institution.

Our patient underwent surgical intervention without bowel perforation. Most of the previously reported cases with bowel injury were managed conservatively [2–5]. Emergency surgery should be considered only when a bowel injury causes obstruction and perforation. However, in this case, the surgical findings showed necrosis in the colon wall induced by PCA,

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Fig. 3  (A) The posteromedial side of the affected colon showed a focal dark purple area. (B) The mucosal surface of the resected specimen showed focal deep ulceration. (C) A photomicrograph of the affected colon showing the mucosal necrosis, submucosal hemorrhage, small vessels with thickened and inflamed walls, some of which are thrombosed, and necrotic foci in the muscularis propria.
which would have caused penetration or perforation. In addition, emergency surgery after the development of peritonitis can be potentially lethal for patients at an advanced age (as in this case) [8].

For our patient, the periprocedural CT images (including the iceball location), dynamic contrast-enhanced CT images, and macroscopic or microscopic appearances were well correlated with each other. All procedures were performed within 25 h, except for the microscopic examination. Regarding the CT image evaluation, the most specific CT finding for the diagnosis of intestinal ischemia has been reduced or no enhancement of the bowel wall on contrast-enhanced CT images, and macroscopic or microscopic evaluations are not useful because cryoablation and hydrodissection can cause these findings. A pathologic specimen in a previous report showed only the suberosal bowel wall perforation could have occurred, which was evidenced by the presence of multifocal necrotic foci throughout the colon wall.

In addition, various findings indicative of bowel necrosis including peri-bowel stranding and fluid attenuation are not useful because cryoablation and hydrodissection can cause these findings. A pathologic specimen in a previous report showed only the subacute phase (2 weeks after PCA) of a bowel injury [3], and there have been no reports on the pathologic evaluation of acute bowel injury after PCA, to our knowledge. In the present case, there was no enhancement of both mucosa and muscle layers; in addition, the iceball temperature is suspected to be lower at the proper muscle layer than at the mucosa, depending on the proximity to the cryoprobe. Thus, colon wall perforation could have occurred, which was evidenced by the presence of multifocal necrotic foci throughout the colon wall.

Although emergency surgery might be an over-treatment, in our present patient's case, the CT findings were well correlated with those of the macroscopic and microscopic evaluations. Our findings will be useful for patient management in similar cases.

References


