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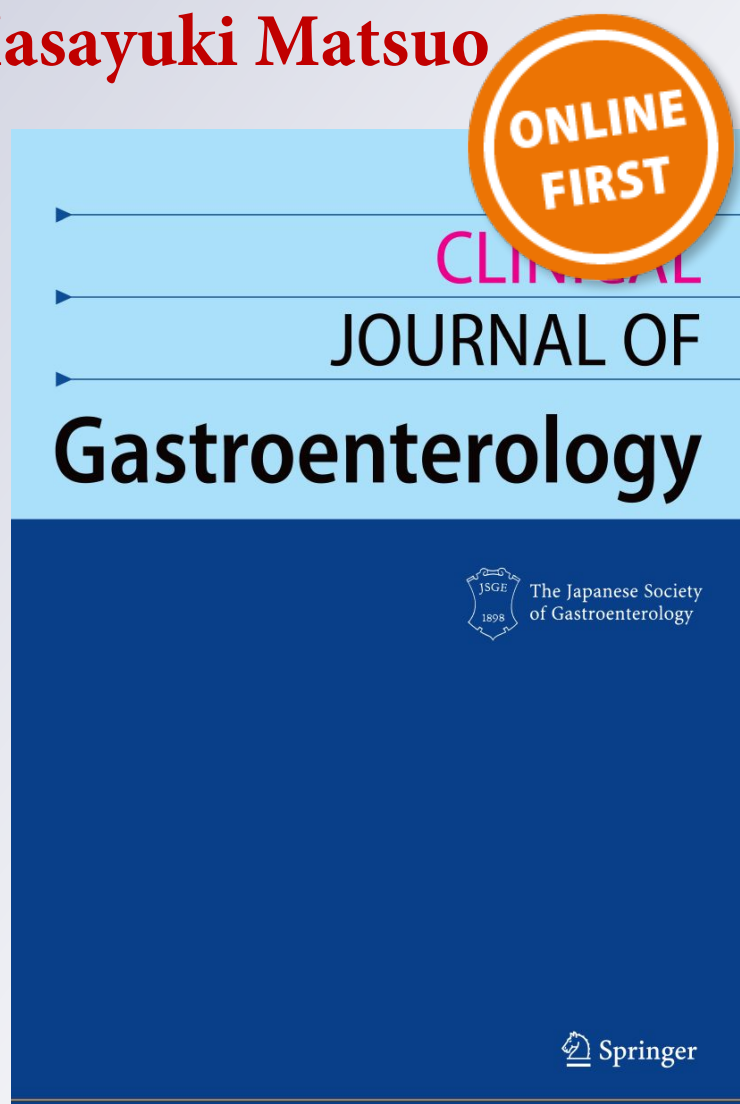
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# Usefulness of diffusion-weighted magnetic resonance imaging for evaluating the effect of hemostatic radiotherapy for unresectable gastric cancer

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## Abstract

There are several reports that vouch for the usefulness of diffusion-weighted image (DWI) in making a diagnosis before treatment. However, no study has evaluated the effect of radiotherapy (RT) for unresectable gastric cancer. In the present case report, we evaluated the effectiveness of RT using DWI. An 81-year-old man was hospitalized with a broken bone and then diagnosed with advanced gastric cancer with bleeding. He had chorionic renal failure and surgery was impossible. Further, contrast-enhanced computed tomography and magnetic resonance imaging (MRI) were not performed due to renal failure, whereas palliative RT was performed. We followed up the patient using blood test and MRI (DWI) to estimate whether bleeding had stopped or not after radiotherapy. Hemostasis effect was found after 2 weeks of RT. In DWI examination, there was a decrease in the tumor signal intensity 30 days after RT. Similarly, at day 60, the tumor signal intensity further decreased on DWI and the blood test results indicated no progression of anemia. At 4 months after the RT, the patient died because of respiratory failure without any bleeding. DWI is useful not only for the initial diagnosis but also for evaluating the effectiveness of RT.

**Trial registration:** National clinical study registered number: UMIN000026362.

**Keywords** Radiotherapy · Gastric cancer · Diffusion-weighted magnetic resonance imaging

## Introduction

Magnetic resonance imaging (MRI) has been increasingly used to evaluate the stage of solid cancer and to determine the therapeutic effect, particularly with the aid of diffusion-weighted imaging (DWI) [1–6]. The technique is applied for staging the disease prior to commencing the treatment for

gastric cancer. Recently, the use of DWI has been reported as an effect of treatment by RT and chemotherapy for solid cancer. However, to the best of our knowledge, there is no report that estimated the treatment effect of RT on the gastrointestinal tract [4–6]. In the present case report of gastrointestinal tract cancer, we evaluated the effectiveness of RT using DWI.

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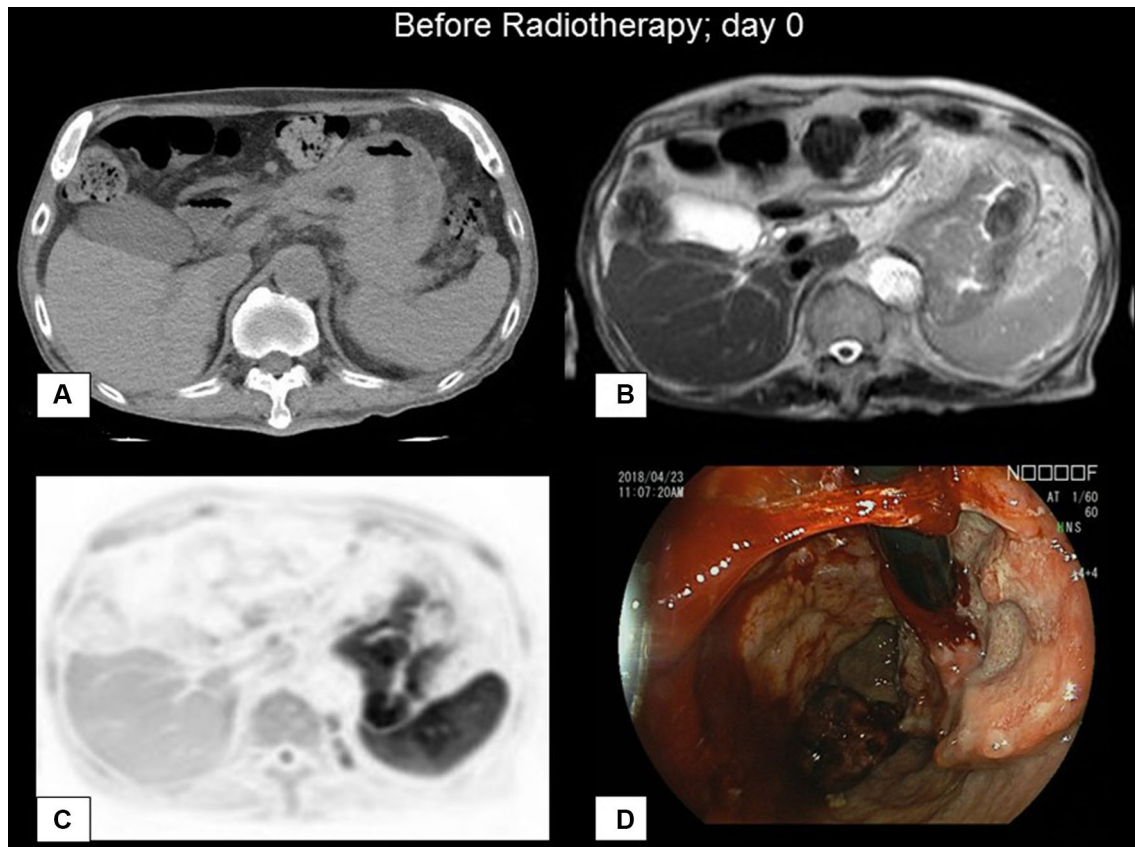
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## Case report

An 81-year-old man was hospitalized with a broken bone and then diagnosed with advanced gastric cancer. The condition was endoscopically diagnosed as adenocarcinoma with Bormann type 3 with bleeding (Fig. 1). The patient underwent plain computed tomography (CT) because his renal function was compromised and contrast agents could not be used. CT revealed surrounding lymph node metastasis, pancreatic invasion, and left adrenal metastasis. His tumor was inferred to be unresectable.



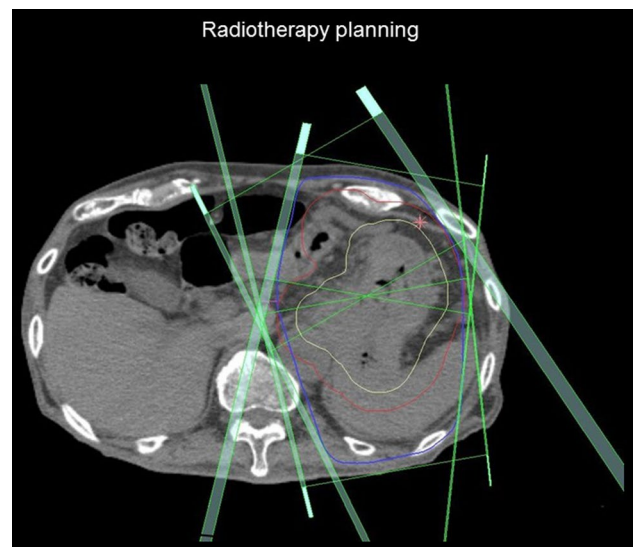
**Fig. 1** **a** Plain CT; The margin of the gastric wall was delineated. **b** T2-weighted image; Moderate increase in the signal intensity in the margin of the gastric wall. **c** Diffusion-weighted image; High signal

intensity in the margin of the gastric wall. **d** Upper gastrointestinal endoscopy; Gastric cancer with bleeding. Borrmann type 3

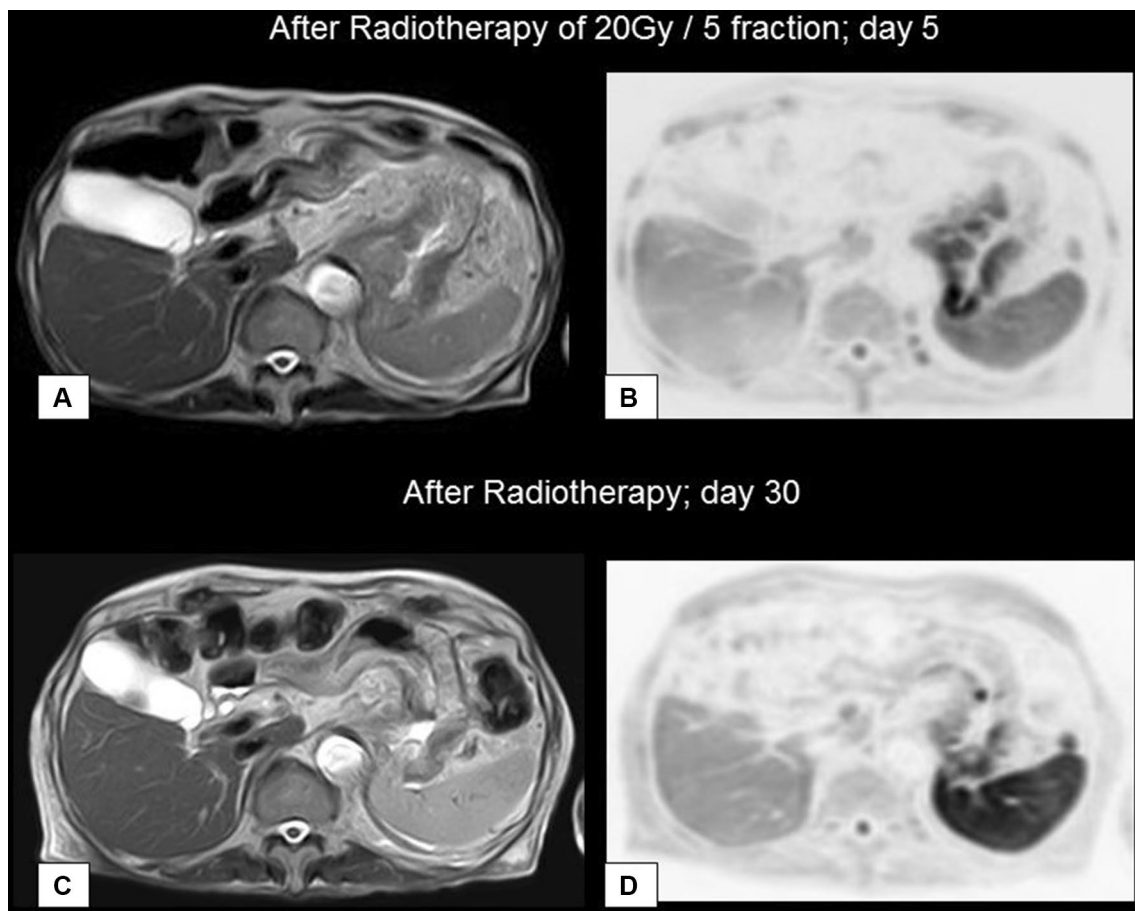
Plain CT (16-row multidetector CT; Alexion, Toshiba Medical System; Otawara, Japan) and MRI (MRI, Achieva; Philips Medical Systems, Best, The Netherlands) were used to investigate the extent of tumor development. Parameters for CT were as follows: slice thickness of 2 mm, field of view of  $50 \times 50$  cm, and settings of 150 mA and 120 kV. Parameters for T2-weighted imaging (T2-WI) were as follows: fast spin-echo; repetition time (TR)/echo time (TE) in ms: 433/80; number of sample (signals) averaged (NSA): 1; and matrix:  $256 \times 204$ .

Parameters for DWI were as follows: gradient echo; TR/TE in ms: 1200/65; NSA: 5; matrix:  $80 \times 142$ ; and B-value: 1000. The signal intensity in the gastric wall on DWI was checked and compared with that in the spleen before RT (day 0), immediately after RT (day 5), 30 days after RT (day 30), and 60 days after RT (day 60).

The patient was incapable of receiving chemotherapy owing to chronic renal failure. Bleeding from the stomach could not be controlled by endoscopic treatment. Therefore, 20 Gy/5 fx of RT (Elekta Synergy System, Elekta Ltd, Crawley, UK) was administered. The extent of tumor spread could not be accurately measured; the entire outer



**Fig. 2** Radiotherapy planning; Contouring of the entire outer wall of the stomach. From the contoured line, the clinical target volume (CTV) was contoured with a 1-cm margin from the outer wall of the stomach (yellow line) and the planning target volume (PTV) was contoured with a 1-cm margin from the CTV (red line)



**Fig. 3** **a** T2-weighted image; Moderate increase in the signal intensity in the margin of the gastric wall. **b** Diffusion-weighted image; High signal intensity in the margin of the gastric wall. There was no obvious change in the signal intensity before RT on comparison with

the spleen's intensity. **c** T2-weighted image; No obvious change compared with that in a previous study. **d** Diffusion-weighted image; The signal intensity in the gastric wall decreased in comparison to that in a previous study

wall of the stomach was contoured. From the contoured line, the clinical target volume (CTV) was delineated with a 1-cm margin from the outer wall of the stomach and the planning target volume (PTV) was contoured with a 1-cm margin from the CTV (Fig. 2).

There were no changes in the tumor signal intensity on DWI before and 5 days after RT (Fig. 3a, b). Following RT, we confirmed for 2 weeks that the hemoglobin level did not decrease below the normal limit. We decided to administer hemostasis irradiation to which the patient responded. At day 30, there was a decrease in the tumor signal intensity on DWI (Fig. 3c, d). Similarly, at day 60, the tumor signal intensity further decreased on DWI (Fig. 4) and the blood test results indicated no progression of anemia.

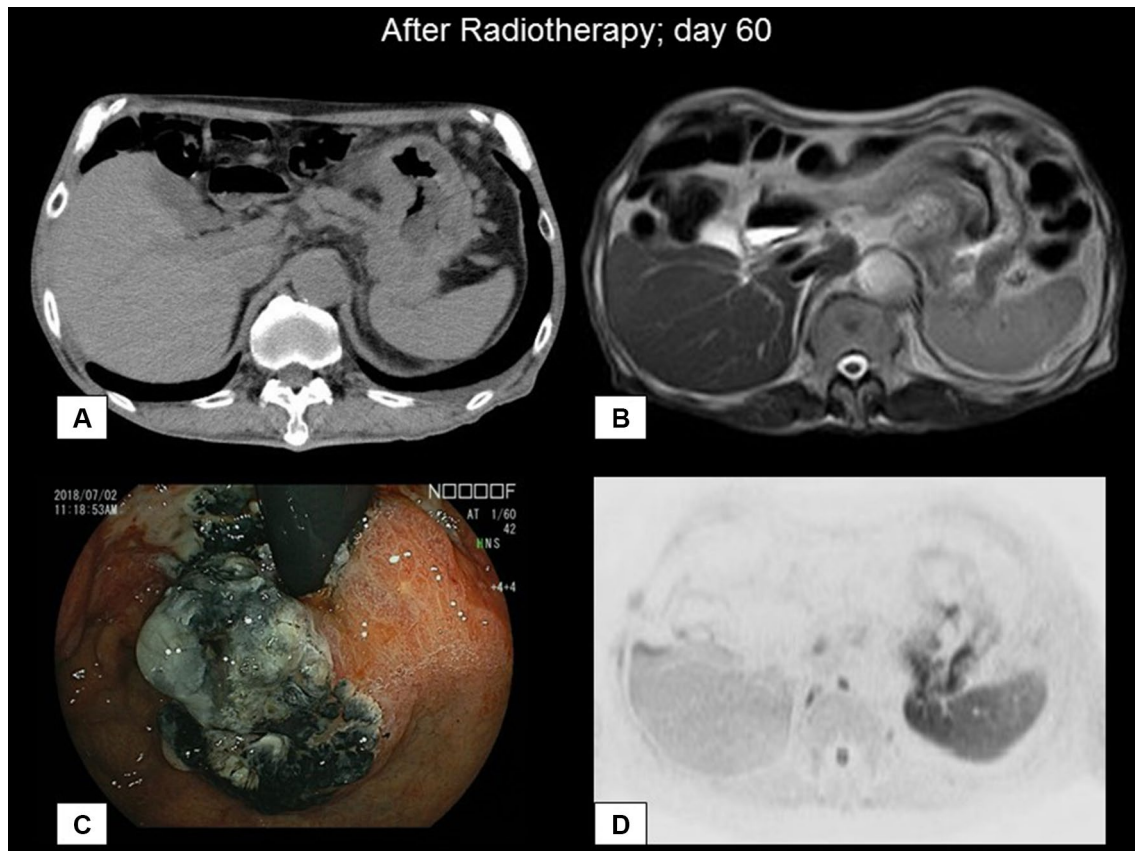
During endoscopy, the tumor was ulcerated and flattened (Fig. 4c). Subsequently, he was discharged from the hospital; however, he was hospitalized with anorexia after 4 months of treatment. Plain CT revealed pneumonia and pleural effusion. Endoscopy revealed minimal bleeding from the tumor

that did not necessitate blood transfusion. We continued to provide palliative care, and at 4 months after the initial RT, the patient died because of respiratory failure without any bleeding.

## Discussion

In Japan, gastric cancer is the second prevalent cancer followed by colorectal cancer. Surgery and pre- or postoperative chemotherapy are common treatment choices for gastric cancer [7, 8]. However, in advanced cases, it is often impossible to perform surgery. Besides, in the event of bleeding, endoscopic treatment is often difficult. Therefore, hemostasis irradiation is preferred [9–11]. Various authors have reported a response rate of 70–90%, which is quite effective for palliative treatment [12].

We performed hemostasis irradiation on patients who could not tolerate contrast agents or chemotherapy owing to decreased renal function. RT results in tumor cell death



**Fig. 4** **a** Plain CT; The margin of the gastric wall reduced in comparison to that in a previous study. **b** T2-weighted image; The margin of the gastric wall was reduced in comparison to that in a previous study. **c** Upper gastrointestinal endoscopy; Gastric cancer was minimized

as compared to that before radiotherapy. Ulcer and flat surface was observed. **d** Diffusion-weighted image; The signal intensity in the gastric wall was decreased in comparison to that in a previous study

and apoptosis, which correlates with an increase in the value of the apparent diffusion coefficient (ADC) [13–15]. DWI is routinely used for staging the disease before treatment, especially in malignant lymphoma and cancers of the head and neck, lungs, and esophagus.

ADC serves as a functional biomarker allowing individual adaptive therapy based on the observed response. We did not obtain the ADC map because it is prepared only for solid organs, such as the liver and pancreas. However, measuring the ADC value of the gastric wall was a better option and it would have to be estimated by quantitative analysis. In the present study, we did not estimate ADC value; therefore, the signal intensity of the gastric wall was estimated using a contrast of the signal intensity of the spleen. It would be better to measure whether the ADC changed with visual recognition to yield quantitative results. There are several reports that vouch for the usefulness of DWI in making a diagnosis before treatment [13, 14]. There is also a report that DWI can be used for cancer staging, such as (18)fluoro-deoxyglucose positron emission tomography/CT. We previously documented that

DWI is beneficial in determining the therapeutic effect of radiation chemotherapy in head and neck cancer [15]. Unlike CT, DWI does not require contrast media, and a hybrid of a tissue can be identified using DWI. Although only the surface of the gastric inner wall can be observed with the endoscope, evaluation of the stomach wall is also possible using MRI. Bleeding increases as the tumor volume increases. DWI reflects the diffusion limitation of the analyzed tissue. When the tumor is damaged by radiation, the tumor volume decreases, resulting in decreased diffusion limitation and changed signals on the image.

The stomach is a moving organ and is thus difficult to assess with an imaging modality, such as MRI. However, in the present case, the stomach was emptied and peristaltic movement was suppressed by butylscopolamine. Therefore, the form of the stomach could be maintained and reproducibility of the examination could be enhanced. We followed this approach in every RT and succeeded in performing hemostasis irradiation.

Because endoscopic examination is an invasive procedure, non-invasive follow-up is desirable after palliative

treatment. Plain CT is advantageous owing to its rapid scanning (approximately 2–3 s) and as it is rarely influenced by the movement of organs; however, it cannot detect biological changes. To overcome this disadvantage, MRI can be used for estimation of biological changes. Moreover, in situations wherein contrast-enhanced CT or MRI cannot be performed, DWI is useful in evaluating the effect of treatment, especially in gastric cancer. Alternatively, the degree of bleeding may be evaluated using a blood test. Nevertheless, it is difficult to distinguish gastric bleeding from that in other organs. Moreover, when a contrast agent cannot be used owing to renal failure, it is difficult to accurately assess with plain CT. In such instances, DWI is useful not only for the initial diagnosis but also for evaluating the effectiveness of RT. Besides, endoscopy is an invasive technique, and application of further invasive examination should be avoided. DWI reflects the decreased tumor size in solid cancers such as lung, head and neck, and prostate cancer. However, there was no report regarding the estimation of change in tumor size in gastric cancer using DWI after RT. We examined effectiveness of RT as clinical trial of DWI for hemostasis RT without endoscopy following RT is ongoing. If DWI can become an alternative to endoscopy, it will prove useful for end-stage patients.

Although DWI has long been considered useful for solid cancer, it has been useful for preoperative evaluation of conditions such as lymph node metastasis in the gastrointestinal tract. In addition, it has been used more frequently in the judgment of curative effects of radical chemotherapy of cancer such as esophageal cancer. Because there are currently few reports on gastrointestinal cancer treated by palliative hemostasis RT, additional cases are required in the future.

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### Compliance with ethical standards

**Conflict of interest** Osamu Tanaka, Tatsushi Omatsu, Syuji Kariya, Ryoshu Maejima, Takuya Taniguchi, Kousei Ono, Yuka Kunishima and Masayuki Matsuo have no conflict of interest.

**Human rights** We registered Institutional review board and national clinical trial UMIN.

**Informed consent** Informed consent was obtained from the patient for being included in the study.

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