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Krukenberg Tumors in Young Women: Computed Tomography and Magnetic Resonance Imaging Diagnosis

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Introduction: The purpose of this report was to present the computed tomography (CT) and magnetic resonance imaging (MRI) features of Krukenberg tumors and to review the pertinent clinical data about the rising incidence of this malignancy among young women.

Material and Methods: This series included 8 women who ranged in age from 24 to 44 years (mean, 36.3 years). They were diagnosed to have Krukenberg tumors during a 5-year period (2011–2016). All patients were evaluated by abdominal CT and pelvic or transvaginal sonography. Five of them also had MRI of the abdomen, and 3 had positron emission tomography scans.

Results: The primary cancer was located in the stomach of 7 patients and in the colon in 1. The initial presentation was due to large pelvic mass and abdominal distention by ascites in 3 patients, gastrointestinal symptoms in 4, and small bowel obstruction by carcinoma of the ascending colon in 1 woman. Ovarian metastases were demonstrated on the initial imaging examination of 5 patients and developed as metachronous lesion during follow-up in 3 cases. Six women died 3 to 23 months (mean, 11 months) after the diagnosis. One has survived for 6 years after extensive surgery, and 1 was lost to follow-up.

Conclusions: Krukenberg tumors are being diagnosed with an increasing frequency because of well-documented rising incidence of gastric and colorectal carcinomas among young women. Therefore, those presenting with gastrointestinal cancer should have careful imaging of their ovaries for possible metastases, and conversely, the clinical or sonographic detection of bilateral ovarian masses would require evaluation by CT or MRI of the abdomen in search for a potential primary gastrointestinal cancer. This report highlights the CT and MRI features of this neoplastic process and reviews the current concepts about its development and management.

Key Words: computed tomography, MR imaging, Krukenberg tumor, ovarian metastasis, gastric cancer, colon cancer

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HIGHLIGHTS

- Krukenberg tumors are being encountered with increasing frequency.
- This reflects the widespread use of sectional imaging modalities.
- It is also due to higher incidence of gastric and colon cancer among young women.

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- This article presents the CT and MR features of this malignancy in 8 cases.
- Pertinent literature and supporting clinical data are reviewed.

Krukenberg tumors represent metastatic involvement of ovaries by mucin-producing signet cell carcinomas that mainly originate in the stomach or colon. Less common primary sites are the breast and lung. They involve both ovaries in about 80% of cases and account for nearly 10% of all ovarian tumors.^{1–3}

Krukenberg tumors had been relatively rare in the past and usually described in isolated case reports and small series. However, they are being encountered with an increasing frequency in the recent 2 to 3 decades because of rising incidence of gastric and colon cancer in young adults and particularly female patients.^{4–8} The widespread application of sectional imaging modalities has also contributed to the improved recognition of this entity.^{9–11}

The aims of this article were to illustrate various presentations of Krukenberg tumors on abdominal computed tomography (CT) and magnetic resonance imaging (MRI) studies, and to review the recently published data about the clinical aspects of this malignancy. The herein provided information will be important when the practicing radiologists encounter such cases because an analysis of Mayo Clinic records for 1997 to 2018 revealed that radiology reports had only 60.7% accuracy in the diagnosis of either Krukenberg tumors or primary ovarian cancers.²

MATERIALS AND METHODS

The clinical and radiological record of 8 women who had been diagnosed with Krukenberg tumors during a 5-year period (May 2011–December 2016) were reviewed retrospectively. Their age ranged from 24 to 44 years (mean, 36.3 years). All had been initially evaluated with abdominal CT and pelvic or transvaginal sonography. Additional CT and radiographs of chest and abdomen were obtained in the course of their treatment and follow-up, 5 of them also had MRI and 3 had positron emission tomography scans. All 8 patients had histopathological confirmation of Krukenberg tumors. Four gastric and 1 colon carcinomas were resected, and total abdominal hysterectomy and oophorectomy were performed. Three patients with advanced disease had endoscopic biopsy of their gastric cancer and ultrasound-guided biopsy of the ovarian metastases before chemotherapy. It should be noted that patients' consent and institutional review board approval were waived because of the retrospective review of the already performed and medically warranted radiological examinations.

RESULTS

The primary source of ovarian metastasis was gastric carcinoma in 7 patients and colon cancer in 1 patient. There were considerable variations in terms of presenting clinical symptoms, as well as the size and configuration of the primary cancers and ovarian metastases.

Three women who had presented with large pelvic masses and distended abdomen due to ascites were initially evaluated by abdominal and transvaginal sonography. The appearance of

well-circumscribed solid ovarian lesions and ascites suggested their malignancy. However, their metastatic nature became apparent when the subsequent CT or MRI demonstrated unsuspected gastric carcinomas (Figs. 1, 2). In each of these 3 patients, the thickened gastric walls due to primary carcinoma was confirmed by endoscopic biopsy.

The other 4 women with gastric carcinoma had been referred for abdominal CT examination because of gastrointestinal symptoms that included dyspepsia, early satiety, weight loss, and melena. All had marked gastric wall thickening that proved to be infiltrating mucinous adenocarcinoma. Two of them already had ovarian tumors, and 2 developed metachronous metastases visualized on follow-up imaging studies after chemotherapy (Figs. 3, 5, and 6).

These Krukenberg tumors appeared as well-circumscribed masses that were hyperintense on gadolinium-enhanced T1 sequence, whereas their cystic part was best visible as hypointense lesion with thin capsule and internal septations on T2-weighted fat-suppressed sequence (Figs. 2, 3). On contrast-enhanced CT examinations, however, the ovarian metastases in the early stage of development were usually seen as low-attenuated cystic structures (Fig. 4).

One woman presented with small bowel obstruction, and her CT disclosed a carcinoma of the ascending colon with coexistent ovarian masses consistent with Krukenberg tumor (Fig. 4). This patient underwent a segmental colectomy, hysterectomy, and oophorectomy. She has remained cancer-free for the past 6 years. Another young female had gastrectomy and chemotherapy, but metachronous ovarian metastases appeared 1 year later (Fig. 5). However, the remaining 6 patients with advanced disease who were treated with chemotherapy and conservative management had all died 3 to 23 months after the initial diagnosis (mean survival time, 11 months).

It is of interest to note that 1 woman with biopsy-proven infiltrating signet cell carcinoma of the stomach demonstrated punctate calcifications of her gastric tumor on the initial CT study. After chemotherapy, the calcifications markedly increased in extent. Although her liver and ovarian metastases decreased in size, they did not demonstrate any visible calcifications (Fig. 6).

The survival time of 6 women after the initial diagnosis ranged from 3 to 23 months (average, 11 months). The patient with colon cancer and ovarian metastases has survived 6 years without recurrence after radical surgery. One woman who

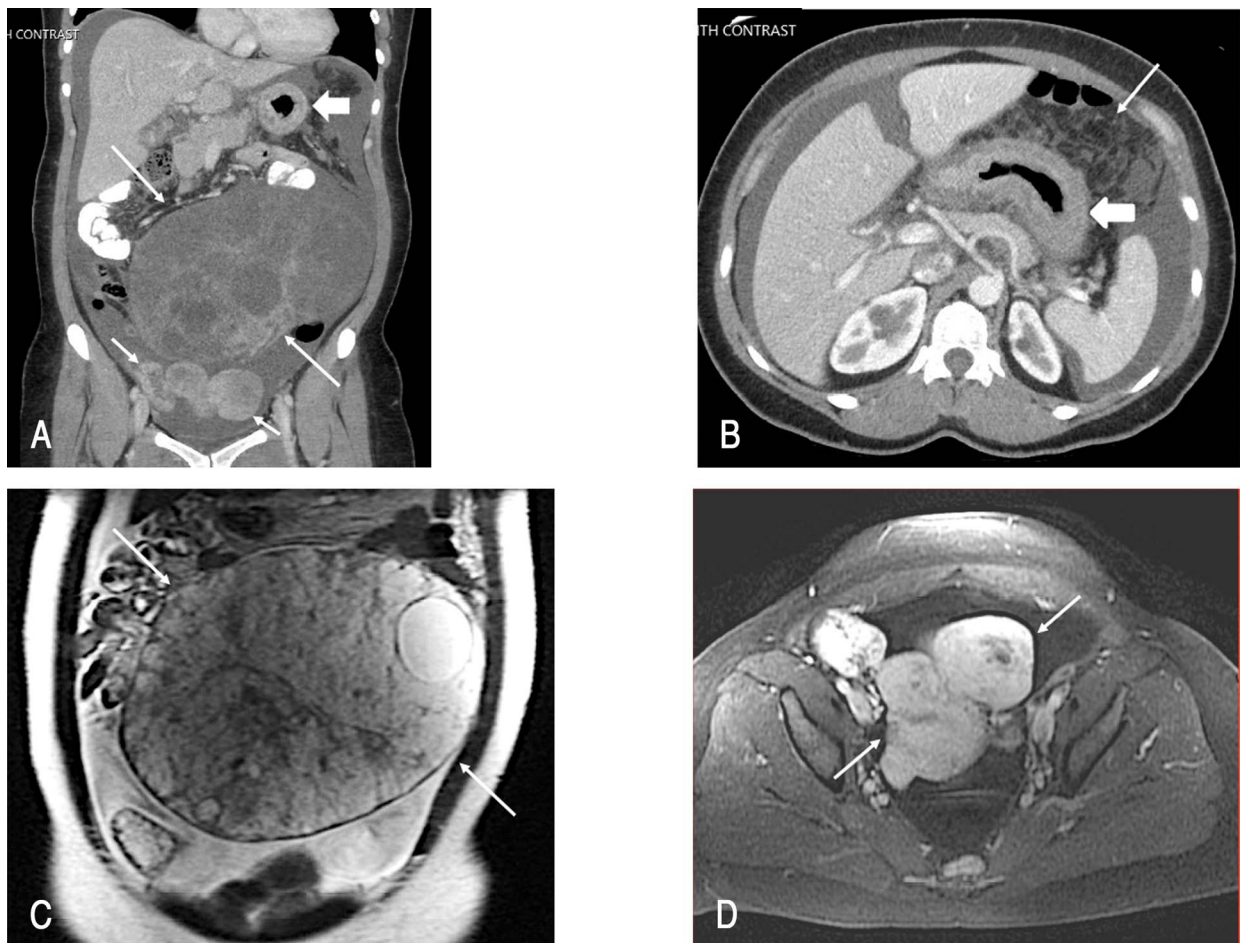


FIGURE 1. Large Krukenberg tumor in a 39-year-old woman. A, Coronal CT image of the abdomen shows a 19×23 -cm cystic mass of the left ovary that extends to the mid-abdomen (long arrows), and several round metastases involving the right ovary (short arrows). Circumferential thickening of the gastric wall (thick arrow) and associated ascites are present. B, Axial section of the upper abdomen reveals diffusely thickened gastric walls due to primary carcinoma (thick arrow), with metastatic infiltration of the gastrocolic ligament (thin arrow). C, Coronal MR image shows the large left ovarian cystic mass with thin margins and internal septations on T2-weighted sequence with fat suppression (arrows). D, Axial MR section of the pelvis demonstrates multiple hyperintense metastases of the right ovary on T1-weighted postgadolinium sequence (arrows).

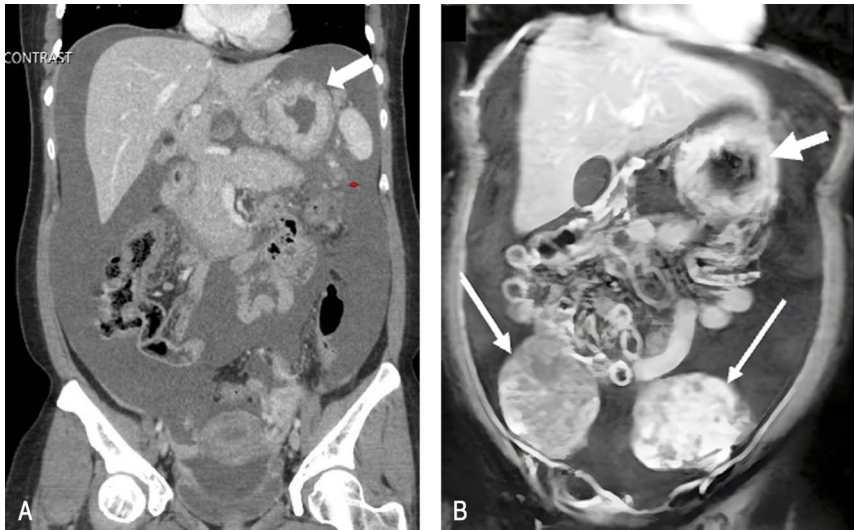


FIGURE 2. Krukenberg tumor in a 41-year-old woman. A, Coronal image of the initial CT examination shows circumferential thickening of the stomach (arrow) and a massive amount of ascites. B, Coronal MR section 6 months later demonstrates the gastric cancer (short arrow) and bilateral ovarian metastases (long arrows) on gadolinium-enhanced T2-weighted study.

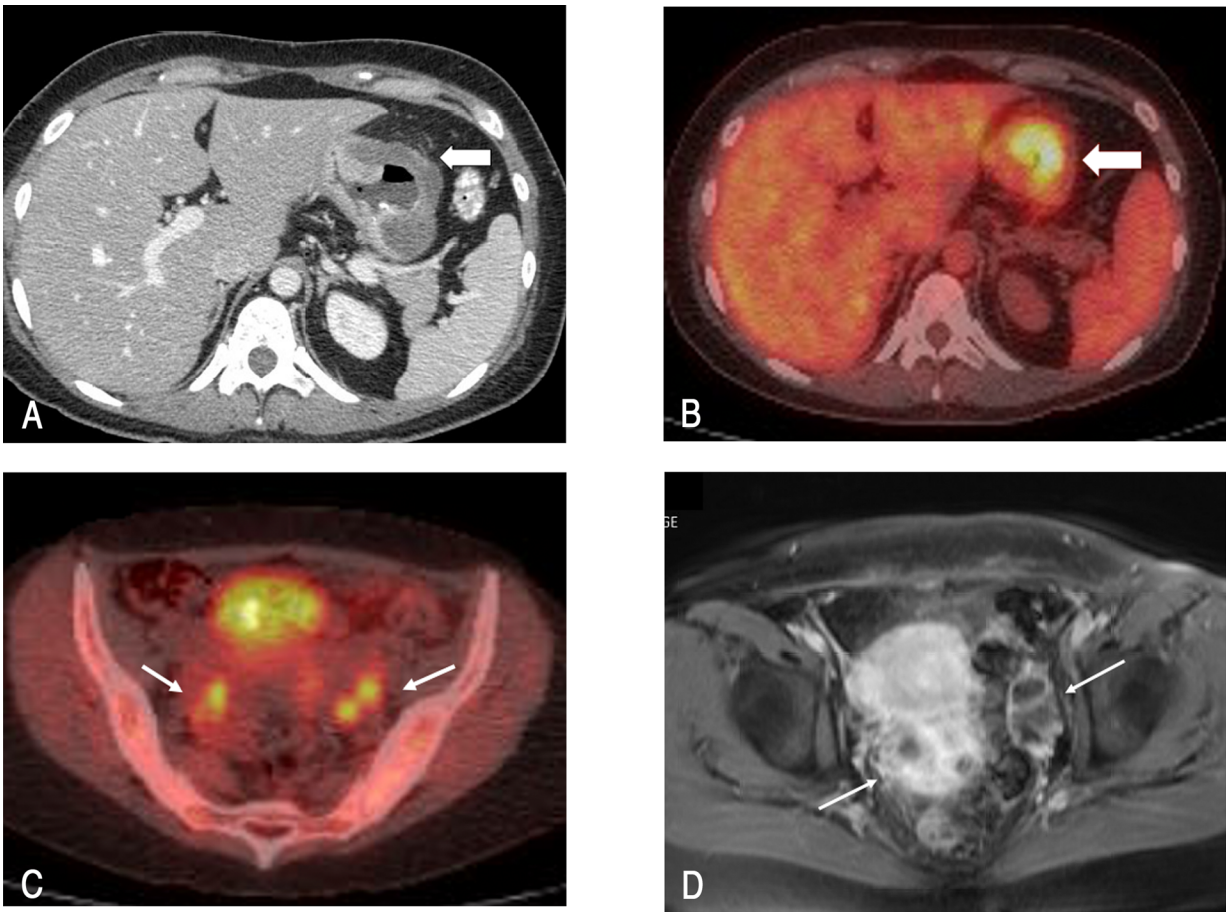


FIGURE 3. Krukenberg tumor in a 38-year-old woman. A, Axial CT section of the upper abdomen reveals the primary gastric cancer (arrow). B and C, Positron emission tomography scans reveal intense F-18 fludeoxyglucose activity in the gastric tumor and small foci of physiologic uptake in both ovaries during luteal phase of menstruation (arrows). D, MR image of the pelvis 1 year after total gastrectomy and chemotherapy demonstrates the hypertense metachronous right ovarian metastasis and cystic lesions of the left ovary on gadolinium-enhanced T1-weighted sequence (arrows).



FIGURE 4. Krukenberg tumor caused by colon cancer in a 44-year-old woman. A, Contrast-enhanced coronal CT of the abdomen shows distended small bowel loops due to an obstructing carcinoma of the ascending colon (thin arrow) associated with a cystic ovarian mass (thick arrow). B, Axial CT image of the pelvis clearly demonstrates this Krukenberg tumor as a large low-attenuated multicystic lesion (arrows).

underwent a total gastrectomy was lost to follow-up after transferring to another out-of-state hospital, and the eventual course of her malignancy is uncertain.

DISCUSSION

Pelvic masses involving one or both ovaries are usually evaluated by abdominal CT, MRI, and pelvic or transvaginal sonography. The main goal is to recognize or exclude a primary ovarian carcinoma, which is the seventh most common malignancy in women and the fifth common cause of their morbidity. However, the differential diagnosis also includes metastases and various benign or malignant ovarian lesions.^{8–11}

Krukenberg tumors account for about 10% of ovarian neoplasms and involve both ovaries in 80% of cases.^{2,10} Their preferential occurrence in young women is due to hypervascularity of ovaries and hormonal effects during the childbearing age. In fact, the development of Krukenberg tumor during pregnancy has been reported by several authors.^{12,13}

The exact mechanisms for the spread of gastrointestinal cancers to the ovaries have not been fully elucidated. It is postulated that lymphatic pathways are primarily involved in the development of Krukenberg tumors from gastric cancer, whereas the transperitoneal seeding or hematogenous metastases occur in patients with colon carcinoma.^{1,3,10}

The correct radiological diagnosis of a Krukenberg tumor depends on the concurrent demonstration of the primary cancer that is usually located in the stomach or colon (Figs. 1–4).^{9–11} However, the original source may not be readily apparent as indicated by Mayo Clinic experience that revealed 60.7% accuracy of radiology reports in diagnosing Krukenberg tumors.² It is crucial that a careful search for a primary gastrointestinal tumor be conducted in patients presenting with bilateral ovarian masses, and conversely, the ovaries of young women with any type of gastrointestinal cancer should be evaluated for possible metastatic involvement.

Krukenberg tumors often present with very distinct imaging features. The typical CT appearance is that of complex bilateral masses with varying amounts of solid and cystic components,



FIGURE 5. Gastric carcinoma causing metachronous ovarian metastases in a 26-year-old woman. A, Coronal image of the initial CT study reveals the diffusely thickened walls of the stomach (arrows). B, Reexamination 7 months after chemotherapy disclosed interval development of ascites and low-attenuated bilateral ovarian metastases (arrows).

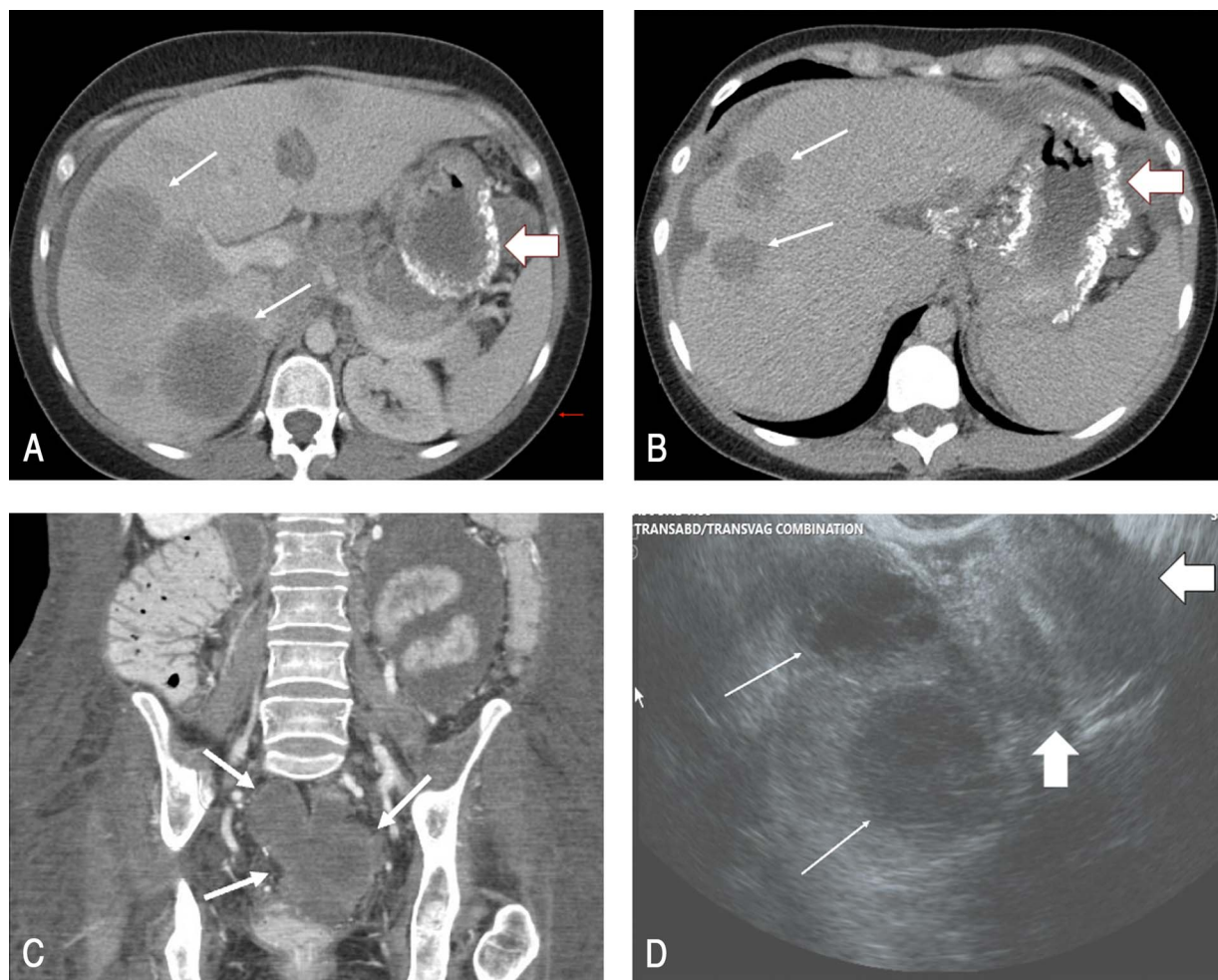


FIGURE 6. Krukenberg tumor due to a calcified signet-cell carcinoma of the stomach in a 35-year-old woman. A, Axial CT section of the upper abdomen shows punctate calcifications of the gastric wall (thick arrow) and several hepatic metastases (thin arrows). B, Reexamination 9 months after chemotherapy demonstrates markedly increased calcifications of the gastric cancer (thick arrow) but reduced size of liver metastases (thin arrows). C, Coronal image of the abdomen in her terminal stage 6 months later shows multiple cystic ovarian masses (arrows), massive subcutaneous and soft tissue edema, and ascites. D, Pelvic sonography shows 2 cystic lesions of the right adnexal region (thin arrows), whereas the left ovarian mass contains some semisolid components (thick arrows).

sharp borders, and oval configuration (Fig. 1). Magnetic resonance images demonstrate these tumors to have hyperintense solid components because of dense stromal fibrosis on gadolinium-enhanced T1-weighted sequence, and hypointense mucin-containing cystic areas on T2-weighted images (Figs. 1–3). Krukenberg tumors associated with colon carcinoma often appear more cystic because of their mucoid content (Fig. 4). Furthermore, the ovarian metastases in their early stages of development may present as low-attenuated masses on contrast-enhanced CT (Figs. 5, 6).^{9–11}

The sonographic features of Krukenberg tumors are reported to be complex solid masses in gastric carcinomas and predominantly cystic in colon cancers.^{10,11,14} These patterns closely correlate with their appearances on subsequent CT and MRI (Figs. 1, 2, 4, 6).

Positron emission tomography/CT scans with F-18 fludeoxyglucose performed in 3 of these patients demonstrated intense activity in their gastric carcinoma but variable uptake in ovarian metastases depending on their stage of development (Fig. 3). Similar findings have been described by other authors.^{15,16}

The herein presented patients had survived 11 months on average, and such a dismal prognosis of Krukenberg tumors has been reported in previous studies.

In 2 large series of cases from China, the mean survival time was 16 months even after extensive cytoreductive surgery and systemic chemotherapy.^{3,17}

It should be noted that Krukenberg tumors have been recognized more frequently in the recent years.^{1–3,9–12} The herein presented cases were encountered over a 5-year period, whereas only a few cases had been diagnosed by the author during the prior 40 years of clinical practice at major teaching hospitals. This may reflect the wider use of sectional imaging techniques, as well as the increasing incidence of gastric and colorectal cancers among young women.^{9–11,15,18,19}

Gastric cancer accounted for about 1 million new cases diagnosed worldwide in 2018, and 5% had presented before the age 50 years.⁴ Anderson et al⁵ reviewed the data from the US National Cancer Institute and found that gastric carcinoma incidence per 100,000 person-years among adults aged 25 to 39 years had increased from 2.7 in 1977 to 1981 to 4.5 in 2002 to 2006. The

responsible factors include widespread *Helicobacter pylori* infection and hormones such as estrogen in young women.⁴

Other investigations have revealed that colorectal cancer in adults aged 20 to 39 years had 2.4% annual increase during the 1974–2013 period.²⁰ From 2012 to 2016, there was a 2.2% annual increase of this cancer incidence in patients younger than 50 years, with the greatest rise among the 20- to 34-year-old individuals.²¹ The colorectal cancer is now the second most common malignancy in men and the fourth most common in women. It is estimated that by 2030, about 1 in 10 colon cancers and 1 in 4 rectal cancers will occur in patients younger than 50 years.⁶ Therefore, it seems likely that the prevalence of Krukenberg tumors associated with gastric and colorectal cancer in young women will be even higher in the future.

CONCLUSIONS

A significant percentage of ovarian cancers are metastatic and present as a Krukenberg tumor. It is most frequently associated with primary gastric cancer, followed by those located in the colorectal region, and occasionally the appendix, breast, or lungs. The typical CT and MRI features of Krukenberg tumors are that of well-circumscribed oval masses with cystic and solid components usually involving both ovaries.

The practicing radiologists should be aware that the demonstration of such ovarian masses would require a careful search for an underlying primary gastrointestinal carcinoma, whereas any young women presenting with gastrointestinal cancer should also be evaluated for possible ovarian metastases. This approach would be important for the correct diagnosis, therapeutic management, and follow-up of this malignancy.

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