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Imaging in secondary tumors of the ovary

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Abstract

Metastatic involvement of the ovaries is not rare. The most common tumor types metastasizing to the ovaries, from non-gynecological organs, are breast, colorectal, gastric, and appendix tumors. Lymphogenous, hematogenous, and transcoelomic pathways have all been proposed among potential pathways. Early diagnosis and treatment have an important potential to improve the patient outcome. Krukenberg tumors typically appear as complex semisolid masses with varying amounts of solid and cystic components. Ovarian metastases from the colon primaries are predominantly cystic in nature. Secondary lymphomatous involvement of ovary is mostly bilateral and solid with heterogeneous signal intensity on MRI. Metastatic breast cancer to the ovaries is typically bilateral and tends to be of small size. Among all the other imaging characteristics, bilateral involvement of secondary tumors of the ovary appears to be most potentially helpful finding in differentiating from primary ones.

Key words: Ovary—Metastasis—Tumor—Computed tomography—Magnetic resonance imaging

The secondary tumors of the ovaries have been known for a long time. German gynecologist and pathologist Friedrich Ernst Krukenberg first described a supposedly new type of primary ovarian tumor which he later named as ''fibrosarcoma ovarii mucocellulare carcinomatodes'' in 1896. Five years after this first description, Kraus first correctly identified the metastatic nature of this tumor and coined the eponym of ''Krukenberg tumor'' [1].

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Metastatic involvement of the ovaries is not rare and around 7% of all ovarian masses presenting as primary ovarian tumors are substantially metastatic in origin [2]. The most common tumor types metastasizing to the ovaries, from non-gynecological organs, are breast, colorectal, gastric, and appendix tumors [3]. There is also a variation in the incidence of secondary tumors of the ovaries across different geographical regions, e.g., Asian countries have been reported to have consistently higher rates of secondary tumors of the ovaries when compared to European countries. This significant variation may be partly attributed to the increased prevalence of the cancers, which tend to metastasize to the ovaries, in these countries [4, 5]. Gastric cancers represent 23.4–30.4% of secondary tumors of the ovaries in Japan, whereas in Netherlands this percentage is only 4.5% [3, 5, 6]. In the western hemisphere of the world, the most common secondary tumors of the ovaries are from the breast and colorectal primaries in contrast to the Asian countries [3, 7].

The age at the time of diagnosis is also variable geographically. Patients with primary origin of gastrointestinal (GI) tract are diagnosed at a later age than the patients with non-GI tract tumors. On the other hand, patients with breast cancer primary present at a significantly younger age than those with other primary tumors located elsewhere in the body [1, 3]. Denser ovarian vascularization at patients with younger ages was hypothesized to facilitate secondary tumors of the ovaries in this age group [8].

Clinical signs and symptoms

The clinical diagnosis may be delayed as for the insidious nature of secondary tumors of the ovaries, similar to the primary ovarian cancers. Non-specific and vague symptoms such as abdominal pain and fullness, weight loss, post-menopausal bleeding, and increased abdominal

circumference are among the commonly observed clinical signs and complaints [9]. Ascites is not a common ancillary finding which is detected in 39% of the cases, a stark difference when compared to primary ovarian cancer where ascites is mostly the presenting clinical finding [10].

Given the extremely high prevalence of breast cancer, this tumor type deserves special attention. Malignant adnexal lesions, in the form of primary ovarian cancers and secondary tumors of the ovaries, are common among these patients and they can be observed in almost half of the patients who underwent resection for breast cancer [11]. Coexistence of breast malignancies and primary ovarian cancers is often encountered in hereditary conditions including breast cancer gene (BRCA1) and BRCA2 mutations. The risks of developing breast and ovarian cancer were reported as 85% and 40–60%, respectively, in women BRCA1 alterations. Breast cancer occurrence rate is similar in women with BRCA-2 alterations while 15–30% of patients develop ovarian cancer in BRCA-2 group [12].

Pathogenesis

The exact mechanism of non-ovarian tumors metastasizing to ovaries is not very clear. Lymphogenous, hematogenous, and transcoelomic pathways have all been proposed among potential pathways [1]. Transcoelomic dissemination basically refers to the tumor spread via the peritoneal surfaces [13]. Despite the confusion surrounding the mechanism, there are some data relating different tumors with different modes of spread. Colorectal cancers appear to spread to the ovaries mostly hematogenously, whereas lymphogenous route appears to play an important role in gastric cancers [14]. A possible explanation for lymphangitic tumor spread in gastric cancers is the presence of rich lymphovascular network in the gastric mucosa and submucosa [15]. Among all different pathways, transcoelomic pathway appears to be insignificant in secondary tumors of the ovaries when compared to the other spread routes [1]. The absence of peritoneal involvement in most of the secondary tumors of the ovaries and the smooth and non-tumor involved capsules of the ovaries are other important features that even more support this assumption [16].

Prognosis

The prognosis of patients with secondary tumors of the ovaries is generally poor, as it usually is seen in patients with advanced stage cancer. The survival rates of these patients were reported to be poorer when compared to patients with primary ovarian tumors; however, it should be noted that this clinical situation may differ with some subtypes of primary ovarian tumors [17]. The prognosis was reported to be better in patients with the primary origin of genital tract when compared to tumors originating from non-genital organs (median overall survival is 48 vs 12 months) [18]. The patients with secondary tumors of the ovaries arising from pancreas and the small bowel have the poorest prognosis [3].

Secondary tumors of the ovaries are typically detected at the follow-up of patients with known malignancies; however, it is also not uncommon to see them at the time of the initial diagnosis. The overall survival rates were reported to be better with the former group than the latter [1]. Several prognostic factors were reported to associate with the survival, including age at the time of diagnosis, bilaterality, preoperative serum level of carbohydrate antigen 125 (CA-125), primary tumor origin and extent of cytoreductive surgery [4, 8, 17, 19, 20].

Ovarian metastases from gastrointestinal source

Primary cancers of the GI tract are among the most common cancers. These tumors may frequently metastasize to the ovaries. The most common GI source is colon (33%). Around 1.2–14% of all enteric cancers metastasize to the ovaries at some point during the course of the disease [21]. The index of suspicion should be even higher in cases with bilateral ovarian tumors. From the pathologist's point of view, among the most challenging cases are the mucinous tumors detected in the ovaries. To come up with a correct diagnosis, all the clinical, morphologic, laboratory, and radiologic features must all be evaluated together. Separate clinical disciplines should all be must be aware of the utility of the multidisciplinary approach.

Early findings of secondary tumors of the ovaries can be notoriously misleading, and subtle, that all follow-up imaging studies should be meticulously evaluated even in patients with subtle imaging findings. All imaging modalities including ultrasonography (US), computed tomography (CT), and magnetic resonance imaging (MRI) may be used for detecting and diagnosing these tumors.

Metastases from gastric cancer

Despite the fact that the term "Krukenberg tumor" is erroneously used for all type of secondary tumors of the ovaries, this eponym should be strictly reserved for patients who have pathologically confirmed detection of mucin filled signet ring cell carcinomas metastasizing to the ovaries from primary tumors originating in any glandular organ including gastrointestinal tract, breast, pancreas, lung or other organs where signet ring cell type malignancies may develop [2]. Krukenberg tumors are most commonly bilateral and of complex morphology. Pathologically, marked stromal proliferation and variable degrees of luteinization are commonly detected. The

constellation of these pathological findings may be evocative for ovarian fibroma or other spindle cell tumors [2, 22]. The most common presenting symptoms are non-specific. The intense luteinization that was previously mentioned may also give rise to paraneoplastic symptoms secondary to hormone secretion [2]. One important note to mention is the strong tendency of gastric tumors to metastasize to the ovaries during the pregnancy and these Krukenberg tumors may show rapid enlargement after the delivery [22, 23].

Krukenberg tumors typically appear as complex masses in both ovaries. They are usually solid but cystic components may also be associated [2, 23, 24]. Bilaterality is the key imaging finding as seen in other secondary tumors of the ovaries (Fig. 1). In contrast to signet ring cell type, intestinal-type gastric carcinomas are larger in size and histologically they resemble colon carcinomas with more cystic components. On US, the tumors typically show solid mural and septal components in addition to cystic spaces. CT clearly shows the bilaterally enlarged ovaries that are completely replaced by the malignant masses. CT demonstrates avid enhancement in solid parts of the mass (Fig. 1). MRI may better demonstrate the internal architecture of these complex masses where the cystic component most commonly appears as hyperintense on T2-weighted images. The solid parts of the tumors most commonly appear as hypodense/hypointense on pre-contrast CT/T1-weighted MR images, respectively. Both low and high signal intensities can be observed with heterogeneous appearance on T2-weighted images (2). After contrast agent injection, these solid parts avidly uptake contrast, an indirect sign of increased and anarchic vascularity of the tumors. T2 hypointensity of the solid tumor components may refer to increased fibrous content of these areas [24]. Krukenberg tumors may be extremely difficult, or impossible, to differentiate from primary ovarian tumors when they occur unilaterally and final histopathological evaluation is almost always necessary for a confident diagnosis. However, it should be kept in mind that Krukenberg tumors originating from primary gastric carcinomas have a higher tendency to be predominantly solid compared to primary ovarian tumors (2). Choi et al. reported that ovarian metastases from gastric cancers appear to be more solid than metastases from the colon (28) (Fig. 2). More intense enhancement of the solid portions was reported to be more suggestive of gastric cancer over the primary colon [25].

Metastasis from colorectal cancers

Colorectal cancers are among the tumors that most commonly metastasize to the ovaries. The history of colorectal cancer may be present at the time of the initial diagnosis, but ovarian metastases emerging as the primary finding is also not rare. The age and gender of the patient are also critical factors in this clinical situation, as the women under 40 years of age tend to have more frequent ovarian involvement (18–27%) from the colorectal primaries than women of older age [26, 27].

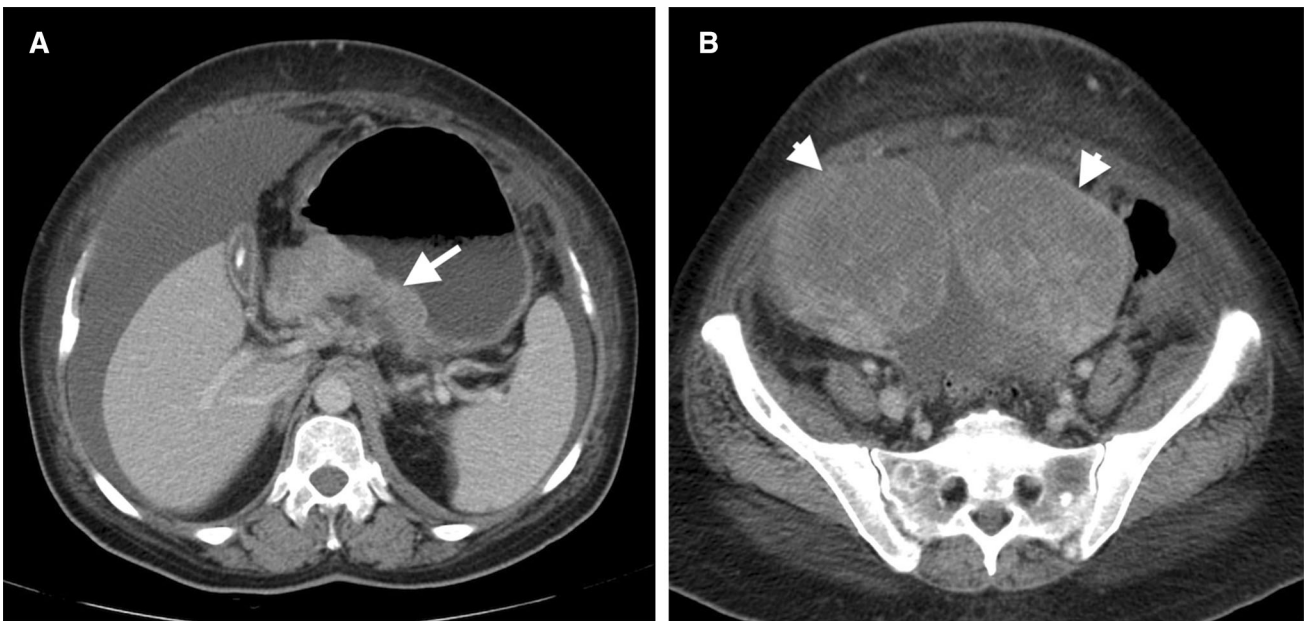

Fig. 1. Forty-one-year-old woman with newly diagnosed gastric signet ring cell carcinoma. CT scan was performed for staging purposes before treatment planning. **A** Axial contrast CT image demonstrates diffuse wall thickening in the lesser curvature of the stomach (arrow). **B** Large complex looking adnexal masses (arrowheads), suggestive of ovarian metastases, were also detected in the same CT study. The other abdominal findings were unremarkable with no evidence of metastatic disease elsewhere in the chest or abdomen.

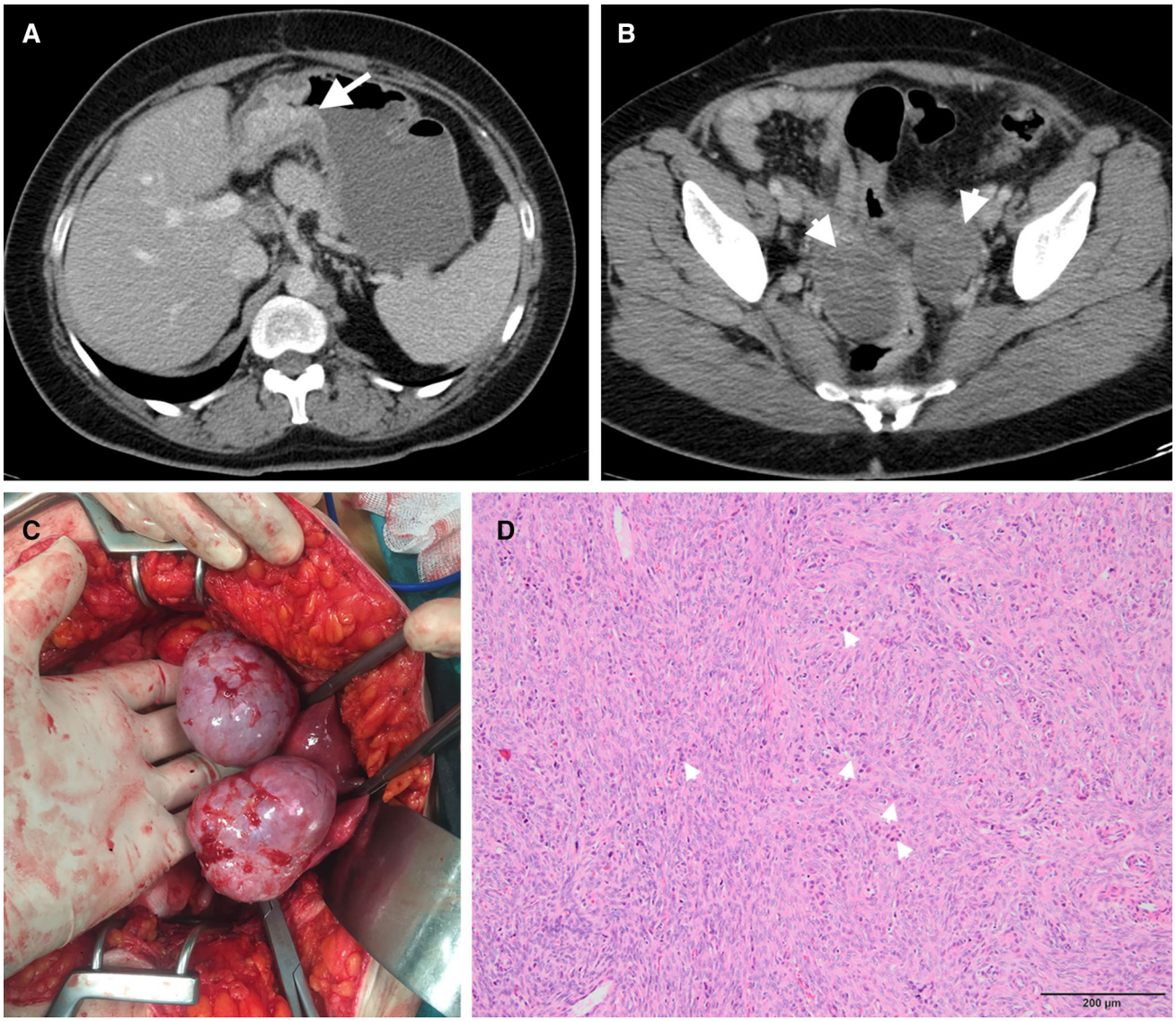

Fig. 2. Thirty-five-year-old woman with recently diagnosed gastric adenocarcinoma. **A** Axial contrast-enhanced CT reveals irregular wall-thickening in the gastric antrum (arrow). **B** Axial contrast-enhanced CT also demonstrates bilaterally enlarged ovaries (arrowheads) suggestive of metastatic involvement. **C** Surgical exploration shows bilateral ovarian masses with lobulated appearance. **D** Photomicrograph of high power field of the area with hematoxylin and eosin (H&E) stain depicts increased cellularity and mitotic activity (arrowheads) representing metastatic undifferentiated adenocarcinoma of the stomach to the ovary.

Metastases to the ovaries most commonly originate from distal colonic tumors, especially from the recto-sigmoid area [21].

Bilateral ovarian involvement is common (80%) and the lesions are predominantly cystic in nature [2, 21] (Fig. 3). In case of unilateral involvement, right ovary is more commonly affected than the left [21]. Histologically metastatic colorectal cancers may appear similar to endometrioid and mucinous types of primary ovarian tumors [28]. In these cases, immunohistochemical studies may be helpful for the correct diagnosis. Colon cancers tend to conform to the oval shape of the ovaries in contrast to other secondary tumors of the ovaries and necrotic areas within the tumor mass appear to be more common. Colon cancers also tend to locate more commonly on the ovarian surface [29]. The great majority of the ovarian metastases (95.2%) from the colorectal source tend to have smooth margins compared with 45% of the primary ovarian cancers [30]. Peritoneal seeding is not uncommon (52.2%) in these tumors [25].

All cross-sectional imaging modalities can be used for imaging, with CT and MR being more frequently used. The imaging features closely mimic primary ovarian tumors. MRI may better delineate the internal structure. T1-weighted images may better demonstrate multilocular nature of the lesion with typical stained-glass appear-

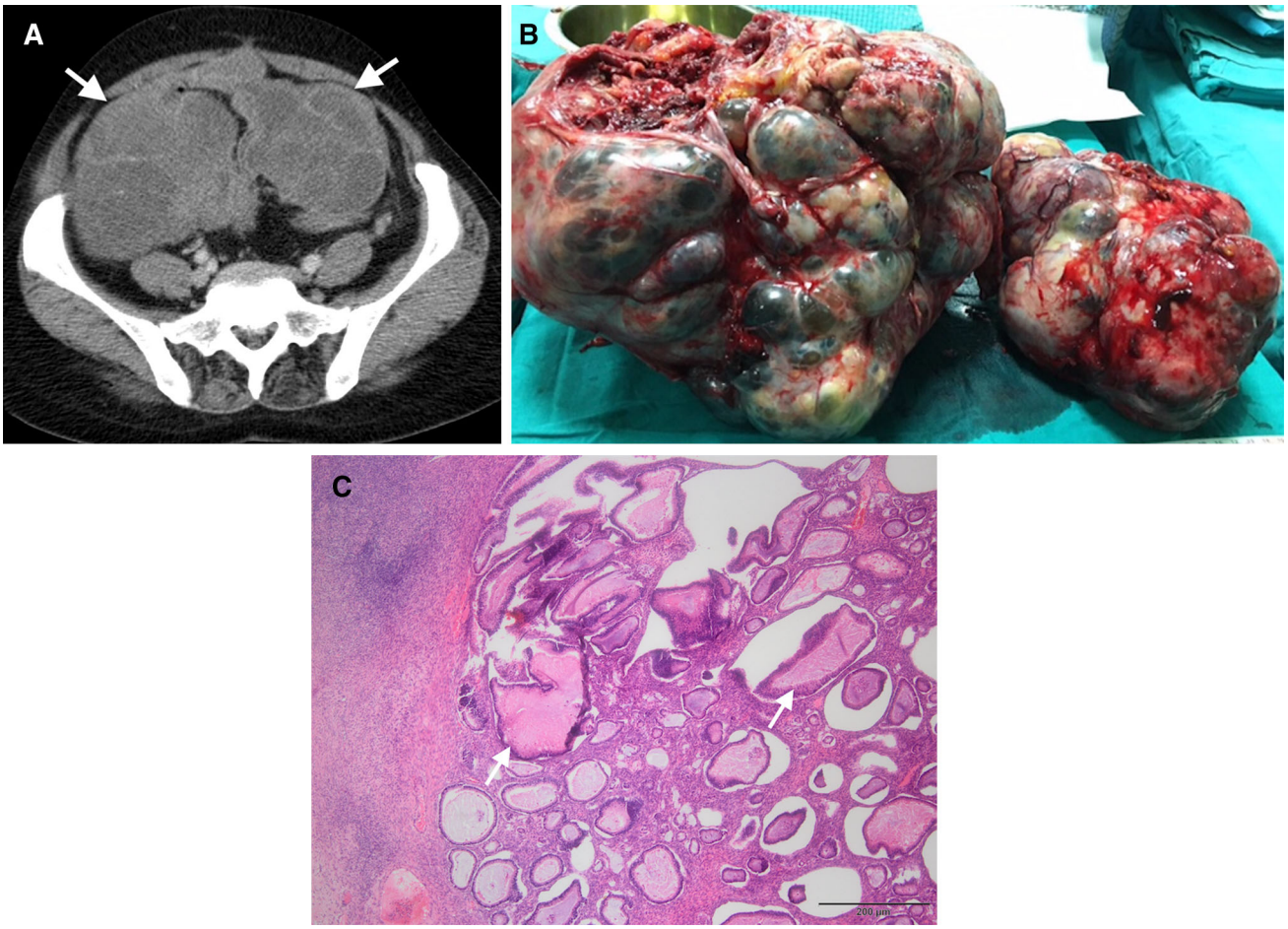

Fig. 3. Forty-four-year-old woman with known colon cancer who was treated with surgery and chemotherapy. Two years after the diagnosis the patient presented with progressively increasing abdominal fullness and pain. **A** Axial contrast-enhanced CT image demonstrates bilateral giant semisolid masses (arrows) in both adnexa. The masses appear to have both cystic and contrast enhancing solid areas. **B** Photograph of surgical specimen demonstrates bilateral masses with multilobulated appearance. **C** A metastatic nodule of well-differentiated colon adenocarcinoma in the ovary that contains cystic spaces with necrosis (arrows) (H&E).

ance, whereas on T2-weighted images heterogenous signal intensity within the tumor mass may be better appreciated (Fig. 4) [31].

Radiologists should consider colorectal cancer in patients with bilateral complex looking ovarian masses, as bilateral primary ovarian mucinous carcinomas are rare [2]. Radiologic features may also help the pathologists for final diagnosis. One study showed the presence of smooth tumor margins and predominantly cystic character to be more suggestive for ovarian metastases than primary ovarian tumors. Despite these helpful imaging features, one should always keep in mind the several overlapping features of primary ovarian tumors and the metastases from colorectal cancers [30].

Metastases from appendiceal tumors

Primary appendiceal tumors are rare and represent the 0.5% of all gastrointestinal tumors [29]. These tumors may be classified as primary epithelial neoplasms and neuroendocrine tumors. Epithelial tumors of the appendix form the most commonly encountered malignant appendiceal tumors and consist of low-grade mucinous neoplasia, high-grade mucinous neoplasia, mucinous adenocarcinoma (MAA), colonic-type adenocarcinoma, and goblet cell carcinomas [32]. Most common appendix tumors involving the ovaries are low-grade mucinous tumors which have low-grade cytologic atypia, slow progress and better prognosis compared to other types. MAAs present with infiltrative manner. The overall 5-year survival in MAA is around 46% and the presence of signet ring cells in the pathological specimen is an independent risk factor for poor survival [32, 33].

Ovarian metastases from MAAs are common and seen in 16.7–37% of the cases [34]. The presence of ovarian masses in association with pseudomyxoma peritonei is currently considered as indicative for ruptured primary low-grade appendiceal tumor over pri-

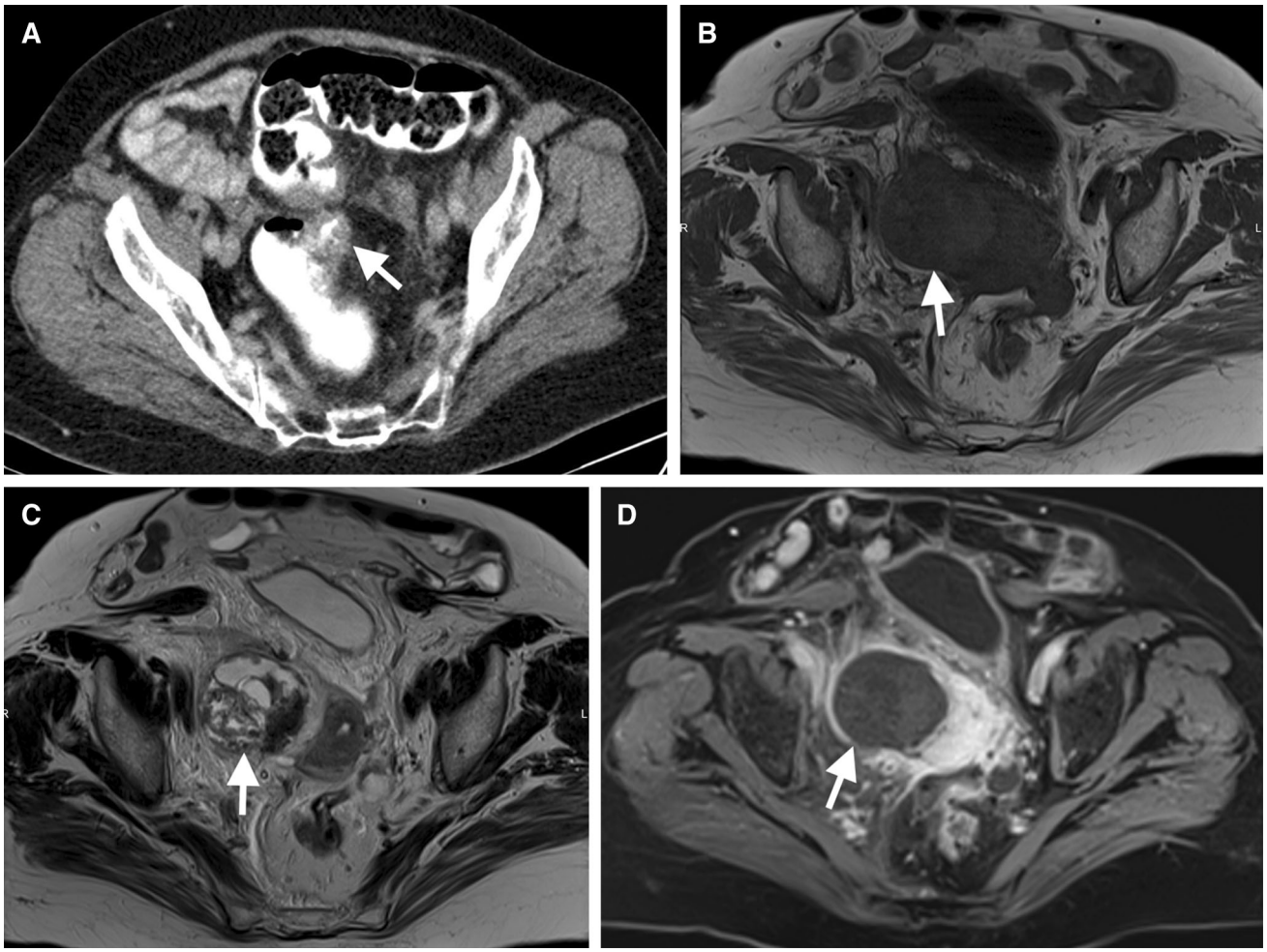

Fig. 4. Ovarian metastasis from colon cancer. **A** Axial CT of a 62-year-old female with colon carcinoma presents with asymmetrically wall thickening (arrow) of the sigmoid colon. **B** T1-weighted MR image shows right adnexal mass (arrow) with hypointense appearance. **C** Adnexal mass presents with hyperintense appearance (arrow) on T2-weighted image. **D** Axial T1-weighted MR image after intravenous gadolinium administration shows peripherally enhanced mass (arrow) with centrally cystic component.

mary ovarian cancer [29]. In this type of tumor, appendix mostly appear dilated and covered with mucin. The hallmark imaging features of pseudomyxoma peritonei are irregularly bordered, loculating fluid density structures within the peritoneal cavity. Peritoneal based nodules may or may not associate the process. The loculated fluid may indent the contours of the intraabdominal solid organs.

Ovarian involvement is mostly bilateral, whereas in patients with unilateral involvement right ovary is the most commonly involved side, most likely due to the close proximity of right ovary to the appendix [2]. Histologic appearance is characteristic in these patients. Typically, few or no mucinous epithelial cells are detected. When detected, low or moderate degree of atypia in a mucin rich sample is typical and also is very useful for intraoperative frozen section consults (Fig. 5). Appendiceal intestinal-type carcinomas have no specific macroscopic features and appendiceal metastatic carcinoids are usually bilateral, of moderate size and predominantly solid.

Primary ovarian mucinous cancers are usually unilateral and are confined within the boundaries of the ovary [2, 22]. Therefore, multiloculated cystic ovarian masses in both ovaries should alert the imager for the presence of metastatic MAA and an appendiceal source should be meticulously searched for in these patients.

Secondary lymphomatous involvement of the ovaries

Despite the rare occurrence of primary ovarian lymphomas, secondary involvement is not very unusual. The incidence of ovarian involvement in systemically disseminated malignant lymphoma was reported to have an incidence of 7–26% [35]. As in metastases from GI tract

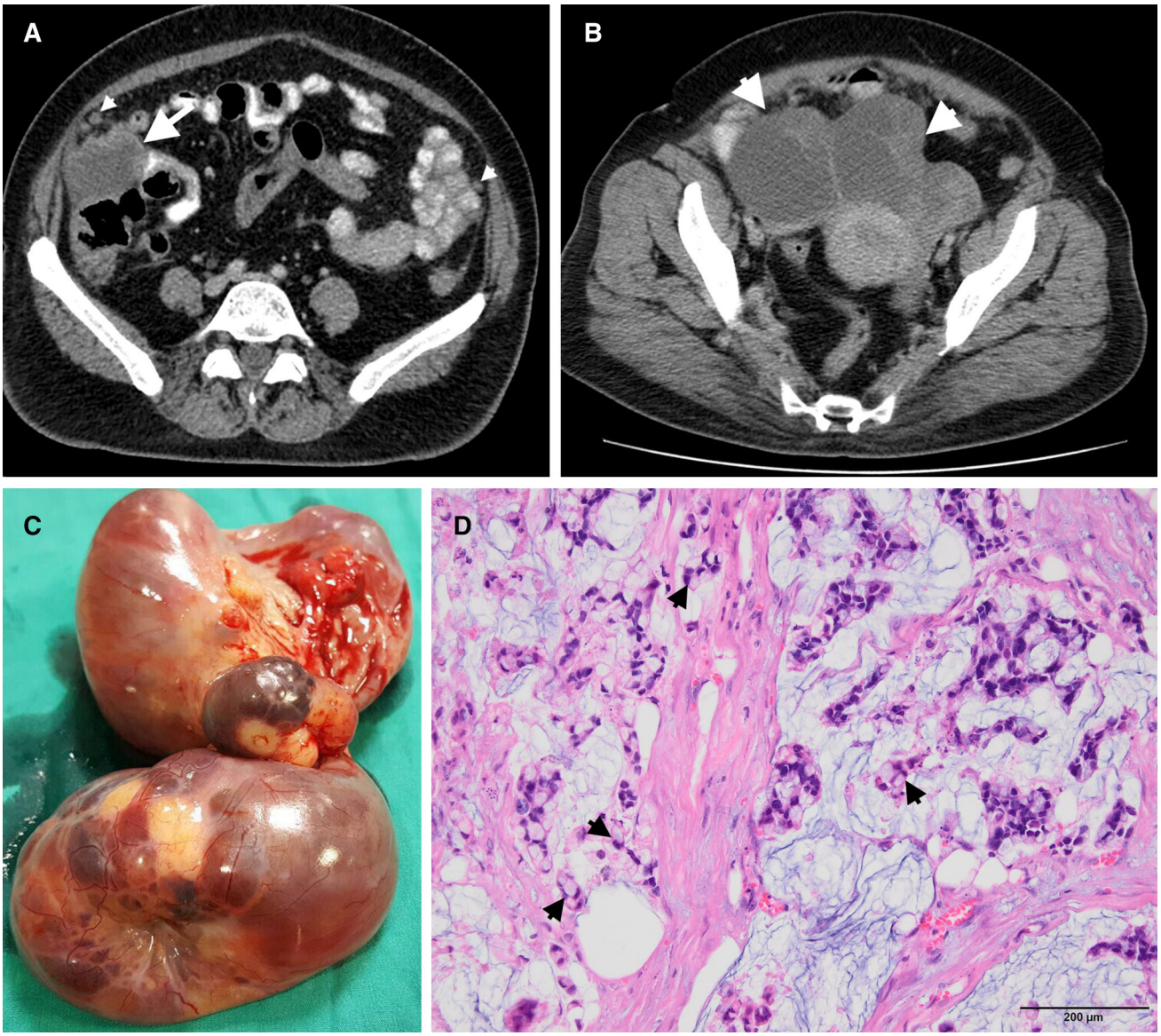

Fig. 5. Fotry-eight-year-old woman with progressively increasing constipation and right lower quadrant pain. **A** Axial contrast-enhanced CT image demonstrates a hypodense mass (arrow) near the cecal apex and several nodules (arrowheads) scattered throughout the mesenteric fat planes consistent with peritoneal and mesenteric carcinomatosis. **B** CT image through pelvis showed complex looking, predominantly cystic, semisolid masses (arrowheads) located in both adnexa. **C** Photograph of surgical specimen shows bilateral masses with smooth contours. **D** Metastatic mucinous carcinoma with signet ring cells (black arrowheads) from appendix (H&E).

primaries, bilateral involvement is common and this finding is usually a sign of disseminated disease [2]. The age range is also highly variable reported as between 18 and 74 years [36]. The lesions are generally are of large size with no associating ascites [37]. Extraovarian extension is also not unusual, with pelvic and paraaortic lymph node involvement [37]. Malaise, fatigue, and weight loss are among the common clinical symptoms.

There are no much published data on the imaging findings of lymphomatous involvement of the ovaries. These tumors are reported to be mostly bilateral and solid with heterogeneous signal intensity on MRI and septa-like structures can be visualized within these masses (Fig. 6) [38, 39]. The imaging features may closely mimic other primary and secondary ovarian tumors and differential diagnosis may be difficult in some cases. The more solid appearance compared to other primary and secondary ovarian tumors and the presence of other ancillary imaging findings suggestive of lymphoma (such as pathologically enlarged pelvic and paraaortic lymph nodes, typical findings for lymphomatous involvement of the liver and spleen) may be useful for correct differentiation.

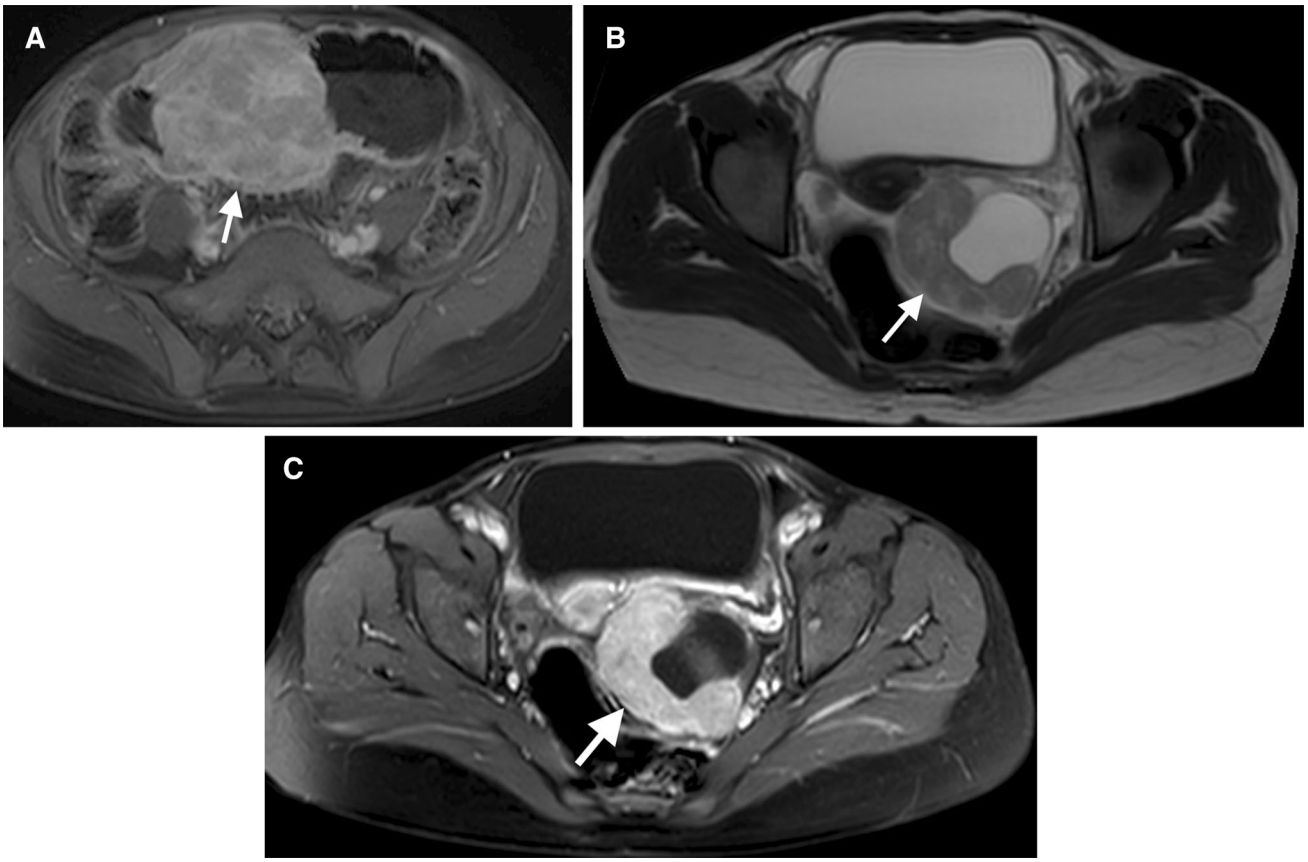

Fig. 6. Twenty-nine-year-old woman presented to emergency department with severe abdominal pain and clinical findings suggestive of intestinal obstruction. Axial contrast-enhanced CT (not shown) demonstrated severe wall thickening in distal ileal segments and upstream intestinal obstruction. Also noted was a left adnexal mass. A pelvic MRI study was immediately performed to better characterize the adnexal mass. **A** Axial T2-weighted image at the level of pelvic inlet reveals long segment malignant appearing wall thickening in the distal ileum (arrow). **B** Axial T2-weighted image demonstrated a complex looking semisolid mass (arrow) in the left ovary. **C** Axial post-contrast T1-weighted image demonstrated intense contrast enhancement within the solid portions of the left ovarian mass.

Metastases from breast carcinoma

Ovarian involvement was reported to be around 10% in patients with breast cancer. Lobular subtype tends to involve the ovaries more than the commonly encountered ductal carcinomas [40]. The presence of complex ovarian masses in patients with breast cancer should always raise the possibility of a secondary ovarian involvement as well as coexistent primary ovarian cancer, especially in patients who genetically harbor BRCA mutations [29]. The ovarian metastases being the first sign of a breast cancer is a rare clinical occurrence and, therefore, a complex ovarian mass in a patient with early stage disease should always raise concern for an ovarian primary rather than a secondary ovarian involvement. This point is particularly important, as patients with such ovarian masses may benefit from an early stage medical/surgical intervention for the primary ovarian cancer.

Metastatic breast cancer to the ovaries is typically bilateral and tends to be of small size (smaller than 5 cm). The detection may be difficult in a significant percentage of the patients (46%) as the metastatic foci does not grossly distort the ovarian morphology [28]. Metastatic tumor cells were found within the surgically removed ovaries in 2–11% of patients with known breast cancer who had prophylactic oophorectomy [2].

Ovarian metastases from the breast primary tend to present as solid masses with occasional cysts within the tumor (Fig. 7). As the metastatic deposits tend to be small in size, even a small interval enlargement within the ovaries should be reported, as early metastatic deposits may present in this fashion. Small breast tumors may also initially present with ovarian masses and patients with breast cancer also have an increased risk of developing ovarian cancer [41].

Metastases from uterus

Simultaneous tumor formation within the ovaries and uterus is a not a very common clinical event [2]. Interestingly, survival rates in this patient group are more

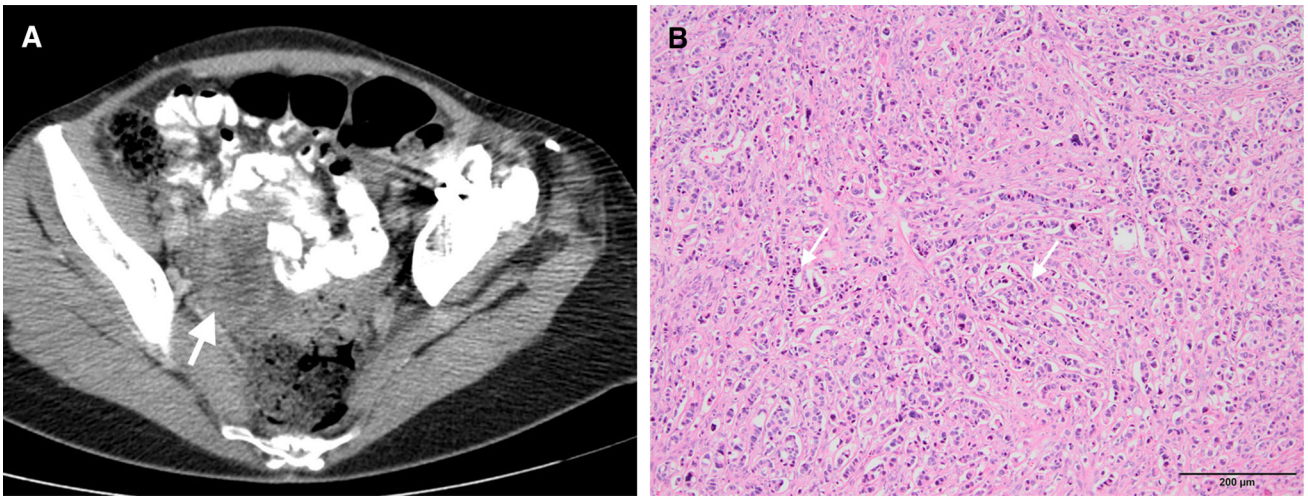

Fig. 7. Fifty-five-year-old woman with a history of surgically and medically treated breast cancer. She was under clinical and radiological remission for 3 years after the end of her therapy. A recent CT scan was performed for surveillance. **A** Axial post-contrast CT image demonstrated asymmetrically enlarged right ovary (arrow), concerning for a neoplastic process. The other compartments of the abdomen and chest were free of macroscopic disease. **B** Breast carcinoma with mixed morphology containing both lobular and ductal carcinoma (arrows) metastatic to the ovary(H&E).

favorable than patients with metastases from non-gynecological organs [6]. The detection of ovarian masses may pose difficulty to radiologists for correct staging. The detection of an ovarian mass may be especially important in patients with cervical cancer, as the presence of extra cervical tumor typically precludes definitive surgery with curative intent in this patient group. This may not be as problematic in patients with endometrial as oophorectomy is a routine part of surgical staging of these tumors. The differential diagnosis may be difficult from a radiological standpoint, but this difficulty may be encountered even in pathological evaluation [29].

Metastasis from primary kidney tumors

Renal cell carcinomas (RCC) are among the common malignant neoplasms in the abdomen. The risk of metastasis from RCC is mostly dependent on the biological behavior and the stage of the tumor. Lungs (50–60%), lymph nodes (36%), bones (30–40%), and brain (5%) are among the common sites for metastases [42]. In addition to these commonly target sites virtually every organ system can be involved in advanced stage RCC cases [43].

In the female genital tract, vagina appears to be most commonly involved site and ovarian metastases appear to be relatively rare with very limited number of reported patients [44]. Bilateral involvement is rare and metastasis may be diagnosed even before the primary tumor and confusion with primary ovarian tumors may happen [45].

The main pathway for tumor spread is hematogenous and renal-ovarian axis appears to play a significant role. The direct drainage of the left ovarian venous outflow into the left renal vein may facilitate the tumor spread [46]. This anatomic relationship may help to explain the slightly higher number of patients with left-sided RCCs metastasizing to the left ovary. Synchronous primary renal and ovarian cancers are rare with very few reported cases [47]. Clear cell type RCCs were reported to be most commonly metastasizing subtype [44].

These tumors usually present as large masses with, solid, semisolid or cystic appearance (Fig. 8). Due to scarcity of cases, not surprisingly, there is not much information available in the literature regarding the imaging morphology of these metastases. Again, the primary differential diagnosis is primary ovarian tumor and considering the unilateral nature of the RCC metastases the differential diagnosis may even be more difficult, or even impossible, without pathologic evaluation of the mass. Histopathologically, as these renal tumor metastases to the ovaries may closely mimic primary ovarian clear cell carcinomas, knowing the clinical history of the patients is crucial for correct pathological diagnosis.

Metastases from unusual sources

Virtually, all malignancies can metastasize to the ovaries and there are no much data in the literature for the imaging findings of these unusual tumors. Biliary tumors, lung cancer, pancreas, and gastrointestinal stromal tumors (GIST) may all metastasize to the ovaries (Fig. 9). Ovarian metastases from GISTs are extremely rare and ovarian masses may also be the presenting sign of the disease [48]. GISTs typically arise from the interstitial cells of Cajal and can occur anywhere along the GI tract. The GISTs originating from the small bowel segments tend to metastasize more than their gastric coun-

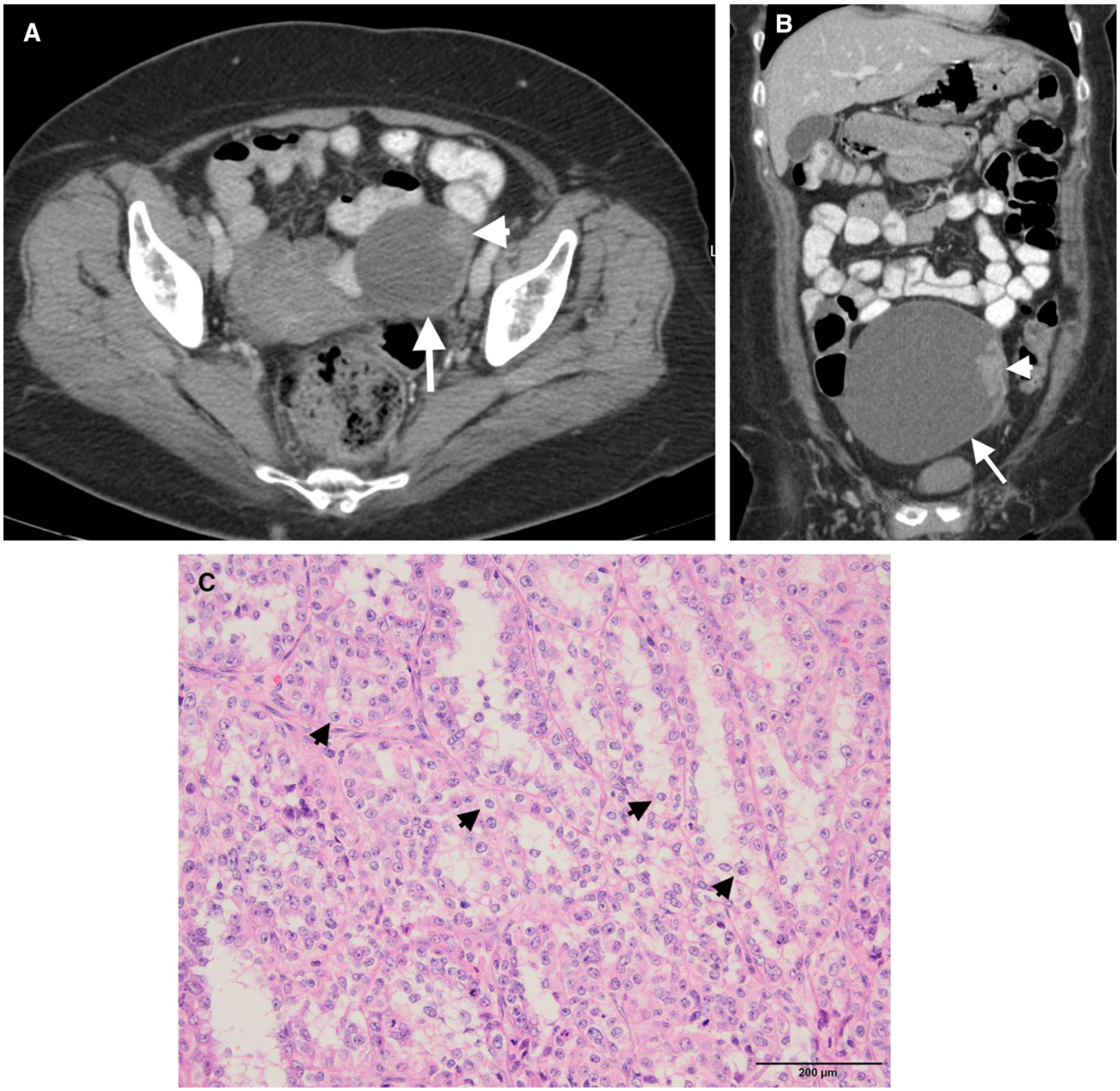

Fig. 8. Fifty-two-year-old woman with a history of RCC treated with left radical nephrectomy 4 years before the current CT study. The patient was asymptomatic at the time of the presented CT study. **A** Axial post-contrast CT demonstrated a complex looking cystic mass (arrow), with mural enhancing nodule (arrowhead), in the left adnexa. The patient elected for a follow-up over surgical intervention. **B** Two months after, a follow-up CT study demonstrated significant interval enlargement of the left adnexal mass (arrow) and mural nodule (arrowhead). **C** Renal cell carcinoma with clear cells (black arrowheads) metastatic to the ovary (H&E).

terparts (Fig. 10) [48]. The malignant potential of these tumors is highly variable and depends mainly on the tumor size and location, as well as the mitotic activity [49]. The overall prognosis of the disease is favorable if the tumor is located within the organ; however, even in patients with metastatic disease the overall survival rates are greatly improved with new treatments [50].

Lung cancers also very rarely metastasize to the ovaries, representing 2–4% of patients with secondary ovarian tumor involvement. These numbers are currently increasing due to the rising incidence of lung cancer in women [51]. Small cell and adenocancer types appear to more commonly involve the ovaries than the other types of lung cancer [52].

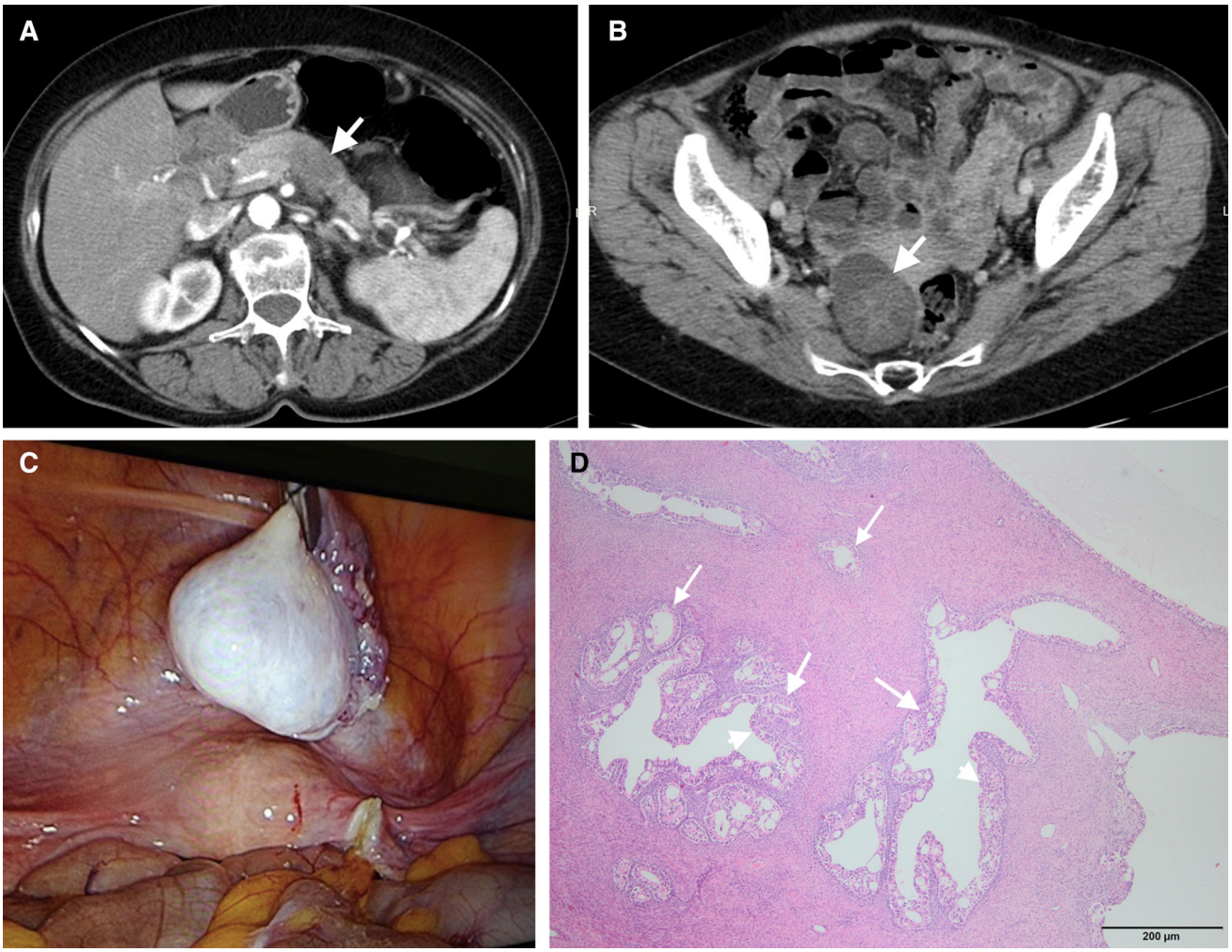

Fig. 9. Fifty-five-year-old woman, with no significant medical history, presented with weight loss and epigastric pain. **A** Axial post-contrast CT image reveals a hypodense solid mass (arrow) within the pancreatic body. Subsequent percutaneous biopsy showed that the lesion was a pancreatic adenocancer. **B** Axial contrast-enhanced CT image also demonstrated an indeterminate mass (arrow) within the right ovary. **C** Laparoscopic surgical removal of adnexal mass. **D** Cystic and glandular structures (arrows) lining with atypical mucinous cells (arrowheads) depicting a metastasis from pancreas (H&E).

Conclusion

Secondary tumors of the ovaries are not uncommon and early diagnosis and treatment have an important potential to improve the patient outcome. The imaging characteristics are not always typical and helpful to differentiate them from primary ovarian tumors. Among all the other imaging characteristics, bilateral involvement appears to be most potentially helpful finding.

MRI appears to have the highest precision in assessing the internal morphology of the ovarian masses but that does not really help for differential in most of the cases, in our experience. Solid tumor with heterogenous signal intensity in a patient with bilateral ovarian masses may be suggestive of a Krukenberg tumor [2]. Breast metastases appear to be smaller in size than other metastases, which may be helpful in the presence of known breast cancer. The detection of pseudomyxoma peritonei in the presence of ovarian masses is a very useful finding for a GI tract origin, especially from appendix.

Radiologists should be vigilant in comparative assessment of the ovaries with prior imaging studies, as even minor morphological changes and vague interval enlargement in size may be indicative for ovarian metastases. The presence of peritoneal carcinomatosis, in association with the bilateral ovarian masses, is another very helpful finding for the correct diagnosis. Attention should be paid for the potential masses within the gastric or colonic walls in patients with bilateral ovarian masses. In the presence of gastric or colonic mural lesion, the diagnosis of ovarian metastasis may be strongly consid-

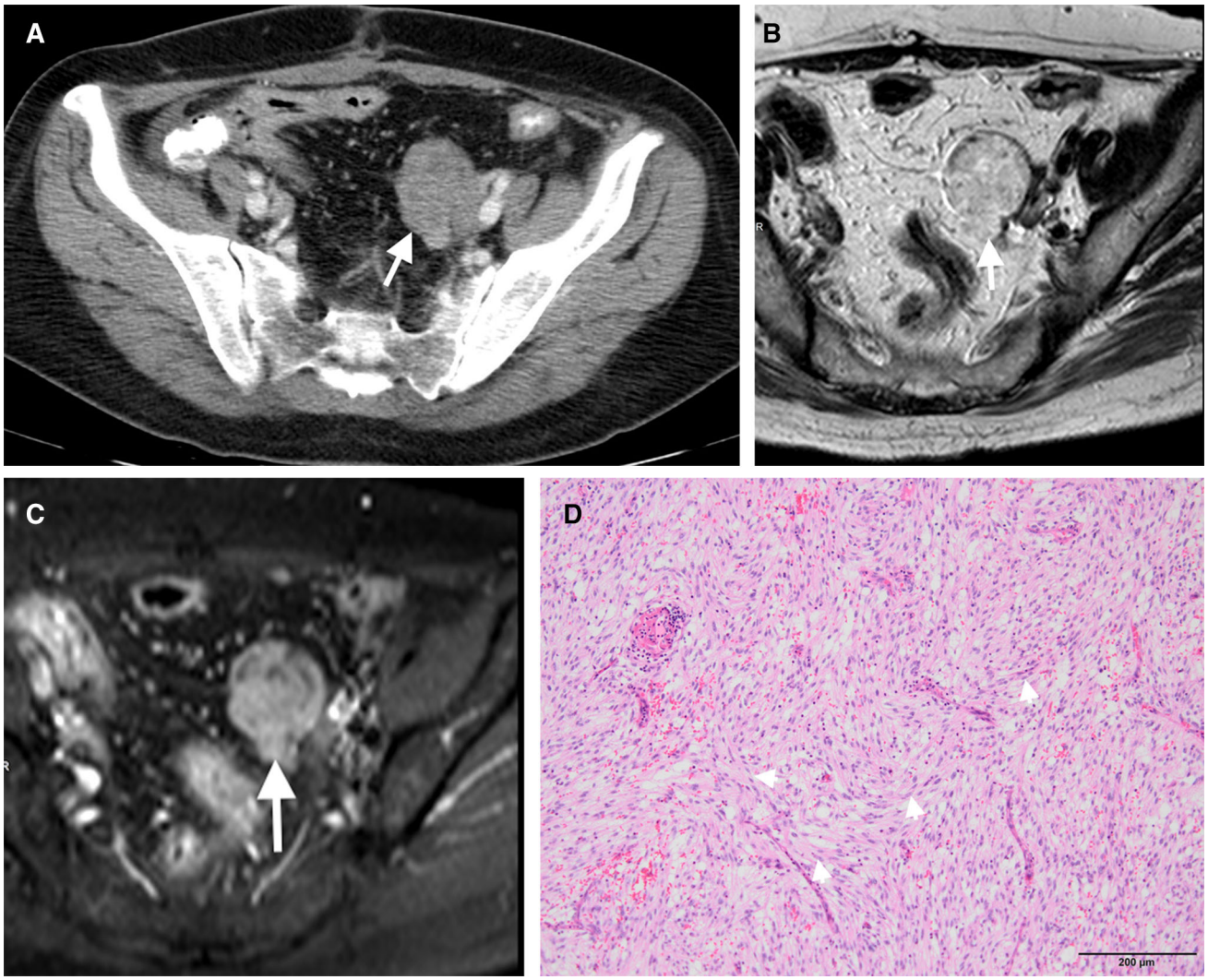

Fig. 10. Sixty-two-year-old woman with a history of ileal GIST treated with surgery and chemotherapy 4 years ago. The patient was under clinical remission since then. **A** Axial post-contrast CT image demonstrated a newly appeared left adnexal mass (arrow). **B** Axial T2-weighted MR image showed hyperintense solid mass (arrow) with well-defined borders. **C** Axial post-contrast T1-weighted image revealed intense enhancement of the same lesion (arrow). **D** Monotonous bland appearing spindle cells (arrowheads) of GIST; this tumor showed diffused positivity with c-kit and DOG-1 by immunohistochemistry (H&E).

ered. Despite all of the aforementioned potentially helpful imaging findings, imagers should be cognizant about the fact that in most of the patients the final diagnosis may only be achieved with histopathological assessment. Multidisciplinary approach is of fundamental importance to make an accurate histopathological diagnosis and all the microscopic, clinical, laboratory and radiologic information should be evaluated together.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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