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PICTORIAL ESSAY

Multidisciplinary Management of Ovarian, Fallopian Tube and Peritoneal Cancers with Emphasis on the Role of Cross-Sectional Imaging

OL Chan[1], SC Young[2], WWL Yip[3], WH Chong[1], KY Kwok[1]

[1]Department of Radiology, Tuen Mun Hospital, Hong Kong SAR, China
[2]Department of Obstetrics and Gynaecology, Tuen Mun Hospital, Hong Kong SAR, China
[3]Department of Clinical Oncology, Tuen Mun Hospital, Hong Kong SAR, China

INTRODUCTION

Ovarian cancer is the eighth most common cancer among women worldwide and the second most common gynaecological cancer mortality after cervical cancer.[1] In Hong Kong, ovarian cancer ranks as the sixth most common cancer in female and the most common cause of gynaecological cancer mortality in 2020.[2] Approximately two-thirds of patients with ovarian cancer are reported to present with stage III-IV disease.[3,4] High-grade serous carcinoma accounts for about 70% of malignant ovarian tumours.[5]

There is recent evidence that ovarian or peritoneal cancer may have a common origin from the fimbrial end of the fallopian tubes. The ovarian cancer staging system was updated in 2014 to include cancer of the fallopian tubes and peritoneum.[3]

One of the most important prognostic factors in ovarian cancer is the volume of residual disease after surgery. Cytoreductive surgery is the mainstay of treatment and is considered optimal if there is no or ≤1 cm of gross residual tumour and suboptimal if the residual tumour is >1 cm.[6,7]

In patients who present with advanced-stage disease, preoperative imaging to assess the abdominopelvic disease burden can help identify those at risk of having >1 cm gross residual disease and help avoid futile laparotomy. These patients may be first treated with neoadjuvant chemotherapy followed by reassessment imaging and interval debulking surgery if optimal tumour debulking is deemed possible.[3]

At our institution, management of patients with ovarian, fallopian tube and peritoneal cancers is discussed by a multidisciplinary team consisting of gynaecologists, radiologists, and oncologists. A multidisciplinary approach to cancer management has been shown to improve a patient's quality of life and prognosis.[8,9]

Correspondence: *Dr OL Chan, Department of Radiology, Tuen Mun Hospital, Hong Kong SAR, China*
Email: col950@ha.org.hk

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This article describes the role of imaging in the management of patients with ovarian cancer. The anatomy of common sites of peritoneal lesions is reviewed and features that may preclude optimal debulking surgery are highlighted.

ROLE OF IMAGING

The role of imaging in the management of ovarian cancer is to delineate the disease extent so that primary treatment can be planned and indicate possible sites for image-guided core biopsy for histological confirmation when necessary.[4]

Previous studies compared the diagnostic accuracy of different imaging modalities for detection of peritoneal carcinomatosis in ovarian cancer. Computed tomography (CT), magnetic resonance imaging, and positron emission tomography/computed tomography (PET/CT) all demonstrated >90% accuracy when compared with diagnostic laparoscopy.[10] Magnetic resonance imaging has the advantage of providing better soft tissue differentiation but is less readily available and motion artefacts may affect image quality. PET/CT is useful for whole-body assessment but is likewise not readily available. CT remains the most commonly performed pretreatment imaging since it has high accuracy and accessibility.

Compared with diagnostic laparoscopy, CT has a high accuracy of >90% for detection of peritoneal deposits. It is also more accurate in detecting peritoneal disease in upper abdominal regions when compared with laparoscopy. Limitations of CT are nonetheless its reported decreased sensitivity of <80% in depicting implants <1 cm in size, and inferior accuracy compared with laparoscopy in detecting disease in pelvic and small intestinal mesenteric regions.[11]

At our institution, CT of the abdomen and pelvis is performed for pretreatment staging, with the lung bases included in the scan range. The latter enables a search for suspicious cardiophrenic lymph nodes and pleural effusion that will require further investigations such as pleural tapping to look for stage IV disease.[4] Looking for stage IV disease is essential because this group of patients may not be candidates for surgical debulking.

In patients with inoperable disease, interval debulking is considered after two to three cycles of systemic chemotherapy.[3] As well as monitoring cancer antigen 125 level, CT should be used to assess treatment response and the feasibility of interval debulking surgery. PET/CT is often supplementary when CT findings are inconclusive.[4] Arrangement of timely follow-up imaging and planning for interval debulking surgery following neoadjuvant chemotherapy can be facilitated by a multidisciplinary meeting.

PERITONEAL ANATOMY AND FLOW OF PERITONEAL FLUID

Knowledge of the anatomy of the peritoneum and flow of peritoneal fluid is important when assessing peritoneal spread of disease. The internal surfaces of the abdominopelvic cavity are lined with parietal peritoneum. The visceral peritoneum lines the organs that are intraperitoneal. The potential space between these two layers of peritoneum is the peritoneal cavity and generally contains a small amount of fluid to allow frictionless movement of visceral organs within the abdominal cavity. Ascites is often detected in a disease state and may be due to increased capillary permeability or obstructed lymphatics resulting in overall increased peritoneal fluid.[12]

There are multiple peritoneal folds and reflections that compartmentalise the abdominopelvic cavity. The transverse mesocolon divides the peritoneal cavity into the supracolic and infracolic spaces. The supracolic space is separated by the falciform ligament into the left and right. The right supracolic space contains the right subphrenic space, subhepatic space, and the lesser sac. The left supracolic space includes the perihepatic and left subphrenic space. The infracolic space is further divided by the small bowel mesentery into the larger left and smaller right spaces. The small bowel mesentery attaches from the ligament of Treitz at the left upper quadrant to the ileocaecal junction at the right iliac fossa.

Initially, peritoneal fluid collects at a gravity-dependent site, the pouch of Douglas in woman and the rectovesical space in men. It travels in a cephalad direction, entering the paracolic gutters and then the supracolic spaces. On the left side, fluid passage is superiorly limited by the phrenicocolic ligament, hence more peritoneal fluid flows into the right paracolic gutter (Figure 1). The flow of peritoneal fluid is slow or arrested at dependent regions due to gravity, and fluid stasis allows tumour cells to be deposited. The four dependent areas include the rectouterine pouch, right lower quadrant, sigmoid colon, and right paracolic gutters.

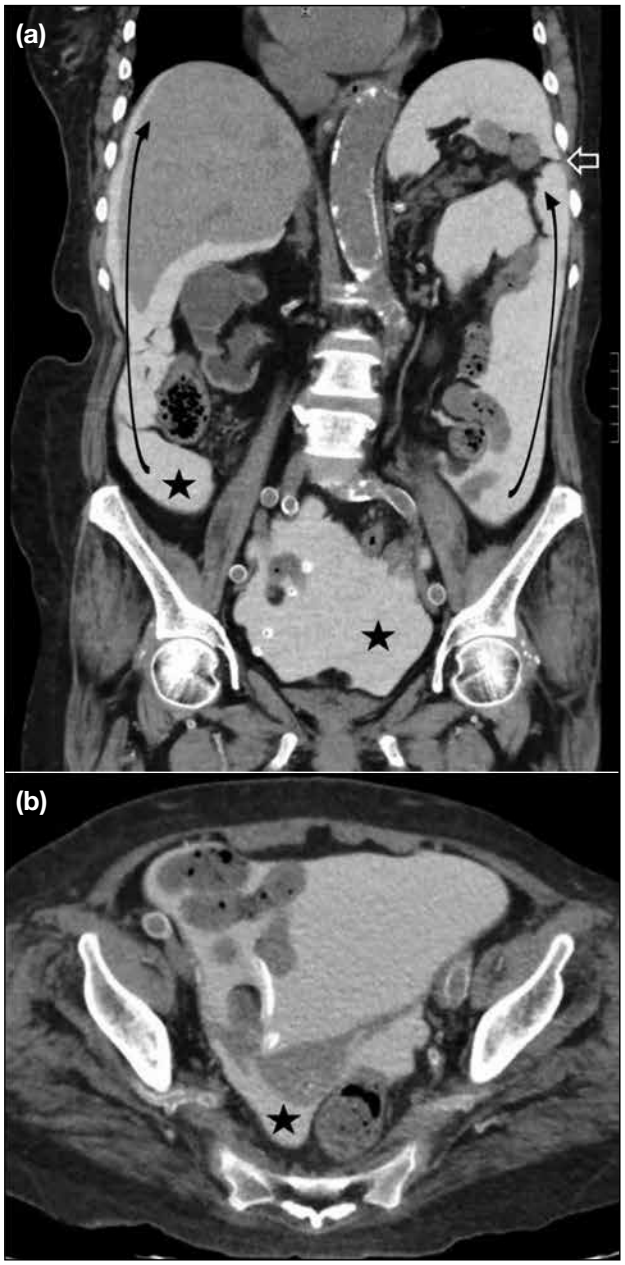

Figure 1. (a) Coronal and (b) axial images of computed tomography peritoneogram with intraperitoneal contrast to demonstrate peritoneal cavity anatomy. Peritoneal fluid initially collects at the pelvis, then travels cephalad due to pressure gradients produced by inspirations (curved arrows in [a]). Fluid passage on the left side is superiorly limited by the phrenicocolic ligament (open arrow in [a]). The rectouterine pouch, right lower quadrant, sigmoid colon, and right paracolic gutters (asterisks in [a] and [b]) are dependent regions in which there is stasis of peritoneal fluid.

ASSESSMENT OF ABDOMINOPELVIC DISEASE BURDEN

The most frequent routes for dissemination of ovarian cancer are by direct pelvic invasion and via transcoelomic peritoneal spread.[13] Less frequently, it may also spread along the lymphatics via the utero-ovarian, infundibulopelvic and round ligament pathways.[3] The most common lymphatic spread is along the utero-ovarian pathway to the para-aortic and paracaval nodes at the level of the kidney.[7] Haematogenous spread is rare and seldom present at initial diagnosis.

Primary Tumour

The size and location of the primary ovarian tumour should be described. Pelvic sidewall invasion is suspected when the distance between the tumour and the muscular pelvic sidewall is <3 mm, or when there is encasement of >90% of the circumference of iliac vessels.[13] Any invasion to the adjacent organs such as the urinary bladder or rectum should be noted since it may require additional surgical input from other subspecialties to achieve optimal debulking (Figure 2).

Peritoneal Carcinomatosis

Assessment of peritoneal carcinomatosis is crucial since it affects staging and subsequent management. The presence of ascites raises a suspicion of peritoneal involvement and loculated ascites usually indicates peritoneal metastasis. Signs of early peritoneal disease are subtle and can be easily missed. Multiplanar reformatted CT images are helpful in the assessment of peritoneal lesions. Coronal and sagittal reformatted

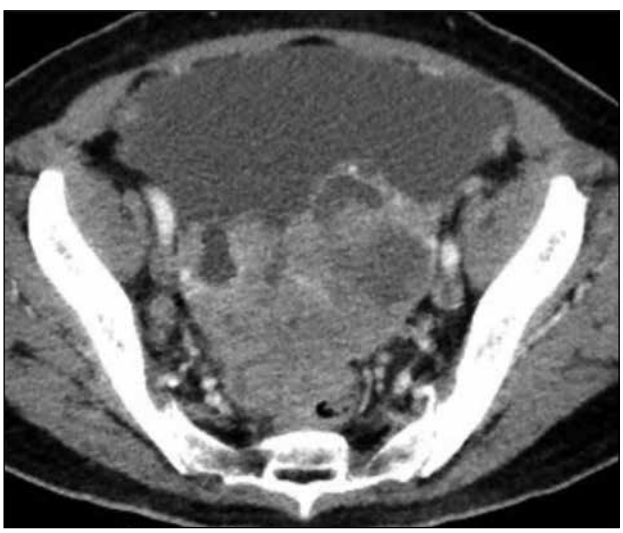

Figure 2. Contrast computed tomography demonstrating large heterogenous pelvic tumour blended with the uterus, with extension to the pouch of Douglas and the rectum. Optimal debulking of this tumour will likely require pelvic exenteration and requires input from a colorectal surgeon.

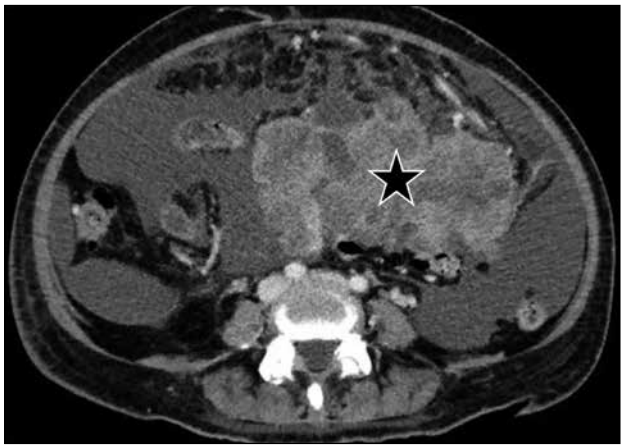

Figure 3. Contrast computed tomography image demonstrating large left ovarian tumour (asterisk), loculated ascites and omental stranding, suggestive of peritoneal metastases.

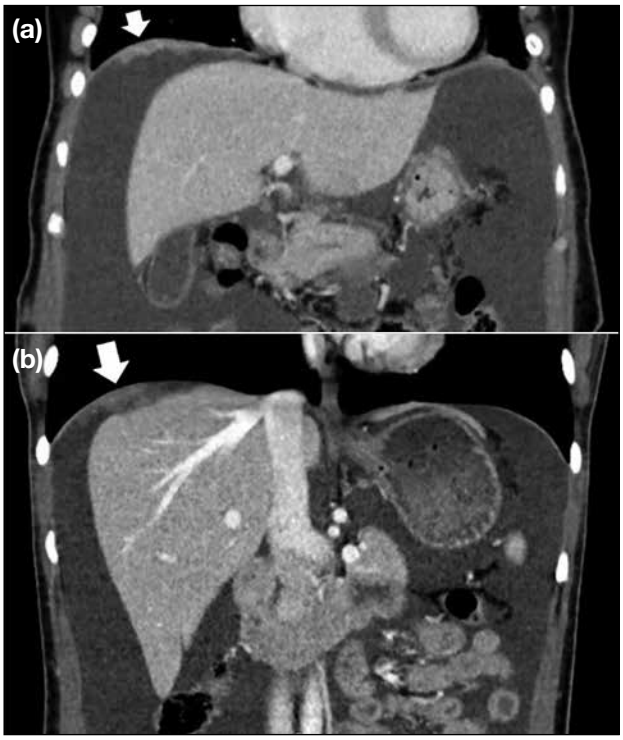

Figure 4. Contrast computed tomography images demonstrating right subphrenic deposits (arrows in [a] and [b]) that are best appreciated on coronal image. (b) Larger subphrenic deposits can cause scalloping of liver contour.

images improve detection of lesions on curved surfaces such as the diaphragm, paracolic gutters, and pelvis (Figure 3).[7]

The operability of peritoneal lesions is related to multiple factors such as the location of peritoneal deposits, their morphology and multiplicity, and their size and relationship with adjacent organs. Peritoneal carcinomatosis can present with a wide range of morphological appearance on CT. Subtle soft tissue infiltration, mild thickening or nodularity of the peritoneum may be the only findings in early peritoneal disease. Soft tissue peritoneal implants are usually observed in advanced peritoneal disease. These can present as solitary or multiple nodules, or coalesce to form plaque-like lesions and larger masses. They may show contrast enhancement; metastases from serous cystadenocarcinoma may be calcified.[12]

Upper Abdomen

The right subphrenic region is frequently involved since there is preferential flow of peritoneal fluid along the right side of the abdomen. Coronal and sagittal images enable better assessment of peritoneal deposits at the hemidiaphragm. Nodular- or plaque-like thickening may be observed. Larger deposits at the subphrenic region may cause scalloping of the liver or splenic contour. On post-contrast phase, these implants are hypoenhancing relative to the liver or splenic parenchyma (Figure 4).

In the upper abdomen, it is also essential to look for any involvement of the peritoneal ligaments, including the gastrohepatic and gastrosplenic ligaments (Figure 5). Increased soft tissue stranding, thickening or nodular deposits at these ligaments usually suggest involvement.

Any tumour deposits at the perihepatic spaces should be specified, including the fissure for falciform ligament, gallbladder fossa, porta hepatism, and lesser sac (Figure 6). Peritoneal lesions at these sites, particularly when >2 cm in size, are probably non-resectable.[14] Any subcapsular implants at the Morison's pouch extending to the inferior vena cava must be described because they pose a surgical challenge due to increased bleeding risk.[7]

Since haematogenous metastases are extremely rare at presentation, apparent parenchymal involvement of the liver and spleen are more commonly caused by invasive serosal surface implants rather than haematogenous metastases (Figure 7). Differentiation of a surface lesion versus parenchymal invasion lesion is particularly important for the liver because partial hepatectomy may

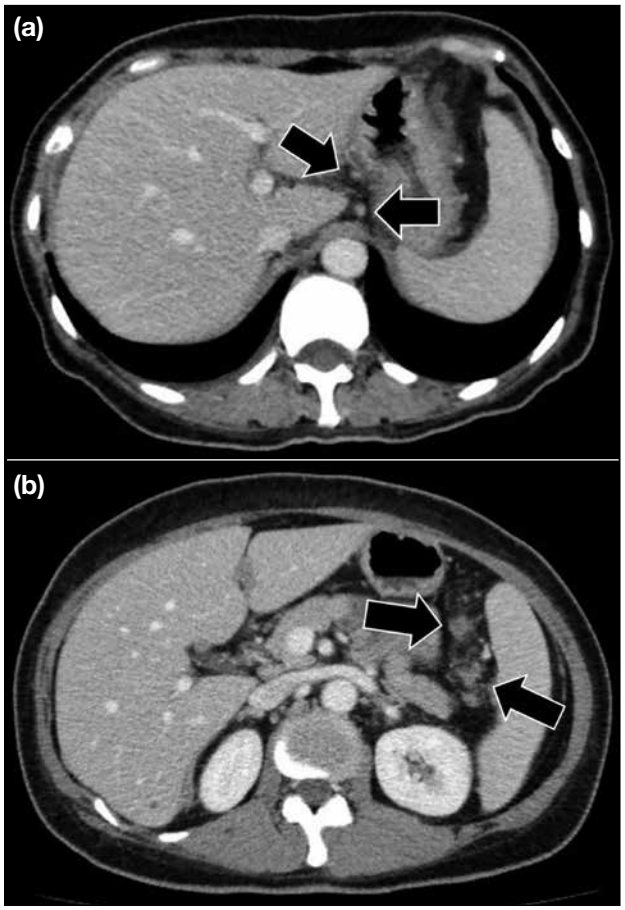

Figure 5. Contrast computed tomography images demonstrating peritoneal deposits at the upper abdominal ligaments, where (a) shows nodular deposits at the gastrohepatic ligament (arrows) and (b) shows nodular deposits at the gastrosplenic ligament (arrows).

be required in the latter with assistance of a hepatobiliary surgeon. Distinguishing between a surface lesion and invasive parenchymal lesion at the spleen is less important because splenectomy is more easily performed (Figure 8).[13]

Paracolic Gutters, Omentum, and Mesentery

The bilateral paracolic gutters are also common sites of peritoneal deposits because of peritoneal fluid stasis. It is helpful to assess with both axial and coronal images. Tumour deposits present as irregular thickening and nodularity (Figure 9).

Infiltration of the omental fat can present as increased soft tissue stranding and omental nodules of various sizes. When these small nodules coalesce, they give rise to larger omental plaques or mass-like lesions that are commonly referred to as omental cakes. Greater omental involvement usually does not preclude surgery since omentectomy is routinely performed in debulking surgery. Nonetheless extension of omental metastases to the anterior abdominal wall or umbilicus may preclude surgery (Figure 10).[4,12]

Infiltration of the mesentery can present as misty mesentery or clustered soft-tissue nodules (Figure 11). Peritoneal deposits at the mesentery can cause tethering of the bowel loops and intestinal obstruction. Intestinal obstruction is a common morbidity associated with metastatic ovarian cancer, reported to occur in about

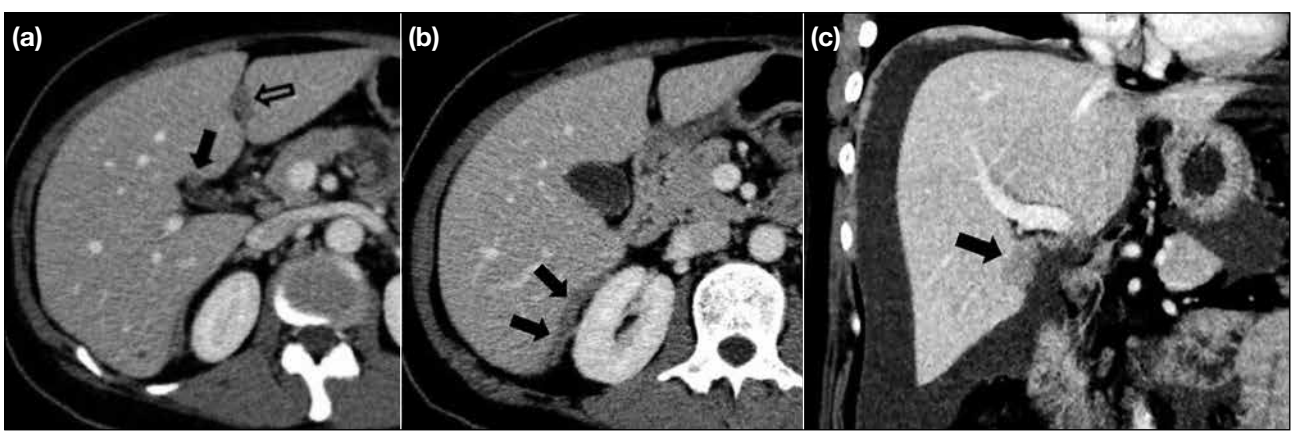

Figure 6. Contrast computed tomography images demonstrating peritoneal deposits at the perihepatic spaces, where (a) shows deposits at the falciform ligament (open arrow) and gallbladder fossa (block arrow), (b) shows deposits at the Morison's pouch (arrows), and (c) shows deposits at the hepatic hilum (arrow). It is important to identify these peritoneal deposits on pretreatment imaging since they are difficult to visualise on laparoscopy.

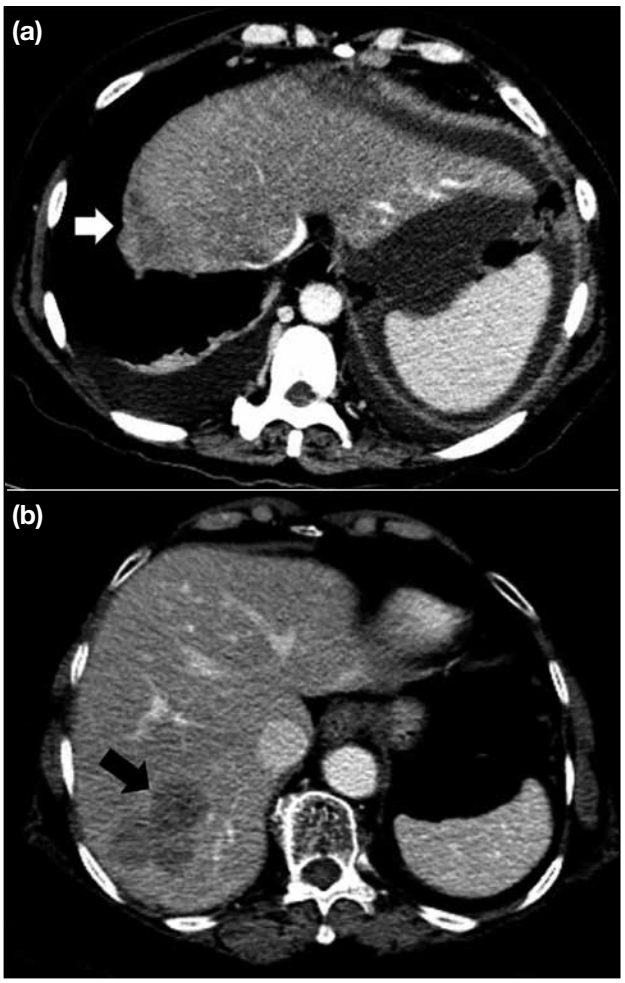

Figure 7. (a) A subphrenic deposit with hepatic parenchymal invasion (arrow) and (b) a haematogenous hepatic metastasis (arrow). Presence of these lesions might require assistance from a hepatobiliary surgeon for optimal bulking.

50% of cases.[12] Detection of segmental small bowel obstruction and extensive tumour deposits on the small bowel surface or at the mesenteric root is important because these features may preclude surgery.[14] Serosal implants at the bowel loops are difficult to detect, particularly in the absence of complications such as intestinal obstruction. Involvement of the small bowel may present as segmental mural thickening and soft-tissue mass involving the serosa and adjacent mesentery. Depending on the extent of involvement, these bowel serosal implants may be resected with the assistance of a gastrointestinal surgeon.

In the pelvis, common sites of deposits include the surface of the urinary bladder, sigmoid mesocolon, pelvic sidewall, pouch of Douglas, and surface of the sigmoid and rectum. Lesions at the bilateral uterosacral ligament and pelvic sidewall are better seen on axial and coronal images. Lesions at the peritoneal surface of the bladder, pouch of Douglas, and rectosigmoid regions are better observed on sagittal images. Again, these deposits can present as soft tissue thickening or a mass (Figure 12).

Lymphadenopathy

Lymphatic spread commonly involves the para-aortic lymph nodes. An enlarged node with >1 cm short axis suggests malignant lymphadenopathy.[13] Apart from increased nodal size, necrosis or clustering of lymph nodes are also suspicious features of metastatic involvement. Any enlarged lymph node at the suprarenal

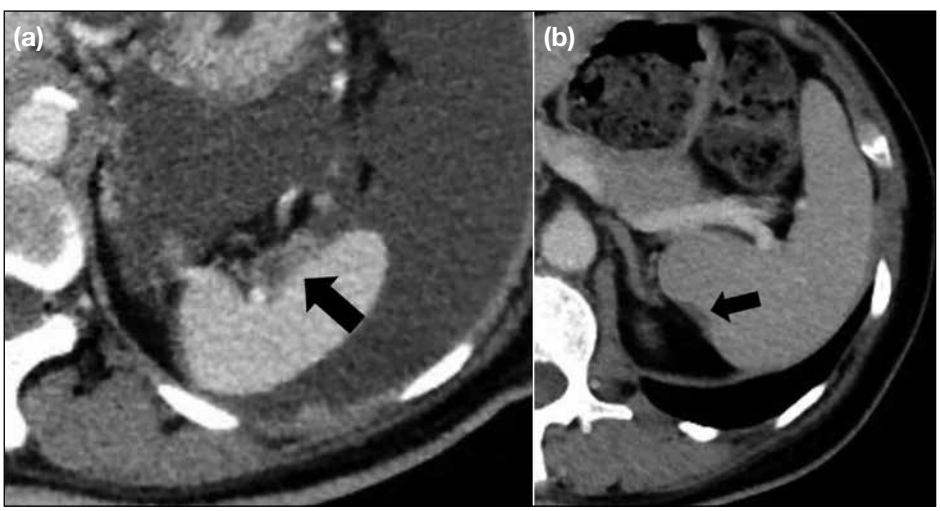

Figure 8. Contrast computed tomography images demonstrating deposit on the splenic surface, with (a) showing deposit at the splenic hilum (arrow) and (b) showing deposit at the posteromedial surface of the spleen (arrow). As these sites are difficult to assess on laparoscopy, pretreatment imaging is essential.

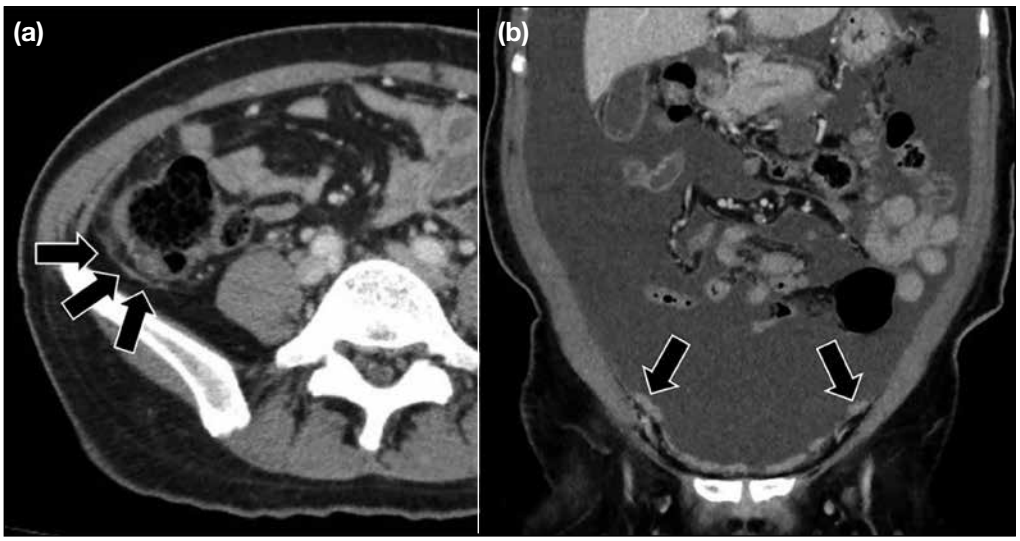

Figure 9. (a) Axial and (b) coronal images from contrast computed tomography demonstrating deposits at the paracolic gutters (arrows).

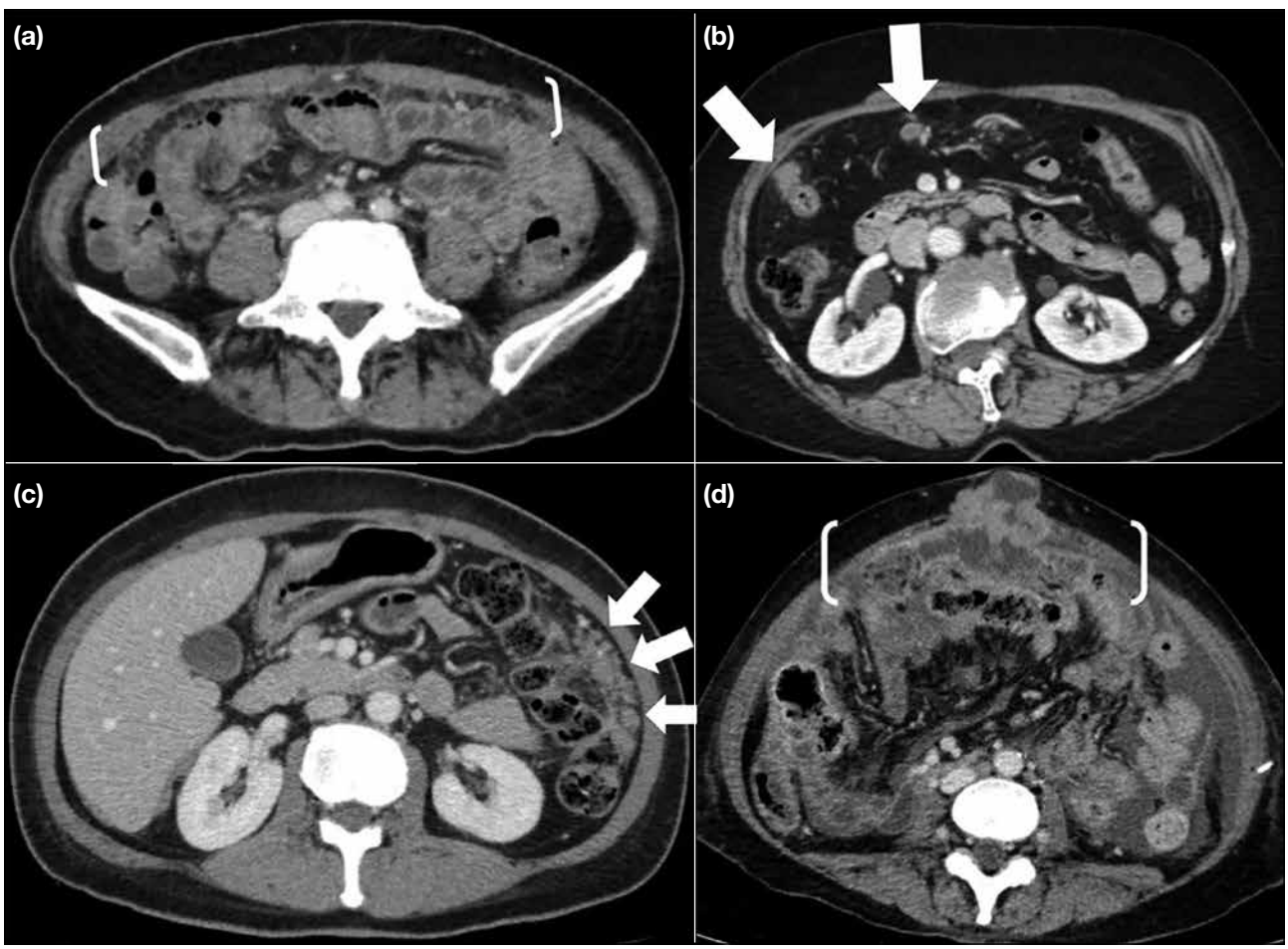

Figure 10. Contrast computed tomography images demonstrating the different morphologies of omental deposits, from mild increased stranding at the omentum (brackets in [a]), small omental nodules (arrows in [b]), confluent nodules and plaque-like deposits (arrows in [c]), to omental cake appearance with extension to the umbilicus (brackets in [d]).

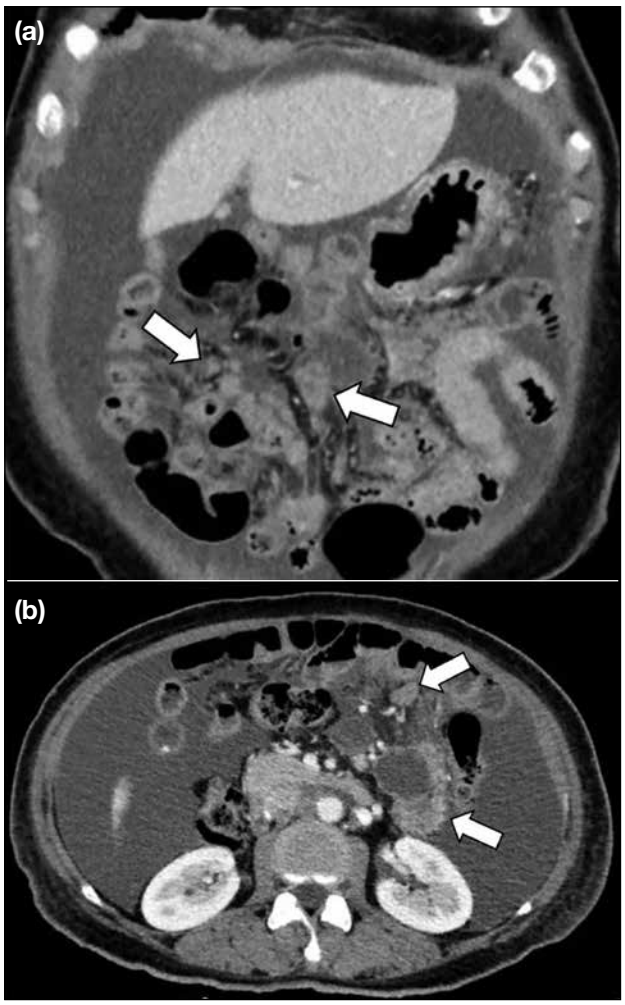

Figure 11. (a) Coronal and (b) axial images from contrast computed tomography demonstrating nodular deposits at the mesentery (arrows).

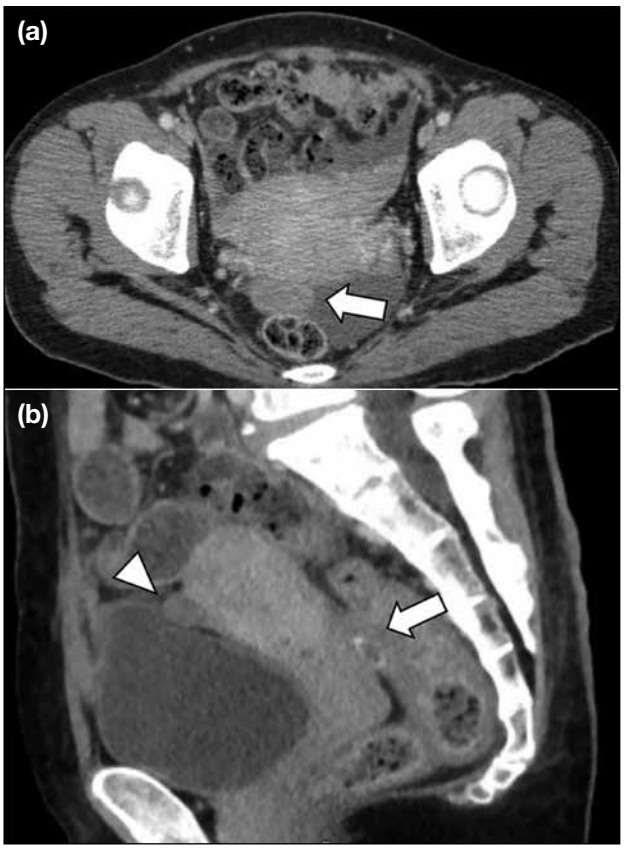

Figure 12. Contrast computed tomography images demonstrating peritoneal disease at the pelvis, with (a) showing deposits at the pouch of Douglas (arrow). (b) This image allows better appreciation of deposits at the peritoneal surface of the urinary bladder (arrowhead) and pouch of Douglas (arrow).

para-aortic, portacaval, porta hepatis or celiac axis should be specified because these sites may preclude surgery (Figures 13 and 14).

Lung Base

Assessment of the lung bases on preoperative CT is crucial since these extraperitoneal sites are not accessible by laparoscopy. The cardiophrenic lymph node is considered enlarged when the short axis is >5 mm[7,15] and may suggest stage IV disease. This precludes surgery. Any pleural effusion should be further investigated to look for stage IV disease that is deemed inoperable (Figures 15 and 16).

Assessment for Interval Debulking Surgery

At our institution, follow-up imaging is performed after three cycles of neoadjuvant chemotherapy in patients with inoperable disease. Images are reviewed at the multidisciplinary meeting for consideration of interval debulking surgery (Figures 17 and 18).

Cancer of the ovaries, fallopian tubes and peritoneum share similar morphological and clinical features. In patients with advanced disease, a tubal or ovarian origin can be difficult to delineate because tumour growth may obscure the primary site.[6] Preoperative assessment for these patients should be similar.

Figure 19 summarises CT assessment of peritoneal lesions and the Table lists potentially non-resectable disease.

CONCLUSION

Pretreatment imaging is helpful to evaluate

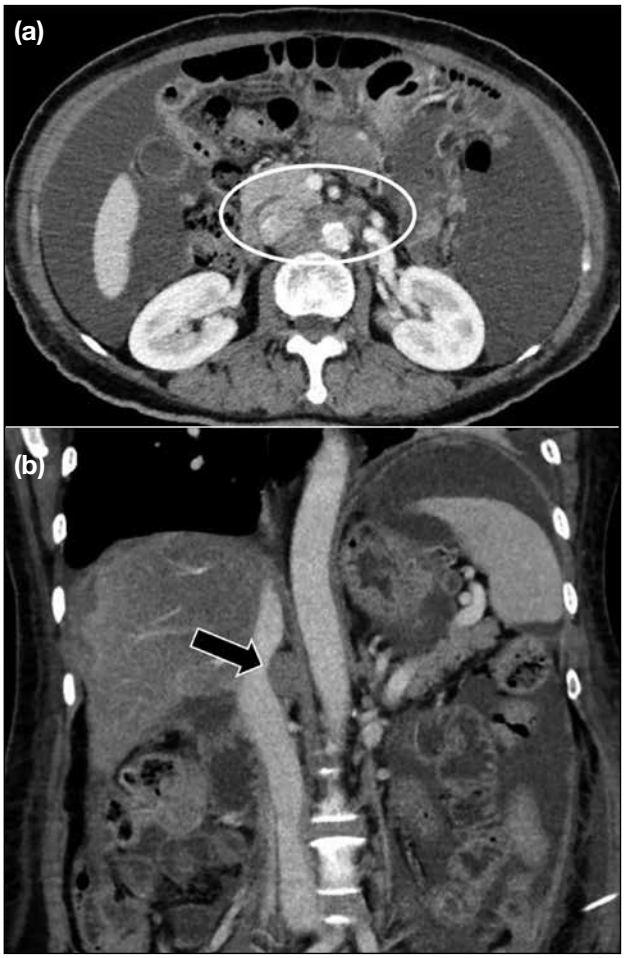

Figure 13. Malignant para-aortic lymphadenopathy above the level of the renal vein (circle in [a]) and enlarged paracaval lymph node (arrow in [b]). These are considered surgically difficult sites.

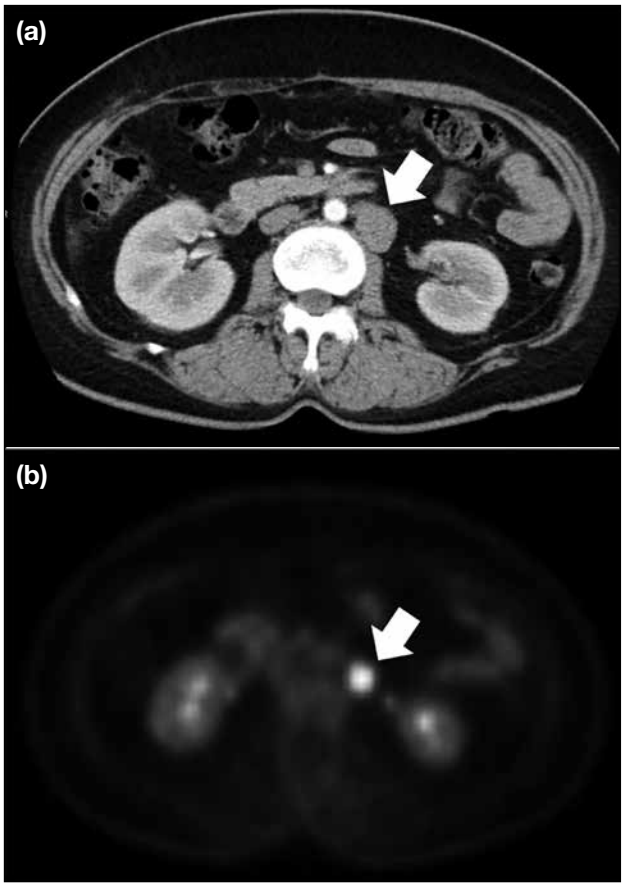

Figure 14. (a) Contrast enhanced computed tomography image demonstrating a solitary enlarged left para-aortic lymph node (arrow). (b) Further evaluation with positron emission tomography shows that this lymph node is hypermetabolic with standardised uptake value of 11 (arrow), suggestive of metastatic lymphadenopathy.

abdominopelvic disease burden in patients with ovarian, fallopian tube and peritoneal cancers, and to identify patients at risk of having suboptimal debulking surgery in whom laparotomy would be futile. It has been shown that CT has high accuracy in detecting peritoneal lesions. Assessment of peritoneal involvement can be improved by understanding the peritoneal anatomy, route of tumour dissemination, as well as common sites of peritoneal deposits. The role of radiologists in the multidisciplinary team is to alert clinicians to the presence of lesions that may complicate surgery or preclude optimal debulking. Patient-centred management should be discussed at the multidisciplinary meeting to decide which of cytoreductive surgery or neoadjuvant chemotherapy is most appropriate.

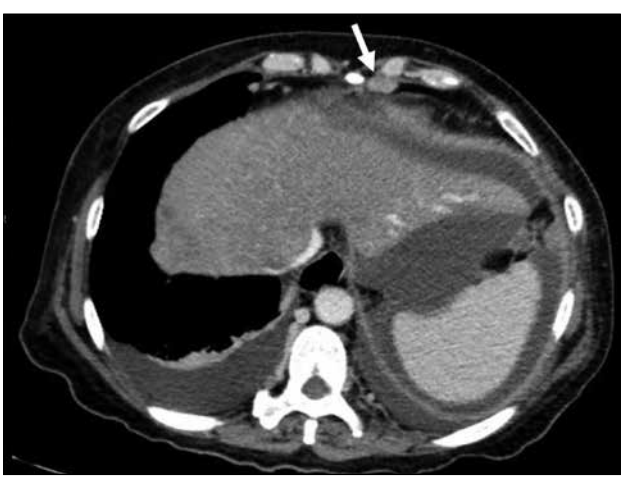

Figure 15. Contrast computed tomography image demonstrating bilateral pleural effusion and an enlarged cardiophrenic lymph node (arrow), worrisome of stage IV disease.

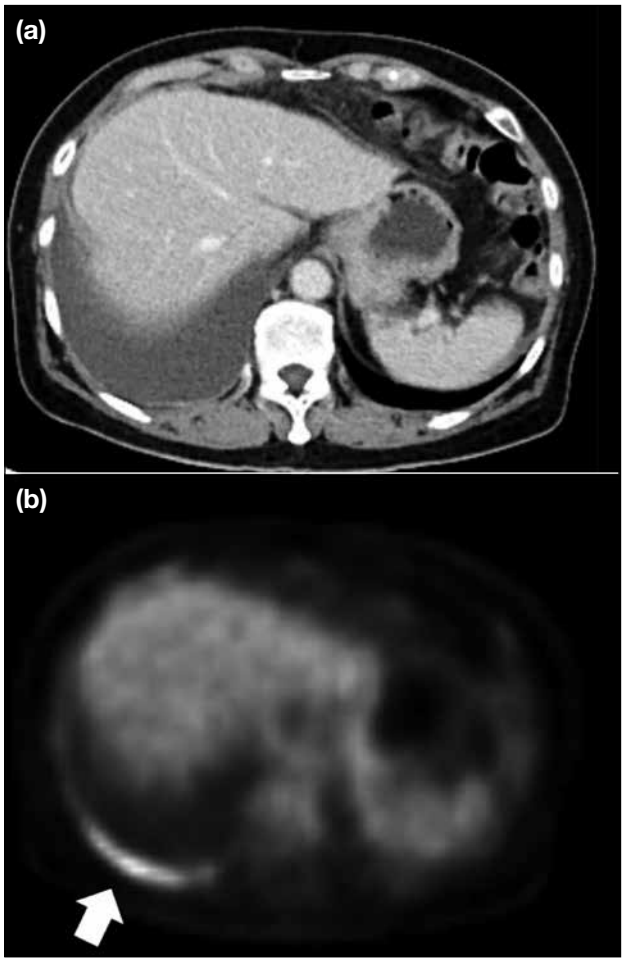

Figure 16. (a) Contrast enhanced computed tomography image showing right pleural effusion. (b) Positron emission tomography shows increased fluorodeoxyglucose uptake along the pleura (arrow), suggestive of metastatic deposits and stage IV disease.

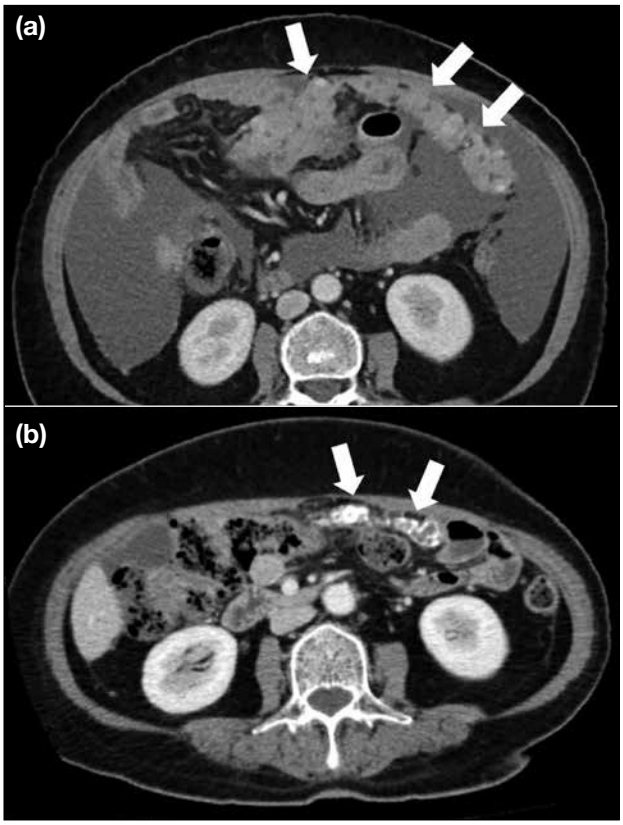

Figure 18. (a) Staging computed tomography (CT) image showing extensive omental deposits (arrows). (b) Follow-up CT after neoadjuvant chemotherapy showing interval shrinkage of omental deposits (arrows). Development of calcifications at the omental deposits is suggestive of post-treatment changes.

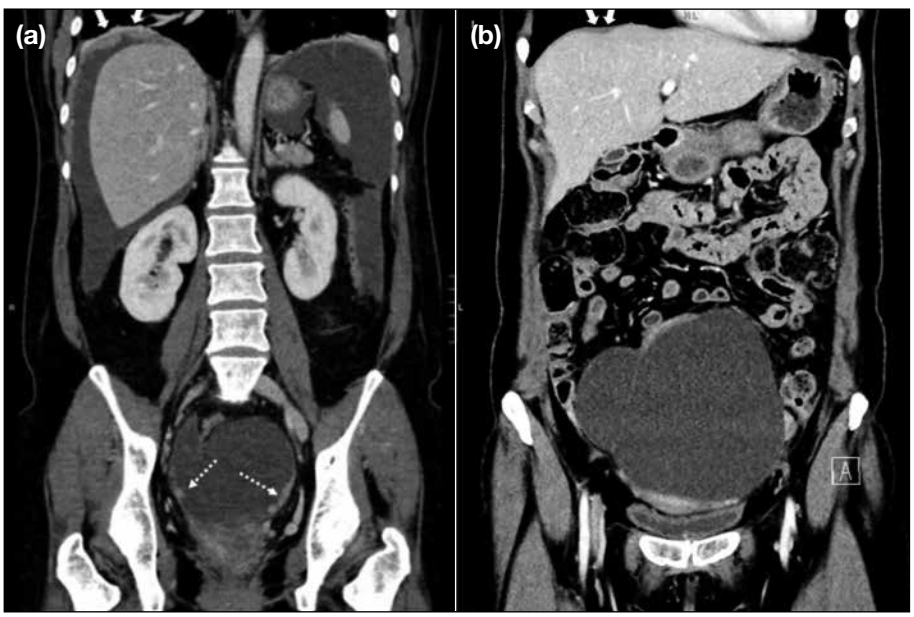

Figure 17. (a) Staging computed tomography (CT) image showing extensive peritoneal deposits at the right subphrenic region (arrows), which are surgically challenging. The primary ovarian tumour with solid components (dashed arrows) is also detected. (b) Follow-up CT after neoadjuvant chemotherapy showing interval shrinkage of the concerned right subphrenic deposits (arrows). The primary tumour also shows a decreased solid component. Images were reviewed at the multidisciplinary meeting and the patient subsequently underwent interval debulking surgery.

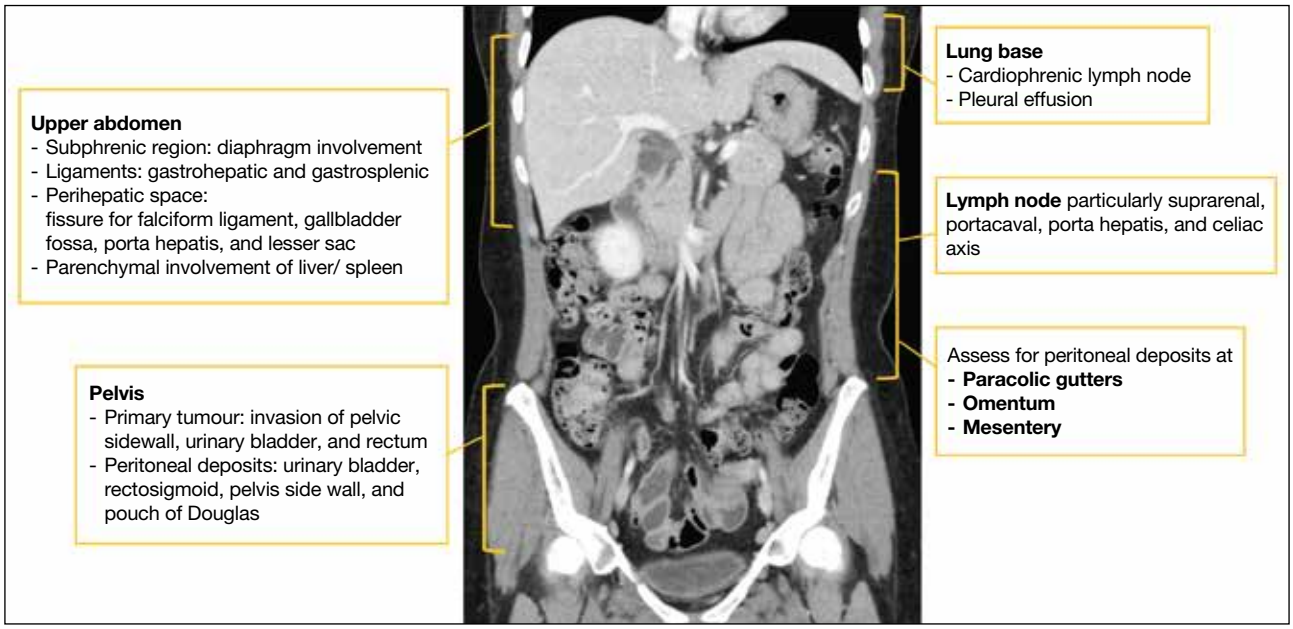

Figure 19. Summary of computed tomography assessment of peritoneal lesions.

Table. Summary of potentially non-resectable diseases.

• Implants >2 cm at the diaphragm, lesser sac, porta hepatis, fissure for falciform ligament, gallbladder fossa, gastrohepatic or gastrosplenic ligament
• Haematogenous hepatic parenchymal metastases
• Extensive involvement of the mesenteric root
• Pelvic sidewall invasion
• Involved lymph nodes superior to the level of renal vein (including suprarenal para-aortic, portacaval, porta hepatis, and celiac axis)
• Pleural infiltration and cardiophrenic lymph nodes

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