TRANSCOELOMIC SPREAD OF OVARIAN CANCER: WHAT THE ONCOSURGEON WANTS TO KNOW

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AIMS AND OBJECTIVES

1. To discuss the peritoneal ligaments, spaces, and fluid circulation.
2. To revisit the sites of abdominal metastasis from ovarian carcinoma.
3. To explain the relevance of location of intraperitoneal metastasis in cytoreductive debulking.

METHODS AND MATERIALS

- Contrast-enhanced CT and MRI scans performed for the evaluation of abdominal metastasis from ovarian carcinoma were included.
- Patients undergoing PET evaluation for similar evaluation were also included.
- Imaging was reviewed by 2 senior radiologists, in order to accurately locate metastatic implantation.
- Surgical implications were discussed with senior oncosurgeons and will be discussed in detail in the exhibit.

THE PERITONEUM

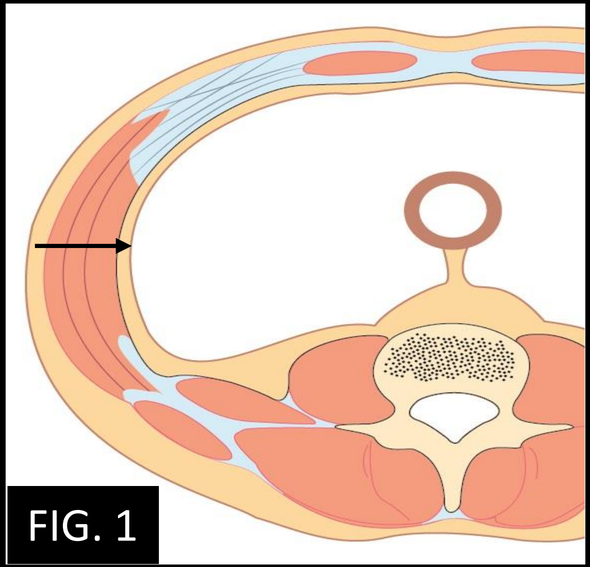
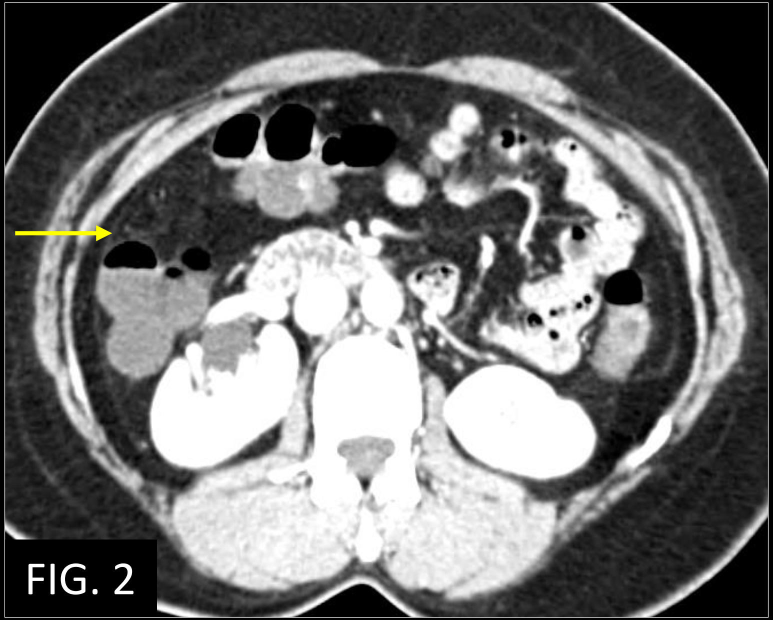


FIG. 1

The peritoneum (Fig. 1) is a thin, contiguous, serous membrane that lines the abdominal wall (parietal peritoneum) as well as some solid and hollow abdominal organs (visceral peritoneum). Both types of peritoneum are composed of a single layer of simple cuboidal epithelium known as mesothelium. Between the layers of the peritoneum is approximately 50–100 mL of serous fluid, which helps to lubricate these membranes. Under normal circumstances, the peritoneum is almost never visualized. At CT (Fig. 2), narrow window levels may help visualizing the peritoneum, however it must be remembered that thickening and enhancement of the peritoneum (Fig. 3, 4) always indicates the presence of an infective, inflammatory or neoplastic disease process of the peritoneum.



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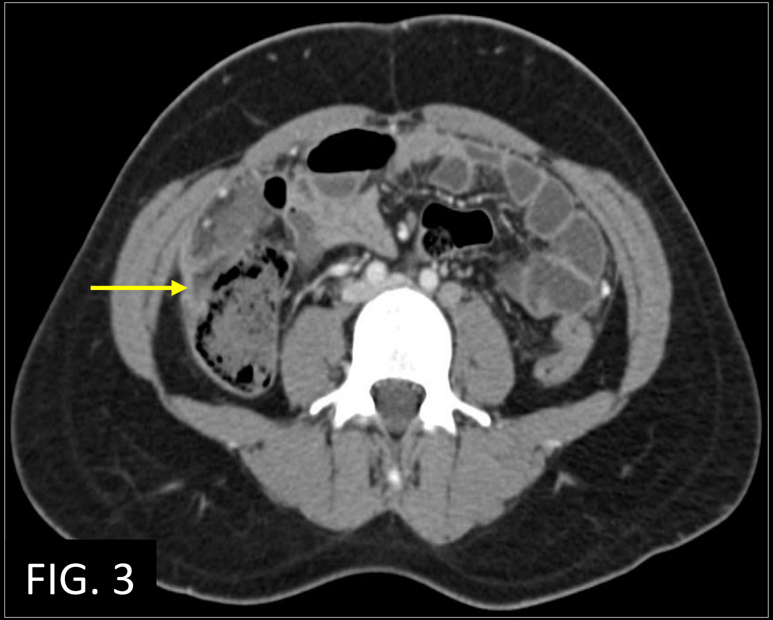

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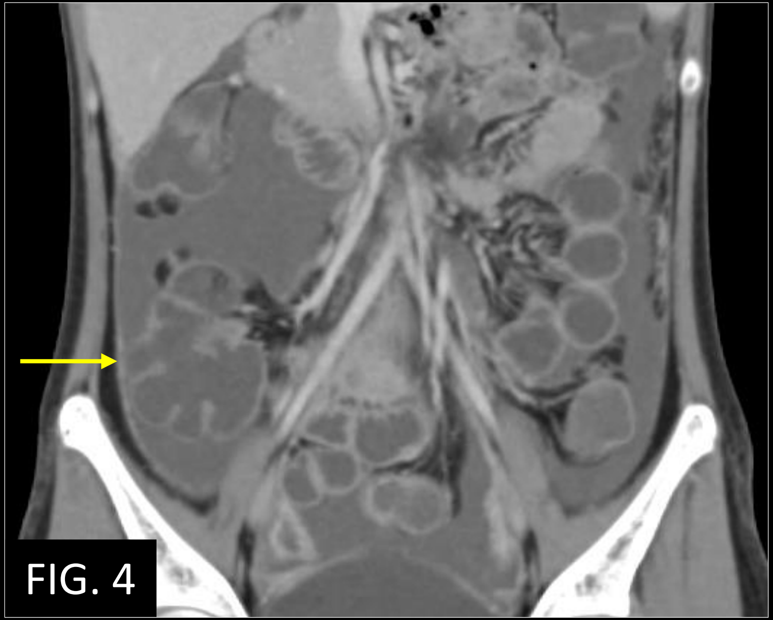


FIG. 4

THE GREATER OMENTUM

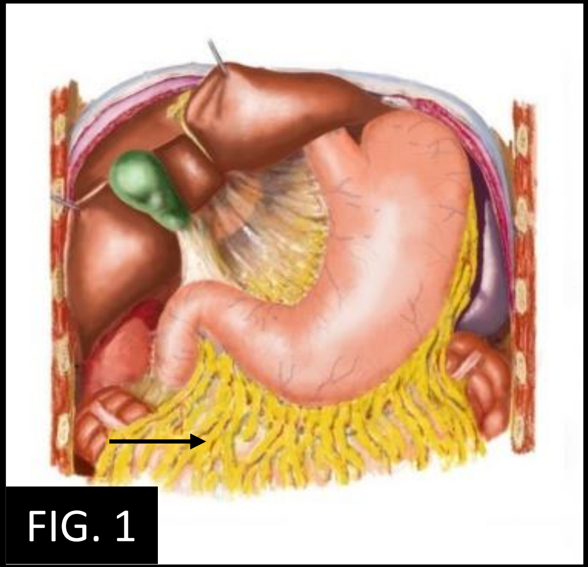
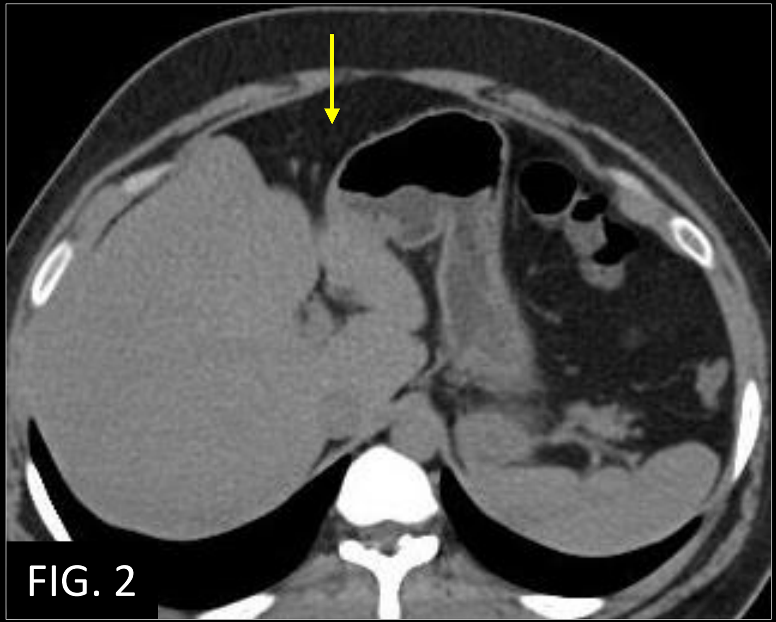


FIG. 1

The greater omentum is a mobile, double layer of peritoneum that hangs from the greater curvature of the stomach and the proximal part of the duodenum (arrow in Fig. 1), covering the anterior aspect of the small intestine. It is composed of adipose tissue with some gastroepiploic vessels. It serves as a visceral fixator and helps in limiting spread of pathologies. It also helps in the resorption of the peritoneal fluid, predisposing it to metastatic seeding. At CT (Fig. 2-4), it appears as a band of fatty tissue, lying beneath the anterior abdominal wall and the anterior aspects of the stomach, transverse colon, and small intestine. Ascites makes the omentum appear as a simple fatty layer, and while soft-tissue deposits create hazy stranding or a mass-like appearance at CT.



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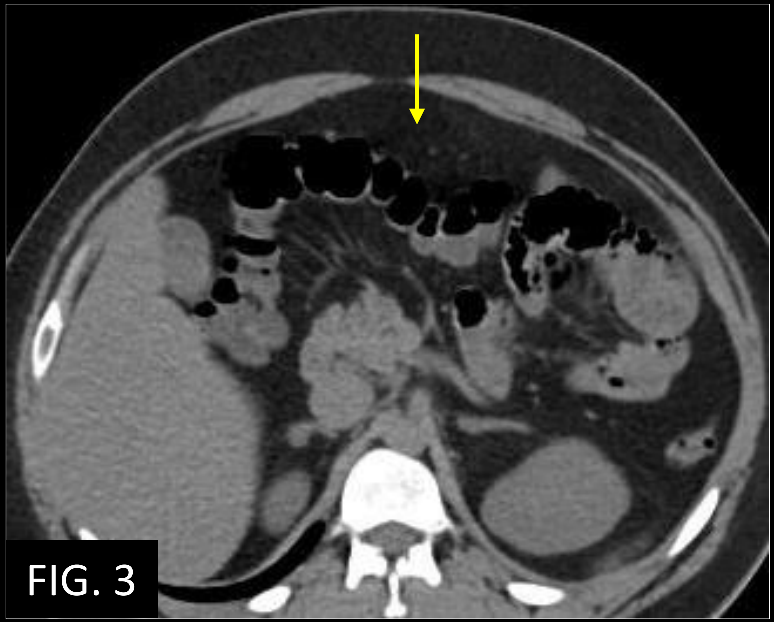

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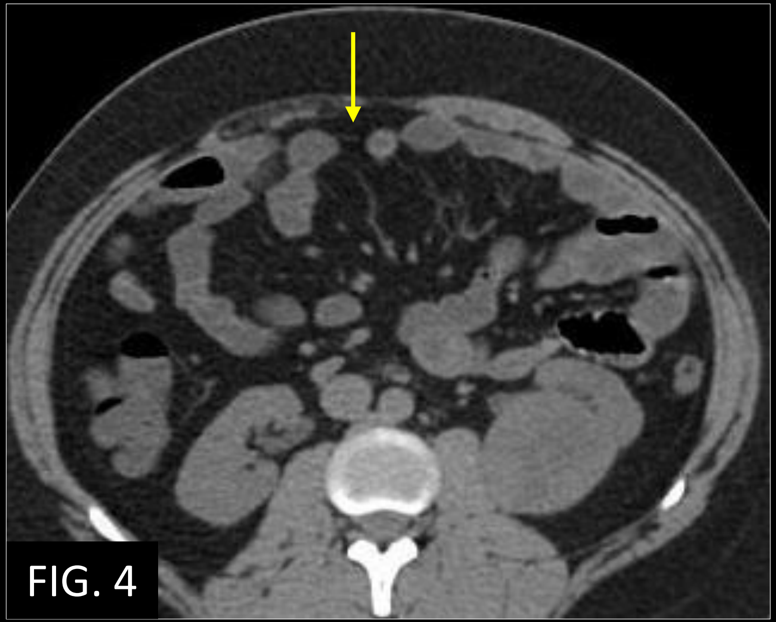


FIG. 4

THE LESSER OMENTUM

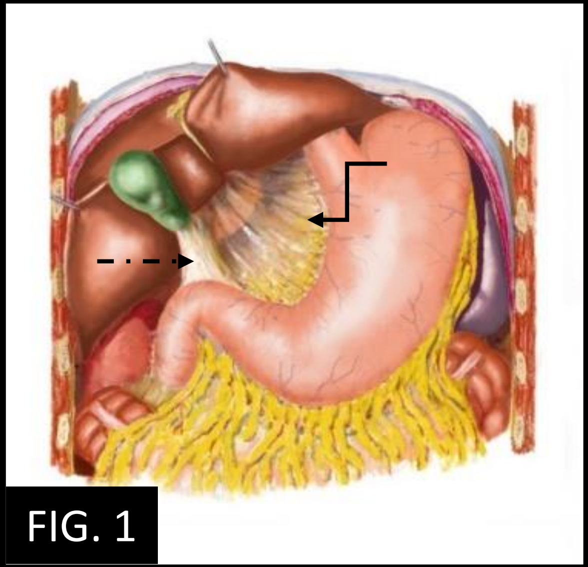


FIG. 1

The lesser omentum is a combination of the gastrohepatic (stepped arrow in Fig. 1, 2 and 3) and hepatoduodenal ligaments (dotted arrow in Fig. 1, 3). These ligaments connects the liver to the lesser curvature of the stomach and proximal duodenum, respectively. They also form the anterior boundary of the lesser sac anteriorly (arrow in Fig 4). The gastrohepatic ligament contains the left gastric vessels and left gastric lymph nodes. The hepatoduodenal ligament, contains the portal vein, hepatic artery, extrahepatic bile duct, and hepatic nodal group. At CT, the gastrohepatic ligament is seen as a triangular fat-containing area between the stomach and liver. However, the hepatoduodenal ligament is often identified only in the presence of neoplastic involvement.

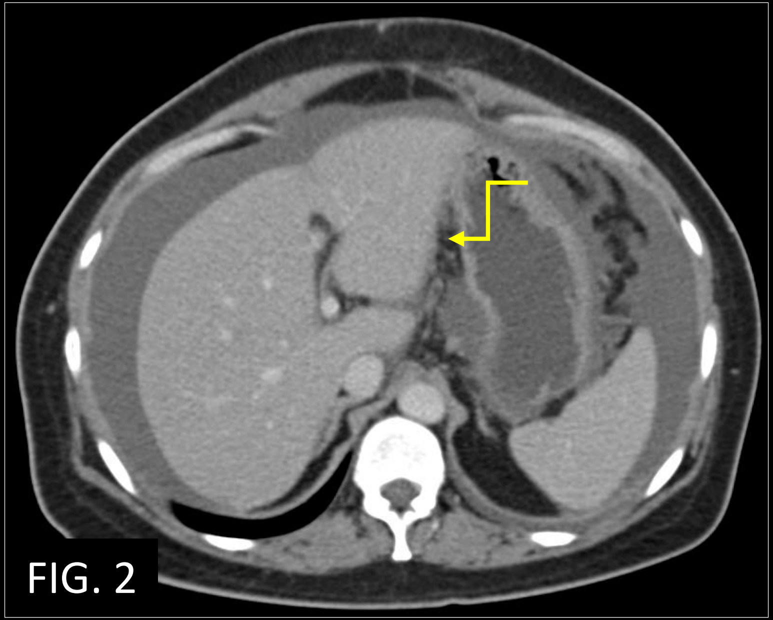


FIG. 2

FIG. 3

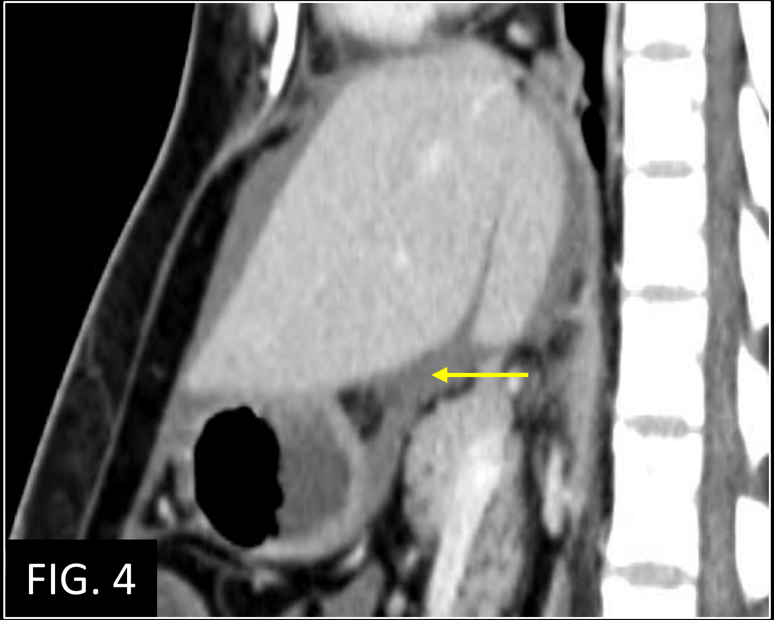


FIG. 4

THE MESENTERY

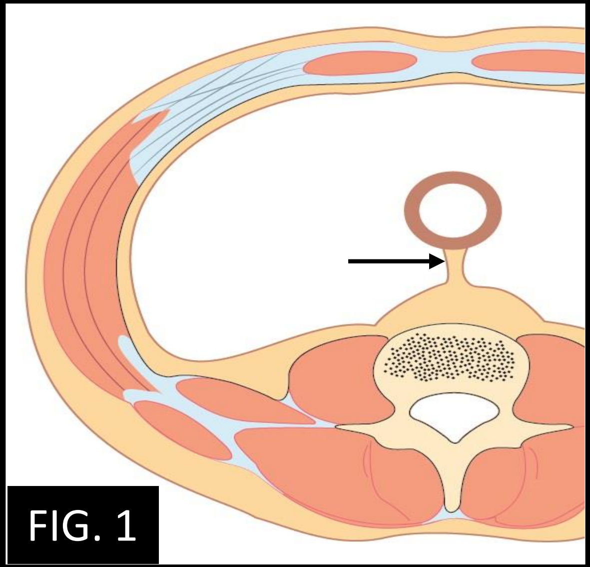
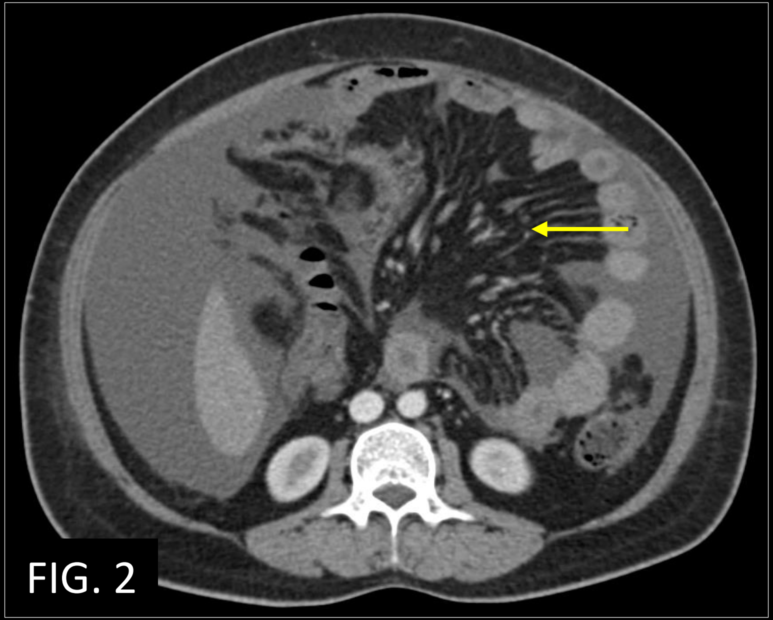


FIG. 1

The mesentery is the fan-shaped suspensory ligament of the jejunum and ileum (arrows in Fig. 1, 2 and 3). This membrane is composed of adipose tissue, blood vessels, nerves, and lymphatics. The intestinal border of the mesentery (attached to the small intestine) is about 6.5 meters long. The root of the mesentery (yellow line in Fig. 4) is about 15 centimetres in length, and is attached to the posterior wall of the abdominal cavity. At CT, the mesentery is best visualized in the presence of ascites, as a fatty membrane with a 'spoke wheel appearance'. Fluid typically collects in the peritoneal spaces, along the anterior aspect of the bowel (antimesenteric border). The root of the mesentery can be identified by drawing a straight line from the duodenojejunal flexure to the ileocaecal junction (Fig. 3).



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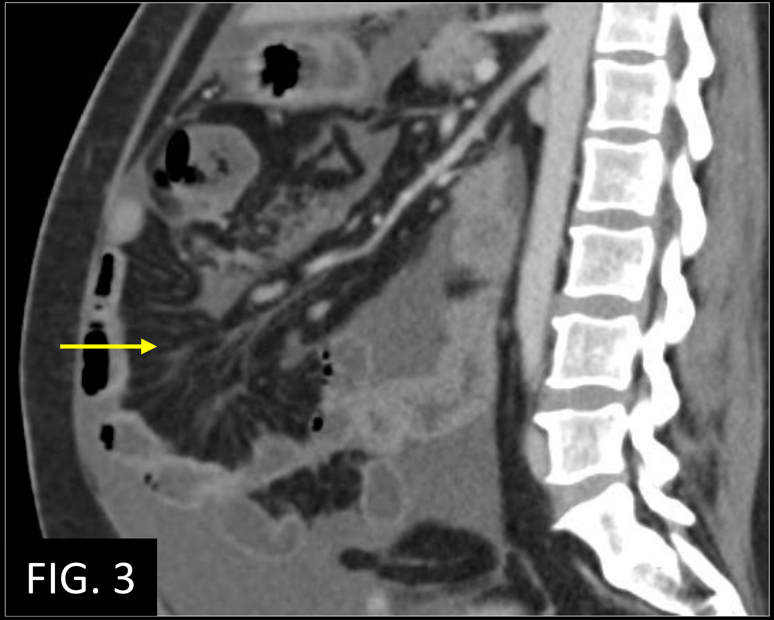

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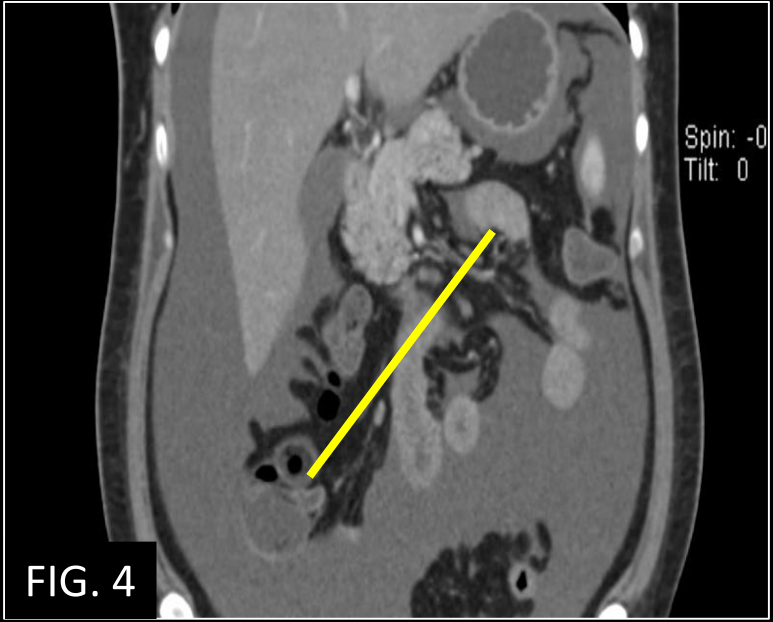


FIG. 4

THE MESOCOLONS

FIG. 1

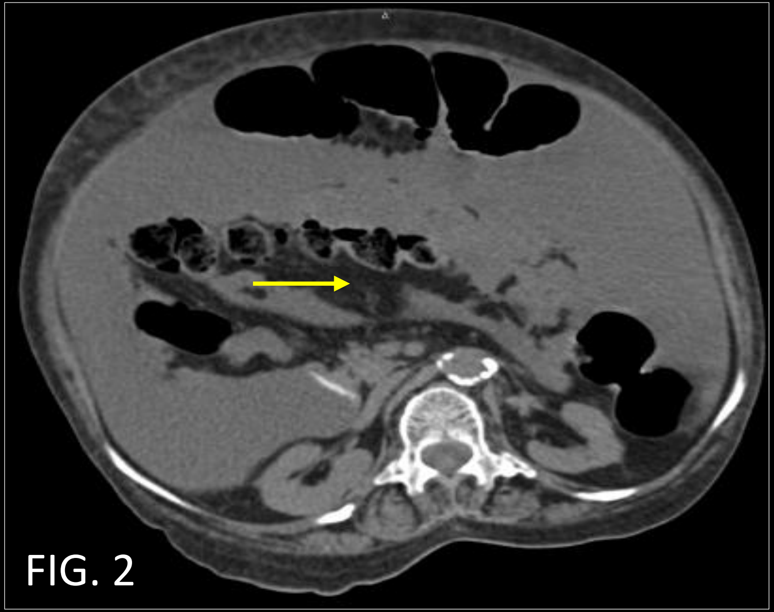
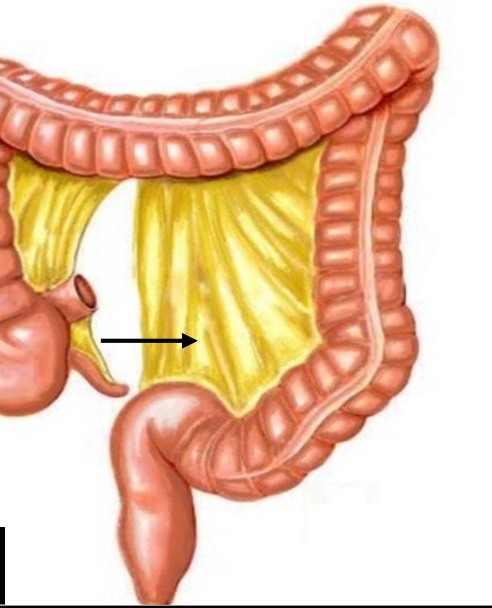


FIG. 2

The transverse mesocolon (Fig. 1, 2) is the broad fold of peritoneum connecting the transverse colon to the posterior abdominal wall. It is formed by the ascending layer of the greater omentum. Between its layers pass the blood vessels, lymphatics, and nerves supplying the transverse colon. It divides the abdominal cavity into two compartments: the upper or the supramesocolic compartment and the lower or the inframesocolic compartment.



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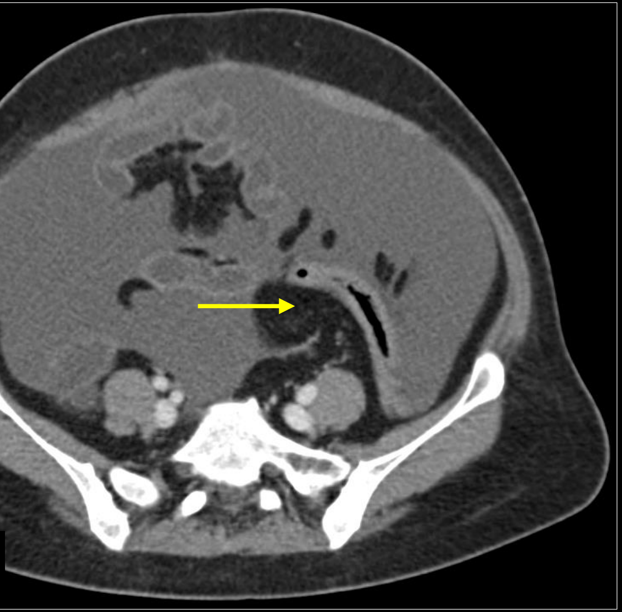


FIG. 4

The sigmoid mesocolon (Fig. 3, 4) is the reflection of peritoneum which connects the sigmoid flexure with the posterior wall of the extreme lower portion of the abdominal cavity and the posterior wall of the pelvic cavity. It extends from the termination of the descending colon in the iliac fossa, at the lateral border of the psoas major muscle, to the commencement of the rectum, opposite the middle portion of the sacrum.

THE HEPATIC LIGAMENTS

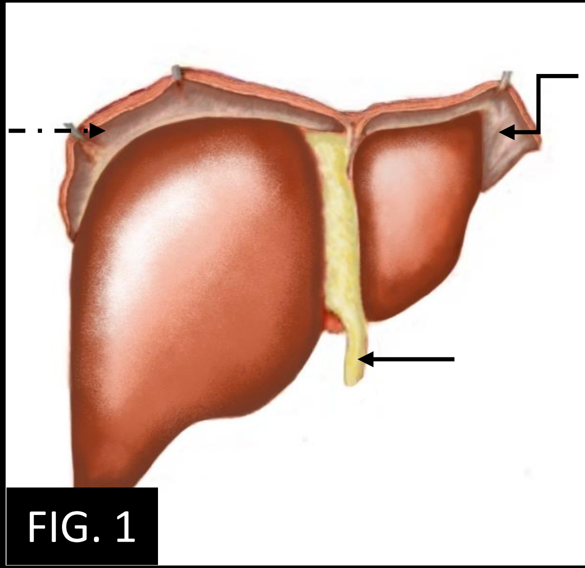


FIG. 1

Various peritoneal reflections attach the liver to the surrounding soft tissues. The falciform ligament (arrow in Fig. 1) is a sickle-shaped ligament attaching the anterior surface of the liver to the anterior abdominal wall. It forms a natural anatomical division between the left and right lobes of the liver. The free edge of this ligament contains the ligamentum teres, a remnant of the umbilical vein. The triangular ligament (stepped arrow in Fig. 1, 3) is an extension of the Glisson's capsule and attaches the left lobe to the diaphragm. The coronary ligament (dotted arrow in Fig. 1, 4) is an extension of the capsule of the liver and attaches the right lobe of the liver to the posterior abdominal wall. These ligaments form the boundaries of the subphrenic and the right subhepatic spaces.

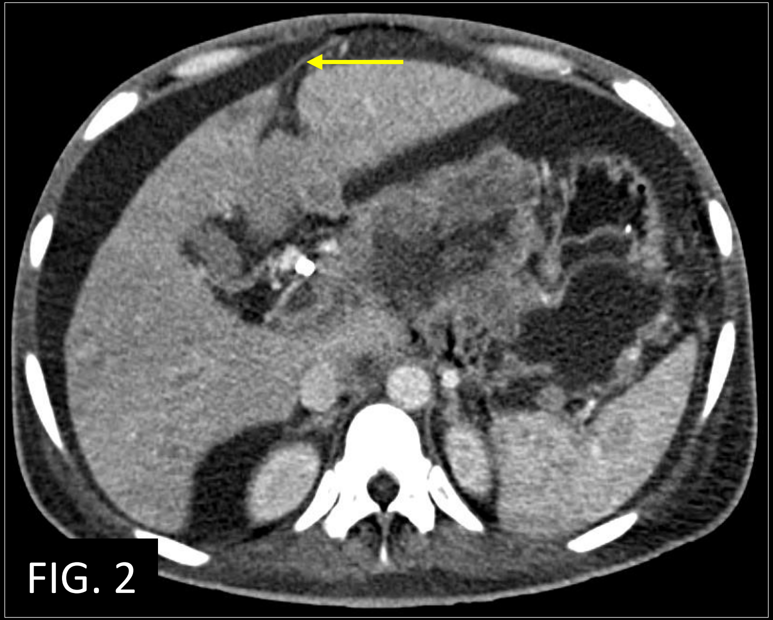


FIG. 2


FIG. 3

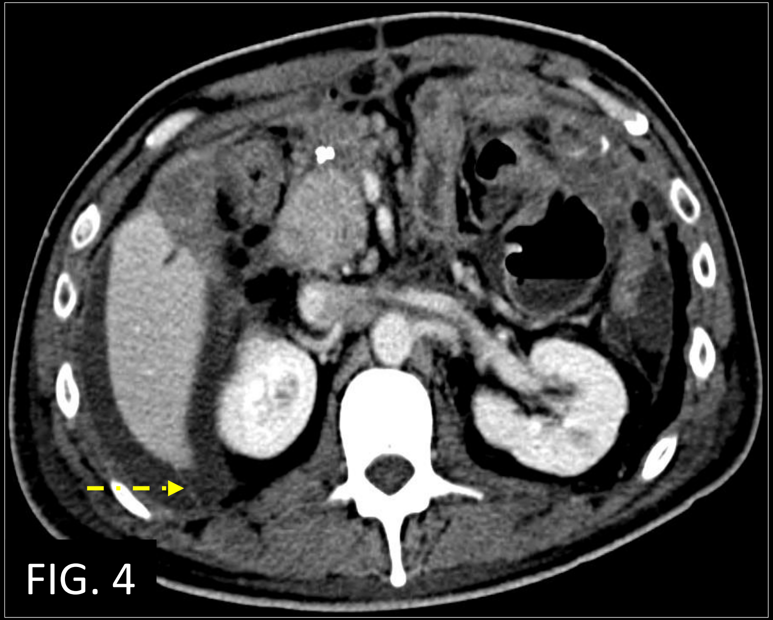


FIG. 4

OTHER LIGAMENTS

1. The gastrophrenic ligament (Fig. 1) arises from the fundus of the stomach and extends upwards to the diaphragm. Its superior portion is transparent and avascular, continuous with the poster layer of the triangular ligament. The inferior portion is continuous with the gastrosplenic ligament. The ligament contains short gastric vessels and lymph nodes.
2. The gastrosplenic ligament extends from the gastric fundus to the hilum of the spleen. It continues inferiorly with the greater omentum. It consists of two layers of peritoneum, between which pass the gastric branches of the splenic artery,. The structures in the gastrosplenic ligament are the short gastric vessels, left gastroepiploic vessels, lymph vessels, and sympathetic nerves.
3. The phrenicocolic ligament (Fig. 3) is a fold of peritoneum which extends from the splenic flexure to the diaphragm opposite the tenth and eleventh ribs.

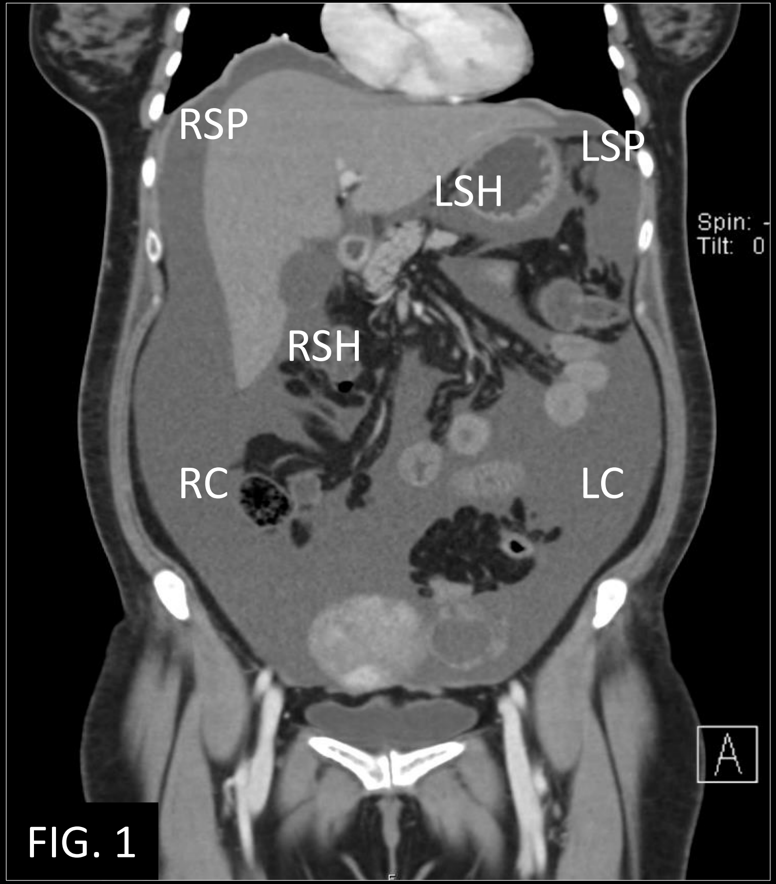
FIG. 1

FIG. 2

FIG. 3

PERITONEAL SPACES

The transverse mesocolon divide the peritoneal cavity into the supramesocolic and the inframesocolic compartments. The supramesocolic compartment is composed of the subphrenic or the subdiaphragmatic space on the right (RSP) and left (LSP) side. This space communicates with the right and left paracolic gutters (PG) across the right subhepatic (RSH) and left subhepatic spaces (LSH). These supramesocolic spaces communicate directly and indirectly with the vesicouterine pouch (between the uterus and bladder) (arrow in Fig. 2) and the rectouterine pouch (between uterus and rectum) (stepped arrow in Fig. 2). Peritoneal fluid circulates across these spaces, predisposing them to metastatic seeding (Fig. 3).



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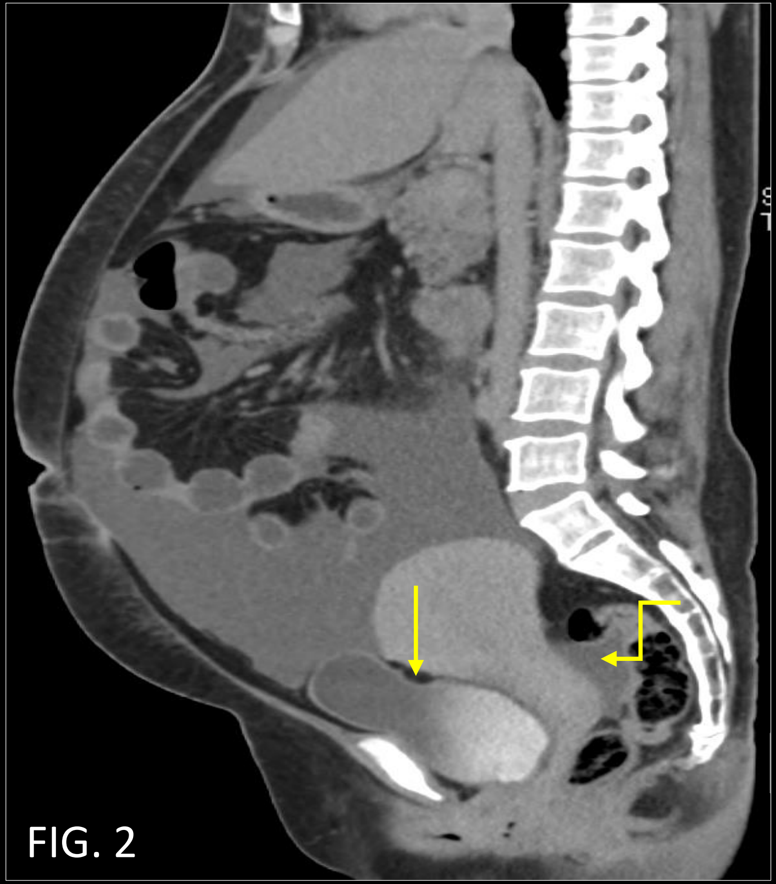


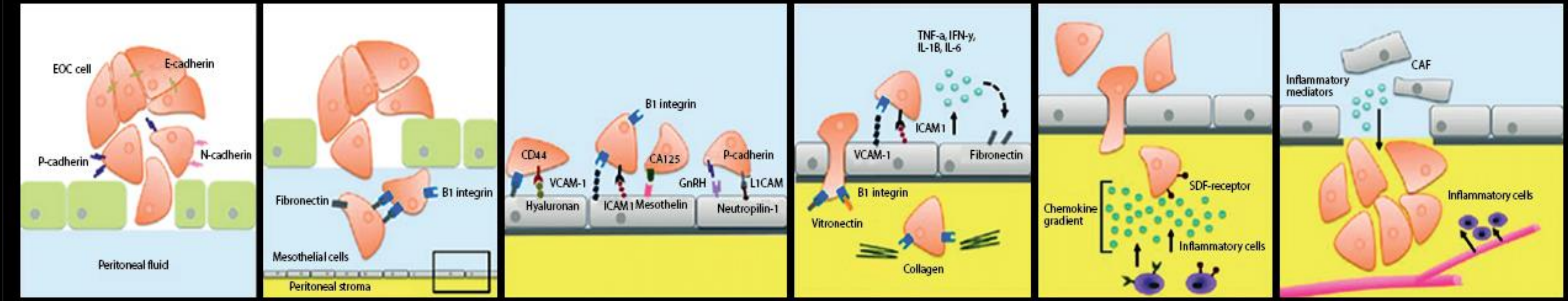
FIG. 2


FIG. 3

IMAGING MANIFESTATIONS OF OVARIAN CARCINOMATOSIS

BIOLOGY OF TUMOR SPREAD

- The exfoliation of a neoplastic cell from an epithelial ovarian cancer (EOC) is facilitated by E-cadherin. The exfoliated tumor cells (eEOC) are carried passively to remote sites in the peritoneum due to fluid circulation. Within the peritoneum, the eEOCs undergo epithelial-to-mesenchymal transition (EMT) to acquire an invasive phenotype and eventually form tumor cell clusters via β 1 integrin-fibronectin interactions that prevents anoikis.
- In the development of peritoneal metastasis, the eEOCs adhere to the mesothelial cells by integrin and non-integrin mediated interactions. Once they have penetrated the mesothelial cell layer, they bind to the extracellular matrix within the peritoneal stroma. An inflammatory response is simultaneously generated resulting in increased production of pro-inflammatory cytokines. Within the peritoneal stroma, a chemokine gradient is produced. Inflammatory cells are recruited along the gradient toward the tumor cells and contribute to cancer progression by production of proteases, angiogenic factors, growth factors, and cytokines, which suppress immune responses.



a. EOC cell detachment from primary tumor

b. Dessemination of EOC cells in peritoneal fluid

c. Adhesion of EOC cells to mesothelial cells

d. Adhesion of EOC to ECM components

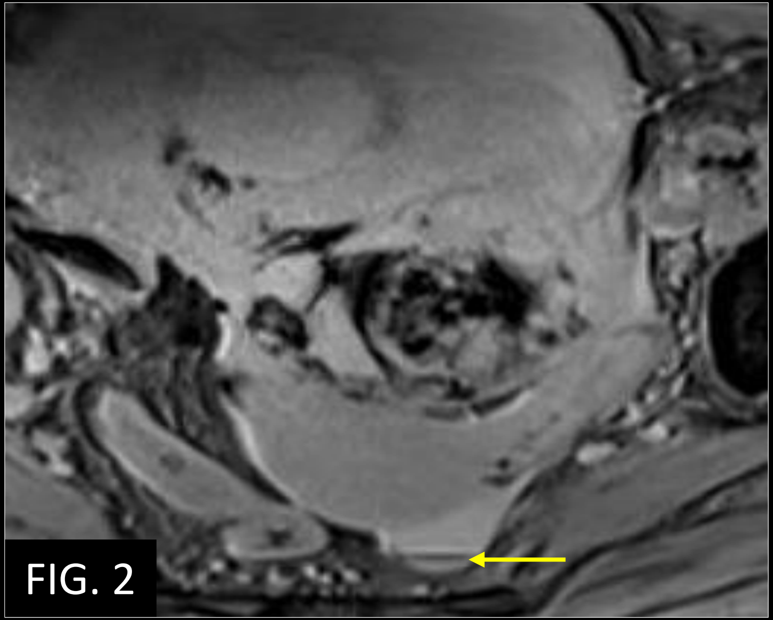
e. Establishment of a chemokine gradient

f. Creation of a tumor supportive microenvironment

NEOPLASTIC ABDOMINAL FLUID

- Ascites (Fig. 1) in cases of ovarian carcinomas occurs due to increased production of peritoneal fluid, secondary to leakiness of tumor microvasculature and obstruction of the lymphatic vessels. Metastatic cells also colonize sites of fluid resorption (e.g. greater omentum), further hampering its function. Hemorrhagic ascites (Fig. 2) is not uncommon in ovarian carcinomatosis and is thought to occur due to bleeding of the peritoneal implants.
- Pseudomyxoma peritonei (Fig. 3) refers to copious, mucinous or gelatinous material on the surfaces of the peritoneal cavity. Pseudomyxoma peritonei may contain benign or borderline epithelial cells from well-differentiated (low-grade) mucinous carcinomas (disseminated peritoneal adenomucinosis), which are amenable to surgical resection or cells from poorly differentiated mucinous ovarian carcinoma which invade peritoneal organs. Classically, pseudomyxoma peritonei demonstrates low attenuation on CT images, with or without calcification, and scallops the serosa peritoneal viscera.


FIG. 1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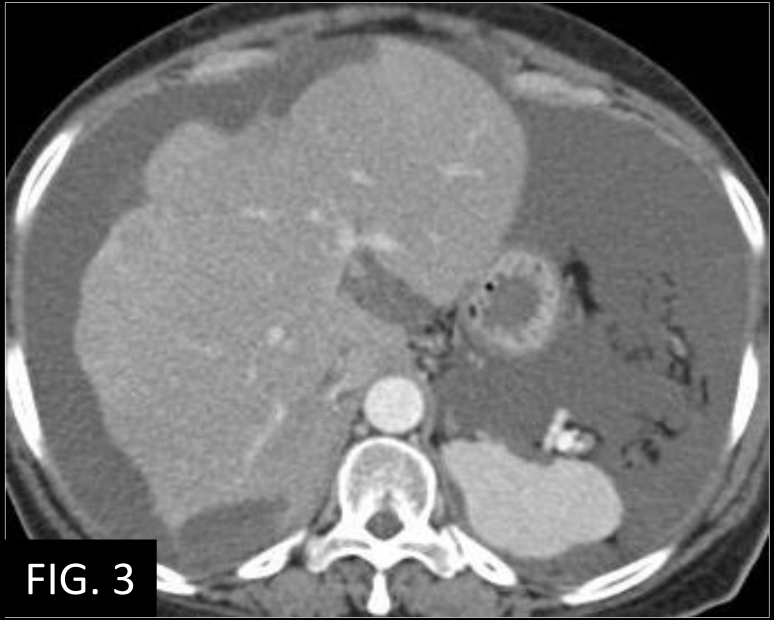
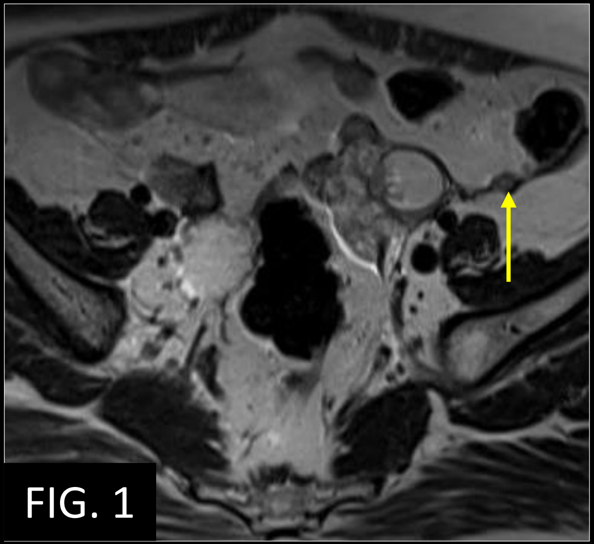


FIG. 3

PERITONEAL NODULARITY



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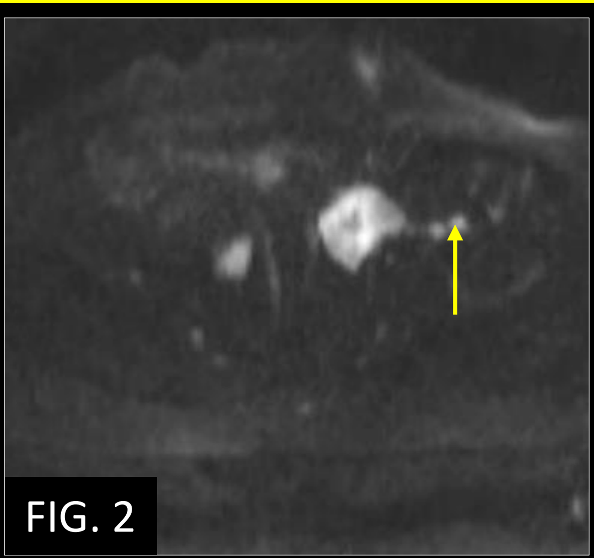

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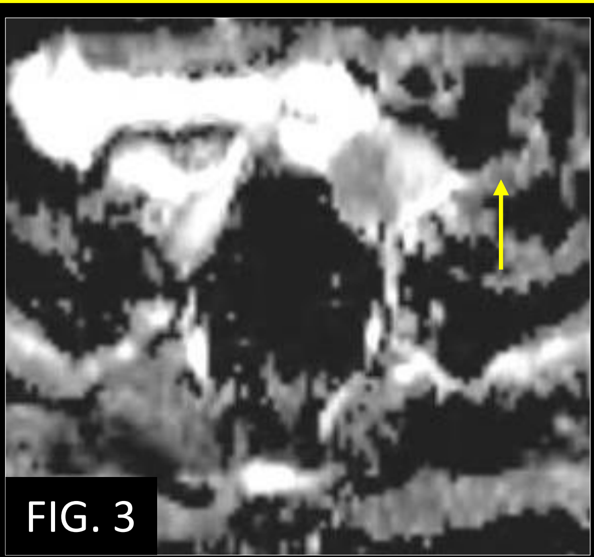

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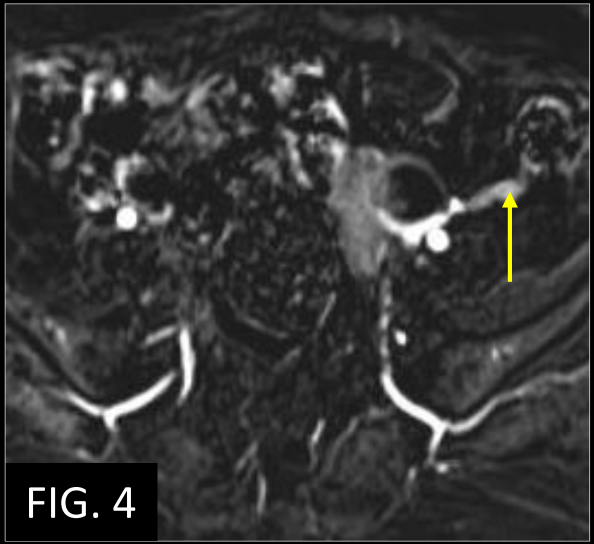


FIG. 4

At MRI, peritoneal metastasis are usually hypointense on T2W images (Fig. 1) and demonstrate restricted diffusion (Fig. 2, 3). Contrast enhanced imaging, particularly with subtraction (Fig. 4), help increase the rate of identification of these lesions.

In our institution, a delayed contrast-enhanced axial scan of the upper abdomen using a 3D volumetric interpolated breath-hold sequence is acquired in patients with ovarian carcinoma. This helps in detecting even small peritoneal deposits (Fig. 5, 6). The presence of such deposits alerts the oncosurgeon towards the requirement of complete parietal peritonectomy. If metastatic peritoneal nodules are not detected, the peritoneum may be left intact during surgical resection of the ovarian primary.

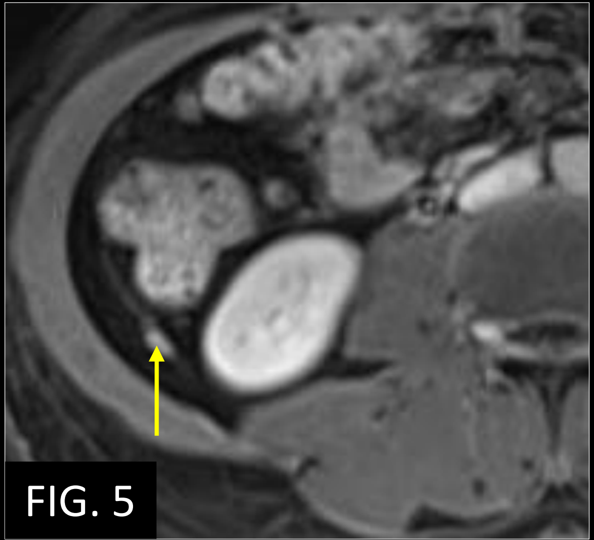


FIG. 5

FIG. 6

GRAVITY DEPENDENT SITES

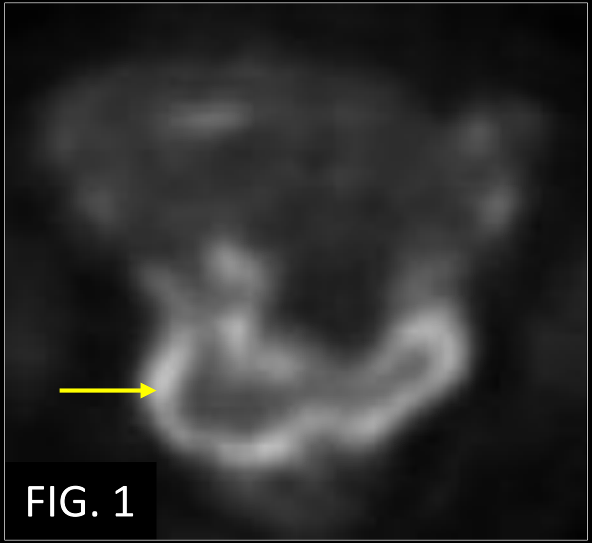


FIG. 1

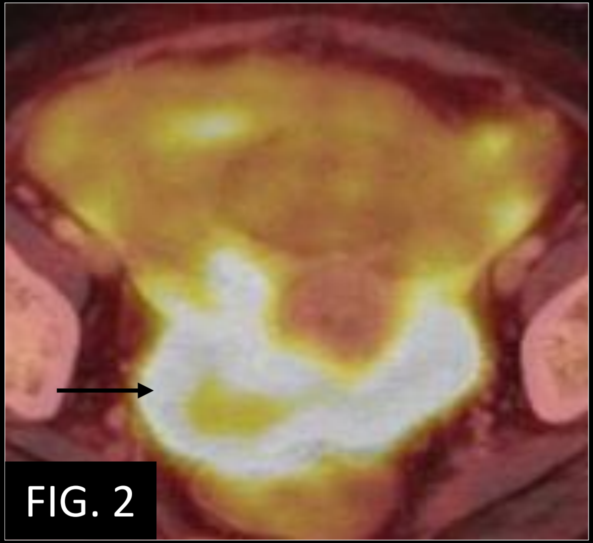
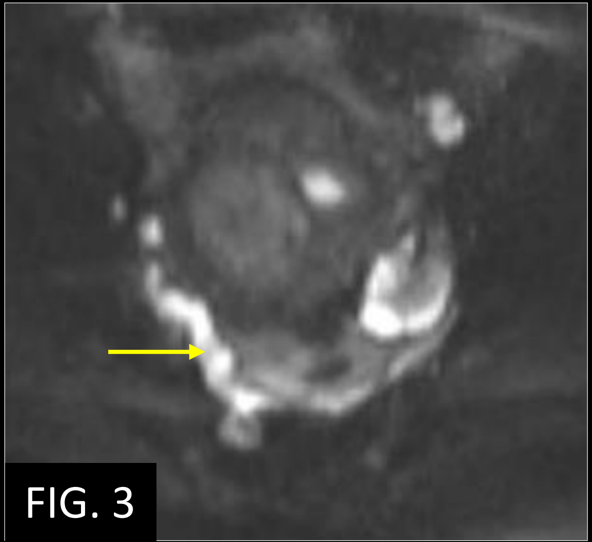


FIG. 2

Shed tumor cells from ovarian neoplasia initially drift downward under the pull of gravity into the rectouterine pouch (cul-de-sac as in Fig. 1, 2). Resection of metastatic deposits in this region involves the dissection of the mesorectum with electrosurgery. The perirectal fat is divided beneath the peritoneal reflection so that all tumor that occupies the cul-de-sac is removed intact with the specimen. The rectal musculature is skeletonized and the rectal stump is closed with the help of a stapler.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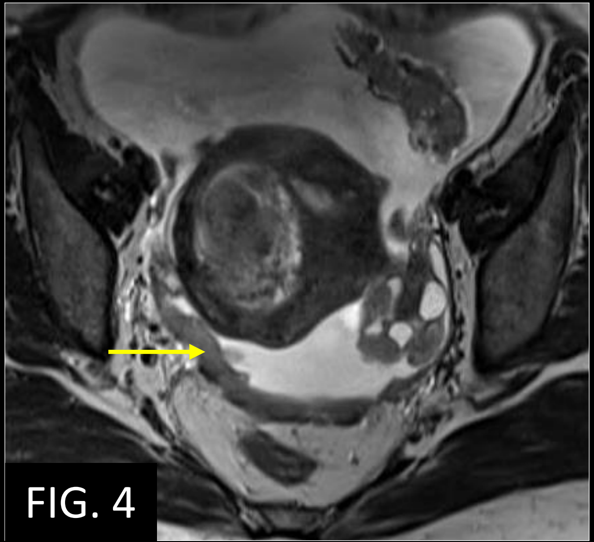
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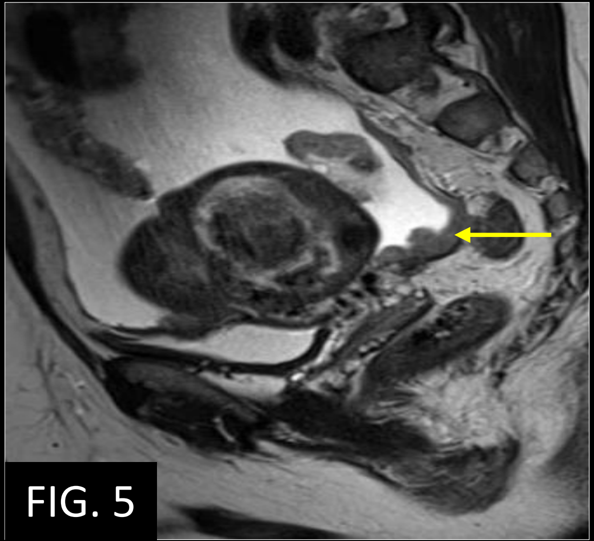
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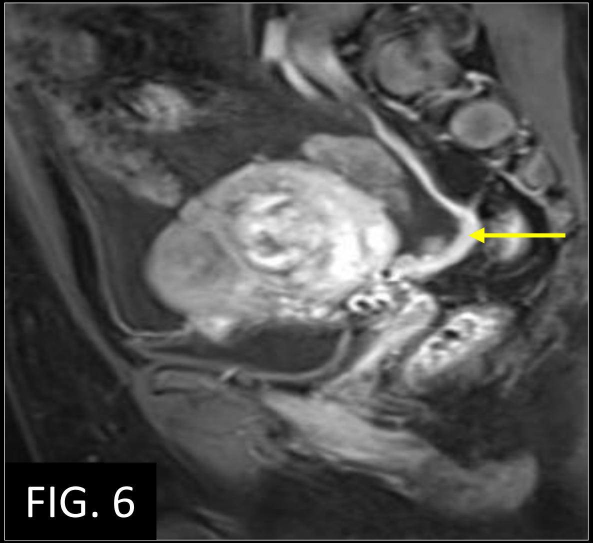


FIG. 6

Multiplanar Multiecho MRI of a patient with metastatic ovarian carcinoma in the rectouterine pouch. Note the nodular soft tissues demonstrating restricted diffusion (Fig. 3) T2W hypointensity (Fig. 4, 5) and post contrast enhancement (Fig. 6).

OTHER GRAVITY DEPENDENT SITES

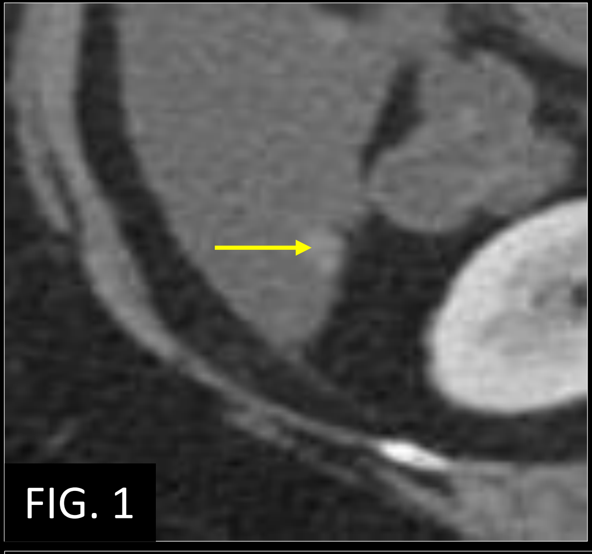
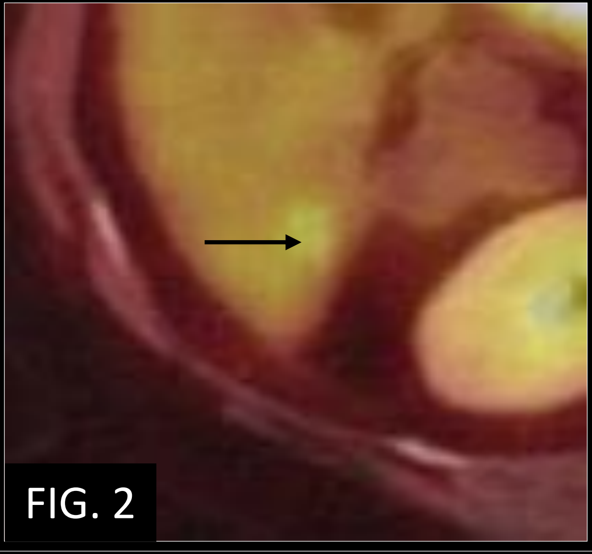


FIG. 1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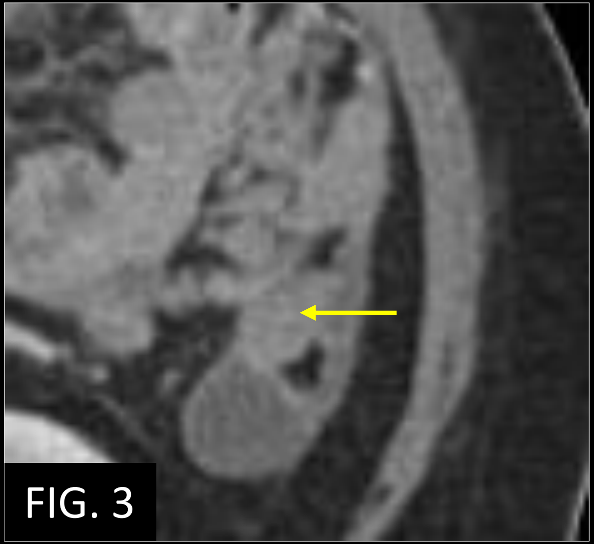
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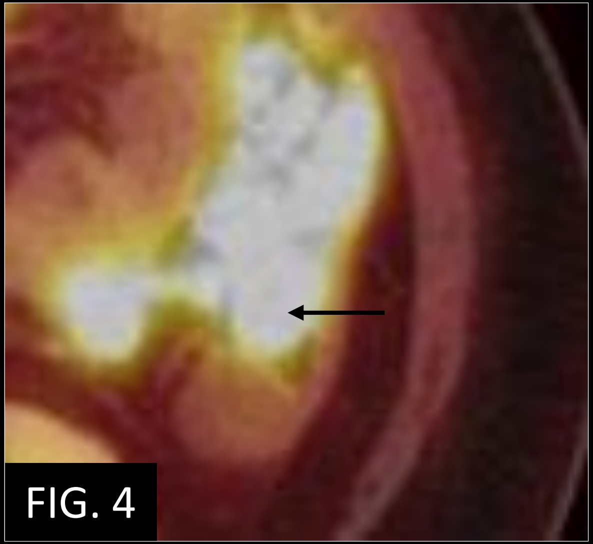


FIG. 4

CT and Fusion PET/CT of two patients with seeding in the right (Fig. 1, 2) and left (Fig. 3, 4) paracolic gutters, respectively

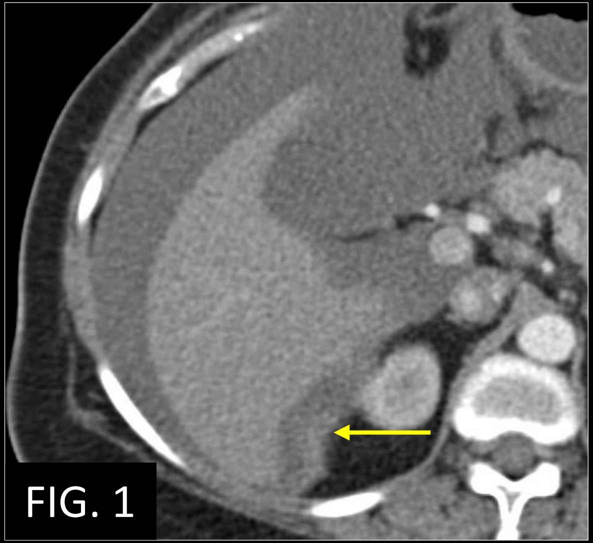
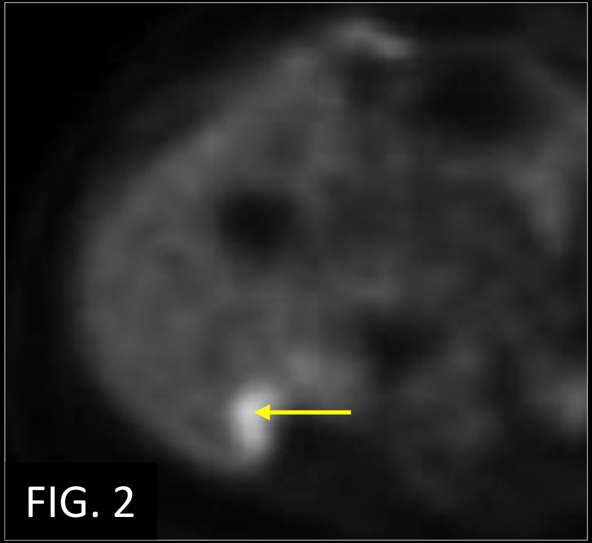


FIG. 1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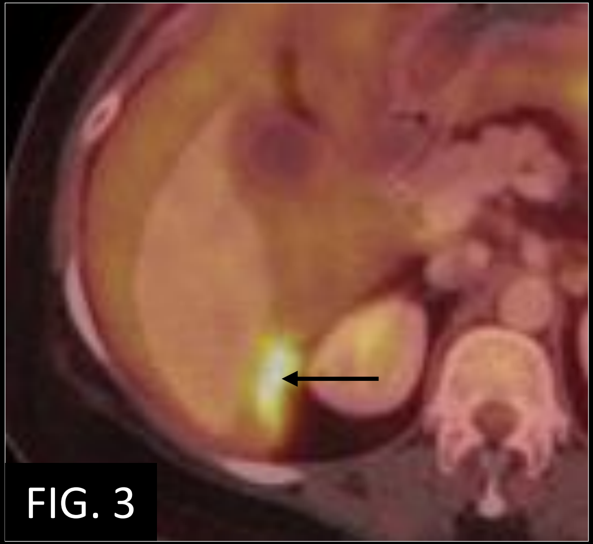
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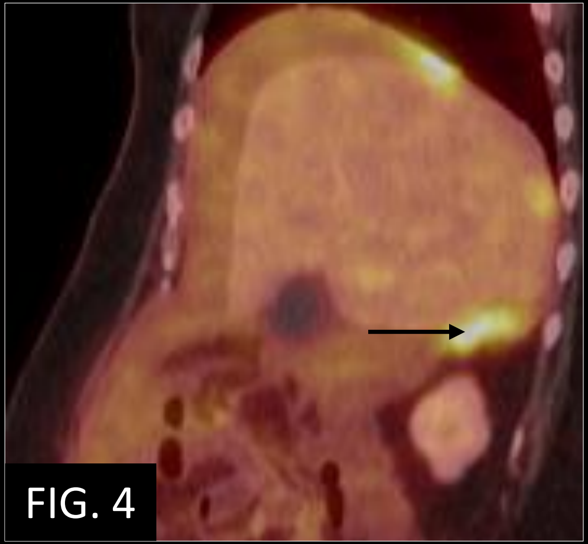
FIG. 4

CT (Fig. 1) and PET/CT (Fig. 2) with fusion (Fig. 3, 4) show with seeding of epithelial ovarian cancer in the hepatorenal space.

AREAS OF FLUID RESORPTION

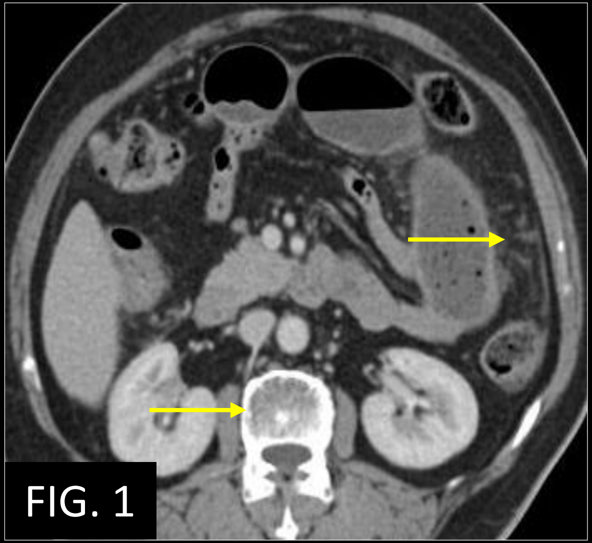
FIG. 1


FIG. 2

The greater omentum is the most common site of peritoneal carcinomatosis. Imaging manifestations may be subtle, seen as mild haziness of the fatty tissues (Fig. 1, 2), evolving into discrete nodules and eventually into confluent masses known as omental caking. Involvement of the greater omentum poses no particular surgical challenges, and omental lesions are routinely removed during debulking surgery. However, its involvement indicates an extension of the surgical incision to the xiphioid process.

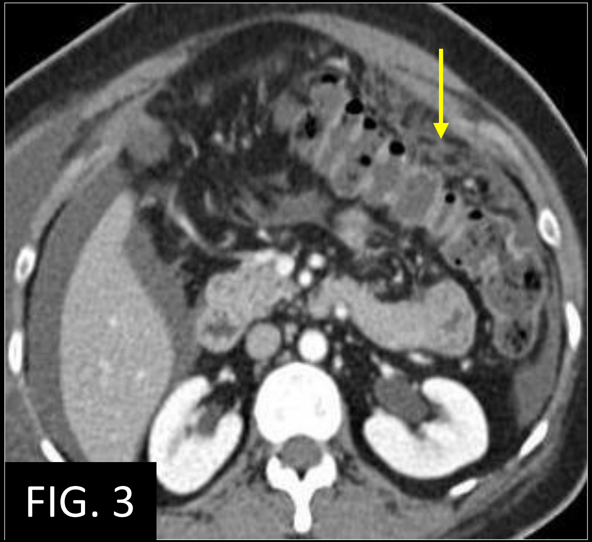
FIG. 3


FIG. 4

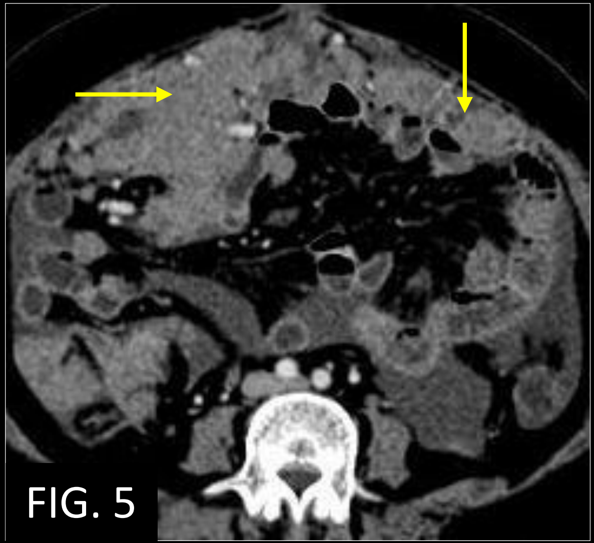
FIG. 5

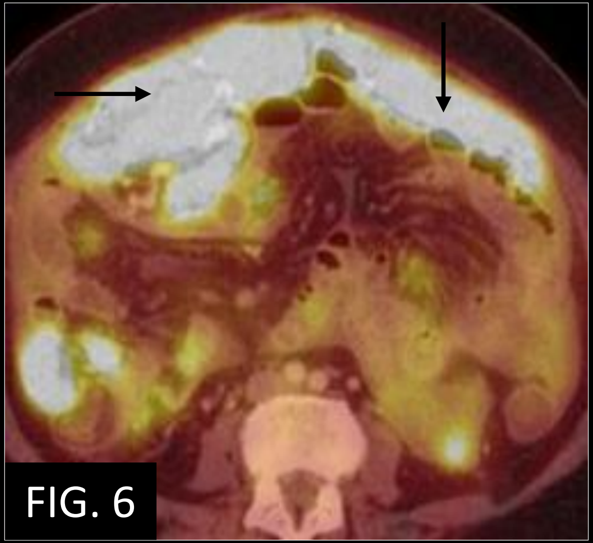
FIG. 6

CT and corresponding Fusion PET/CT images of a patient with omental metastasis. Note the subtle stranding (Fig. 3) and mild uptake of the radiotracer, progressing to confluent soft tissue caking of the omentum on the follow up scan (Fig. 5, 6).

AREAS OF FLUID RESORPTION

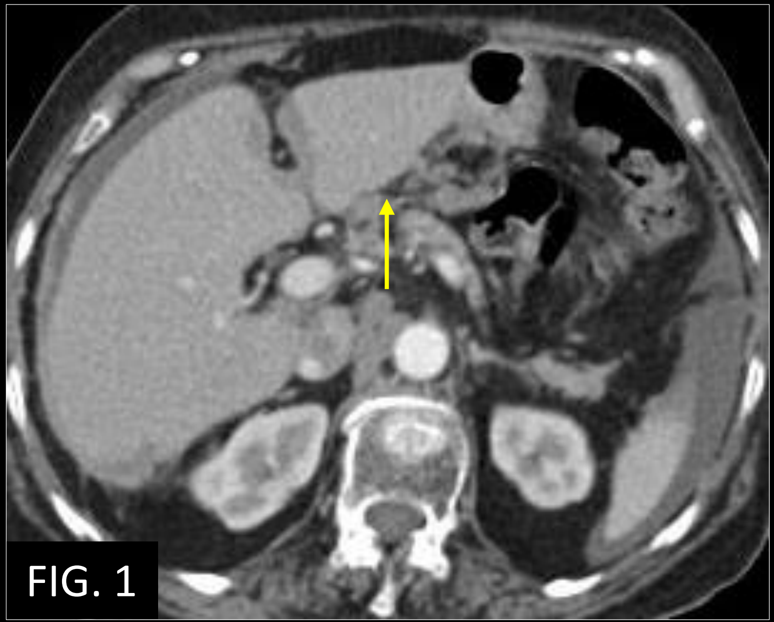

FIG. 1

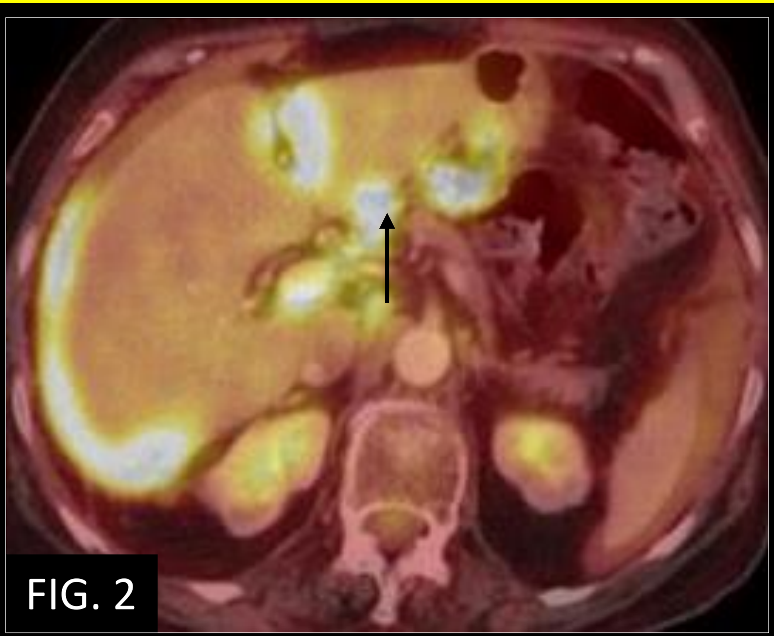

FIG. 2

Infiltration of the lesser omentum is not uncommon (Fig. 1, 2). Involvement includes subtle stranding, nodules, and lymphadenopathy. Because of the regional complexity in this region and resultant technical difficulties, such findings often preclude surgery. Some institutions perform lesser omentectomy and hepatoduodenal stripping when implants measure less than 2 cm in maximum dimension.

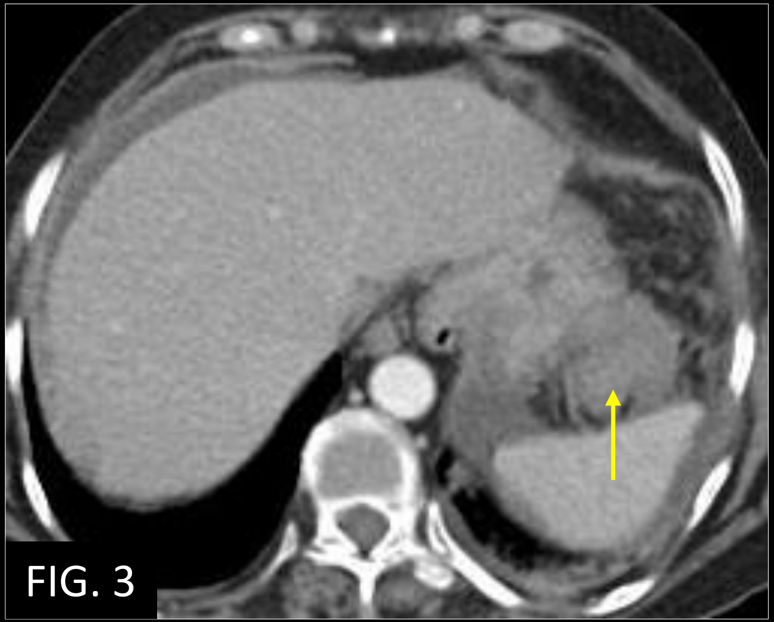

FIG. 3

FIG. 4

The involvement of the lesser sac and the other gastric ligaments (gastrosplenic, gastrophrenic) are not as common as the lesser omentum. Involvement of the gastric ligaments (gastrophrenic ligament in Fig. 3, 4) and distention of the lesser sac must always be reported as lesions in these locations frequently preclude surgery due to the risk of ischaemic injury to the stomach following extensive extirpation.

AREAS OF FLUID RESORPTION

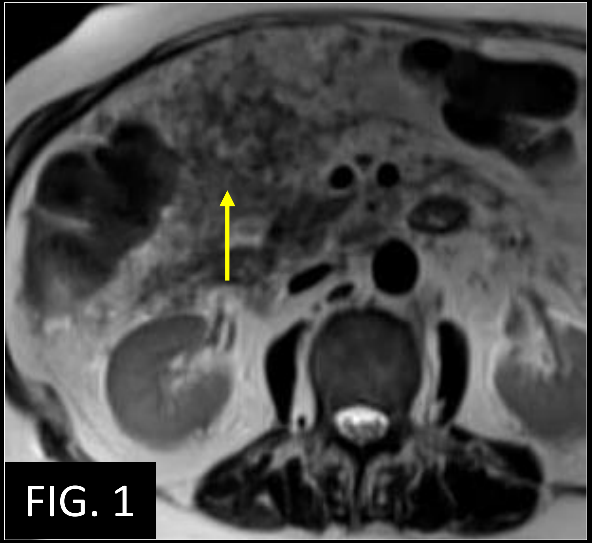
FIG. 1

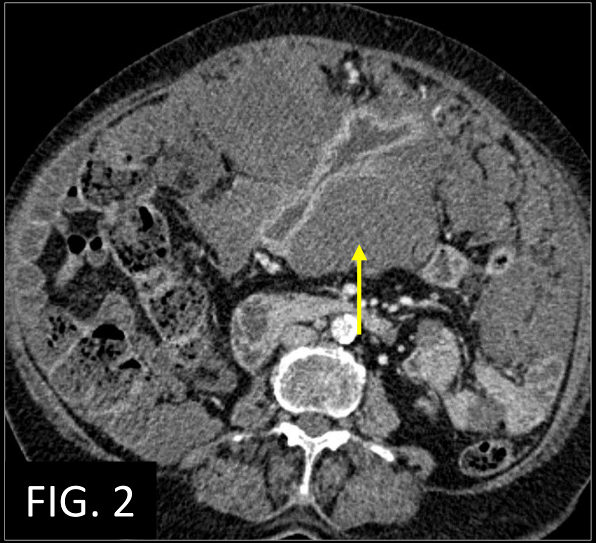
FIG. 2

Like the omenta, mesenteric involvement may be subtle (stranding or small ovoid soft-tissue densities) or obvious (large confluent masses as in Fig. 1, 2) characteristically distributed around the superior mesenteric vessels. Smaller nodules are removed with electrosurgery, if the vascular supply to the segment of bowel is not compromised, where as larger lesions require a segmental small bowel resection with generous proximal and distal margins on the bowel wall and on the mesentery.

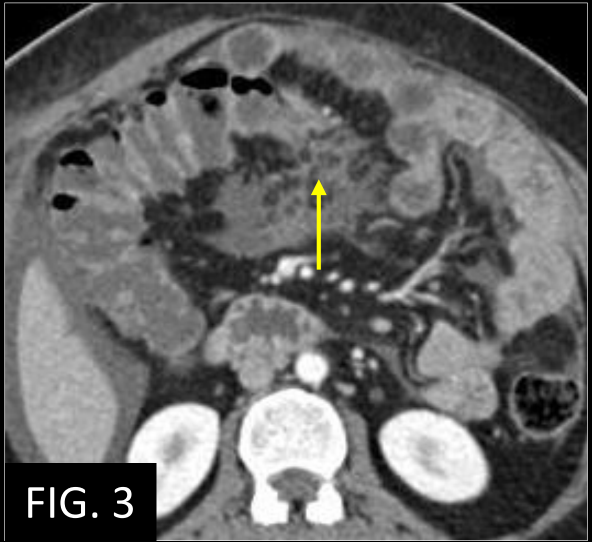
FIG. 3

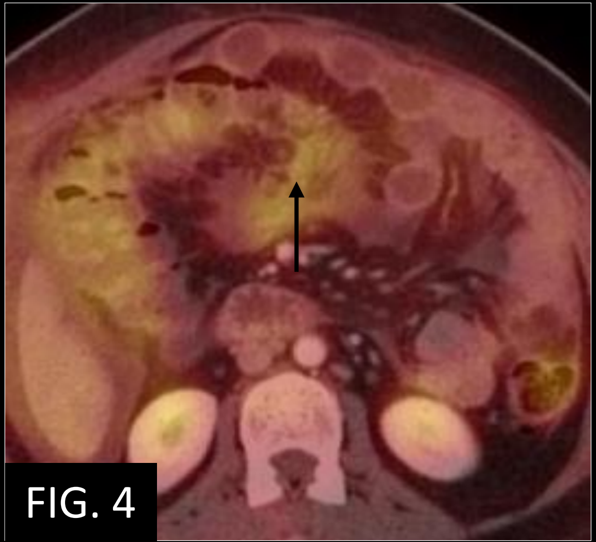
FIG. 4

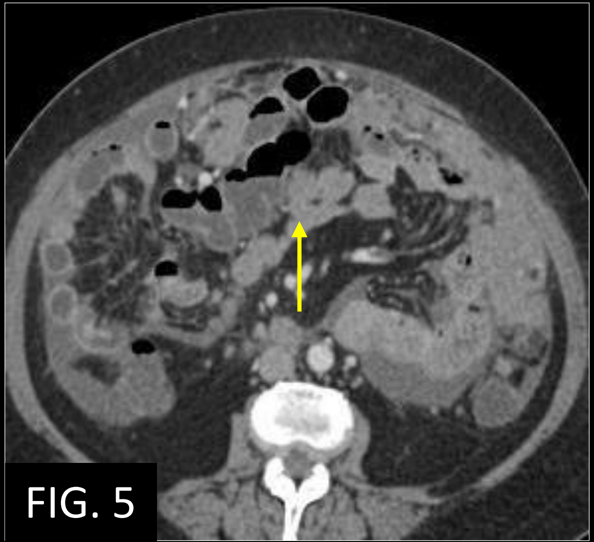
FIG. 5

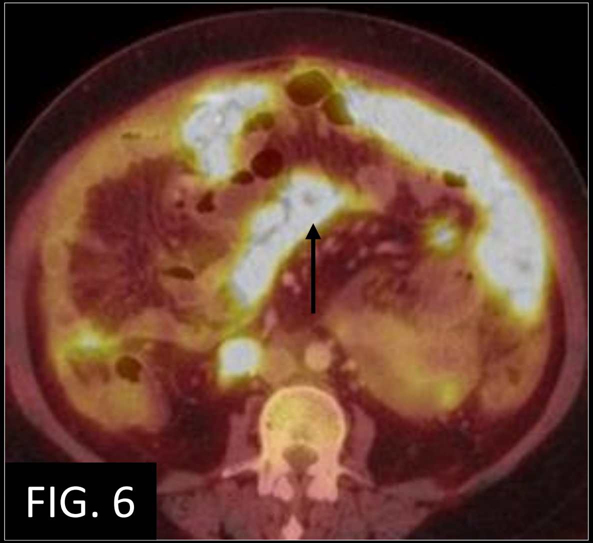
FIG. 6

CT and Fusion PET/CT images of two different patients, (Fig. 3, 4 and Fig. 5, 6) with ovarian carcinomatosis involving the transverse mesocolon. Involvement of this membrane is surgically challenging and usually requires subspecialty expertise.

AREAS OF FLUID RESORPTION

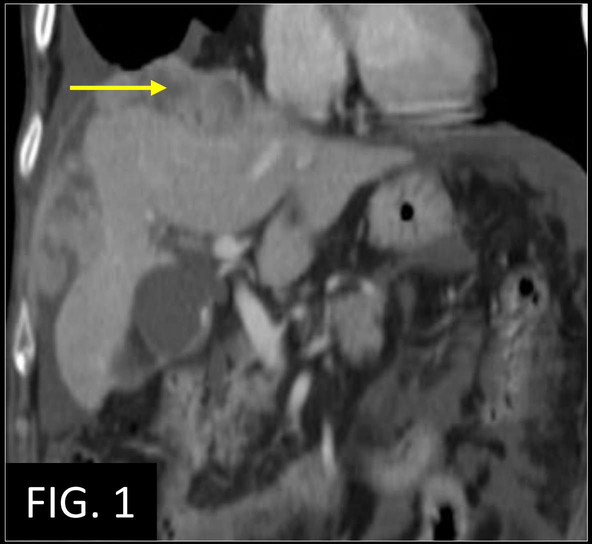
FIG. 1


FIG. 2

The subphrenic space (Fig. 1, 2) involvement is common in patients with peritoneal carcinomatosis and typically involves the right side. This is due to the preferential flow of peritoneal fluid into this space from the right paracolic gutter. Subphrenic involvement must be determined with a careful assessment on coronal images. Metastasis to this region generally requires an upper-quadrant peritonectomy, which involves stripping of the peritoneal layer containing tumor nodules from the underlying diaphragmatic muscle.


FIG. 2


FIG. 3

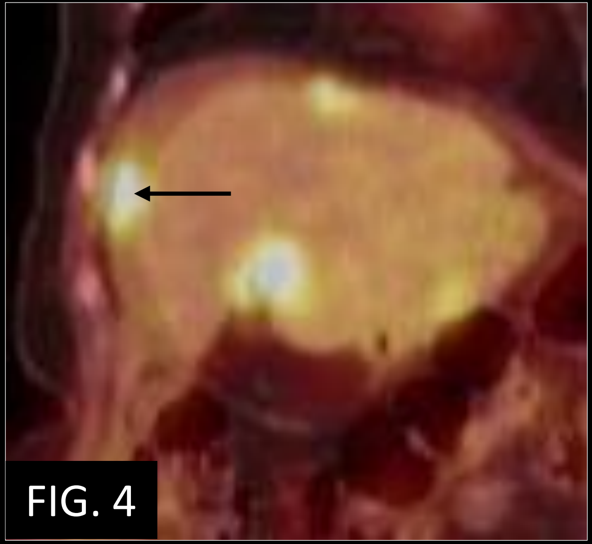
FIG. 4

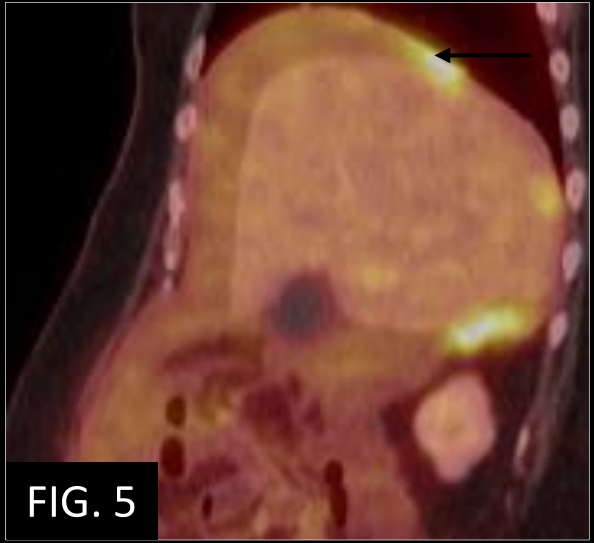
FIG. 5

CT (Fig. 3) and Pet/CT with fusion (Fig. 4 - 6) reveal metastatic soft tissue deposits in the subphrenic regions. It must be remembered to evaluate all cases of suspected ovarian metastasis with multiplanar reformats to avoid false negatives.

LYMPHATIC SPREAD


FIG. 1

Three pathways of ovarian lymphatic drainage have been identified: The first consists of the lymphatic ducts, which follow the ovarian veins to the paraaortic and paracaval nodes at the level of the kidney. The second group drain into the pelvic lymph nodes (the external iliac, hypogastric, and obturator nodal chains). The third group drain into the inguinal nodes. Regional lymphatic spread of early stage ovarian cancer upstages the patient to FIGO stage III, making them appropriate candidates for chemotherapy after surgery. In patients with clinical stage I ovarian cancer pelvic lymphadenectomy significantly improves survival. Therefore a radiological report must include possible metastatic regional lymph nodes for staging, prognostication and management.

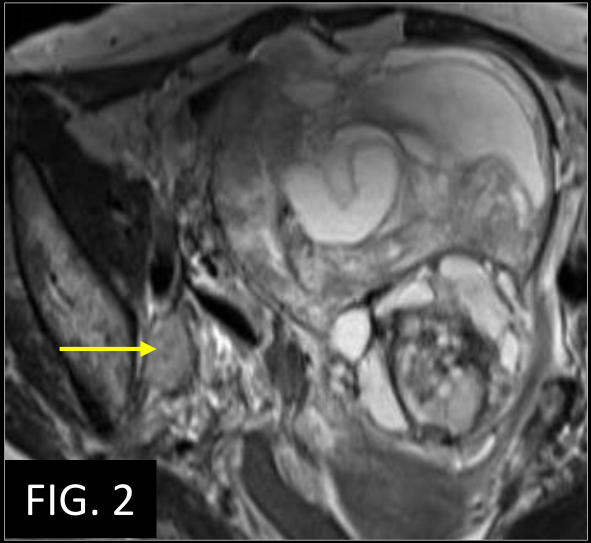
FIG. 2

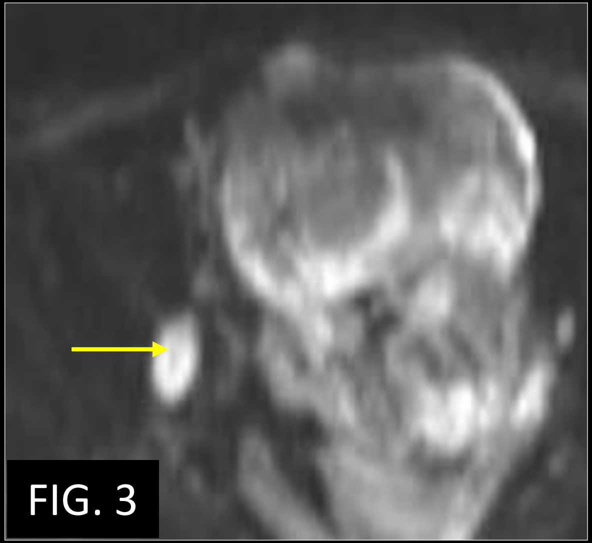
FIG. 3

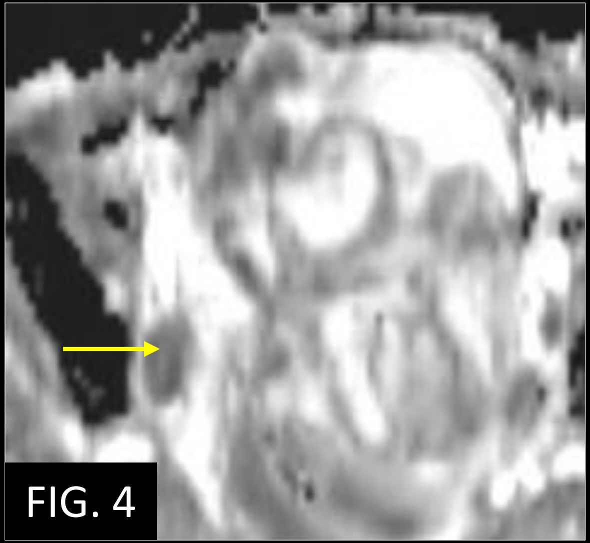
FIG. 4

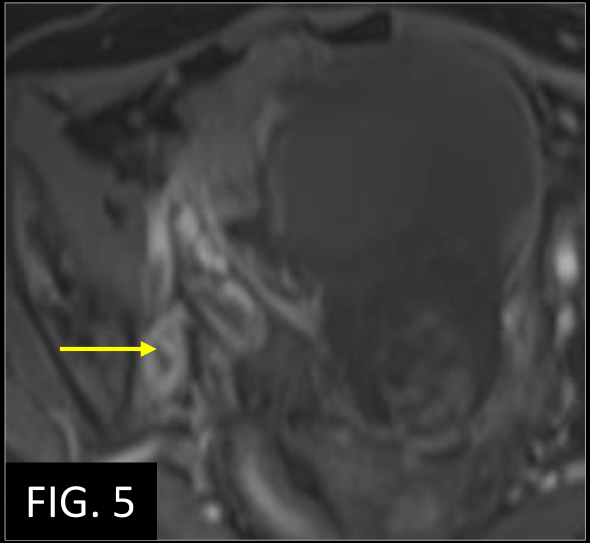
FIG. 5

Contrast enhanced CT (Fig. 1) and MRI (Fig. 2-5) in ovarian adenocarcinoma. Note the enhancing right external iliac lymph node (solid arrow) demonstrating restricted diffusion (Fig. 3, 4). Diffusion MRI is useful in the detection of nodal metastasis.

LYMPHATIC SPREAD

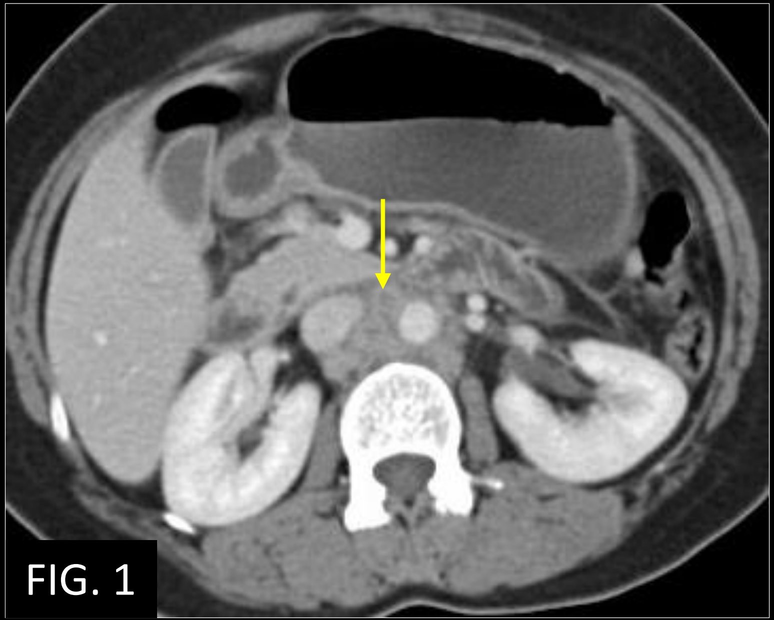

FIG. 1

FIG. 2

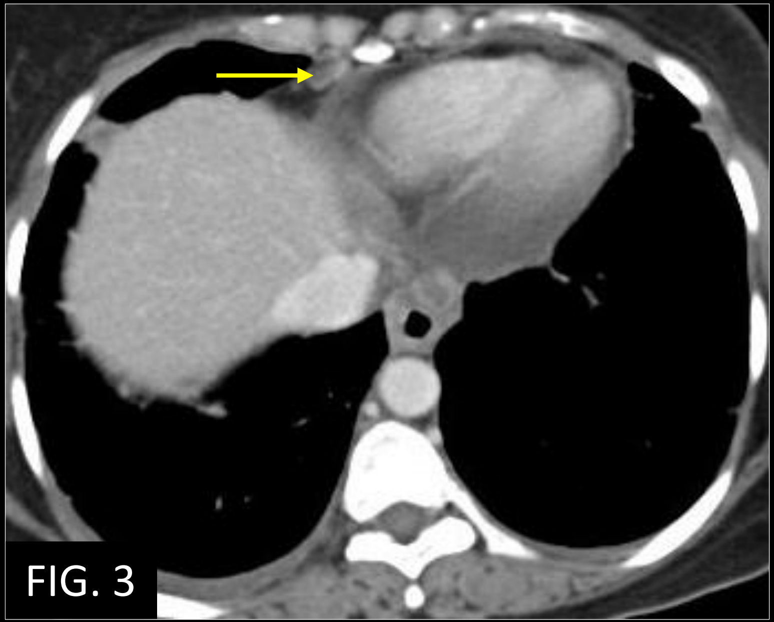

FIG. 3

FIG. 4

Lymphatic dissemination to the para-aortic lymph nodes is common, particularly in advanced disease. Spread through the lymphatic channels of the retroperitoneal lymph nodes (Fig. 1, 2) and the diaphragm (Fig. 3, 4) can lead to dissemination of disease into the supraclavicular lymph nodes. Apparent stage I and II tumors have retroperitoneal lymphatic dissemination in about 5% to 10% in most series, whereas lymphatic dissemination in stage III has been reported to be as high as 42% to 78% in carefully explored patients. During cytoreductive surgery, retroperitoneal lymph nodes are sampled as a part of the staging technique and every effort is extended to remove suspicious nodes when the peritoneum is cleared of the disease. Supradiaphragmatic lymph nodes however are associated with short progression-free survival and poor overall survival, and are managed with neoadjuvant chemotherapy.

SEROSAL IMPLANTS


FIG. 1

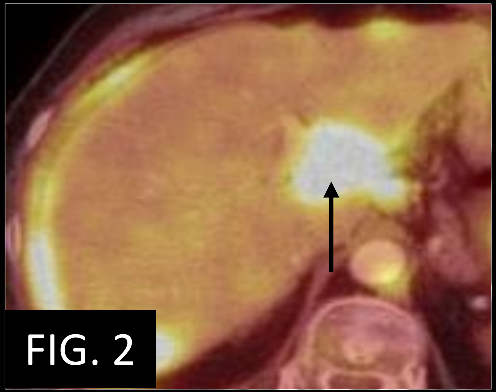
FIG. 2

Implants on the liver surface (Fig. 1, 2) are the commonest form of hepatic involvement in ovarian cancer. Serosal metastases can secondarily invade the liver. A clear tissue plane or a well-defined lesion-liver interface, has a high sensitivity for the exclusion of hepatic invasion. The preoperative detection of hepatic invasion is important for planning the extent of resection. However, multiple perihepatic metastases or multiple sites of invasion of the liver may preclude resection.

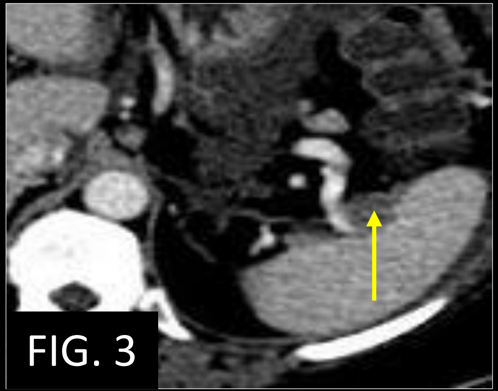
FIG. 3

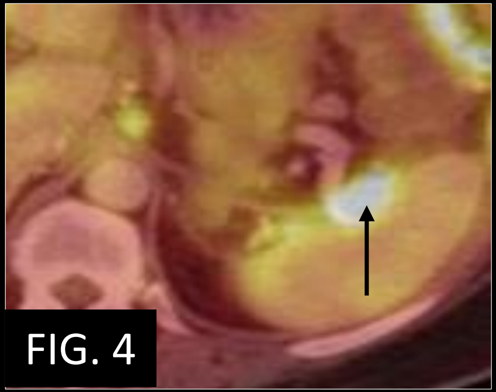
FIG. 4

The distinction between capsular implants and parenchymal invasion is less critical in the spleen than in the liver, as splenectomy is more easily performed than hepatectomy and is not associated with substantial morbidity. A detailed account all evidence of splenic involvement (Fig. 3, 4) allows the surgeon to determine whether a splenectomy is needed. In the absence of splenic parenchymal invasion, spleen-sparing surgery with hilar stripping may be performed successfully.

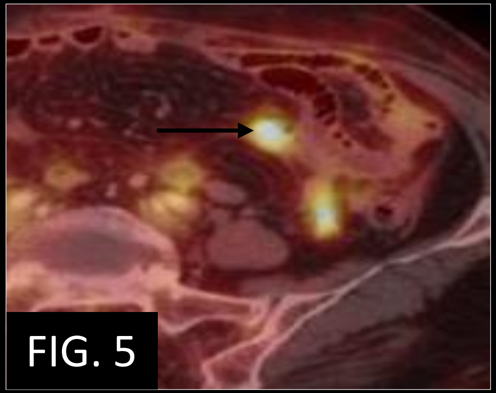
FIG. 5

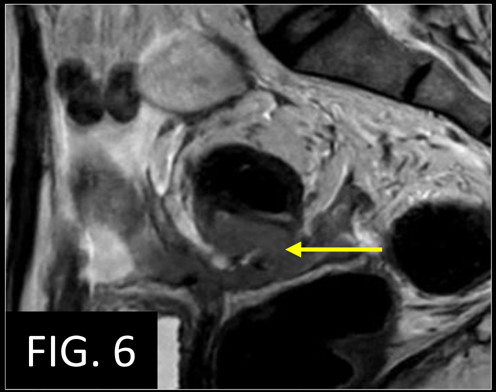
FIG. 6

The imaging features of involvement of the bowel serosa include focal nodules (Fig. 5) or a well-defined mass involving both the serosa and the adjacent peritoneum (Fig. 6). Partial or complete bowel obstruction may be an end result of carcinomatous involvement, and such findings preclude optimal debulking. Bowel serosal deposits may be surgically resected or may be an indication for neoadjuvant chemotherapy, depending on the institutional protocol.

AREAS OF ARRESTED PERISTALSIS

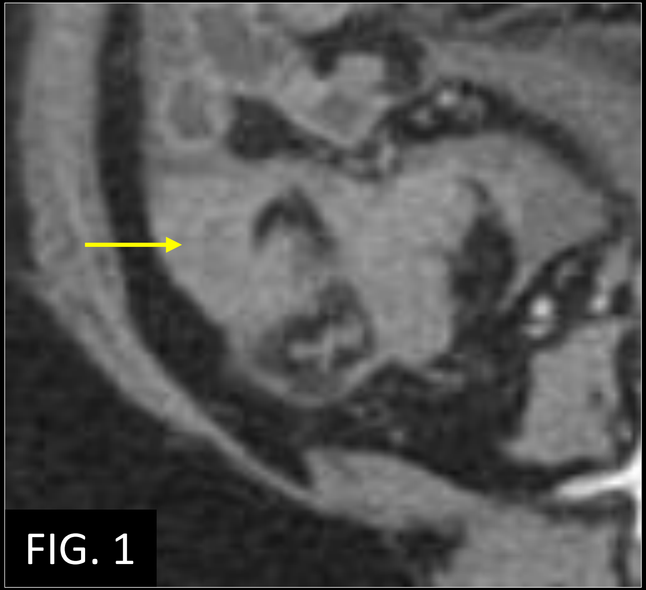
FIG. 1

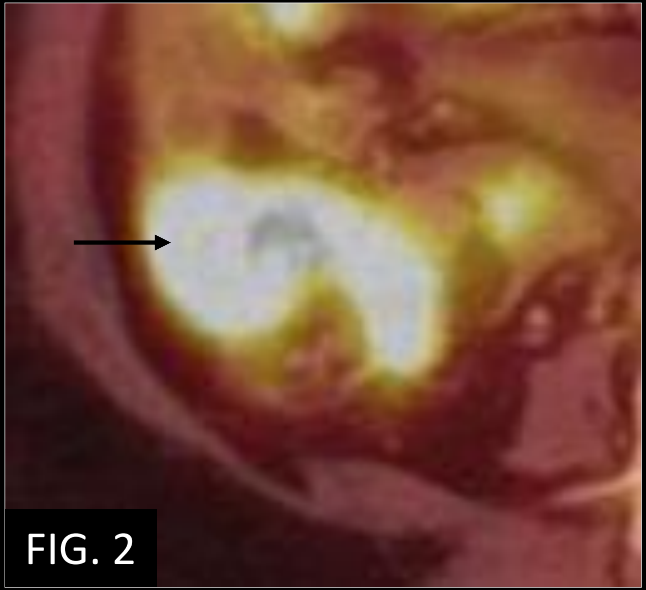
FIG. 2

Bowel peristalsis in the right lower quadrant is generally slow. As a result, stasis of peritoneal fluid is common in this location resulting in metastatic seeding (Fig. 1, 2). It is critical to evaluate this region with care as deposits may invade the ileocaecal junction. On most occasions, such patients require bowel resection.

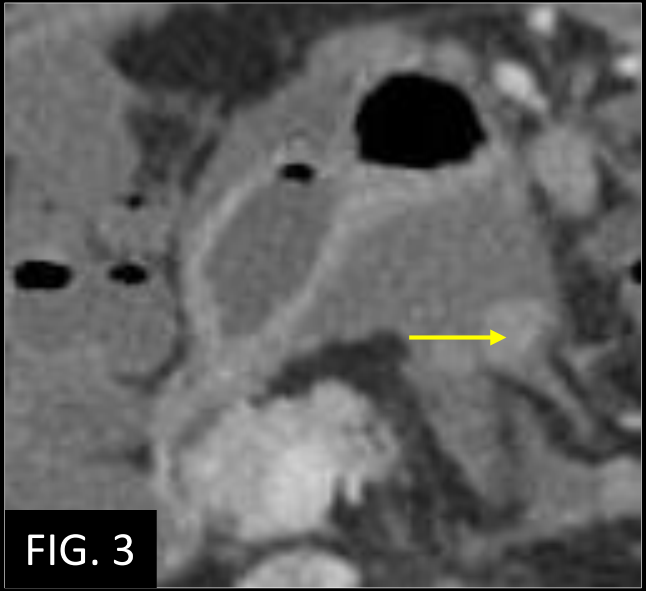
FIG. 3

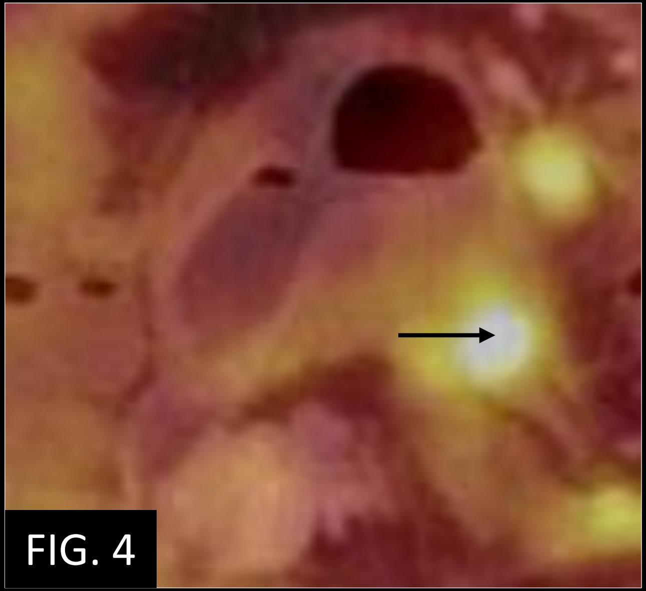
FIG. 4

Care must be taken to inspect the lesser sac (Fig. 3, 4), as small metastasis in these regions may be missed. In cases of metastasis to this region, the surgeon divides the peritoneum from the superior recess of the omental bursa, from the crus of the right hemidiaphragm, and from beneath the portal vein, in order to access this location.

HAEMATOGENOUS SPREAD

FIG. 1

FIG. 2

A careful evaluation of metastasis to the gastrointestinal tract (Fig. 1, 2) is essential as resection of such lesions requires the presence of a colorectal surgeon. The mean survival time of patients following surgery is approximately 30.3 months. This is governed by those having superficial invasion of the intestinal wall, optimal cytoreduction of tumour and relatively sufficient postoperative chemotherapy

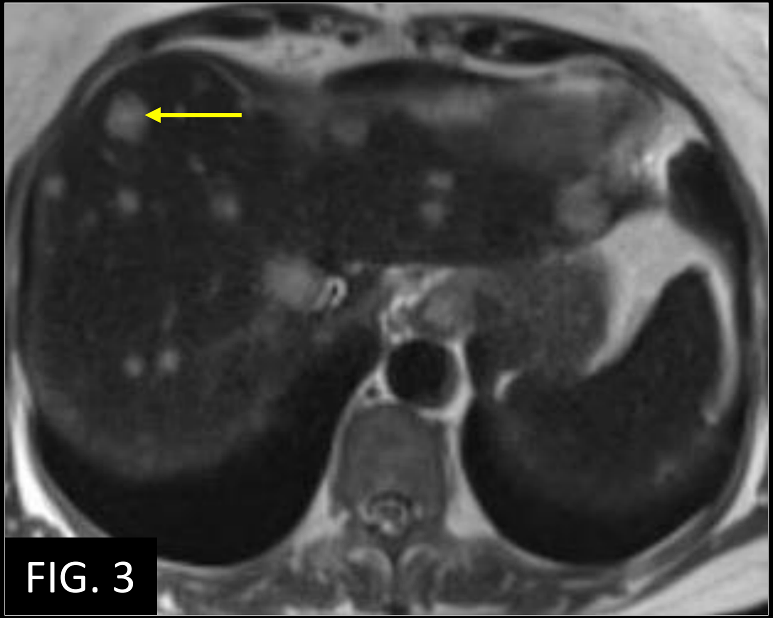

FIG. 3

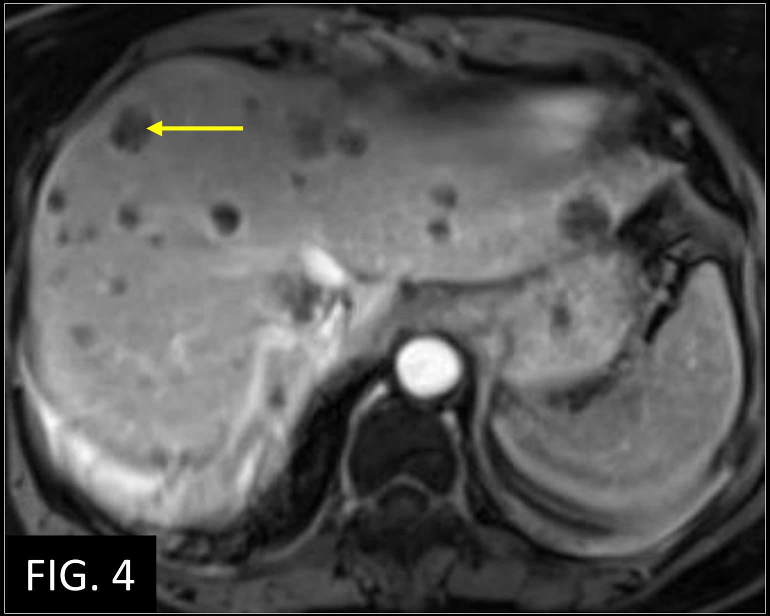

FIG. 4

Hepatic metastasis from an ovarian cancer are rare, but not unknown (Fig. 3, 4). Small hepatic metastasis, especially those adjacent to the capsular surface of the liver, may be easily resected, with the help of subspecialty expertise. However in the presence of large or multisectoral metastasis, surgery is generally precluded and neoadjuvant chemotherapy is offered to patients.

CONCLUSION AND SUMMARY

- Sound understanding of the disease process is critical in providing optimal care for patients suffering from the peritoneal spread of ovarian primaries.

- Understanding the peritoneal anatomy helps communicate imaging findings with oncosurgeons and medical oncologists. This also goes a long way in follow up imaging and in the reduction of interobserver variation.

- Knowledge of peritoneal hotspots is crucial in reporting as it can help in identifying lesions, predict surgical and long term outcome and most importantly triaging surgeries.

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We wish to sincerely thank Dr. G. N. Mahapatra, (Head of Department of Nuclear Medicine, SevenHills Hospital) for his continued support.

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