Original Research

OMENTUM IN ABDOMINAL SURGERY

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ABSTRACT
Background: The omentum is a versatile peritoneal organ with important roles in local immune surveillance, wound healing, angiogenesis, fat metabolism and in the dissemination and containment of intra-abdominal disease. Objective: To synthesize current knowledge of omental anatomy, microanatomy, immunobiology, and pathophysiology and to examine its clinical relevance across surgical practice, including diagnostic considerations, operative management, reconstructive applications, oncologic implications and emerging regenerative uses. Methods: Narrative synthesis of anatomical, experimental, imaging and clinical literature addressing omental structure and function, common and rare omental pathologies, imaging features, operative strategies (including omentectomy and omental flaps) and translational research on omental-derived stromal cells and peritoneal immunity. Results: The omentum's mesothelial surface, milky spots, resident macrophages and stromal cells mediate rapid peritoneal immune responses and promote localized containment of contamination, often limiting diffuse peritonitis. Its rich vascularity and trophic factor secretion underpin effective wound healing and make it an effective reconstructive flap. Pathologically, the omentum is implicated in infarction, torsion, abscess formation, sclerosing mesenteritis, primary tumours and peritoneal metastasis with characteristic "omental caking" on imaging. Omental adipocytes and stromal elements actively support tumour implantation and growth. Management principles emphasize preserving healthy omentum when beneficial, resecting necrotic or tumour involved tissue, employing image-guided drainage for abscesses and using cytoreductive omentectomy in selected malignancies (notably ovarian cancer). Emerging data support therapeutic potential of omentum-derived mesenchymal stromal cells and targeted strategies against omental tumour–stroma interactions, though randomized evidence for many surgical practices outside ovarian cancer remains limited. Conclusions: The omentum is central to peritoneal defence, healing, and tumour biology. Surgical decisions should be individualized to balance its protective and regenerative functions against its role as a niche for disease. Ongoing research into omental immunobiology and regenerative applications promises to refine indications for omentectomy, optimize reconstructive use and develop novel anti-metastatic strategies.

Keywords: Omentum, Greater Omentum, Peritoneal Immunity, Milky Spots, Omental Metastasis, Omental Infarction, Omentectomy, Omental Flap, Peritoneal Carcinomatosis, Intraperitoneal Chemotherapy (HIPEC), Mesenchymal Stromal Cells, Sclerosing Mesenteritis.

INTRODUCTION
The omentum is a mobile, fatty apron of peritoneum occupying a unique position at the intersection of anatomy, immunology, metabolism and surgery. Historically regarded as passive adipose tissue, contemporary research has redefined the omentum as an active organ. Its mesothelial surface, milky spots, resident macrophages and stromal cells perform specialized intraperitoneal immune surveillance, modulate fibrinolysis and wound healing, secrete angiogenic and trophic factors and interact metabolically with adjacent organs and tumours. These biologic properties underpin the omentum's classical clinical behaviours that is the ability to localize contamination and form protective adhesions, to support tissue repair and paradoxically to serve as a fertile niche for peritoneal metastasis.

For surgeons, the omentum is therefore both an ally and adversary. Its preservation can aid containment of infection, bolster anastomotic healing and provide a vascularized flap for complex reconstructive tasks. Conversely omental infarction, abscess, sclerosing mesenteritis, primary omental neoplasms and omental involvement by intra-abdominal malignancies frequently mandate intervention. Moreover, in oncologic practice the presence or absence of omental disease crucially influences staging, cytoreductive strategy and the use of intraperitoneal therapies. Parallel advances in regenerative medicine have highlighted the omentum as a source of multipotent stromal cells and as a vascular bed for tissue engineering thereby expanding its therapeutic relevance beyond traditional operative roles.

This review synthesizes current understanding of omental anatomy, microanatomy and immunobiology. It surveys the spectrum of omental

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pathology, summarizes imaging and diagnostic approaches, details of operative implications including omentectomy and omental flaps. It also examines oncologic, reconstructive and regenerative applications as well. Emphasis is placed on integrating mechanistic insights with practical surgical decision making and on identifying areas where evidence is evolving or remains insufficient, to inform clinicians and guide future research.

Anatomy and Macroscopic Features

The greater omentum is a mobile apron-like double-fold (four layers) of peritoneum arising from the greater curvature of the stomach and proximal duodenum, draping over transverse colon and small bowel. Its vascular supply is dominated by the right and left gastroepiploic arcades and short gastric arterial branches. [1] The lesser omentum (hepatogastric and hepatoduodenal ligaments) contains the portal triad in the hepatoduodenal ligament and is surgically significant. [2] Omental lymphatics and milky spots are concentrated along the peritoneal surface and near the splenic and gastric ends. Embryologically the greater omentum originates from the dorsal mesogastrium while the lesser omentum from the ventral mesogastrium, with stomach rotation determining the final relationships. [3]

Microanatomy and Immunobiology

Omental surface is lined by mesothelial cells that produce hyaluronan, plasminogen activators and cytokines. Submesothelial milky spots contain macrophages, B- and T-lymphocytes and high endothelial venules functioning as a specialized peritoneal immune niche. [4,5] Resident macrophages and mesothelial cells modulate fibrinolysis and adhesion formation while omental stromal and adipose-derived cells secrete VEGF, FGF, HGF and chemokines (e.g., CXCL12), supporting angiogenesis and recruiting progenitor cells. [6,7] The balance between mesothelial fibrinolytic activity and pro-fibrotic signals determines propensity for adhesion formation after injury [8].

Physiologic Functions

The omentum acts as the "policeman of the abdomen," migrating to and adhering over inflamed or perforated viscera to localize infection and promote abscess formation rather than diffuse peritonitis. [9] It secretes growth factors and recruits stem or stromal cells aiding wound healing and neovascularization, stores visceral fat with endocrine or adipokine activity affecting systemic metabolism and contributes to peritoneal fluid absorption and lymphatic drainage. [6,10] Under healthy conditions it may reduce adhesions, but inflammation shifts it toward pro-adhesive behaviour. [8]

Pathologic Processes Involving the Omentum

Omental infarction or torsion: Primary (idiopathic) and secondary (adhesions, hernia) torsion cause focal omental ischemia and acute abdominal pain mimicking appendicitis. CECT features (fatty mass with hyperattenuating streaks) are characteristic. [11,12]

Omental abscess: Omentum walls off contamination leading to localized collections. Percutaneous drainage with antibiotics is often effective. [13]

Omental metastasis and "omental caking": Peritoneal seeding of ovarian, gastric, colorectal cancers frequently involves omentum via exfoliation and chemokine-mediated homing to milky spots, producing nodular or confluent soft-tissue replacement ("caking") indicating advanced disease. [14,15]

Primary omental tumours: These include rare entities (lipoma, liposarcoma, mesothelioma, solitary fibrous tumour) necessitating imaging and histologic diagnosis. Management involves surgical excision with subtype-directed therapy. [16]

Sclerosing mesenteritis or omental panniculitis: It is a chronic inflammatory fibrotic process causing pain and obstruction. Imaging shows fat stranding and mass effect. Medical therapy (steroids, tamoxifen) is the first-line followed by surgery for complications. [17]

Adhesions and postoperative changes: Omental mesothelial injury and altered fibrinolysis enable adhesion formation, contributing to chronic pain and obstruction thereby complicating reoperations. [8,18]

Traumatic and iatrogenic injury: Blunt trauma or surgical devascularization may cause omental haemorrhage, rupture, or necrosis necessitating selective resection or embolization depending on the hemodynamic status. [19]

Diagnostic Imaging

Ultrasound is useful for diagnosing superficial omental masses, free fluid and guiding drainage but happens to be operator-dependent thereby imposing diagnostic limitations.[13]

CECT is the modality of choice for detecting omental infarction, abscesses (rim-enhancing fluid collections) and omental caking. It is also helpful in guiding specific percutaneous interventions. [11,14]

MRI is useful for soft-tissue characterization and in patients where CT contrast is contraindicated. Fat-suppressed sequences help to differentiate between inflammatory and solid components. [16]

PET scan assists in oncologic staging and identifying metabolically active omental disease, though inflammation can cause false positives. [15]

Diagnostic laparoscopy enables direct visualization, targeted biopsies and therapeutic omentectomy or drainage when imaging is inconclusive. [20]

Surgical Implications and Operative Management

General principles include preservation of healthy omentum for its immunologic and reparative functions, resection of necrotic, infected or tumour-infiltrated omentum. [9,20] Indications for omentectomy include staging and cytoreduction in ovarian cancer, removal of metastatic or necrotic tissue and diagnostic excision of masses. [14,21] Choice of Techniques: Partial omentectomy for limited disease, total omentectomy for achieving oncologic goals. This can be performed either by open surgery or laparoscopically with careful control of gastroepiploic vessels. [21] Omental flaps (pedicled or free) can be used to fill dead space, cover infected prostheses, buttress anastomoses and obliterate cavities because of vascularity and immunologic activity. However free omental transfers require microsurgical expertise. [22,23] Complications include haemorrhage, donor-site morbidity, herniation through defects and rarely postoperative torsion. [11,22]

Management Strategies by Condition (Table 1)

Omental infarction confirmed by CECT in stable patients often can be managed conservatively (analgesia, observation). Laparoscopic resection is reserved for diagnostic uncertainty or clinical deterioration. [11,12]

Omental abscess: CT or ultrasound-guided drainage with antibiotic cover is the first-line of treatment. Surgery is indicated in inaccessible collections or associated bowel pathology. [13]

Peritoneal carcinomatosis and omental metastasis: Cytoreductive surgery including omentectomy aims for complete macroscopic resection combined with HIPEC in selected peritoneal surface malignancies to improve locoregional control. [14,24] In epithelial ovarian cancer, omentectomy is the standard for staging and cytoreduction with demonstrated impact on management and outcomes. [21]

Primary omental tumours require resection with negative margins for sarcomas followed by adjuvant therapy as guided by histologic subtypes. [16]

Sclerosing mesenteritis needs medical therapy primarily followed by surgery for obstruction or diagnostic uncertainty. [17]

Traumatic omental injury: Hemodynamically unstable patients need laparotomy. Whereas stable patients may be observed or managed with embolization as per CT findings and IR availability. [19]

Omentum in Oncologic Spread and Prognosis

Tumour cells exfoliate into the peritoneal fluid and preferentially implant on the omental milky spots via chemokine-mediated homing and stromal support. Omental adipocytes can fuel tumour growth by lipid transfer. [6,14,25] Omental involvement signifies advanced disease and guides staging and treatment. In ovarian cancer omentectomy is the standard of care while in other GI cancers the role is individualized. [21,24] Removing bulky omental disease enhances penetration and efficacy of intraperitoneal therapies such as HIPEC. [24]

Regenerative Medicine and Research Uses

Omental-derived mesenchymal stromal or stem cells (OM-MSCs) are multipotent, secrete angiogenic and immunomodulatory factors and are therefore being investigated for wound healing, tissue engineering, myocardial repair models and as vascularized support for grafts. Omentum is an attractive autologous source accessible during abdominal surgery. [6,26,27] Omentum has been used experimentally to vascularize and integrate engineered tissues and as a platform for immunologic research on peritoneal immunity and tumour microenvironment. [7,28]

Controversies and Challenges

Extent of omentectomy in GI malignancies remains debatable. With the exception of ovarian cancer, randomized data is limited and therefore the practice varies between routine and selective omentectomy based on preoperative imaging and intraoperative findings. [21,24]

Preservation vs resection in contaminated fields: The balance between omentum’s containment, healing roles and risk of harbouring necrotic or infected tissue requires individualized consideration and judgement. [9]

Use of omental flaps vs synthetic or biologic materials for reconstruction involves trade-offs. Vascularized omentum offers infection resistance and healing potential but at the cost of donor-site morbidity and operative time. [22]

Translating OM-MSC therapies to clinical practice requires safety and efficacy data from controlled trials. [26]

Practical Surgical Considerations

Handle omentum gently to preserve vascularity for flaps. Ensure meticulous haemostasis while dividing gastroepiploic vessels. Consider laparoscopic approaches for mobilization and resection to reduce morbidity. When leaving residual omental tails be mindful of torsion risk. Always obtain preoperative imaging to plan for oncologic omentectomy or for reconstructive harvest. [11,21,22]

Future Directions

Research priorities include deeper characterization of the omental immune microenvironment and milky spots to develop anti-metastatic strategies. Randomized trials to define omentectomy extent in non-ovarian GI cancers. Clinical translation of OM-MSC therapies and optimization of minimally invasive omental flap harvest and free-transfer techniques. [6,24,26,28]

CONCLUSION

The omentum is a multifunctional organ with powerful roles in peritoneal defence, healing, and tumour biology. Surgical strategy should always be individualized. Preserve healthy omentum for its protective and regenerative functions. Resect only when diseased or when oncologic control requires removal. Ongoing research into its immunobiology and regenerative potential promises to expand the therapeutic applications.

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Table 1. Omental Conditions: Features, Imaging and First-line Management

Condition	**Key features**	**Typical imaging findings**	**First-line management**
Omental infarction/torsion	Acute localized abdominal pain, possible fever	CT: focal ovoid fatty mass with hyperattenuating streaks	Conservative (analgesia, observe) if stable; laparoscopic resection if uncertain or worsening
Omental abscess	Localized sepsis after perforation or surgery	CT: rim-enhancing fluid collection, possible gas; US-guided accessibility	Percutaneous drainage + IV antibiotics; surgical drainage if inaccessible or bowel pathology
Omental metastasis / caking	Peritoneal seeding (ovarian, gastric, colorectal); advanced disease	CT: nodular or confluent soft-tissue replacing omental fat; PET/CT metabolically active	Cytoreductive surgery including omentectomy; consider HIPEC when indicated
Primary omental tumour (liposarcoma, mesothelioma)	Mass, pain, or incidental finding	CT/MRI: fat or soft-tissue mass; MRI better for characterization	Surgical excision with oncologic margins; adjuvant therapy per histology
Sclerosing mesenteritis	Chronic pain, weight loss, possible obstruction	CT: fat stranding, mass-like lesion in omentum	Medical therapy (steroids, tamoxifen); surgery for obstruction/diagnosis
Traumatic omental injury	Haemorrhage, hematoma, rupture after blunt trauma	CT: omental hematoma or hemoperitoneum	Hemodynamically unstable → laparotomy; stable → observation or IR embolization
Postoperative adhesions (omental involvement)	Chronic pain, SBO risk, reoperation difficulty	CT: adhesive obstruction signs, loculated fluid	Preventive measures intraop; adhesiolysis when symptomatic
Omental flap use (reconstruction)	Vascularized tissue for coverage, infection control	Preop CT for anatomy; intraop assessment	Pedicled or free omental flap to fill dead space, cover grafts, buttress anastomoses

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