IRANIAN JOURNAL OF VETERINARY SURGERY (IJVS)
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Greater Omentum: the Surgeons' Friend, no Longer a Forgotten Organ

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Abstract

In the past, the omentum was considered to be an inert tissue without much biological significance. But since the beginning of the last century, innumerable studies and trials have been conducted by surgeons and scientists all over the world, which have proven that the omentum is a unique, physiologically dynamic tissue with immense therapeutic potential. I have undertaken the present review to provide a concise account of the variety of applications of the omentum in the various disciplines of surgical practice. The omentum is indeed an organ of exceptional versatility. This review will enable the readers to appreciate the fact that, clearly the omentum was placed in the abdomen for a reason.

Key words: Omentum, Omentoplasty, Surgical Uses of Omentum

The word omentum derives from the ancient Egyptians who, when embalming human bodies, used to assess their "omens" by looking at the variations in what we recognise today as the omentum[1]. Galen (128-199 AD) thought that the role of the omentum was to warm the intestines. This was on the basis of a gladiator who had an omental resection after a stab injury and suffered greatly from cold for the rest of his life[2]. A more conventional view of the omentum is that it plays a central role in peritoneal defense by adhering to sites of inflammation, absorbing bacteria and other contaminants, and providing leukocytes for a local immune response[3].

The omentum appears to have evolved as a primitive effector organ in lower vertebrates. It develops as a loose mesothelial sheet of tissue from the yolk sac and is capable of basic immune functions such as allorecognition, natural cytotoxic reactions and the elaboration of cytokines. The greater omentum develops in the eighth week of gestation from the dorsal mesogastrium[4]. It is composed of two mesothelial sheets which enclose predominantly adipocytes embedded in a loose connective tissue, and also aggregates of

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mononuclear phagocytic cells. The omentum has a rich vascular supply with numerous characteristic capillary convolutions which are termed omental glomeruli due to their similarity to renal glomeruli. These capillary beds lie directly under the mesothelium[5]. In the omentum, the leukocytes aggregate in the perivascular area to form what is termed milky spots. Both the endothelium lining the omental capillaries and the mesothelium overlying the milky spots are specially adapted to facilitate transmigration of leukocytes[6], and for rapid fluid shifts. The macrophages in the mature omentum are essentially scavengers. The omentum contains large numbers of B and T lymphocytes which are usually located in the periarteriolar area. Mesothelial cells lining the peritoneal cavity and endothelial cells lining blood vessels share the same mesodermal origin[7]. Human omental microvascular endothelial (HOME) and mesothelial (MESO) cells share many phenotypic properties.

Omental Function

Foreign Bodies

Most surgeons have observed the ability of the omentum to adhere to intra abdominal foreign bodies such as drains and catheters. In dogs it has been noted that following the placement of various types of drains into the peritoneal cavity, that within seven days all tubes are surrounded and occluded by omentum[8]. This may lead to drainage problems in patients requiring long term catheters placed in the abdominal cavity, such as those for peritoneal dialysis. In such patients, removing the omentum has been found in a number of retrospective and uncontrolled studies to reduce the incidence of catheter blockage and to improve drainage [9-13].

Peritonitis

The omentum performs a number of functions during episodes of peritonitis. The first of these is the rapid absorption and clearance of bacteria and foreign material from the peritoneal cavity. The omentum is the only site, other than the diaphragmatic stomata, that has a documented ability to absorb particles from the peritoneal cavity[14]. But unlike the stomata, the omentum contains potent local effector mechanisms that are mediated by especially macrophages (and probably also B lymphocytes) contained within the milky spots. These macrophages appear to be the principal site for the phagocytosis of particles and bacteria from the peritoneal cavity[15]. The second function of the omentum is to supply leukocytes to the peritoneal cavity. In experimental animals with peritonitis, the omentum appears to be the principal site by which firstly macrophages and then neutrophils migrate into the peritoneal cavity [15, 16]. The omentum also allows for the easy migration of neutrophils from the circulation[17]. Due to the structure of the milky spots, there is direct exposure of the postcapillary venules to inflammatory stimuli from the peritoneal cavity [18]. The neutrophils are then recruited from the circulation and extravasate via the post-capillary venules in the glomerular tufts into the milky spots and then via the mesothelial stomata into the peritoneal cavity. In addition, the omentum was the only abdominal organ which showed an increase in blood flow during peritonitis [18]. The third function of the omentum is to adhere to and attempt to seal off areas of contamination. The omentum can rapidly produce a layer of fibrin by which to adhere to the contaminated area at the point of contact. In the course of a few days, the fibrin begins to organise with the development of new blood vessels and fibroblasts. In the long term, if the host survives, the contaminated area will be walled of with collagen, and thereby forming dense adhesions [19].

Neovascularisation

It has long been recognised that the human omentum can promote angiogenic activity in adjacent structures to which it is applied. Indeed, lipid material obtained from the omentum has been found to induce angiogenesis in rabbit corneas after only a single injection. This angiogenic material obtained from the omentum is abundant in supply [20]. Further evaluation of the factors involved in this process has found that the human omental microvascular endothelial cells (HOME cells) express the angiogenic peptide 'basic fibroblast growth factor'[21]. This process of neovascularization allows the omentum to provide vascular support to adjacent tissues such as the gut and promote function and healing in ischaemic or inflammed tissue [19, 22]. Another example of the angiogenic activity of the omentum has been its ability to support splenic autotransplantations. Although the clinical practice of re implantation of splenic remnants following splenic injuries has largely been abandoned by surgeons, it is interestingto note that such implants are supported by the omentum and function to a limited capacity [23]. The omentum has also be found to be capable of supporting free structures such as the trachea, segments of intestine, sciatic nerve grafts. Such structure can then be used for reconstructive purposes [24-26].

Clinical Issues

Reconstruction

Surgeons have long exploited the unique structure and function of the omentum[27]. In paricular, its rich blood supply that supports a high absorptive capacity, its pronounced angiogenic activity which may support local tissues (and ischaemic tissues), its innate immune function, its ability to adhere to local structures, and finally its high concentration of 'tissue factor' which promotes haemostasis [2, 28]. In 1927, Perrotti [29] used free and pedunculated flaps of omentum to enhance intestinal suture lines in dogs.

Omentum has also been used: to close perforations in the gastro-intestinal tract; to reinforce gastrointestinal anastomoses; to aid haemostasis during liver resections; to line the bed of hydatid cysts in the liver; as a pedicled graft to cover defects or to reconstruct areas from the chest wall to the perineum; to protect exposed carotid arteries; as free vascularized grafts in head and neck surgery; to repair bronchopleural fistula; and others [27, 30, 31].

There are several reports of the use of an omental flap to reconstruct the mediastinum in patients with mediastinitis secondary to open heart surgery [32-34]. These reports are retrospective and not adequately controlled. Nevertheless, they all comment that omental flaps are associated with fewer septic complications than pectoralis major flaps, and are associated with high rates of healing and lower mortality when compared with debridement. Similarly, there have been reports on the use of the omentum as a free transfer graft for the treatment of chronic ulcers, progressive hemifacial atrophies, and contused wounds. The transferred omentum appears to maintain its volume and nature under normal circumstances [35].

Gastrointestinal Anastomoses

There have been numerous studies evaluating the use of the omentum to support gastrointestinal anastomoses. In animals, there have been conflicting results as to whether reinforcing a compromised (i.e., ischaemic or technically inadequate) anastomosis with well vascularized omentum improves healing [1, 36, 37]. However, the clinical relevance of studying anastomotic healing of grossly ischaemic segments of bowel is, I believe, questionable. In contrast, Carter *et al.* [38] evaluated the ability of omental wrapping to improve the healing of anastomoses using non compromised large intestine. They observed no improvement in fatal leak rates. There has been one large clinical trial evaluating this issue in humans. This included 705 patients undergoing elective resections from the caecum to the midrectum with a mean age of 66 years. Patients were randomized after colectomy to undergo either omental reinforcing of the colonic anastomosis or no reinforcing. The intraoperative findings were similar between the two groups, except that there were significantly more septic operations performed in the control group. When comparing the omental reinforcement group with the controls, there was no significant difference in either anastomotic leakage (4.7% *vs* 5.2%) or deaths (4.9% *vs* 4.2%). The authors concluded that omental reinforcement of colorectal anastomosis was of no clear benefit *et al* [39].

Neurosurgery

Placing the omentum on the brain surface by surgical transposition or transplantation has been found to result in the development of numerous neovascular connections between these two structures. This phenomenon occurs even in the absence of cerebral ischemia. In a series of 30 children with moyamoya disease, aged from 2 to 17 years, omental transplantation was used to improve vascularity in either the anterior or the posterior cerebral artery territory. All 19 patients treated with omental transplantation to the anterior cerebral artery and 11 (84.6%) of the 13 treated with omental transplantation to the posterior cerebral artery showed improvement in their neurological state [40].

Vascular Synthetic Grafts

Synthetic vascular grafts lined with HOME cells appear to remain patent for longer periods [7]. However, HOME cells remain difficult to extract and culture. In contrast, MESO cells can be readily harvested in large numbers from the omentum, and by culturing them in specific conditions their natural tendency to express tissue factor which is thrombogenic can be inhibited. Such cells are an excellent alternative to HOME cells in seeding synthetic grafts [41]. This technique has been used to line the luminal surface of small diameter prosthetic bypass grafts, thereby lowering the grafts thrombogenicity. These grafts were then implanted into the carotid artery of dogs and have been found not to develop neo-intimal hyperplasia or stenosis when compared with controls [42].

Malignancy

The omentum has been observed to be a frequent site of metastatic disease for many malignancies. In animals, malignant cells inoculated into the peritoneal cavity preferentially infiltrate the milky spots in the omentum and grow into distinct metastic [43, 44]. The omentum appears capable of supporting not only malignant cells in the milky

spots but free intraperitoneal cells. It achieves this due to its intrinsic angiogenic properties. In animals, removing the omentum impacts on the survival of free intraperitoneal malignant cells and there by reduces the rate of local recurrence [45, 46]. Because of these observations, the omentum is frequently removed as part of resections for malignancies of various intra abdominal organs [47]. Ovarian cancers, in particular, are characterized by their tendency to spread intraperitoneally and involve the omentum. Hence, there has evolved a general consensus that surgical management of ovarian cancer should include optimal cytoreduction [48-51]. The minimum surgical requirements of this are to perform a total abdominal hysterectomy, bilateral salpingo-oophorectomy, and omentectomy. The apparent value of performing an omentectomy is that it provides staging information and selects patients for adjuvant chemotherapy [51, 52].
In addition, in patients with advanced disease, there appears to be a survival advantage in debulking tumour deposits [53]. Nonetheless, with borderline ovarian tumours, omentectomy is also frequently advocated but the evidence to support this remains limited [54].
The omentum is intimately associated with the stomach and the gastric lymphatic drainage. Therefore, it is invariably removed as part of a curative resection for gastric cancer [55, 56]. Nonetheless, there is no clear evidence to provide guidance as to the extent of such a resection, and whether the entire omentum has to be removed [57, 58]. Pseudomyxoma peritonei is a rare neoplasm characterized by mucinous ascites and the mucinous involvement of peritoneal surfaces, omentum and bowel loops. Usually pseudomyxoma peritonei is associated with benign or malignant mucinous tumor of the appendix or ovary, and cytoreductive resections, including omentectomy, are advocated as the treatment of choice [59, 60].

Conclusion

Our concept of the omentum as an abdominal policeman has obviously evolved since the days of Rutherford Morrison. We now understand that it occupies a central position in the peritoneal defense mechanisms. It achieves this by virtue of its innate immune function, its high absorptive capacity, and its ability to adhere to adjacent structures to both seal off gastrointestinal defects and promote their healing with its pronounced angiogenic activity.
Because of these attributes, surgeons have utilized the omentum in a variety of settings, from reconstructing soft tissue defects, to supporting tissues to promote healing. In managing patients with intra abdominal malignancies, the role of omentectomy requires further evaluation to determine whether it is associated with a clear survival advantage, and to evaluate how much needs to be removed. In conclusion, the omentum needs to view as an important intra abdominal organ and hence careful consideration needs to be given before it is removed.

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