MANAGEMENT OF EXTENSIVE OR INFECTED SOFT TISSUE DEFECTS IN UPPER LIMB BY MEANS OF PEDICULATED OMENTAL FLAPS

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The basis for the treatment of deep tissue defects, particularly those that are infected, is coverage of the exposed anatomical structures with well vascularized tissues. To this end various kinds of vascularized-pedicled and free flaps are utilized. Post-trauma, soft tissue defects in the region of the upper extremity often involve areas of tissue poorly perfused, affected by necrosis and bacterial colonization. The size of the defect with accompanying intense purulence limits the application of local reconstruction and fasciocutaneous and muscle flaps. The greater omentum is one of the most promising and universal flaps on account of its bactericidal and angiogenetic properties. The first report regarding a successful application of omentum in plastic surgery dates from 1965 year.

The aim of the study was to present treatment results of extensive as well as infected tissue defects of upper limb with the application of pedicled omental flaps in material from Sub-Department of Limb Replantation in Trzebnica.

Material and methods. Between 2005-2009 in the St. Hedwig’s Hospital 35 patients (30 M, 5 F) avg age 38.3 (range 10-73) were treated using omentum flaps. The causes of defects were primarily crush injuries (13), burn wounds (2), secondary necrosis of replanted/revascularized limb tissues (14) including chronic bone infections, contaminated degloving injuries of upper limb (4). The area of tissue defect amounted to avg 84 cm² (range 25-227 cm²)

Most of this, 31/35 (89%) posed infected wounds (Staphylococcus aureus 11, Escherichia coli 12, Enterococcus faecalis 11, Staphylococcus coagulase negative 10, Pseudomonas aeruginosa 5, Acinetobacter baumanii 6, Proteus mirabilis 6, Enterobacter cloacae 4). The procedure was based on covering of the defects with pedicled omental flap obtained during epigastric laparotomy, with split-thickness skin graft. After the procedure apart from the surgical prophylaxis general antibiotic therapy was not applied, nor locally. After 3-4 weeks the pedicle of flap was cut and its appearance was modeled as well as covered using skin graft.

Results. Complete healing with good functional and cosmetic results was achieved in 32/35 cases, after transplantation of omentum in 52% of wounds a change in bacterial flora was observed to saprofitic and antibiotic-sensitive, and in 38% donor site was aseptic. Cultures were attained, in the remainder signs of infection receded despite the presence of pathological flora. In 2 cases complete or partial necrosis of flap was observed, in one the vital flap was removed due to amputation of limb (crush syndrome). Complication in the form of hernia were observed in 5/35 patients, however no complaints of abdominal pain or abscess of space drawing.

Conclusions. Free and pedicled omental flaps appear to be the ideal solution in the treatment of tissue defects and bone infections chronically infected with antibiotic-resistant cultures. The omentum also is an appropriate material for covering of fresh defects with exposed ligaments, nerves and bones. The complications at the obtaining site in our material occurred rarely when compared to the available published data. Currently it is possible also to harvest the omentum laparoscopically.

Key words: greater omentum, pedicled flaps, upper limb defects, infected wounds, osteomyelitis
Massive upper limb injuries are often accompanied by destruction of tissues of significant area, the extent of created soft tissue defects precludes or limits application of local skin plastics methods (fig. 1a, 2a and 3a). Covering with full-thickness, well vascularized tissue, of injured, or only exposed, deeper situated anatomical structures (bones, ligaments, nerves, vessels) pre-requisites of appropriate course of their healing, as well as poses a key to the success of repeat reconstruction procedures. However, frequently these defects due to their recurrent infection and/or presence of questionable vitality, metal implants do not qualify for covering through application of skin-fat, muscle tissue flaps (1, 2, 3). An additional problem in chronic cases is the increasing bacterial drug-resistance and lack of adequate antibiotic penetration to the focus of infection. The method which in this type of clinical situation exhibits high effectiveness is the application of greater omentum flaps. (GOF) Greater omentum is one of the most promising and universal materials for flap, with unestimated angiogenetic and bacteriocidal potential, under physiological environment fullfills the role of „police” of the peritoneal cavity and as a flap somehow „forgotten” is undergoing its renaisanse. The greater omentum’s contribution role in combating infection within the peritoneal cavity is well recognized. Its rich arterial and lymphatic vascular network. Plays a significant role in resorption of inflammatory exudate (lymphatic drainage), limit and elimination of infection (macrophages – phagocytosis), through which action it represents an active vasculo-and immunological natural wound dressing material. It is characterized by good adhesiveness to injured tissue, potential for neogenesis and neo-osteogenesis. Revascularization of base allows for transport of antibiotic inside the focus of infection (4, 5, 6).

Ion Kiricuta, a Romanian surgeon-oncologist, should be considered the author of this method, who in the 1960s applied pedicled greater omentum flaps in the treatment of vaginal fistulas, thoracic post-radiation injuries, and in later years (demonstrating the

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**Fig. 1a.** Condition on the 3rd day after after extensive crush injury to the hand and forearm in a 16-year old patient, managed microsurgically (anastamosis of radial artery) at a hospital in Serbia

**Fig. 1b.** Condition of limb 10 days after coverage of defects with the GOF

**Fig. 1c.** Condition after autotransplantation of toe extensor tendons into the area for digit flexors of the hand (10 months after injury)
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The capability of freely flap elongation) as well as in the treatment of lymphatic edema (6, 7). In the current times the range of application of this „live wound dressing” has substantially expanded (thoracosurgery, maxillo-facial surgery, cardiosurgery, plastic surgery), however the last of the enumerated applications still remains the most frequent (3, 8, 11, 15, 19).

The objective of this study is the presentation of treatment results of extensive as well as infected tissue defects of upper limb using the pedicled greater omentum flap method.

MATERIAL AND METHODS

In the Sub-department of Limb replantation of St. Hedwig’s Hospital in Trzebnica in the period from June 1, 2003 through June 1, 2009 39 patients with extensive, infected soft tissue defects and chronic bone infections were treated using greater omentum flaps (35 upper limb 30 M, 5 F; 8 hands, 13 hands and forearms, 14 forearms). Avg, age of patients 38.3 years (5-76 years). For the operation we qualified patients after crush injuries, degloving (printing press, agricultural machinery, transportation accidents), improperly treated typical lacerated wounds (injury with circular saw), burns, cases of recurrent necrosis of re-planted/revascularized tissues of limbs, cases of post-traumatic bone inflammation (fig. 1a, 2a and 3a). The extent of defect on an average was 84 cm² (range 25-227cm²). Most cases, 31/35 (89%) were consisted of infected wounds, and in 60% of cases bacteriological analysis revealed a mixed flora (Staphylococcus aureus – 11, Escherichia coli – 12, Enterococcus faecalis – 11, Staphylococcus coagulzonegative – 10, Pseudomonas aeruginosa – 5, Acinetobacter baumanii – 6, Proteus mirabilis – 6, Enterobacter cloacae – 4).

The surgery (except bone inflammations) were conducted on an average in the 15.3 day after the accident (range 1-43 days), after initial local treatment of infected wounds with silver releasing dressings or an antiseptic solution of octenidine, using vaccum pack. In cases of sensitive strains, patients received antibiotic congruent with the antibiogram. Characterization of patient material is presented in tab. 1.

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Table 1. Characterization of patients treated with GOF

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cases</th>
</tr>
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<tbody>
<tr>
<td>Infected third degree burns</td>
<td>2</td>
</tr>
<tr>
<td>Infected soft tissue defects and bone inflammations</td>
<td>13</td>
</tr>
<tr>
<td>after crush injury</td>
<td></td>
</tr>
<tr>
<td>Infected or contaminated degloving injuries</td>
<td>4</td>
</tr>
<tr>
<td>Infected soft tissue defects and bone inflammation</td>
<td>14</td>
</tr>
<tr>
<td>after replantation</td>
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days). Until now the patient’s wound dressings care was conducted in their residences.

RESULTS

We noted one (1/35) failure – necrosis of entire flap, which we attribute to the compression of flap pedicle caused by too tight suture of fascia of the rectus muscle, as well as its bending; in three cases we run into peripheral edge necrosis of the flap, not exceeding 1/5th of the entire surface. In 5/39 patients a small hernia occurred in the inferior pole of the surgical scar, 3 reported for secondary surgical treatment. We did not diagnose other kinds of complications in the course of haling of the flap, however we did observe in the course of this process the receding of signs of inflammation in the area of the wound with a reduction of exudate as well as colonization by bacteria. Cultures from the defect areas covered with the GOF showed, at most a meager colonization with saprophytic flora (52%), and aseptic wounds in 38%.

In the remainder of the 10% of cases we achieved wound healing with persistence of primary flora in the swab. In all cases operated due to exposure and infection of the implant we achieved a complete coverage and healing of the flap without the necessity of removing the implant. The functional and aesthetic result of the surgery was satisfactory, to further cosmetic improvement after reduction of the flap thickness. 13 patients underwent this procedure, in 8 of the patients this surgery constituted an addition to second-
ary reconstructive operation, such as: implantation of temporary prosthetic silicone rods – 4 patients, reconstruction of nerves – 2 patients, filler of bone defects in 3 patients; 4 patients await further reconstructions in the area of injured limb. All patients were satisfied with the results of the conducted surgery, in their final assessment not regarding the treatment method associated with necessity of mandatory suspension of limb for 3 weeks as excessively burdensome.

**DISCUSSION**

The greater omentum fulfills a role in the peritoneal cavity of a „watchdog of the abdomen” (8). This role is fostered by certain features of the greater omentum, such as large surface as well as excellent arterio-venous vascularization and lymphatics supply, greater omentum anatomically and physiologically is designed to survive in a purulent environment which stems from, as was demonstrated by Goldsmith and Browne, from the fact that it produces active lipid substances of angiogenetic, osteogenetic as well as immunostimulant properties. (4, 6, 9-12).

Particular capacities of the omentum is proven its overgrowth of artificial nets, ceramic materials, and adhesion to metal implants (13). The greater omentum superbly allows for modeling, filling all depressions and curvatures of the defect, without leaving dead space. These unique rare properties render it an almost ideal biological material for filling areas filled with necrotic tissue (for example after brachyradiotherapy, classical burns) and/or involved by purulent process (thoracosurgery, cardiosurgery, plastic surgery). In cases of damage or exposure of ligaments as well as nerve trunks relevant value possesses creation by the transferred in this area flap favorable environment for their sliding. This feature some authors utilize in the treatment of chronic neuritis, for instance after failure of multiple surgical treatment of carpal tunnel syndrome (14).

The greater omentum, due to the presence of relatively large vessels, whose diameter in an adult oscillated in the border of 2-3.5 mm, perfectly affords also for transfer, as a free flap, to distant areas of the body. On account of the profile of the department (hand surgery), in the study we presented results obtained solely in patients in whose treatment pedicled flap

![Fig. 3a. Condition of the limb of a 52-year old patient 3 weeks after replantation due to hand amputation caused by crush/compression injury](image1)

![Fig. 3b. Double-leaf GoF prepared for implantation](image2)

![Fig. 3c. Condition of extremity 30 days after cutting off the pedicle of the GoF](image3)
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sufficed. Most of treated us patients suffered primary vascular injury, which after revascularization of one of the antebrachial arteries often prevented secondary application of microsurgical free flaps (low-flow phenomenon) (18). Moreover, the ease of circumference of the pedicled flap of any upper limb area causes, that the application of free flaps in this case, as more time-consuming and burdened by higher risk of complications does not appear to be advisable. An evident inconvenience of this method is the necessity to maintain the limb for a period of about 3 weeks in compulsory suspension as well as associated with this difficulties in wound care dressings, its advantage in turn is low risk of failure. Thus far the most extensive patient sample comprised of 13 cases presented in Polish literature was by Prowans (15, 16). In 5 patients the author performed a free greater omentum flap, in the remainder of the group pedicled flap. In both groups the same number of complications occurred (2 patients) in the form of partial flap necrosis. The author also reports, that part of the patients during the treatment using pedicled flap complained of ailments of the celiac character stemming from the pulling by the flap pedicle of transverse colon. An appropriately long pedicle obtained through dissection of the omentum from transverse colon allows for leaving of sufficient length reserve inside the peritoneal cavity, which caused that we avoided similar problems in our clinical material. Arnold applied pedicled GOF in the treatment of various types of difficult to heal wounds in the area of upper limb, abdominal wall as well as of the thorax, from which 69% (35 patients) were infected. Complete healing was achieved in 26 of 35 patients (74%), the greater omentum survived in all cases. In our sample we achieved general healing in 34/35 (97%) cases, including bacteriological healing in 28/31 (90%) of those infected.

One of the decisive elements in the choice of flap is the degree of morbidity of donor site (1, 2, 23). There is a lack of reports in literature about unfavorable consequences of the reduction in greater omentum mass (8), in the aspect of risk of occurrence in those patients of “acute abdomen”. The compensatory growth capacity characteristic of this organ may partially at least serve as an explanation (7). Moreover, experimental studies on animals showed lack of influence of removal of the omentum on the defense capacity of peritoneum (24). Critical comments regarding the method, reported by surgeons not utilizing it, regarding to the ability of translocation of infection from the affected area (in this case upper limb) to peritoneum. This possibility appears to be often theoretical. In literature regarding application of GOF we did not find any report evidencing such an eventuality, apart from infections of skin surrounding pedicle (25, 26). We did not come across a similar problem in the sample of patients operated by us. The only, as we perceive, risk of the necessity of opening abdominal cavity is the possibility of occurrence of hernia in the post-operative surgical wound (10-26% in literature) (25-28). Utilization of free greater omentum flap, performed increasingly laparoscopically eliminates also this risk (29, 30). From among other possible complications reported in literature are possibility of arising of ileus (without stating precisely whether this was obstruction due to torsion, or through adhesions after laparotomy) as well as ailments in epigastrium associated with bending of stomach when using the pedicle based on vessel of greater curvature, disorder of stomach emptying cased by severance of the right gastroepiploic nerve (27, 28). Undoubtedly a technical problem is the experience by the patient earlier procedures on the abdominal cavity, preparation of GOF requires in such cases widening of access and extensive freeing of adhesions (25).

Despite the mentioned drawbacks, covering of infected soft tissue defects of the upper limb, which do not surrunde to conventional treatment

Fig. 4. Dissection free of the GOF
(bactericidal dressings/vacuum pack) the GOF flap yields spectacular results in the most difficult cases, which is confirmed earlier applications in cardiosurgery in posternotomy purulent infection of the sternum (7, 11, 26, 28).

CONCLUSIONS

1. The indication to application of GOF in the area of upper limb are infected soft tissue defects as well as areas of wounds covered by poorly vascularized tissue. This flap in this scope of highly effective.

2. The method is not technically complicated (does not demand very special operating backup), it is relatively fast and inexpensive, can also with success applied in every general and trauma surgery department, as well in the emergency conditions.

REFERENCES


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COMMENTARY

Treatment of extensive, deep defects in the soft tissues of the hand and forearm with accompanying exposure of important anatomical tissue structures is a great challenge for the treating team. These tissue defects need to be filled with a valuable tissue material that should meet certain conditions. They include adequate blood supply of transferred tissues and their small thickness.

For this purpose, Authors of the paper used pedunculated flaps of the greater omentum and they should be congratulated on their results.

Previously cutaneous-adipose tissue flaps were usually transferred to remote parts of the body, such as abdominal wall, groin or contralateral arm. All these surgical techniques require immobilization of the upper limb in an uncomfortable, forced position, for several weeks until the flap pedicle could be cut off and it have modeled at the site of the defect. Often these patients experienced rigidity of the immobilized joint that required further mobilization of such joint. Usually, the flap that healed at the defect site required thinning. Despite these inconveniences, these flaps are probably still widely used in many centers of traumatic surgery in Poland.

Coverage of soft tissue defects of the upper limb with pedunculated flaps of the great omentum also requires immobilization of the upper limb in an forced position. 1/3 of the patients in the Authors’ material also required secondary thinning of the healed tissue material. These inconveniences are comparable with inconveniences associated with conventional cutaneous-adipose tissue flaps.

To obtain a greater omentum flap, one has to open the abdominal cavity what poses a risk of early and late complications. Apart from very rare intraoperative and early complications, the most commonly reported complication is a hernia in the postoperative scar. Such complication occurred in more than 12% of cases in the Authors’ material. In theory, one cannot rule out completely that in the future mechanical intestinal obstruction will result from strangulation of an intestinal loop on postoperative intraperitoneal adhesions or on a “bridge” formed by the greater omentum healed in the abdominal wall. Laparotomy requires a separate set of instruments but above all it requires skills and willingness to perform such operation by a team of surgeons who most commonly are surgeons traumatologists. It limits possibility that such operation is performed in an emergency setting. Obviously, use of a laparoscopic technique decreases the risk of hernia in the scar after the conventional surgical incision, but on the other hand hernias have been reported in the umbilicus, at the site of trocar insertion. There is always a risk of damage of intestinal wall of a large blood vessel with an instrument inserted into the peritoneal cavity. Such operation requires specialist, usually set of disposable instruments and high surgical skills of the team.

Current surgical techniques aim at one-stage coverage of the defect with a tissue material without requirement of immobilization of a limb in a forced position. Optimal surgical solution is to use local or remote fascial flaps for this purpose that are simultaneously covered with a skin graft of moderate thickness or to use thin perforator flaps with microvessel anastomoses.

Greater omentum flaps have been used for years in the reconstructive surgery, both as pedunculated flaps and free flaps. Their vast
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advantage is their perfect blood supply and lymphatic drainage as well as ability to cover or fill large tissue defects with them. Such extensive tissue defects seem to be major indications for their use. However, they should not be considered as an optimal operative solution but rather as one of generally accepted alternative methods of tissue reconstruction in difficult clinical cases. Therefore, indications for their use should be established individually.

The material presented by the Authors is the most extensive material published in Poland and their very good results of treatment indicate their substantial knowledge and experience. Sometimes, in our clinical practice, we find cases of extensive, deep tissue defects in the upper limbs, that seem impossible to close from the technical point of view. In my opinion, unfortunately such defects are treated by many centers using conservative methods – granulation tissue develops and later is covered by skin grafts which substantially reduces the chance for full recovery and sometimes for survival of such limb.

The high value of this paper stems from reminding us of possible surgical treatment of extensive soft tissue defects in the upper limb by using the greater omentum flaps and presenting beneficial effects of such management.

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