The laparoscopically harvested omental flap for deep sternal wound infection

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Received 23 March 2009; received in revised form 1 June 2009; accepted 12 June 2009; Available online 30 July 2009

Abstract

Objective: To report our experience with the laparoscopically harvested omental flap in the treatment of deep sternal wound infection, and to present a modification and introduce two supportive techniques in the perioperative management. Methods: Between June 2005 and September 2007, six patients with grade IV (El Oakley—Wright classification) deep sternal wound infection following a median sternotomy for coronary artery bypass grafting underwent a reconstruction with a laparoscopically harvested omental flap. The median age of the cohort of six, consisting of one female and five males, was 67 years (range: 61—77 years). In five patients, an unilateral internal thoracic artery had been used. Considerable preoperative risk factors were present: one patient suffered from severe chronic obstructive pulmonary disease (COPD) Forced expiratory volume in 1 s (FEV1)1L; two from moderate chronic obstructive airway disease, three from insulin-dependent diabetes mellitus and three were on glucocorticoid steroid therapy preoperatively. Abdominal surgery had previously been performed in four patients. In all cases, the mediastinal wound was prepared with vacuum-assisted (≤125 mmHg) therapy following debridement and pulsed irrigation. White, small-pore foam was placed over the right ventricle when the risk of adhesion to the sternal remnants or secondary haemorrhage was a concern. In all cases, the position of the spread-out omental flap was maintained intrathoracically with autologous fibrin glue and in one case the split-skin graft covering the flap was also dealt with in this way. Portable sonography proved useful in monitoring the doubtful intrathoracic flap.

Results: The 30-day perioperative mortality rate was zero, with a 2-year overall survival of 100%. One patient received a temporary colostomy due to a partial transverse colon necrosis. Follow-up ranged from 20 to 53 months (median: 39 months) for the group as a whole. Death occurred in one case 2.8 years after reconstruction due to reasons other than cardiac or mediastinal conditions.

Conclusion: The laparoscopically harvested omental flap can contribute to a successful outcome following deep sternal wound infection and deserves serious consideration in type IV mediastinitis in particular, regardless of the co-morbidity or previous abdominal surgery.

1. Introduction

Deep sternal wound infection (DSWI) presents a therapeutic challenge. Morbidity is substantial and mortality significant. The treatment principles of combating the infection, encouraging wound healing and obliterating dead space are facilitated by introducing well-vascularised distant tissue, in the form of a flap, into the defect. However, the choice of flap is still often debated.

The introduction and improvement of muscle flap closure is said to have reduced the mortality related to these sternal defects from 50% down to the 15—30% range [1]. The three muscles commonly employed are the latissimus dorsi, rectus abdominis and pectoralis major. The latter, in its various forms — unilaterally (as a rotation-advancement or as a turn-over flap) or bilaterally — is the most popular. Each muscle flap (alone or as a musculocutaneous flap) however, has its disadvantages. The pectoralis muscle flaps often lack adequate bulk for wide defects and give insufficient coverage to the distal one-third to a quarter of the sternal defect. The use of, or at least the degree of dissection and mobilisation of, the left rectus abdominis muscle is limited when the left internal mammary artery has recently been used for the coronary bypass procedure. Harvesting the contralateral rectus muscle with its superior epigastric vascular pedicle leaves the abdominal wall potentially weaker, with a remaining rectus with diminished blood supply on the side from which the mamma interna artery was harvested.
The transfer of the pedicled omentum into the chest cavity to re-vascularise the ischaemic heart was originally proposed by O’Shaughnessy in 1936 [2]. An account by Lee et al. [3] of its usefulness in the management of mediastinitis following cardiac surgery was presented 40 years later.

Despite the obvious attractive features of the omentum such as its size [4], its well-known resistance to infection and its promotion of neo-vascularisation, [5] its universal acceptance as a first choice in infected post-sternotomy reconstructions may have been hampered by the fear of opening and exposing a second body cavity with resultant spreading of infection. Furthermore, harvesting the omentum laparoscopically was taken on the precept that harm to the abdominal wall could be contained and the degree of exposure of a second body cavity could be limited, thus preventing injury to the muscle and its blood supply. The few comparative studies we could trace clearly favoured the omentum above the pectoralis muscle as a superior choice in the reconstruction of these difficult cases because of the shorter operating time and postoperative hospitalisation, the lack of flap failure [7] and the lower sepsis-related mortality [8].

It was with the latter potential advantages in mind that we chose the omentum for our cases. The decision to raise the flap laparoscopically was taken on the precept that harm to the abdominal wall could be contained and the degree of exposure of a second body cavity could be limited, thus preserving respiratory function and not promoting the spreading of infection. Furthermore, harvesting the omentum endoscopically is known to be associated with less abdominal pain and minimal scarring [9].

2. Materials and methods

Between June 2005 and September 2007, six patients with severe deep sternal wound infection following a sternotomy underwent a reconstruction with an endoscopically harvested omental flap. This represented 0.5% of all sternotomies (n = 1121) performed during the same period in our hospital. All six patients had had coronary bypass grafts (CABGs) performed through a median sternotomy. In five, an unilateral internal thoracic artery (ITA) had been harvested. The perioperative risk factors are summarised in Table 1.

The plastic surgery team was consulted once the diagnosis of a deep sternal wound infection (or mediastinitis) had been clinically established by wound and sternal dehiscence and positive cultures. One or more radical debridements, resulting in a partial sternal resection, had been performed by the cardiothoracic team prior to consultation. One patient had also had, in addition, a failed closure attempt by means of a pectoralis musculocutaneous advancement. Sensitivity had been determined from tissue and pus cultures, and specifically targeted antibiotic therapy had been started in all six patients. The mediastinitis varied between type IVA (n = 4) and IVB (n = 2), according to the El Oakley–Wright classification [10].

Vacuum-assisted closure (VAC) therapy with sterile polyurethane foam dressing, with either the normal or small-pore, non-reticulated structure of 200–1000 μm (White Foam from KCI Medical BV, The Netherlands) had been instituted and was continued in preparation for a definite repair. The foam was covered with an overlapping transparent adhesive drape, and a continuous negative pressure, not exceeding 125 mmHg (VAC pump unit (KCI)) was used in all cases. The polyurethane foam dressing was changed every 2–3 days. Once the C-reactive protein level had declined below 70 mg l⁻¹, the patient was taken to the theatre for the omental flap procedure. The delay between instituting VAC therapy and flap closure was 13–35 days (median: 23 days). On average, the delay between initial cardiac surgery and omental flap repair was 44 days.

Definitive reconstruction started with the laparoscopic release and lengthening of the omentum. This was performed with the patient supine, under general anaesthesia. A camera port (10 mm, 30°) was inserted at the umbilicus. Two additional 10–12 mm trocar sites were placed on either side, lateral to the rectus muscles, thus preventing injury to the muscle and its blood supply. Ultrascision scissors with bipolar coagulation (Ethicon, Endo-Surgery Inc., Cincinnati, OH, USA) obviated the need for vascular clips. Following abdominal exploration, the omentum and its vascular supply was assessed. In the first two cases, adhesions had to be released down the right paracolic gutter. This was followed by detachment of the omentum off the transverse colon and opening of the lesser sac. Detachment from the greater curvature followed, coagulating the many gastric branches at a safe distance from the pedicle. In our six cases, the omentum was mobilised on the left gastro-epiploic vessels as these were found to be closest to the chest wall defect.

A debridement of the chest wound commenced, after which an opening of approximately three fingerbreadths was made through the thoracic wound, preferably through the diaphragm adjacent to the falciform ligament. The scopist had to ensure that he had the tip of the omentum ready as the advantage of a pneumoperitoneum is then lost. The omental flap was advanced through the opening with great care to avoid torsion and prevent strangulation of the pedicle. The pedicle was tacked with three or four tensionless compass sutures to the thoracic side of the diaphragm. A Redon drain was placed under the omental flap. The omental flap was spread out to fill all cavities and prevent irregularities and, where feasible anterior to the right aspect of the heart. Its position was maintained by ‘gluing’ it into position with autologous fibrin glue (Vivostat Platelet Rich Fibrin (PRF) from Vivostat A/S, Alleroed, Denmark). Two or three tensionless tacking sutures were sited at the entrance through the diaphragm and at the cranial end of the wound.

<table>
<thead>
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<th>Table 1 Patient characteristics.</th>
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<tr>
<td>Gender</td>
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<td>Age (median, range) (years)</td>
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<td>Risk factors</td>
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<td>COPD</td>
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<td>Diabetes</td>
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<td>Obesity (BMI &gt; 31)</td>
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<td>Steroid intake</td>
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In our most critically ill, first patient (FEV1: 1L), the omental flap was covered primarily with a meshed (1:3), split-thickness skin graft held in place with autologous fibrin glue. An uncomplicated, 100% ‘take’ followed. In five of our six cases, it was possible to undermine and advance the surrounding skin and prefascial, subcutaneous tissue to such an extent that tensionless closure over the omentum could be achieved. Redon drains were placed under these flaps. The drains were only removed once the daily amount of effluent was less than 25–30 ml per 24 h.

3. Results

3.1. Patient characteristics (Table 1)

All six of our patients had had CABGs performed through a median sternotomy. In five, a unilateral internal thoracic artery had been harvested. There was one female patient and five males. The median age was 67 years (range: 61–77 years). The group was characterised by a high co-morbidity: one patient suffered from severe (FEV1: 1L) and three from moderate chronic obstructive airway disease; three were on glucocorticoid steroid therapy preoperatively and three had insulin-dependent diabetes mellitus (Table 1). Abdominal surgery had previously been performed in four patients.

All patients routinely received an intravenous first-generation cephalosporin (cefazolin sodium) prophylactically at induction and this was continued for the first 24 h following the CABG. One patient suffered a cerebrovascular accident (CVA) after her CABG, which may have contributed to the sternal instability brought on by severe bouts of coughing.

3.2. Outcome

No patients were lost to follow-up, which ranged from 20 to 53 months (median: 39 months) for the group as a whole. One patient died 2.8 years after the reconstruction due to respiratory failure, secondary to severe chronic obstructive pulmonary disease (COPD) aggravated by pneumonia. The patient, his family and the intensivists had agreed on a non-resuscitation policy prior to the first, extensive debridement. Following discharge, all patients continued to be seen regularly by a cardiothoracic surgeon, a cardiologist, and, in the case of three patients with known lung disease, by a pulmonologist. The median follow-up period of the surviving five patients was 45 months (range: 20–53 months).

3.3. Complications (Table 2)

The 30-day perioperative mortality rate was zero, with a 1-year overall survival of 100%. In every case, all other methods of management (including aggressive debridement and primary reconstruction) had failed. Bilateral pectoralis musculocutaneous flaps had been raised by the thoracic surgeon and failed in one patient. None of the patients experienced any complications from the VAC therapy. The time interval from initial debridement to omental flap was 30 days (range: 14–45 days). In our first and most critically ill patient, the omentum was covered by a split-thickness skin graft following a difficult intra-abdominal dissection (Fig. 1) to save further operative time. In the other five, the omental flap was covered primarily with advancement of the local skin and subcutaneous tissue.

Despite adequate closed-suction drainage, three patients developed progressive serous, non-infected wound drainage several days following removal of the drain. Portable colour-Doppler and grey-scale sonography was used to check pedicle flow and flap viability. One patient developed necrosis of a segment of transverse colon 2 days after the laparoscopy and therefore a temporary colostomy was performed. Continuity was restored and the patient continues to be one of our longest survivors. In another patient, a small sliding hernia of bowel was discovered almost a year after reconstruction. The patient was asymptomatic and preferred conservative management.

The last, very obese (BMI 36) patient in this series presented with a hard subcutaneous epigastric mass of approximately 40 × 30 mm, 112 days following omental flap reconstruction, which on computed tomography (CT) scan appeared to be calcification. The omental vascular pedicle was intact and appeared patent with contrast enhancement. The patient was not a diabetic and, as he was asymptomatic,

<table>
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<th>Complication</th>
<th>Management</th>
<th>Prevention/precaution</th>
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<tr>
<td>Partial transverse colon necrosis</td>
<td>Temporary colostomy</td>
<td>None (unforeseen)</td>
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<tr>
<td>Sliding hernia</td>
<td>None (asymptomatic)</td>
<td>Transdiaphragmatic tunnel</td>
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<tr>
<td>Progressive closed-flap drainage</td>
<td>Duplex Doppler and grey-scale sonography</td>
<td>Drain removal only if ≤30 ml/24 h</td>
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<tr>
<td>Subcutaneous calcification</td>
<td>Contrast-enhanced computed tomography</td>
<td>None (asymptomatic, subcutaneous fat necrosis)</td>
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a conservative approach was adopted. Further recovery was uneventful. No patient required further reconstructive thoracic surgery.

4. Discussion

DSWI following a median sternotomy for cardiac surgery significantly increases morbidity, mortality and cost. In this group of patients, DSWI was defined according to the US Centers of Disease Control (CDC) & Prevention Guidelines: [11] a positive fluid or tissue culture had been obtained from the mediastinum; sternal instability and chest pain were present in all. The patients were referred to the Department of Plastic Surgery once first-line and second-line treatment had failed. The mediastinitis was classified according to the criteria of El Oakley and Wright. In this group, the mediastinitis happened to fall in either class IVA or B (mediastinitis within 6 weeks of operation, all with significant risk factors and one or more failed therapeutic trials).

VAC therapy was initiated following the first debridement and pulsatile jet lavage. Sterile polyurethane foam dressing with a small-pore, non-reticulated structure of 200—1000 μm (White Foam from KCI Medical BV, The Netherlands) was selected where the risk of haemorrhage or right ventricular rupture was a concern. We believe that the smaller pores allow for a stable, definite closure with local tissue. The VAC therapy was continued until the C-reactive protein level had declined to 30—70 mg l⁻¹/C0, and one or more failed therapeutic trials).

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When considering reconstruction, the first question that needs to be answered is: Why choose omentum and not a local or distant muscle flap?

Only two studies comparing the effectiveness of muscle flap and omental flap in the reconstruction of these difficult cases were found. In their study, Lopez-Monjardin et al. [8] found a significant advantage in sepsis control (p < 0.05) in cases where an omental flap rather than a pectoralis muscle flap was used. The postoperative deaths in the pectoralis group could all be attributed to septic shock, whereas this was never the case in the omentum group. A more recent, retrospective study described a significant reduction in length of procedure and postoperative hospitalisation in cases where an omental flap rather than a pectoralis muscle flap was used [7]. Furthermore, significantly fewer early complications and no early or late flap failures or abscesses were found in the omental flap group. The mortality (less than 5%) was accounted for by a single patient with early prosthetic valve endocarditis, which may have preceded the sternal wound complication. In the pectoralis flap group, the mortality was 10.5%.

Saltz et al. [14] take the credit for the first description of harvesting the omentum (as a free flap) endoscopically. In their cases, and other that followed [9], the right gastro-epiploic vessels were then used as vascular pedicle for the anastomosis, the right gastro-epiploic vessels usually being larger than the left [15]. In 1994, Corral et al. presented a case report of the closure of a chest wall defect by means of an endoscopically assisted mobilisation of a bipedicled omental flap [16]. Based on a single, left gastro-epiploic pedicle, Domene et al. were able to reconstruct a large sternal defect with an endoscopically harvested omentum. An earlier attempt at closure of the same defect with a pectoralis muscle had resulted in total flap loss [17]. A similar case, also using an endoscopically harvested omental flap with a left gastro-epiploic pedicle, which was then covered with bilaterally mobilised pectoralis musculocutaneous flaps, presented by Avital et al. [18] is of interest as their patient suffered from methicillin-resistant Staphylococcus aureus (MRSA) infection. They supported the suggestion made earlier made by Yasuura et al. [19] and Milano et al. [7] that the omentum was ideal in the management of severe MRSA mediastinitis. In the latter two series, however, the omentum was not harvested endoscopically, but through a laparotomy. The group of Acarturk et al. reported successful reconstruction of the anterior (sternal) chest wall with an endoscopically harvested, pedicled omental flap in five out of seven cases [20]. In four of these five cases, the omentum was covered with bilateral pectoralis muscle flaps. In two of the seven remaining cases, the omental harvest had to be converted into a laparotomy due to extensive adhesions in one patient and into a free flap in the other after the pedicle became detached during endoscopy.

In all our cases, the first step was to free the omentum from any possible adhesions. Detachment from the transverse colon, which is more easily accomplished from left to right, followed. Epiploic appendices of the transverse colon, when encountered, were carefully separated from the omentum in an effort to reach the relatively bloodless plane of dissection. In one patient, this plane for dissection was obscured due to adhesions from a previous peritonitis following a duodenal ulcer. Regrettably, this resulted in a partial colectomy and temporary diverting colostomy 2 days later, as already mentioned. Das [4], who is quoted in most surgical texts, opined that release from the transverse colon only would lengthen the omentum to reach the sternal angle in 40% of cases. However, although not clearly stated, it is most likely that the omentums in this cadaver study (200 out of a total of 300 cases) were not tunnelled but placed from the exit opening in the abdominal wall on top of the chest and thus, in effect, appeared shorter than in vivo. Detaching the omentum from the stomach, again presuming that the right gastro-epiploic artery was retained, should, according to Das [4], allow the omentum to reach the sternal angle in all cases. Further lengthening is possible with precise knowledge of the five major variants of the vascular arcade in the omentum itself [15]. When the left gastro-epiploic vessels are used as pedicle, as is often the case when the omentum is endoscopically obtained, a mirror image of the original,
partial division patterns of the apron to obtain additional length, as was described by Alday and Goldsmith [21], will be required. In all our cases, sufficient length and bulk was obtained by detaching the omentum from the transverse colon and stomach only, without further omental division.

None of our patients developed any signs or symptoms of intra-abdominal sepsis following flap harvesting. Furthermore, we were unable to find published evidence of a raised incidence of intra-abdominal sepsis following the use of laparoscopically harvested omental flaps. The risk of exposing a second body cavity to sepsis when omentum is harvested, as argued by El Gamel et al. [6] may thus be less of a concern where an endoscopic approach is used. Intra-abdominal calamities may, however, occur: the well-described mortality following a caecal volvulus after lysis of omental adhesions during the raising of the flap for a chest-wall reconstruction [22] and the unfortunate necrosis of a segment of transverse colon in one of our cases (case 2) are examples.

A novel technique for maintaining the spread-out omentum in all cavities and irregularities is to use autologous fibrin glue. In addition, the use of this glue between the meshed skin graft and omentum is advantageous as it prevents shearing strains and resultant graft necrosis, and obviates the need for the compressive dressing normally required for graft immobilisation. It is rapidly prepared and applied, less cumbersome and probably cheaper than the post-skin-graft VAC therapy recently recommended by Ferron et al. [23].

The overall reported incidence of other abdominal complications following omental harvest through a laparotomy has been low, with the most commonly described late complication being herniation. Our first case presented with a small sliding hernia of bowel almost a year after reconstruction. He was the only patient in whom the omental flap was tunnelled subcutaneously. In all our other patients, a transdiaphragmatic route was chosen. Unbeknown to us at the time, a transdiaphragmatic route had also been recommended by Weinzieg and Yetman [24] in an effort to reduce the possibility of a hernia following omental harvesting through a laparotomy. A caveat is to create a transdiaphragmatic tunnel that is too narrow, risking compression of the vascular pedicle. We concur with the finding of Upton et al. [15] that a major concentration of omental fat is found surrounding the gastro-epiploic vessels and it is this part that is tunneled through the diaphragm.

In a further effort to minimise the risk of a sliding hernia, the pedicle is anchored to the thoracic diaphragm with a few tensionless sutures.

In five of our six cases, it was possible to undermine and advance the surrounding skin and some subcutaneous tissue to such an extent that tensionless closure over the omentum could be achieved. On its own, the local tissue was insufficient for a stable, reliable closure. We did not find it necessary, nor would it have been possible in some cases, to cover the omental flap with musculocutaneous flaps, as was done in the one case described by Avital et al. [18] and in four of the five cases mentioned by Acarturk et al. [20] However, as our patients and the one demonstrated by Avital et al. [18] demonstrate local tissue advancement across the omental flap results in a cosmetically far superior appearance when compared with the procedure in which the omental flap is covered by a skin graft alone (Fig. 2).

Direct, tensionless closure by skin advancement flaps does complicate the monitoring of the omental flap position and its viability. Continuous or increased volumes of discoloured lymphatic fluid through the drains or from the wound may signal an omental flap that is necrotic or under duress. We have found portable sonography to be a particularly cost-effective and useful diagnostic and monitoring tool.

In conclusion, we have presented one novel modification and introduced two supporting techniques in the perioperative management of DSWI with an omental flap closure. Finally, from our experience the laparoscopically harvested omental flap can contribute to a successful outcome following DSWI and deserves serious consideration in particularly type IV mediastinitis, regardless of the co-morbidity or previous abdominal surgery, as this series demonstrates.

Acknowledgements

The authors gratefully acknowledge the assistance of Nienke Bruinsma R.N., Research Assistant, Klaas Koster and the staff of the Medical Photography Department, and the enthusiastic encouragement of all the cardiovascular surgeons of the Medical Centre Leeuwarden, without whom it is unlikely this study would have been reported.

References

Omentoplasty has gained widespread use in several surgical fields, becoming a standard procedure and showing optimal results, mainly due to the abundance of viable tissue and excellent vascularisation. The anatomical, physiological and immunological properties of the omental flap make it an excellent reconstructive technique in thoracic surgery, ideally suited for high-risk and complex clinical situations. The omentum is an invaluable tool in the management of several wound infections when other options have failed or are insufficient. Moreover, the omental transposition does not have the disadvantage of producing chest-wall deformities and impairing the muscle function as seen with the use of major muscles flaps. It can also be used with prophylactic intent in thoracic surgery to reinforce the bronchial stump to reduce postpneumonectomy bronchopleural fistula rate for patients considered at high risk for bronchial stump dehiscence.

However, omental flap transposition has the disadvantage of extending the thoracic operation into the abdomen. This aspect has partially limited its acceptance by patients and, especially, its preference among surgeons due to the concern of opening and exposing a second body cavity with resultant spreading of infection, and potentially related additional abdominal and respiratory complications. Therefore, one-stage omentoplasty using such omental multifunctions as hose action, angiogenesis, sucker action and the immune reaction has been found to have clinical significance in the management of several complex thoracic surgical problems: empyema and its complications, deep sternal wound infection after cardiovascular surgery. Ann Surg 1998;227:455–9.


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