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CLINICAL ARTICLE

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Superior epigastric artery perforator flap for reconstruction of deep sternal wound infection

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Abstract

Background: The treatment of deep wound sternal infection requires loco-regional pedicled flaps, usually with muscular flaps. Perforator propeller flaps represent the ultimate progress in the history of reconstructive surgery. We report here our experience with the superior epigastric artery perforator (SEAP) flaps to repair sternal defect.

Patients and methods: Six patients presenting deep sternal wounds infection were treated with SEAP propeller flap, between March 2015 and June 2017. The mean age was 71.5 (range 53–83) years. The mean length and width of the defect were 16.2 × 7 cm (ranging 8–20 × 4–10). An elliptical skin flap pedicled on the SEAP was harvested in the inframammary fold and rotated up to 90° to cover the defect.

Results: All SEAP flaps achieved a successful entire coverage of the defect. The mean size of the skin paddle of the flap was 20.2 × 7.3 cm (ranging 14–27 × 6–9). All flaps were able to provide a complete sternal wound cover. Venous congestion was present in five cases and adequately treated by leech therapy; necrosis was distal in one case, and interesting the entire superficial flap in two cases but with deep tissues remaining viable and able to cover the mediastinum: an infected flap required revision. Satisfyingly, at 2-years postoperative follow-up all-patients were alive with a successful mediastinal cover.

Conclusions: The SEAP Perforator propeller flap is an alternative to muscle flaps to achieve treatment of deep and large sternal wound infection.

1 | INTRODUCTION

Patients who undergo cardiac surgery often suffer from several comorbidities, often leading to multiple postoperative complications. Mediastinitis is a common complication after cardiac surgery, occurring approximately in up to 3.4% of patients (Goh, 2017), and a life-threatening complication with a mortality rate up to 16% (Aliu et al., 2014). In a few cases, after surgical revisions with aggressive debridement, a deep sternal wound dehiscence requires a proper reconstruction. Classical local or locoregional flaps such as pectoralis major muscle, rectus abdominis muscle, latissimus dorsi muscle, or omentum can be used (Jurkiewicz et al., 1980). These flaps are quickly harvested, but are associated with subsequent donor site morbidities. In this context, propeller perforator flaps (PPF) represent the ultimate progress in the history of reconstructive surgery. Indeed, they provide a highly reliable reconstructive method, with two options regarding the anterior thoracic wall reconstruction: the internal mammary artery perforator (IMAP) (Kannan, 2016) and the superior epigastric artery perforator (SEAP) flaps (Eburdery et al., 2016). Their main advantage is to be harvested quickly, as compared with free flaps (procedure duration), along with low donor site morbidity as compared with the muscular flaps (functional sequelae). Moreover, the IMAP flap is not feasible after coronary artery bypass graft (CABG), when the entire length of both internal mammary vessels had been harvested: thus, the SEAP flap remains feasible, due to the retrograde superior epigastric vessels flow. It has now been proved that muscle flaps do not provide any additional benefit in the treatment of underlying infections, as compared with perforator flap (Buono et al., 2018; Hong et al., 2017; Thiessen et al., 2011), and create more donor site morbidity. However, perforator flap after sternal wound infection is still used to superficial defect (Watanabe et al., 2020).

Herein, we report one of the largest series of SEAP flaps for deep sternal wound coverage. We describe the flap harvesting, the postoperative outcomes and the patient's management. In this series, perforator flaps were used with success whatever the surface and the deepest of the sternal wound.

2 | PATIENTS AND METHODS

We report our experience with six patients who underwent prior reconstruction with SEAP flaps, between March 2015 and June 2017 in our department of Plastic and Reconstructive Surgery. This study was performed in accordance with the principles of the Declaration of Helsinki (1964) and in agreement with the French Bioethics Laws of July 7, 2011.

The mean age of the patients was 71.5 (range 53–83) years with a mean body mass index at 27.7 (range 21.1–40.1) kg/m^2. There were three male and three female patients. The initial cardiac procedure was a coronary artery bypass grafting (CABG) (n = 1), aortic valve replacement (n = 3) and a combined aortic valve replacement—CABG (n = 2). The preoperative American Society of Anesthesiologists (ASA) score was 3 (n = 4) and 4 (n = 2). The mean length and width of the defect were 16.2 (range 8–20) x 7 (range 4–10) cm (Table 1).

2.1 | Surgical techniques

The procedure was performed under general anesthesia, and in a supine position. Perforator vessels were identified vertically with an 8-MHz acoustic handheld Doppler (Hadeco ES 100 VX) (Chaput et al., 2015), on each side above the rectus muscle near the defect to choose the best perforating vessels. Preoperative design was based on the location of these perforators (as a propeller perforator mapping) and adapted perioperatively. We created an elliptical skin flap allowing primary closure of the donor site, oriented in the direction of the perforasome (Saint-Cyr et al., 2009) and the inframammary fold.

The surgery was divided in three steps: firstly, flap harvesting; secondly, deep sternal wound debridement; and finally, flap rotation and defect closure. This three stages approach allowed made finding an adequate perforating vessel near the defect, able to supply a skin paddle large enough to cover the defect. If the vessel did not appear sufficient on one side it allowed to approach to other side, without increasing the scar morbidity. If there were no vessels, this made possible to quickly change the reconstruction option during surgery, and harvest a traditional muscle flap before proceeding to wound debridement.

Firstly, we performed a medial vertical small incision to search the previously detected perforators, dissected under loupe magnification (x3.5). If the vessels were not found or their caliber was too small, a common feature in this population with polyarterial diseases, the dissection was pursued on the other side, through the same incision. When the SEAP vessels were found and selected, perforators were dissected under the fascia and skeletonized. Thereafter, the distance between the main vessel and the end of the loss of substance was measured, as well as the width of the defect. These dimensions were reported in the infra-mammary fold, to draw the width and length of the flap. Finally, the skin ellipse incised and the flap elevated. The perforator vessels dissection was pursued intra-muscularly, in order to achieve an optimal flap mobility while minimizing tension on the pedicle. The sternal wound debridement was only performed after making sure that the flap could cover the entire defect. Classically, we performed an aggressive debridement, with multiple bone sampling in order to provide an adequate antibiogram and adapt the infectious treatment. Antibiotics were started immediately right after bone sampling. All exposed bone was removed, as well as any bone still appearing infected until observing a macroscopically healthy bone. An abundant irrigation of the wound was then carried out, with betadine followed by normal saline (3 L at least). Finally, the flap was carefully rotated at 90 degrees to cover the defect, and attached with weak tighten (Chaput et al., 2016) Skoog interrupted sutures (3/0 Ethilon, Ethicon, Inc.), over suction drains. The donor site was closed primarily in three planes with interrupted absorbable sutures (Polysorb 2; Covidien; and Monocryl 3/0; Ethicon, Inc.) and a running suture (Monocryl 4/0) or staples.

In the postoperative course, patients were monitored hourly on the first 2 days, then three times a day until the end of the first week. The skin flap was checked on the following elements: color, heat, skin flexibility. Drains were removed when collecting less than 20 ml/24 h. Initial antibiotic treatment was adapted on the samples culture. All patients wore compression stockings and received subcutaneous low-molecular weight heparin for 15 days after surgery to prevent phlebitis.

3 | RESULTS

The mean size of the skin paddle was 20.2 (range 14–27) × 7.3 (range 6–9) cm. The overall mean operative time was 134.5 (range 116–152) min for the three steps procedure. All SEAP flaps achieved a successful entire coverage of the defect at a short and long term (mean follow up 49.8 months).

As expected, and classically described in propeller flaps venous congestion was often encountered and adequately treated by leech therapy. After the therapy, a distal partial necrosis occurred

TABLE 1 General patient data

Patient	Age	Gender	BMI	Tobacco status	Original procedure	comorbidities	ASA	Defect size (in cm)	Flap skin paddle size (in cm)	Operative time	Flap related complications	Overall outcome	Follow up (months)
1	70	M	27.0	weaned tobacco	ARV	HBP, IHD,COB	3	20 × 6	27 × 8		Venous congestion, leech therapy	Healed wound, Alive	66
2	78	F	40.1	active consumption	ARV	HBP, circulatory arrest, arrhythmias, smoking	4	17 × 10	24 × 9	152	No	Healed wound, Alive	56
3	74	M	28.7	nonsmoker	ARV	HBP, IHD	3	16 × 10	18 × 8		No	Recurrent infection at 9 months, healed wound after reoperation, Alive	51
4	83	F	23.6	nonsmoker	CABG	IHD,obliterative arterial disease, immunosupression	4	16 × 6	22 × 7	116	Venous congestion, leech therapy, partial distal necrosis	Healed wound, Alive	45
5	53	F	21.1	nonsmoker	CABG+ARV	HBP, IDH, obliterative arterial disease	3	8 × 4	14 × 6	140	Venous congestion, leech therapy, superficial skin layer necrosis	Healed wound, Alive	42
6	71	M	26.1	nonsmoker	CABG+ARV	obliterative arterial disease	3	20 × 6	16 × 6	130	Venous congestion, leech therapy, superficial skin layer necrosis	Healed wound, Alive	39

Abbreviations: ARV, aortic valve replacement; CABG, coronary artery bypass graft; COB, chronic obstructive bronchopathy; DM, diabetes mellitus; HBP, hight blood pressure; IHD, ischemic heart disease.

in one case and was treated by a V–Y wound closure: in two cases, the superficial flap layer necrosis was extensive, however preserving the deep layers to successfully cover the sternal wound. In the latest case, superficial flap healing was achieved with Algostéril® dressings (Brothier, Nanterre). A recurrent infection with a cutaneous fistula occurred in one patient, at nine postoperative months. The patient was re-operated with re-elevation of the lateral haft of the flap for perform a total sternum bone ablation to allow disease-control and wound healing. The mean hospital stay after flap coverage was 33.8 (range 17–53) days. At 2-years postoperative follow-up, the six remaining patients were alive with a successful mediastinal cover.

4 | CASE REPORTS

4.1 | Case 1

A 74-year old man with history of aortic valvular replacement, complicated with mediastinitis and deep sternal wound infection. The sternal wound defect was 16 × 10 cm. Before starting the surgery, we performed a preoperative mapping of all perforators possibly available for the reconstruction (crosses), then we perform a preoperative SEAP flap marking to be adapted intraoperatively (Figure 1a). We subsequently harvested a 18 × 8 cm SEAP flap (Figure 1b). This flap was rotated at 90° to close the defect (Figure 1c). In the early postoperative course, no complication occurred, and the wound was successful covered (Figure 1d). The patient was discharged at day 18. Thereafter at nine postoperative months, the patient presented a bone infection associated with a cutaneous fistula on the edge of the flap, requiring a new bone debridement. This patient is presently alive and healed at 51 months follow up.

4.2 | Case 2

A 79 old year man with history of aortic valvular replacement, complicated by mediastinitis and deep sternal wound infection. The sternal defect was 20 × 6 cm and a 27 × 8 cm SEAP flap was harvested. We performed pre-operative SEAP flap markings with mapped perforating vessels (Figure 2a, crosses). We individualized and skeletonized two perforator vessels (Figure 2c). In the postoperative course, the flap was complicated with venous return problem, successfully treated by leeching therapy. The patient was discharged at home at day 35, and presently alive and its sternal region covered at 66 months follow up (Figure 2d).

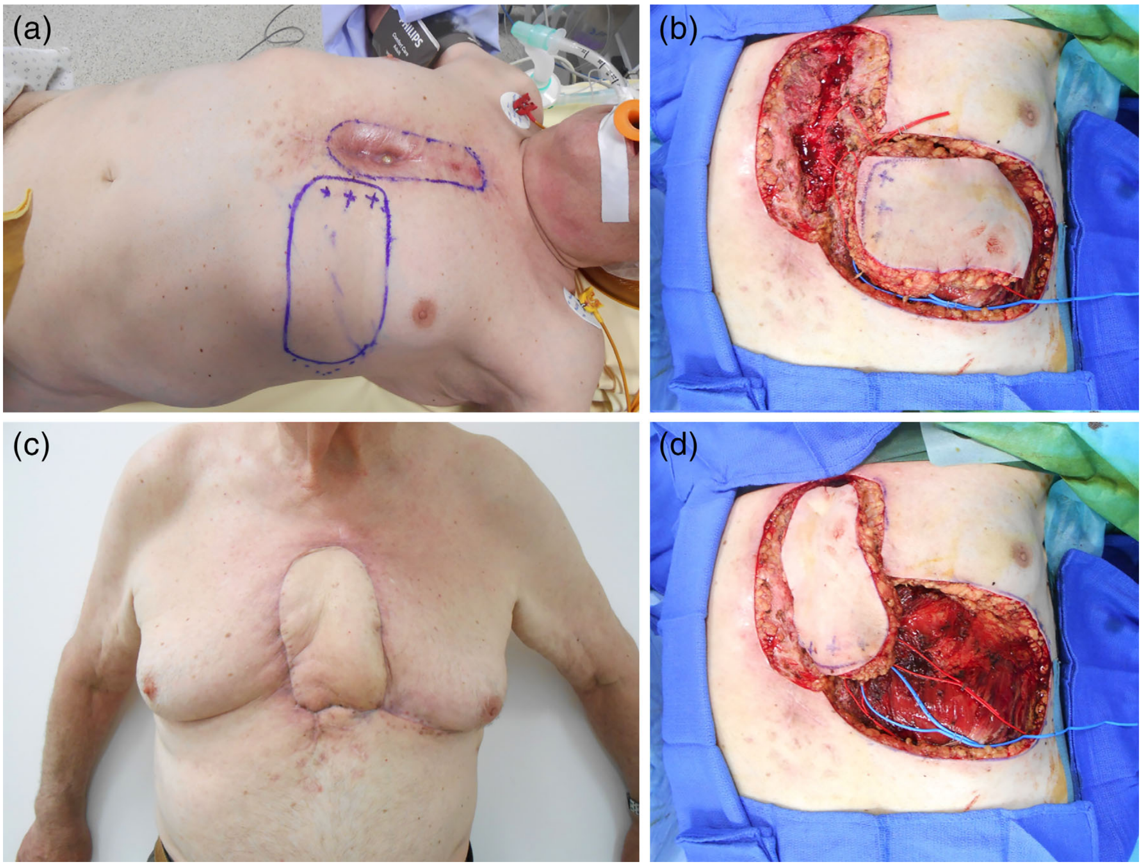

FIGURE 1 (a) Preoperative SEAP flap markings with mapped perforating vessels. (b) Intraoperative view after debridement. (c) Intraoperative view after flap rotation at 90°. (d) Postoperative view at 2 months

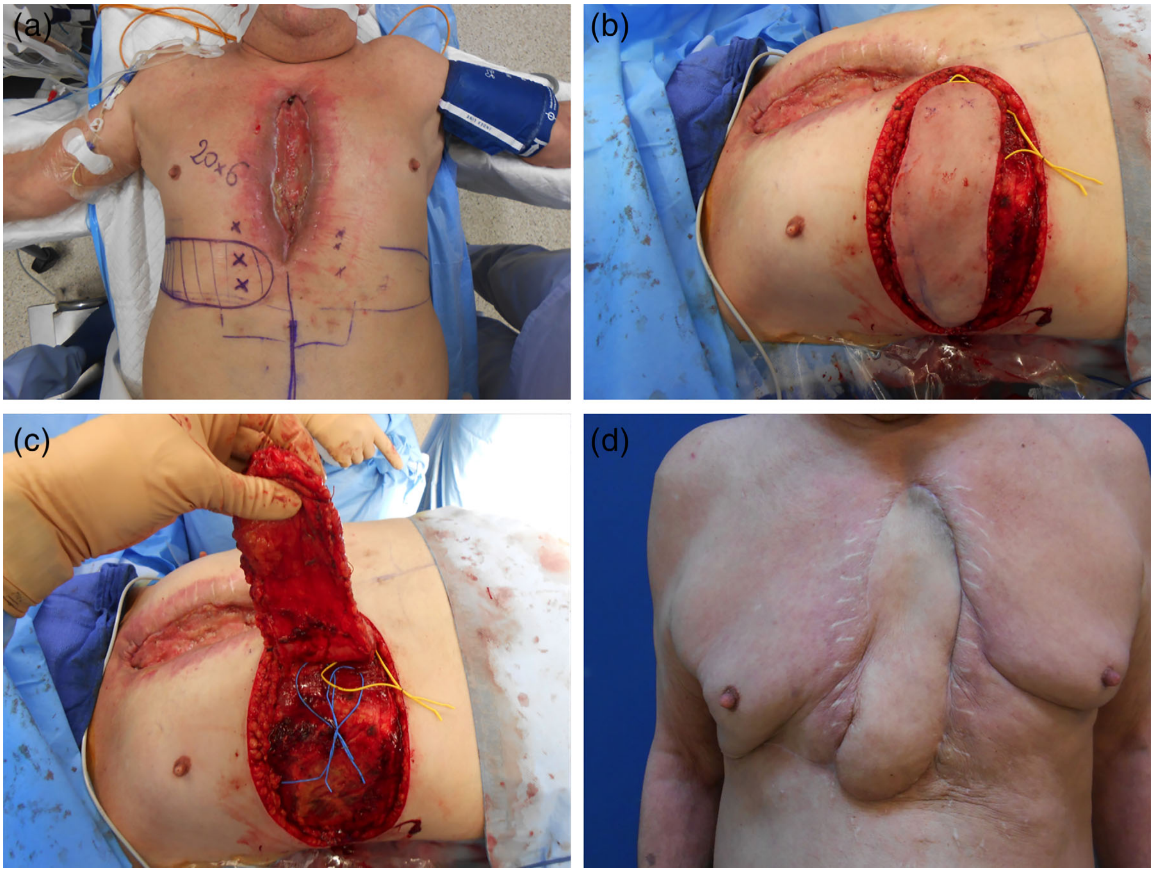

FIGURE 2 (a) Preoperative SEAP flap markings with mapped perforating vessels. (b) Intraoperative view of flap harvesting (c) Intraoperative view of the perforating vessels. (d) Postoperative view at 12 months

5 | DISCUSSION

Deep sternal wound infections and mediastinitis are serious complications following cardiac surgery, representing a true surgical challenge. In rare cases, and despite initial surgical debridement and antibiotics, reconstructive surgery is mandatory to achieve deep sternal wound coverage. Before the advent of perforator flaps, local muscular flaps such as pectoralis major and rectus abdominis flaps, or locoregional flaps like latissimus dorsi flap, were routinely used, however associated with donor site morbidity (Zahiri et al., 2013). Omentum flaps were also used, associated with poor cosmetic results and major risk of eventration (Kolbenschlag et al., 2018). Perforator flaps thus offer new tools in the reconstructive armada, among which the propeller flaps represent a refinement (Pignatti et al., 2011). These flaps achieve a robust reconstruction, with well-vascularized tissues and can address large tissue defects: they then offer a great flexibility and plasticity close to the defect, as well as a direct closure of donor site without any muscular sequalae.

Our study shows that this flap can achieve a complete mediastinal coverage, regardless of any type of previous cardiac surgery (even CABG), unlike IMAP propeller flaps that are no longer feasible when both mammary arteries have been removed (4 of our 7 patients). Unlike other teams which reserve perforator flap to superficial wound, we demonstrated that this flap can achieve coverage of deep and large sternal wound (Watanabe et al., 2020).

We achieved a 100% success rate in the coverage of our patients, making SEAP flaps a first option to seriously consider, knowing that it totally spares the muscles thus available as a second option. However, we highlighted that the postoperative management is very delicate, with a significant complication rate (71.4%), fully addressable in a skilled environment: we do recommend a close monitoring of the flap by a well-trained plastic surgery team involving a specialized and dedicated nurse care. The venous congestion is the main postoperative feature, and probably higher than in other perforator propeller flaps, as the SEAPs perforating vessels caliber is often small, associated with a short length of the pedicle: these anatomical particularities explain a great sensitivity of this flap to a pedicle twist; To limit this phenomenon, the perforating vessels must be dissected as far as possible to reduce the venous twist and subsequent flap congestion. It is also necessary to avoid an excessively tight closure of the flap, to allow a compression-free during the flap's volume increase, maximum at 72 h postoperative time. If still present, the venous congestion can be adequately managed with leech therapy (Herlin et al., 2017). In a previous teams works (Florczak et al., 2018) on PPF for chest wall defect, the SEAP flap had already been associated with a higher complication rate. As previously said, this can rely on intrinsic characteristics of the flap (caliber vessels, length of the pedicle, retrograde vessels flow after CABG), but also on specific characteristics of these patients (arterial disease, smoking status, ASA high score, etc.). In our experience, covering the entire length of the sternum with SEAP flap could favor a venous congestion, especially when greater than 20 cm. Further studies will explore if this limitation is associated with the limit of the venous perforasome (Chaput et al., 2017). Our results are comparable to those from Wettstein et al (2014), using the same flap type on a series of similar patients. Indeed, they also reported 100% coverage success rate, but an overall complication rate of 55.6% and among them three (33.3%) partial flap necrosis. Eburdery et al (2016) reported a venous congestion in one of four patients treated with SEAP flap, resolving after leech therapy. As in our experience, it is interesting to highlight that the venous congestion appeared when the flap 's length was above 20 cm. Moreover, in 1 patient a pectoralis major flap was required to complete the cover of the upper third of the sternum, in order to limit the SEAP length. Besides, Wettstein et al did not specify the length of theirs flaps in the manuscript.

The alternative PPF to cover sternal wounds defect is the IMAP propeller flap: Kannan et al (Kannan, 2016) reported four patients covered by this flap, with two patients presenting partial necrosis. The IMAP flaps were used in a propeller fashion to treat superficial defect, but they preferred musculo-cutaneous IMAP flap to cover deeper mediastinal defects. It should be noted that the authors selected their cases to perform IMAP flaps, according to the initial cardiac surgery. The IMAP flap is equivalent to the SEAP flap in term of cover capacity, as well as regarding the morbidity, but is not feasible in all-patients especially after those after CABG.

Moreover, it is important to mention that these PPF are pedicled flaps close to the defect, these techniques achieve closure in supine position and avoid two operating stages unlike other flaps such as latissimus dorsi.

Even if demonstrative and representing one the largest series, this monocenter study remains limited by the small number of patients included. One should keep in mind that such population of patients remains rare nowadays, even with a high number of patients in cardiac surgery departments. It is currently difficult to compare extensively SEAP and IMAP flaps, considering the lack of randomized studies and in view of the few cases reported. Future meta-analytic studies are required to resolve this issue. However, since SEAP can be performed in all-patients, unlike IMAP, it became our preference as first line of treatment in this population. It would be interesting in future studies to compare with the conventional muscle flaps.

6 | CONCLUSION

The SEAP Perforator propeller flap represents a serious alternative to conventional muscle flaps, in order to achieve deep sternal wound infections treatment. These flaps allowed to cover all types of post cardiac surgery sternal wound even deep and large wound. Postoperative complications were easily managed in a plastic surgery department. PPF increase the reconstructive possibilities of these complex patients, and could be proposed as a reliable first option, allowing to keep the muscle flaps as other possibilities in case of failure: it will then open new possibilities in cardiac and thoracic reconstruction.

CONFLICT OF INTEREST

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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