ALGORITHMIC APPROACH TO LOWER ABDOMINAL, PERINEAL, AND GROIN RECONSTRUCTION USING ANTEROLATERAL THIGH FLAPS

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Lower abdominal, perineal, and groin (LAPG) reconstruction may be performed in a single stage. Anterolateral thigh (ALT) flaps are preferred here and taken as fasciocutaneous (ALT-FC), myocutaneous (ALT-MC), or vastus lateralis myocutaneous (VL-MC) flaps. We aim to present the results of reconstruction from a series of patients and guide flap selection with an algorithmic approach to LAPG reconstruction that optimizes outcomes and minimizes morbidity. Lower abdomen, groin, perineum, vulva, vagina, scrotum, and bladder wounds reconstructed in 22 patients using ALT flaps between 2000 and 2013 were retrospectively studied. Five ALT-FC, eight ALT-MC, and nine VL-MC flaps were performed. All flaps survived. Venous congestion occurred in three VL-MC flaps from mechanical cause. Wound infection occurred in six cases. Urinary leak occurred in three cases of bladder reconstruction. One patient died from congestive heart failure. The ALT flap is time tested and dependably addresses most LAPG defects; flap variations are suited for niche defects. We propose a novel algorithm to guide reconstructive decision-making. © 2014 Wiley Periodicals, Inc. Microsurgery 36:104–114, 2016.

Lower abdominal, perineal, and groin (LAPG) soft tissue defects pose a reconstructive challenge. The plastic surgeon may be confronted by infection, persistent sinuses, fistulae, irradiated tissue, involvement of surrounding organs, and overall poor patient health.[1–6] Successful LAPG reconstruction will protect internal organs, such as the bladder and intestine, and allow for core strength, fertility, urination, and defecation.[7,8] At one time, all such wounds were treated with dressing changes with or without late reconstruction, but primary fascial closure has become today's standard.[9] The ideal reconstruction is aesthetic and functional, and may not be achieved easily. Fortunately, the surgical armamentarium is rich with options from secondary healing to free tissue transfer. When a plastic surgeon is called to reconstruct an extensive LAPG defect, pedicled flaps are generally favored.[8,10,11]

Descriptions of LAPG reconstruction using abdominal, thigh, and gluteal tissue are widely available.[12–16] More recently, a flow-through anterolateral thigh flap (ALT) for sacrectomy reconstruction[17] and pedicled superficial femoral artery perforator flap[18] and have been described. Perforator flaps are gaining popularity. Though technically demanding, they confer decreased donor site morbidity and increased pedicle length.[19–21] Because of this, widespread adoption of perforator flaps put into question whether fasciocutaneous and myocutaneous flaps are passé.[22] However, there was no answer in the literature. In our practice, we generally rely on pedicled ALT flaps for the management of LAPG defects.

The lateral circumflex femoral artery is sizeable with a wide arc of rotation. Flaps based on this pedicle can extend to 8 cm above the umbilicus, the posterior superior iliac spine, ipsilateral groin, perineum, anus, contralateral groin, lower abdomen, and ipsilateral trochanter.[23] ALT flaps may contain muscle, fascia, skin, and any combination of these. Cosmetic and functional deficits in the ALT region after tissue transfer are generally well tolerated.[23–29] All these characteristics make the pedicled ALT flap ideal for lower abdominal, groin, and pelvic floor reconstruction.[30,31]

An algorithm for flap selection in LAPG reconstruction does not exist in the literature. In this report, we aim to present the results of reconstruction from a series of patients and guide flap selection with an algorithmic approach to LAPG reconstruction that optimizes outcomes and minimizes morbidity.

PATIENTS AND METHODS

Between April 2000 and September 2013, pedicled flaps harvested from the ALT region were used for complex LAPG reconstruction at Chang Gung Memorial Hospital. Procedures followed were in accord with the Helsinki Declaration of 1975. 22 consecutive LAPG defects in 22 patients were reconstructed with ALT flaps (Table 1). Twelve men and ten women with an average age of 44.9 years (range: 16–72) were studied. Etiology included infection ($n = 11$), high energy trauma ($n = 7$), and tumor ablation ($n = 2$). Lesions were located in the

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Table 1. Patients' Information

Age/sex	Cause of defect	Associated injury	Wound location	Full thickness	Defect size (cm)	Flap size (cm)	Type of flap	Donor site	Complications	Additional surgery	Eventual outcome
16/M	MVA	Colonic perforation	Lower abdomen	Y	30 × 30	30 × 12	VL-MC	STSG	Wound infection	Serial debridement	Success
51/F	MVA	Small bowel perforation Fem. artery and vein rupture	Lower abdomen	N	15 × 7	17 × 8	ALT-MC	Closure			Success
54/M	MVA	Rectal perforation	Lower abdomen	Y	20 × 6	22 × 8	VL-MC	Closure	Venous congestion	Evacuate hematoma	Success
		Bladder rupture							Urine leak	Bladder revision × 2	Self-voiding
32/M	MVA	Rectal perforation	Groin	Y	30 × 20	26 × 14	VL-MC	STSG	Urine leak	Bladder revision	Urethral stricture
24/F	MVA		Vagina	N	15 × 5	15 × 5	ALT-FC	Closure			Expired—heart failure
62/F	NSTI		Groin	N	30 × 8	28 × 9	ALT-MC	STSG			Success
27/F	MVA	Bladder rupture	Groin	Y	32 × 20	34 × 16	VL-MC	STSG	Venous congestion	Pedicle torsion release	Success
		Rectal perforation	Perineum						Urine leak	Bladder revision × 5	Self-voiding
57/M	NSTI		Scrotum	N	8 × 6	15 × 8	ALT-MC	Closure	Wound infection	Debridement	Success
46/F	NSTI	Femoral nerve exposed EC fistula	Lower abdomen	N	20 × 15	20 × 15	ALT-MC	STSG	Wound infection	Debridement	Success
55/M	NSTI		Groin Scrotum Perineum	N	25 × 15	20 × 10	ALT-MC	Closure			Success
24/M	Crush injury	Rectal perforation	Lower abdomen	Y	A: 7 × 6	39 × 10	VL-MC	Closure	Wound infection	Serial debridement	Success
		Urethral injury	Perineum		P: 6 × 6		2 skin paddles				Cystotomy
63/F	EC fistula	Intraabdominal abscess Radiation enterocolitis	Lower abdomen	Y	24 × 10	24 × 10	VL-MC	Closure			Success
72/F	Crush injury	Pelvic fracture	Groin	N	10 × 6	10 × 6	ALT-FC	Closure			Success
72/M	NSTI		Scrotum Perineum	N	12 × 6	12 × 8	ALT-MC	Closure Closure			Success
41/M	NSTI		Groin	N	22 × 6	22 × 6	VL-MC	Closure			Success
61/F	NSTI		Groin	Y	26 × 11	30 × 11	VL-MC	Closure	Venous congestion	Serial debridement/ STSG	Success
35/F	Paget's disease		Perineum	N	20 × 20	24 × 6	ALT-FC	Shoelace			Success
40/M	NSTI		Scrotum	N	16 × 10	16 × 10	ALT-MC	Closure	Wound infection	Serial debridement	Success
35/M	NSTI		Groin	N	21 × 8	21 × 8	ALT-MC	Closure			Success
60/M	NSTI		Scrotum	N	25 × 11	25 × 11	ALT-MC	Closure	Wound infection	Serial debridement	Success
32/F	MVA	Pelvic fracture	Perineum	Y	25 × 13	25 × 13	VL-MC	STSG	Wound dehiscence	Wound revision	Success
28/F	Desmoid tumor		Lower abdomen	Y	A: 14 × 7	16 × 7	ALT-FC	Closure	Arterial insufficiency	Adventitiectomy	Success
					F: 18 × 15						Success

NSTI: necrotizing soft tissue infection, MVA: motor vehicle accident, EC: enterocutaneous, STSG: split-thickness skin graft, A: abdominal, P: perineal, F: fascia.

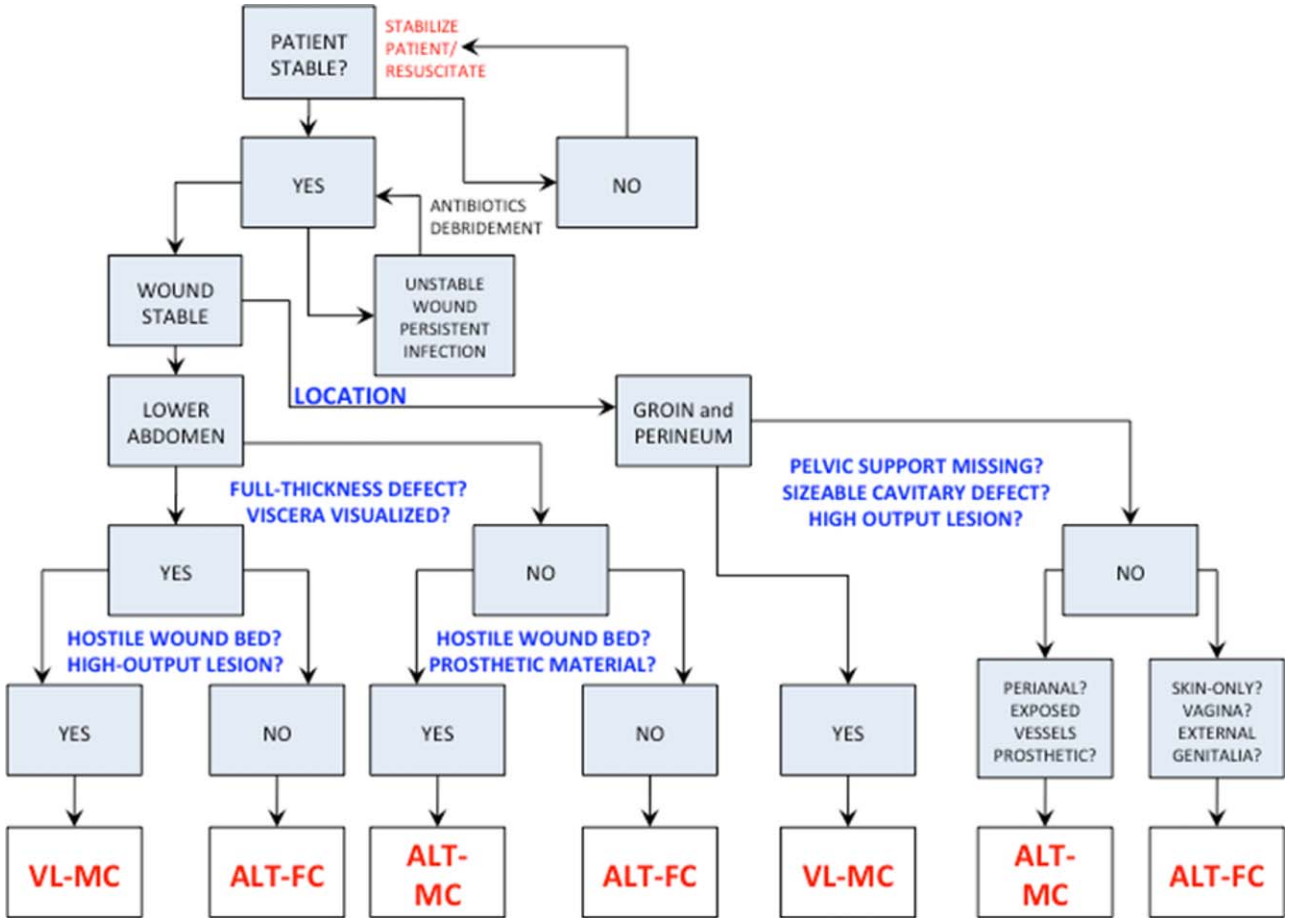

Figure 1. Algorithm for reconstruction.

lower abdomen, groin, perineum, vulva, vagina, scrotum, and bladder. The defects measured 8–32 cm long × 6–30 cm wide.

SURGICAL TECHNIQUE

Elevation of all flaps was performed in the standard fashion, beginning with pedicle identification through the medial incision and traveling proximally.[23–25,31–34] When possible, flaps were transferred under a submuscular tunnel beneath the rectus femoris and sartorius, which might provide 2–3 cm of added pedicle length.

Lower Abdominal Defects

The algorithm is shown in Figure 1. It depicts the steps we followed when confronting LAPG reconstructive challenges and was followed for all patients in this series. Appropriate use of the algorithm entails an accurate preoperative assessment of patient history, concomitant disease, and extent of the soft tissue defect. After the patients and their wounds stabilized, they were candidates for reconstruction. Wounds of the lower abdomen were approached differently than those of the groin and perineum. For abdominal defects, the first consideration was whether the defect was full-thickness; that is to say, whether the viscera was exposed.

If the answer was yes, then the quality of the surrounding tissue and wound environment was considered. A hostile wound bed warranted bulky, obliterative, vascular tissue as was provided by a VL-MC flap (Fig. 2). Conversely, a postextirpative or simple traumatic defect that was not in a hostile environment was managed with an ALT-FC flap, sometimes using the fascia to repair the abdominal wall defect in a tension-free fashion. If the lower abdominal defect was partial thickness without exposed bowel, the quality and hostility of the wound bed was considered, as well as prosthetic material that may be present. Compromised tissue or dysvascular tissue or exposed prosthetic material that could not be removed warranted coverage with healthy vascular tissue. In both situations we used the ALT-MC flap (Fig. 3). In clean and healthy partial thickness wounds not prone to

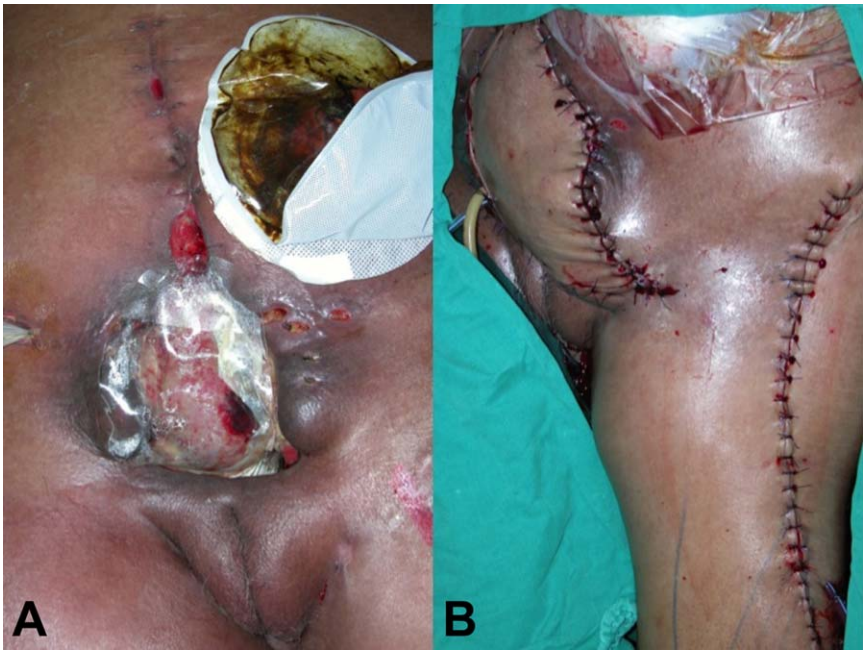

Figure 2. ***A****: A hostile wound bed following radical excision and radiation therapy for cervical cancer with exposed bowel.* ***B****: The defect was treated with a VL-MC flap with a single skin paddle.*

breakdown, the ALT-FC was preferred, minimizing morbidity, and unwieldy and unnecessary bulk.

Perineal and Groin Defects

The first consideration in the management of defects of the perineum and groin was whether pelvic support structures were involved. Conditions associated with loss of pelvic support, a hostile wound bed, and high-output lesions (i.e., urinary leak, enteric fistula) were managed with bulky, vascular tissue. If the defect was not full thickness, a less bulky alternative was used. However, in the setting of a compromised wound bed, exposed vessels, or prosthetic material, a conservative amount of muscle was recruited as an ALT-MC flap. When critical structures were not exposed, such as after tumor ablation or trauma, an ALT-FC flap was chosen. Pliable and

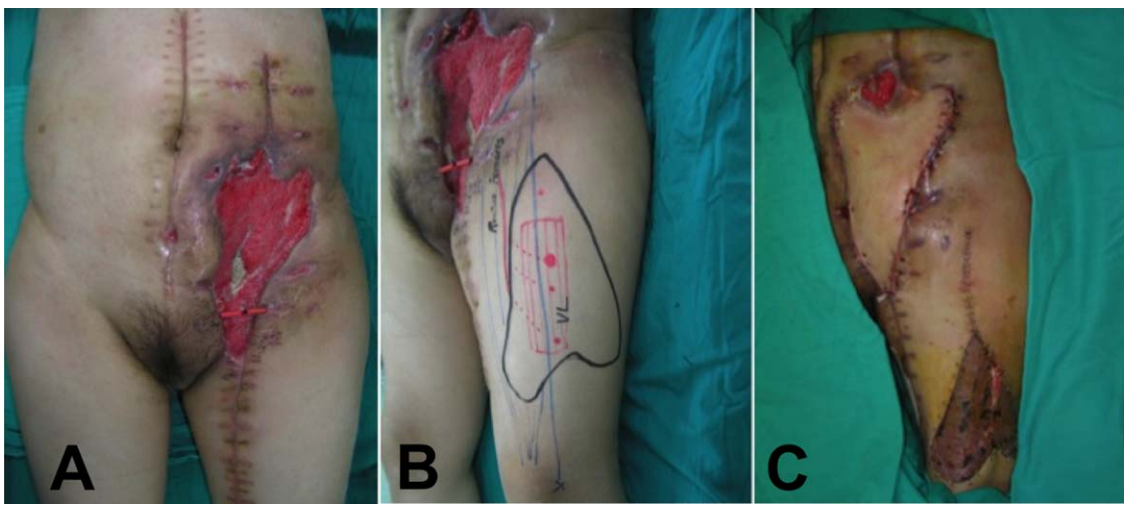

Figure 3. Necrotizing fasciitis defect of the lower abdomen. ***A****: Despite serial debridement, the poorly vascularized wound necessitated coverage. Challenges included an ostomy site at the 12-o'clock position and femoral nerve exposure.* ***B****: The ALT-MC flap was chosen for reconstruction to obliterate the dead space and provide dependable femoral nerve coverage.* ***C****: Two weeks later, the wound healed well.*

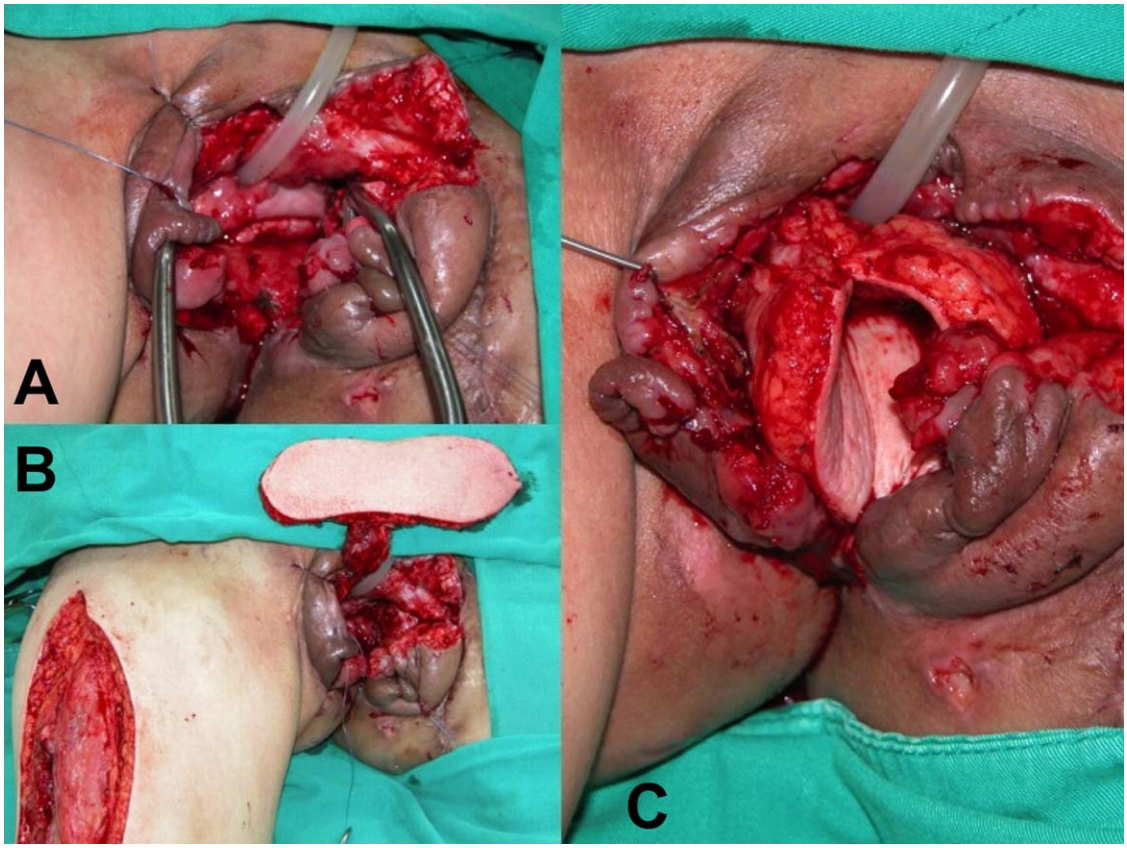

Figure 4. ***A****: Bilateral pubic ramus fracture with perineal crush injury and total vaginal defect.* ***B****: A neovagina was crafted from a thin pedicled ALT-FC flap.* ***C****: It was easily folded and inset.*

wieldy, the ALT-FC was also the preferred flap for genital reconstruction (Fig. 4).

RESULTS

The defects were reconstructed with a pedicled ALT-FC flap in five cases, ALT-MC flap in eight cases, and VL-MC flap in nine cases. The dimensions of flaps ranged from 10 to 39 cm long × 5–16 cm wide. All flaps survived and served their purpose with a minimum follow-up of 6 months (range 6 months–3 years) in patients who survived the perioperative period. One patient succumbed in the perioperative period to congestive heart failure that was not attributable to the index operation. Venous congestion was observed in three VL-MC flaps (33.3%): two were attributed to hematoma formation, and one to pedicle torsion. The hematomas formed in the setting of penrose and closed suction drains, and required takeback and washout without an identifiable source. The kinked pedicle responded to re-exploration and repositioning, and there was no need for additional revision and all three healed well. Wound infection was observed in six high-risk cases (27.3%), five of which were treated with myocutaneous flaps. Three of the six cases were for Fournier's gangrene defects that resolved with additional surgical debridement. Two had colorectal perforations as associated injuries, and one had a pre-existing enteroatmospheric fistula. All infected wounds ultimately healed with debridement, when indicated, and antibiosis. All three cases involving bladder wall reconstruction had some degree of urinary leak; spontaneous voiding was ultimately achieved in two patients after revisionary bladder wall repair.

CASE REPORTS

Case 1

A 28-year-old woman had a right lower quadrant desmoid tumor removed with wide local resection. The resultant full-thickness defect measured 14 × 7 cm at the level of skin and 18 × 15 cm at the level of fascia. The wound bed was nonirradiated and nonhostile. A 16 × 7 cm right-sided fasciocutaneous ALT was harvested with a large fascia lata component and the donor site was closed primarily (Fig. 5A). Contralateral separation of components was not performed and the flap was inset

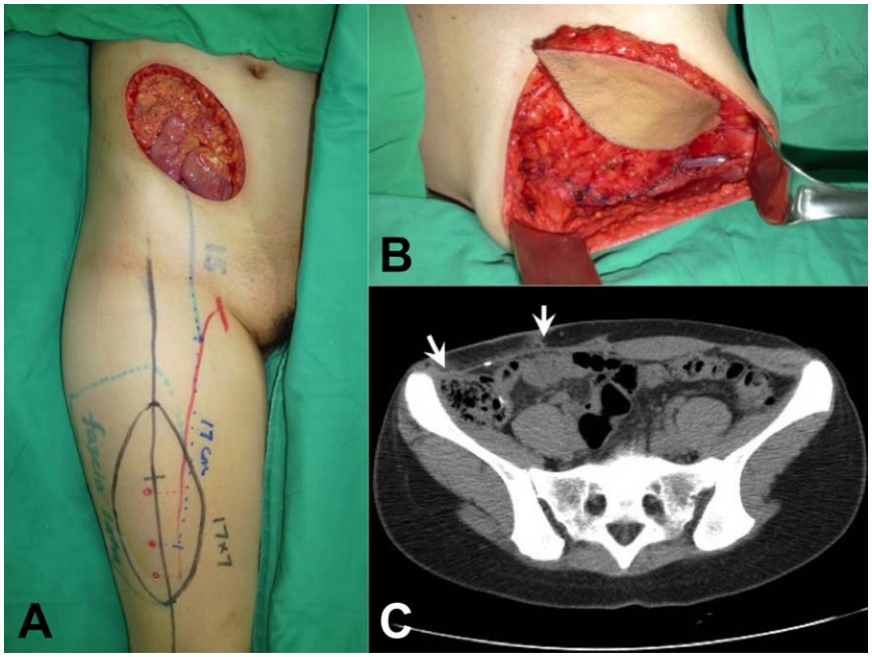

*Figure 5. Case 1. **A**: Full-thickness defect and ALT-FC flap design. **B**: A large fascia lata component was included and inset using permanent sutures. **C**: Postoperative CT revealed excellent integration of the fascia component into the native abdominal wall (*arrows*). No bulge or hernia was noted 6 months after surgery.*

with permanent sutures (Fig. 5B). Immediately after surgery, arterial insufficiency was noted, and the patient was taken back for exploration where arteriospasm was observed. Adventitiectomy and re-inset led to complete flap survival and no bulge was seen at 6 month follow up (Fig. 5C).

Case 2

A 35-year-old male patient suffered from traffic accident injury that resulted in an open pelvic fracture and a through-and-through soft tissue defect including a 7 × 6 cm suprapubic wound and 6 × 6 cm perineal wound (Figs. 6A and 6B). There was exposed internal hardware. After the patient stabilized, a single 39 × 10 cm vastus lateralis myocutaneous flap with two skin paddles was designed to close both wounds and obliterate the dead space (Figs. 6C and 6D). The proximal skin paddle was used to close the suprapubic wound while the distal skin paddle was used to close the perineal wound. The remaining bulk obliterated the dead space and insulated the deep hardware. Early in the postoperative course a hematoma formed requiring operative drainage; the flap survived. At 12 months follow-up, the wounds were healed without further incident (Figs. 6E and 6F).

Case 3

A thin 55-year-old male diabetic and alcoholic was diagnosed with Fournier's gangrene of his perineum and scrotum (Fig. 7A). The infection was managed with broad-spectrum antibiotics and serial debridement, and the patient was then referred to our clinic for consultation after he and his wound stabilized. On presentation, the patient had a 20 × 10 cm complex perineoscrotal wound close to the anus. He was not fecally diverted. A 20 × 10 cm ALT-MC flap was harvested for wound coverage and scrotal reconstruction, with the muscle cuff being used to line the complex topography of the perineal region and the thin fasciocutaneous component to reconstruct the scrotum. The flap survived without any complication, and follow-up at 2.5 months revealed good cosmesis (Fig. 7B).

DISCUSSION

The free ALT described by Song has become widely popular.[31,32] Its pedicled analog is a dependable workhorse for LAPG reconstruction.[26,27,30] Advantages of the pedicled ALT flap include long reach, ease of dissection, and potential for sensory reinnervation (though we did not routinely do this).[28,35] Additionally, donor tissue tends to be uninvolved with infected and irradiated patients and no microsurgical technique is required in the reconstruction.[36] Although many strategies designed to address perineal defects including medial[37] and posterior thigh and gluteal flaps,[38–42] pudendal thigh flaps,[43] musculocutaneous gracilis flaps,[44,45] and abdominal-based flaps[46,47] exist, these alternatives either require position change, cannot provide necessary bulk, or further

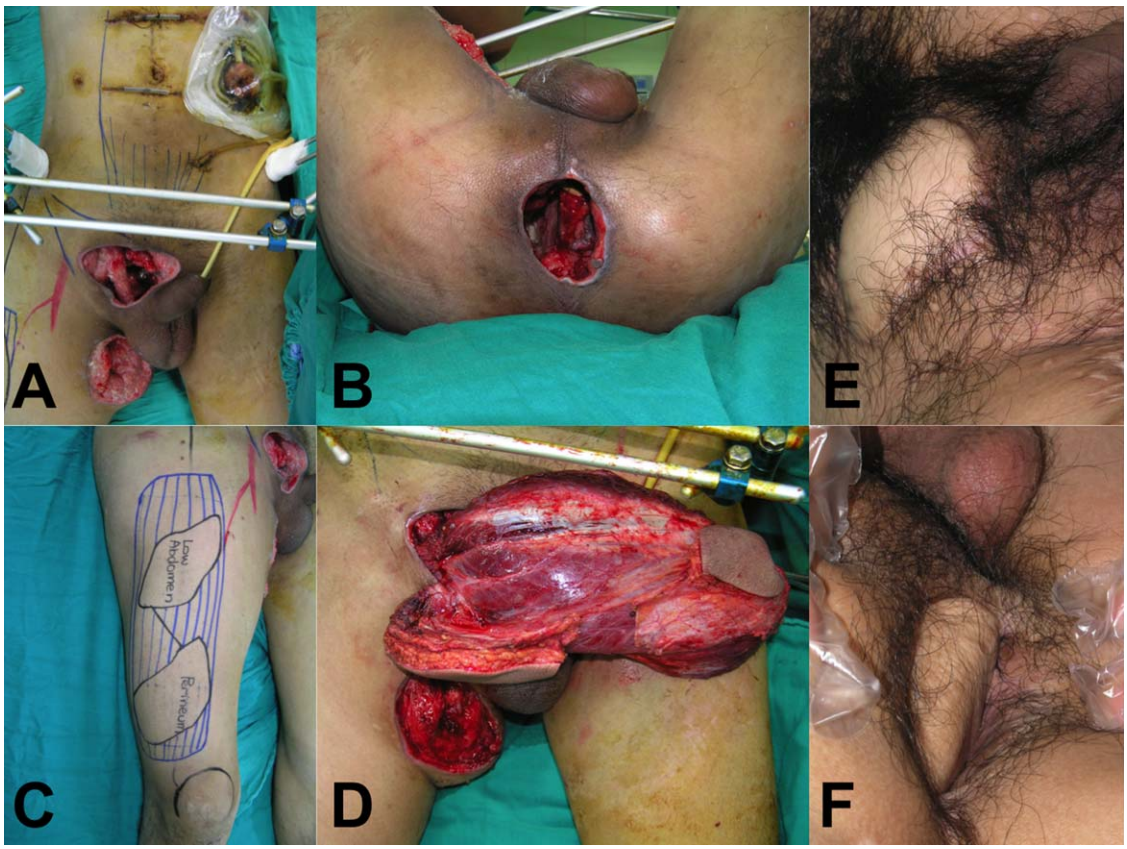

*Figure 6. Case 2. Lower abdominal and perineal full thickness defects (*upper left, upper middle*) was managed using a VL-MC with two skin paddles (*bottom left*). The large flap was used to obliterate dead space and easily inset (*lower middle*). One year later, the lower abdominal (*upper right*) and perineal (*lower right*) wounds healed completely and without hernia.*

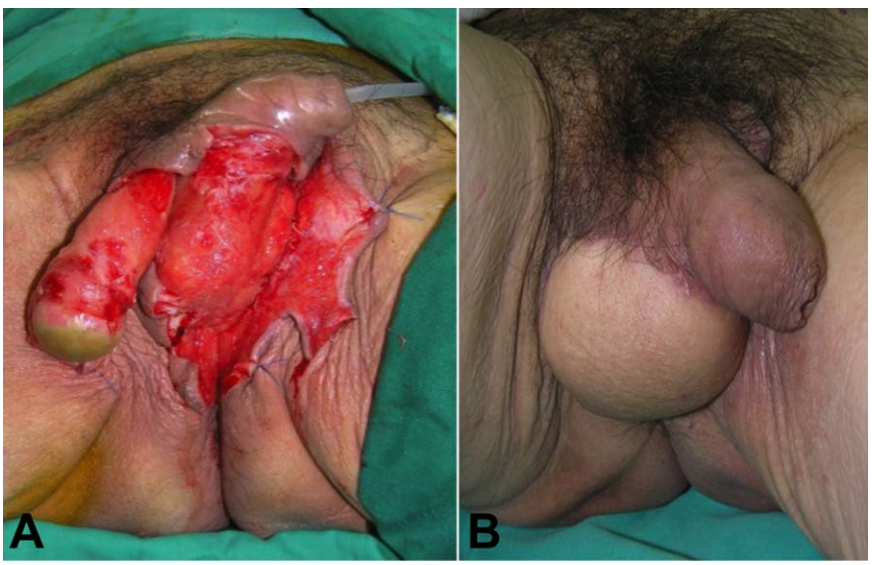

Figure 7. Case 3. ***A****: Defect following Fournier's gangrene debridement. For perineal defects near the contamination-prone anus, a conservative amount of muscle was recruited as a barrier. The ALT-MC flap was used, as the small muscle component protected perforators and resurfaced irregular wound beds with ease.* ***B****: The result at 3 months.*

challenge otherwise compromised abdominal domain. Perhaps more importantly, we lack the vast collective experience that we have with ALT flap harvest to include these alternatives in an algorithm that has worked so well for us.

We consider "ALT flap" to be an umbrella term. At this institution, flaps from the ALT region are further described as: ALT fasciocutaneous (ALT-FC), ALT myocutaneous (ALT-MC), and vastus lateralis myocutaneous (VL-MC) flaps.[32–34,48] Although similar in composition, the ALT-MC and VL-MC flaps have distinct characteristics. The ALT-MC is primarily fasciocutaneous and carries a traditional single skin paddle with an *en bloc* or chimeric muscle component. The VL-MC is a pedicled VL muscle flap with attached skin paddle(s) based on perforating blood vessels.

The skeleton of this algorithm first considers patient stability, then control of infection, and then presence of musculoskeletal compromise. This first tier determines candidacy for surgery and establishes operative goals. Successful reconstruction of full-thickness abdominal wall defects must reestablish structural integrity and protective function.[49] Composite autologous flaps including fascia are ideal for full thickness reconstruction. This contributes to tension-free repair and minimizes risk of recurrent hernia, infection, wound complications, and prolonged hospital stay.[50,51] The next tier of the decision tree accounts for wound condition, location, involved structures and results in a flap choice. The chosen flap should optimize outcomes while minimizing donor site morbidity and unnecessary bulk.

Rohrich et al deemed the VL-MC flap superior to other regional muscular and myocutaneous flaps for pedicle length, skin paddle size, and donor site morbidity for reconstructing composite LAPG defects.[52] We too prefer the VL-MC flap for full thickness lower abdominal wall defects associated with high output lesions, such as enterocutaneous fistula and bladder injury. In these cases, the muscle bulk can be positioned to fit into the abdominal cavity. For other full-thickness lower abdominal wall defects, such as those following extirpative surgery, the ALT-FC flap is adequate. In such cases, the vascular fascial component will promote abdominal wall integrity and prevent hernia recurrence without the need for acellular dermal matrices or prosthetic mesh.[53,54] Partial-thickness lower abdominal wall defects associated with compromised (irradiated, infected, dysvascular) tissue, or exposed mesh, are well served by an ALT-MC flap. Such conditions benefit from hearty muscle, but do not warrant the additional bulk and donor site morbidity of a VL-MC flap. Partial-thickness defects surrounded by relatively healthy tissue, such as following extirpative surgery, should be reconstructed with an ALT-FC flap.

Extirpative surgery, infection, and trauma are common sources of perineal and groin defects. As above, myocutaneous flaps are preferred for full thickness defects to obliterate dead space, prevent visceral eventration, allow for tension-free pelvic floor and skin closure, and minimize chemoradiotherapy-related morbidity.[10,55–59] Urogenital structures differentiate the approach to this region with lower abdominal wall defects. When involved, coverage of vital organs like the major vessels and prostheses is imperative. The authors prefer the ALT-MC to local options, such as the pudendal flap because wounds tend to be irregular and the muscle nicely obliterates three-dimensional defects.[60] Additionally, these wounds often result from necrotizing soft tissue infection and the muscle provides excellent blood supply.

The authors prefer the ALT-FC flap for vaginal and external genital reconstruction. Because the ALT-FC is least bulky, it is particularly handy for reconstruction of these structures**.** Known disadvantages include hair distribution and color mismatch.[61,62] Still, the ALT-FC flap does not require microsurgical instrumentation, unlike the widely utilized free radial forearm flap.[63] The bulk of the ALT-FC flap is thin in many Asians, and can be further thinned, allowing for excellent cosmesis and pliability.[62,63] Finally, functional and aesthetically satisfactory reconstruction has been achieved without unsightly and stigmatic forearm scarring.[35,62,63]

Reconstruction with local skin flaps should not be attempted until there is complete resolution of disease, and this may take 3–6 months. Pedicled ALT-MC flaps can be inset sooner because of a richer blood supply and tension-free repair.[61,64] More importantly, local options would have been insufficient for coverage of the expansive defects described in this article. Regional options including the tensor fascia lata myocutaneous and gracilis flap are associated with short pedicles, less versatility of flap inset, and undesirable dog ears.[44,45,65] The ALT-MC flap has the advantage of a long pedicle, versatile flap composition, acceptable cosmesis at the donor site, and tolerable donor site morbidity.

Many advocate the VRAM flap for its reliable blood supply and well-tolerated donor site morbidity in pelvic reconstruction.[66–70] This is not the authors' preference. The VL-MC flap has several important advantages over the VRAM. It is larger than the rectus abdominis and bilateral harvest is possible without undue morbidity. Large double skin paddles can be designed to achieve closure of more than one defect. Moreover, VL-MC harvest may be safer than the VRAM especially when stomas exist, as they often do. VRAM flaps recruit tissue from abdominal domain that may already be compromised by the disease process. Finally, functional VL-MC donor site morbidity, as for the VRAM, is well tolerated.[56,71,72]

Following bladder injury, we routinely excise a patch of deep vastus fascia from the VL-MC flap to allow urothelium to grow over the raw surface of muscle belly. We observed a urinary leak in three of three patients treated with the VL-MC, and the leak was solved with revisionary surgery in two. The complications may be attributable to injured adjacent bladder tissue and perioperative inflammation. We lack sufficient data to compare our leak rate with alternative strategies. This is a weakness of our study. Regardless, minimization of this complication may be accomplished with bladder decompression and a watertight repair when possible.[72]

In other regions of the body, such as the sacrum, outcomes are statistically similar regardless of flap composition.[73,74] It is conceivable that a fasciocutaneous flap would be equally efficacious in all defects we encounter, minimizing donor site morbidity in all comers. Because microsurgical technique is obviated in pedicled flap reconstruction, we neglected to collect patient parameters including BMI, injury severity score (ISS), smoking history, and time from injury/surgery to reconstruction. The lack of this data may be justified by a tendency toward lower BMI in this Asian population, and the fact that the only vascular compromise witnessed was attributable to a reversible mechanical cause and not patient disease.

We observed an appreciable rate of complications and reoperation in our series. We do not have sufficient data to compare our outcomes to other strategies. Although other series exist, we cannot compare outcomes, such as infection, flap failure, and reoperation rate due to the myriad etiologies, qualities, and comorbidities we encountered. The algorithm described herein is founded on years of ALT flap harvest experience and conventional wisdom and ultimately led to success in every case except one where the patient succumbed to cardiac failure. It is designed to serve as a guide for management of lower trunk and pelvic soft tissue injury using a single flap that is time-proven and easy to raise. Our series did not address the influence of timing, antibiosis, and postoperative management on outcome. We also did not have pedicle length information and defect-to-donor site distances. Despite these shortcomings, our experience does elucidate the importance of meticulous pedicle positioning, hemostasis, and multidisciplinary management of gastrointestinal and genitourinary disease.

The greatest strength is that this algorithm is founded on state-of-the-art principles in reconstructive surgery. It has been proven at this hospital and provides a systematic and logical approach to maximizing patient outcomes and minimizing donor site morbidity. It does not, however, address intricacies in the pattern and layout of free flaps. This is the art of surgery that cannot be guided by a mere algorithm.

CONCLUSION

Our algorithm exploits the unique biologic and mechanical characteristics of three variants of pedicled flaps from the ALT region for the reconstruction of different kinds of defects. We offer a reproducible and systematic guide based on extensive experience with the ALT that has served us well at this institution and ultimately led to success. The authors suggest that surgeons refine their concept of the ALT flap and use this algorithm as a guide in the reconstruction of LAPG defects.

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