Perineal Reconstruction

Principles and Practice

Damir Kosutic
Editor

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Preface

Writing a book on any topic can be a challenging task, requiring not just knowledge and experience on the subject, but also lots of energy and enthusiasm, especially if no such book was written before. Indeed, coordinating authors from 20 different departments across 3 different continents and writing/contributing to many chapters proved to be the biggest academic effort in my career. The idea for this book, focused on all specialties involved in surgical and nonsurgical treatments of perineal area, came about back in 2016 when I met former Springer Editor Dr. Inga von Behrens in Bruxelles at EURAPS Meeting. After she saw my lecture on PAP flap utilized for perineum, a new technique at the time, Inga suggested I take up this challenge with Springer support. I am grateful to Inga for initiating and supporting this unique project during her time at Springer. From the outset, I wanted to involve top experts in reconstructive plastic surgery of this area and beyond and then expanded this to include other specialties. Perineal Surgery and Reconstruction is one of the most multidisciplinary fields one can imagine, from both surgical and nonsurgical perspective; hence we expanded this textbook beyond only flaps and resections, to include other forms of treatment and important considerations for successful patient outcomes. Reconstructive plastic surgery of this area is constantly evolving and improving, and there may still be some techniques not included in the book; however, we here provide descriptions of the most relevant flaps and surgical/nonsurgical treatment options available that stood the test of time. The project took significantly longer than expected, in part due to c19 situation, and in part due to challenging coordination between a large number of authors and coauthors, all very busy clinicians. I would like to extend my personal gratitude to Mrs Juliette Ruth Kleemann, who has been extremely patient, supportive, and understanding as our Springer Editor over the years, pushing this difficult project forward toward its completion and providing authors/editors support in the best possible way. I would also like to extend my gratitude to Ms. Beauty Christobel Gunasekaran, who coordinated the whole project and helped me communicate with authors and coauthors around the world effectively and relentlessly; otherwise this book would never see the light of day. I am also grateful to my family for their support and endorsements as well as all of my colleagues and friends around the world—top experts in their fields—who contributed to this textbook, first of its kind on the subject of perineal surgery and reconstruction.

Manchester, UK Damir Kosutic
June 2022

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About the Editor

Damir Kosutic is internationally respected expert in Plastic and Reconstructive Surgery, with subspecialty interest in complex microvascular reconstruction following cancer resections or trauma for different body areas—particularly Breast Reconstruction, Lymphedema Microsurgery, Sarcoma/Limb, Face and Perineal Reconstruction (first described PAP flap for Perineal Reconstruction). Mr Kosutic, Consultant Plastic and Reconstructive Surgeon, is one of the UK leading lymphedema, sarcoma, and breast reconstructive surgeons, based at the Christie Hospital in Manchester, one of the largest tertiary European Cancer centers. He has completed microsurgical fellowships at Imperial College NHS Trust—Charing Cross Hospital London and Sant Pau Hospital, Barcelona (Microvascular Breast Reconstruction, Perforator flaps, and Lymphedema Surgery with Prof. J. Masia), upon completion of comprehensive plastic surgery training in Maribor and Ljubljana, Slovenia, under the mentorship of famous Marko Godina's colleagues. Additional microsurgical training was undertaken in Vienna, Austria (with Prof. H Millesi and Prof O. Aszmann), Maxillofacial/Head and Neck Surgery in Zagreb, Croatia, MD Anderson Cancer Center, Houston, USA, and Taiwan (with Prof. Ming-Huei Cheng). He has PhD and master's degrees in Biomedical Sciences and has published over 50 scientific papers in top international peer-reviewed plastic surgery journals, which have been cited over 360× in scientific literature, including some of the key papers on planning of perforator flaps. He described a number of innovative techniques and concepts subsequently implemented in plastic surgical practice internationally that improved the quality of reconstruction. He is frequently an invited speaker at top international conferences where he chairs panels on different topics (WSRM, EUROMICRO, EURAPS), courses, and reputable institutions, lecturing on complex cancer reconstructive surgery, microsurgical breast and lymphedema reconstruction, and sarcoma reconstructions worldwide. Mr Kosutic is an active member of European Association of Plastic Surgeons (EURAPS), where he is also a member of Hans Anderl-Award Committee, active member of World Society for Reconstructive Microsurgery (WSRM), Fellow of European Board of Plastic and Reconstructive Surgery (EBOPRAS) and Royal College of Surgeons of England. In 2011, he was awarded EURAPS Young Plastic Surgeon Scholarship and HCA Travelling Scholarship. He was also Assistant Professor at the University of Maribor, School of Medicine, Slovenia, EU. In addition to teaching, Mr Kosutic has been a faculty mentor for a number of medical students, trainees, and senior clinical/microsurgical fellows over the years, helping their careers both clinically and academically. He is a reviewer for several plastic surgery journals including *JPRAS* (*Journal of Plastic, Reconstructive and Aesthetic Surgery*/former *British Journal of Plastic Surgery*) for the past 15 years. In his free time, he is passionate about martial arts (former European Karate Champion, black belt), classical music (violin playing), sailing, and travel.

1 Surgical Anatomy and Pathology of Perineal Area

Patrick Shenjere and Sarah T. O'Dwyer

1.1 Introduction: Surgical Anatomy

From the colorectal surgeon's perspective, the principle aspect of the perineal anatomy relates to the anal sphincter complex. Many of the pathologies and treatments required to deal with these problems will cause injury to the soft tissues of the perineum and pelvic floor and will influence continence of feces and flatus. For the patient, this is paramount as the fear of incontinence and potential permanent stoma is life altering. Where this can be avoided, all efforts should be directed to maintain soft tissue and promote wound healing while preserving the sphincters. Where the disease demands removal of the sphincters and pelvic floor, primary reconstruction avoiding delayed wound healing and potential chronic scarring with sinus formation will allow the patient best opportunity to return to social functioning and maintain the best quality of life. A clear understanding of the potential pitfalls and a multidisciplinary approach to excision and reconstruction will result in best outcomes.

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1.2 The Anal Canal

The terminal portion of the gastrointestinal tract is the anal canal extending from the anorectal junction/ring to the anal verge, i.e., the true hairy skin leading to the perineum. There are some minor anatomical variations in male and female patients principally in that the craniocaudal length of the sphincter is 3–4 cm in males versus 2.5–3 cm in females. Posteriorly, the anal canal is related to the coccyx, laterally to the ischiorectal fossa, and anteriorly to the perineal body, leading further forward to the vagina in females and the perineal urethra in males (Fig. 1.1a, b).

An understanding of the anatomy and physiology of the anal sphincter is fundamental to enabling successful counseling of patients regarding outcomes following surgery in this area. The external sphincter (ES) forms the circular sphincter at the anorectal junction and is an extension of the pelvic floor muscle known as the puborectalis and levator ani (Fig. 1.2). This elliptical sleeve of striated muscle is continuous with the cranial extension of puborectalis forming part of the pelvic floor. This muscle is innervated by the internal pudendal nerve from the sacral nerve route and is functionally voluntary, maintaining continence of solid stool. Posteriorly, the ES is attached superficially to the skin and deeper to the coccyx as part of the anococcygeal ligament. Anteriorly, the muscle attaches to the skin and

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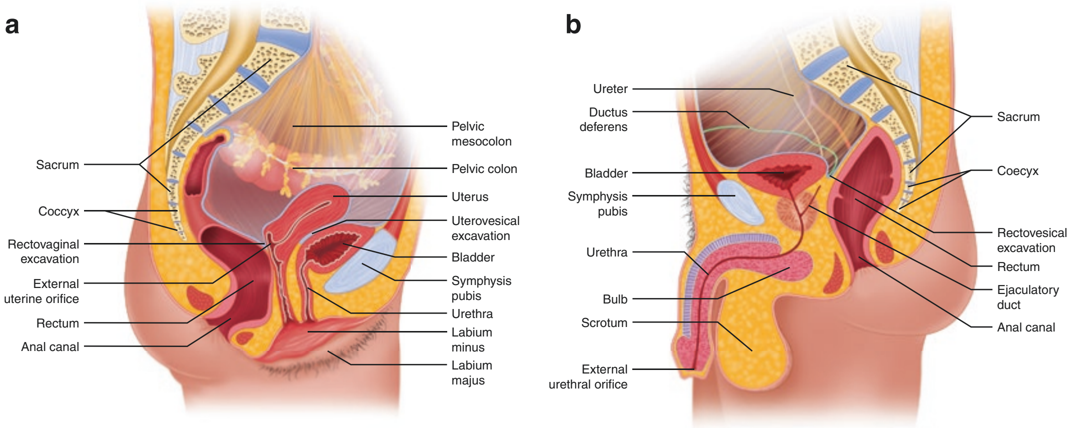

Fig. 1.1 (**a**) Female pelvic contents. (**b**) Male pelvic contents

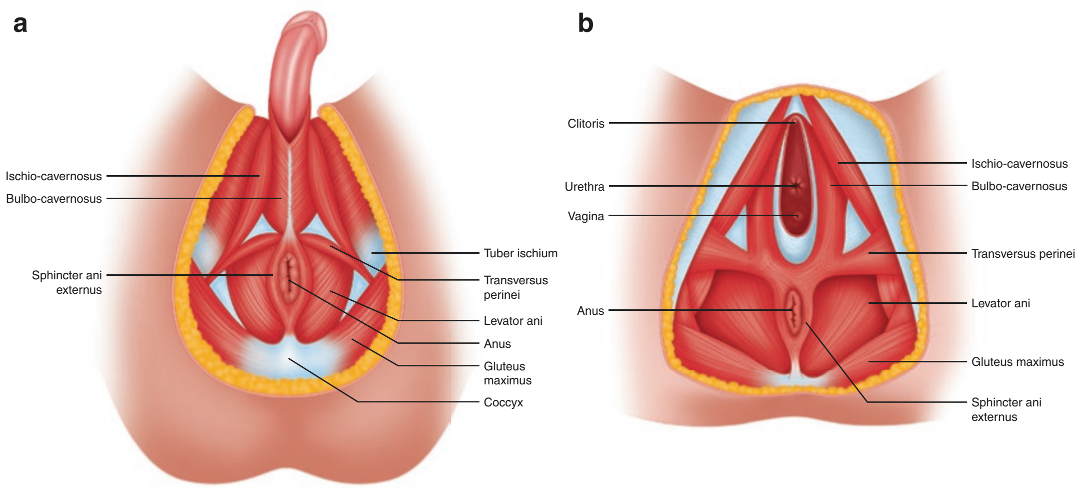

Fig. 1.2 (**a**) Male perineal muscles and compartments. (**b**) Female perineal muscles and compartments

the transverse perinei muscles. Centrally the ES, transverse perinei muscles coalesce as the perineal body.

The internal sphincter which is an involuntary longitudinal muscle, innervated by the parasympathetic fibers, is responsible for continence of flatus and sensorially discriminates for flatus at the transition zone of the anus and rectum. This muscle continues cranially as the circular muscle surrounding the body of the rectum.

Better understanding of anorectal physiology has occurred over the last two decades, which has allowed the coloproctologists to define the consequence of injuries to the innervation of the sphincters and secondary dysfunction of rectal compliance. Much of this work resulted from evaluation of dysfunction following obstetric injuries acutely and over decades following perineal nerve injuries during childbirth. A careful history will identify those women who are already suffering injury or are at increased risk of incontinence with minimal interference with the sphincter and further injury to the perineum. A valuable overview of anorectal physiology has been undertaken by Carrington and colleagues [1].

1.3 Soft Tissues, Pelvic Floor, and Perineum

The anal canal meets the anal verge and continues onto the natal cleft and buttocks posteriorly and laterally; anteriorly, the posterior perineum is separated by the perineal body in the female and transverse perineal muscle in the male: Posterior to these anatomical landmarks is the domain of the colorectal surgeon. Anteriorly, both gynecological and urological specialists will be important in providing the expertise to undertake excision of tissue and assist in maintaining function of urogenital systems. Urinary diversion may be necessary when the urethra is resected.

Damage to the soft tissues occurs from both pathologies and treatment modalities requiring surgical resection and or debridement. Soft tissue reconstruction must be customized, as the tissue defects will vary and a wide range of flaps will need to be deployed by the reconstructive team. It is essential to have an accurate understanding of the anatomy of the tissues to achieve optimal soft tissue interposition.

The greater part of the pelvic floor is formed by the levator ani from right and left, made up from the iliococcygeus and pubococcygeus muscles forming a funnel-shaped sling from the pubic symphysis to the sacrum and coccyx. Supplementary coccygeal muscles run from the ischial spines to the low sacrum and coccyx.

The perineum is separated into two triangles by the perineal body. The arterial and venous supplies are paired: The internal pudendal artery (IPA) and vein originate from and drain to the internal iliac artery and vein. The IPA branches to the inferior rectal artery posteriorly and the perineal artery that supplies the urogenital structures in the anterior triangle.

The nerves run in close anatomical pathways to the vessels: the principle somatic nerve being the internal pudendal nerve splitting into the inferior rectal nerve supplying the ES and the deep and superficial perineal nerves extending to the anterior triangle innervating levator ani and the urethral sphincter. Sensory component of the nerves innervates the skin of the perineum, scrotum, and vulva and continues as the dorsal nerve for the penis and clitoris.

1.4 Applied Anatomy: Anatomical Landmarks and Spaces

In the posterior perineal triangle, there are a number of key anatomical spaces that harbor pathologies that result in loss of healthy tissues. Surgical excision of these areas can lead to significant cosmetic and physiological deficiencies, and it assists the reconstructive team to understand these anatomical boundaries.

Moving laterally to medially, the ischiorectal (better described as the ischioanal) space is filled with fatty tissue. The lateral boundary is the obturator internus muscle running with the fascia is the pudendal neurovascular bundle approaching the most inferior component of the space to branch into the perineal branches on the pelvic floor muscles. Medially lie levator ani and ES of the anal canal. Posteriorly, the space is bounded by gluteus maximus and the sacrotuberous ligaments, anteriorly by the transverse perinei. The space offers a surgical approach to excision of the anal canal as part of an extended abdominoperineal resection. In salvage surgery following radiotherapy, wide excision takes the operator to the lateral sidewalls and there is a need for major soft tissue reconstruction using a variety of flaps.

Postanal and presacral spaces can also present challenges surgically. The postanal space runs from the anococcygeal ligament to the levator ani and has the potential for complex "horseshoe" abscesses to form tracking from one side of the anus to the other buttock: When this space develops chronic infection, significant loss of soft tissue results in deformity requiring reconstructive techniques to maintain anal toilet. Tracking superiorly, the retrorectal space starts at Waldeyer's fascia behind the anus and extends along the presacral fascia posteriorly, enveloping the mesorectum anteriorly and laterally. This is the plain of mobilization of the rectum when undertaking an anterior resection or abdominal component of the rectal resection for a total mesorectal excision. This space is associated with the development of chronic perineal sinus formation and may require flap interposition either at the first surgery or to deal with chronic cavity discharge, when the tissue breaks down and fails to heal by secondary intention.

1.5 Pathology

The pathological conditions affecting the perineum can be divided into non-neoplastic and neoplastic conditions.

1.6 Non-Oncological Conditions

Developmental conditions are rare but can be a challenge to manage due to the anatomical position. Hind gut embryological remnants can present in young adults due to pain and difficulties in defecation. Most are benign but may require intervention as they cause functional abnormalities. MR scanning will define the anatomical position and any associations with the spinal canal.

1.7 Infections

Infections, including some sexually transmitted infections (STIs) such as syphilis, granuloma inguinale, and genital warts, can cause lumps in the perineum. HIV-infected patients may also present with inflammatory lesions of the anal and perianal region.

Granuloma inguinale is a chronic STI caused by the bacteria Klebsiella granulomatis (formerly classified as Calymmatobacterium granulomatis). It is most commonly seen in tropical and subtropical regions of the world. It presents as firm papules or nodules which if left untreated result in chronic superficial ulceration. The lesions of granuloma inguinale clinically resemble carcinomas. Tissue biopsy shows characteristic Donovan bodies [2]. Another STI, which may cause perianal lesions, is lymphogranuloma venereum. This is caused by Chlamydia trachomatis. In chronic cases, it may result in granulomatous proctitis and perianal lesions that simulate Crohn's disease [3].

Genital warts (condyloma acuminata) are caused by infection with human papilloma virus (HPV). The most common strains of HPV that cause condyloma acuminata are types 6 and 11 which are considered low-risk subtypes for developing malignancy. HPV strains 16 and 18 are high-risk subtypes with proven etiological role in the development of anogenital cancer. Condyloma acuminata typically presents as skin-colored painless growths or lumps around the anus, penis, or vulvovaginal area. Their diagnosis is usually established clinically. Histologically, they consist of acanthotic epidermis with surface papillomatosis and overlying hyperkeratosis and parakeratosis. The keratinocytes show variable presence of viral cytopathic changes such as koilocytosis, multinucleation, and dyskeratosis (Fig. 1.3a, b). In healthy individuals, the lesions can be left alone as they often resolve spontaneously over months or years. Persistent lesions or cosmetically abhorrent lesions are treated using topical therapies, cryotherapy, or surgical excision.

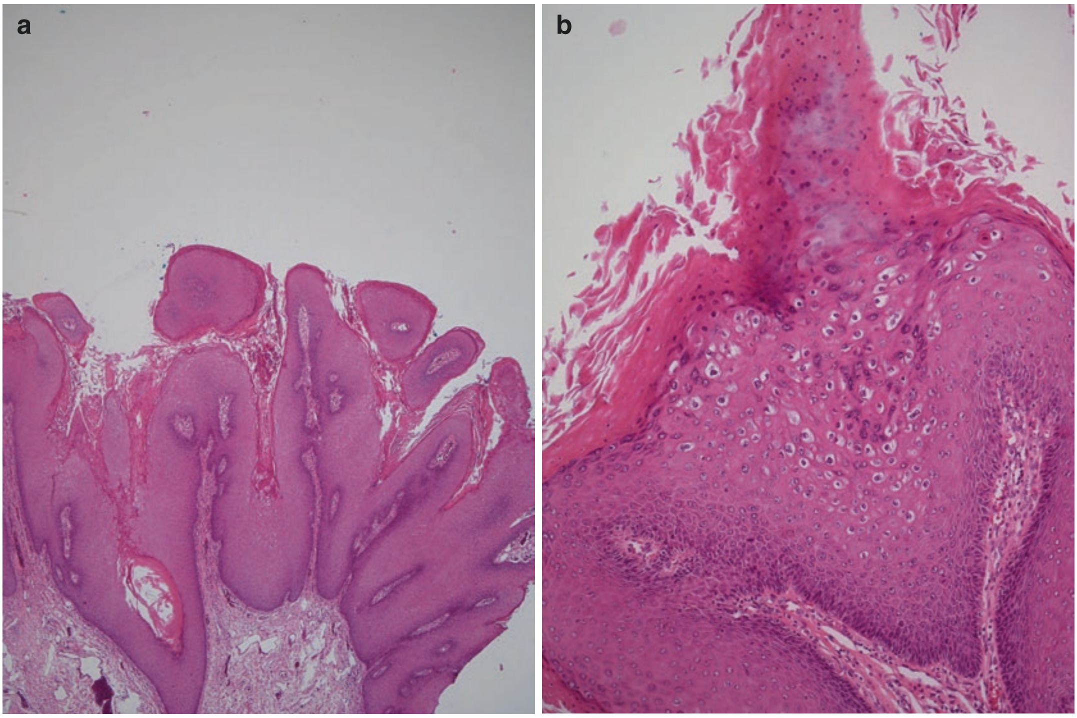

Fig. 1.3 (**a**) Condyloma acuminatum (low-power view). There is characteristic papillomatous hyperplasia with overlying hyperkeratosis. (**b**) Condyloma acuminatum (high-power view). There is parakeratosis, hypergranulosis, and koilocytosis

1.8 Perianal Abscess

Perianal abscesses present as tender erythematous swellings/lumps in the perianal skin. The abscesses can be caused by different conditions, including blocked anal glands, infected anal fissures, sexually transmitted diseases, and infected diverticula. Patients with diabetes, inflammatory bowel disease, diverticulitis, and immunosuppression are at increased risk of developing anal abscesses.

1.9 Fissures and Fistulae

A fissure is a small tear in the mucosal tissue that covers the perineum and anus. Some of the common conditions that predispose patients to develop fissures are childbirth in females, anal intercourse, inflammatory bowel disease, constipation, and chronic diarrhea. Patients with anal fissures present with pain during and after defecation and fresh blood on stool or toilet paper post-bowel motion. They may also have small lumps, skin tags, or visible cracks in the perianal skin. Anal fistulae can occur in both males and females and most often develop after an anal abscess. Other less common conditions that can result in fistulae include chronic infections such as tuberculosis, diverticulitis, and Crohn's disease.

Anorectal sepsis and secondary fistulae can be extensive and complex resulting in significant tissue loss and damage. The most challenging cases are found in patients with Crohn's disease where there can be multiple fistula tracts and longstanding use of drainage setons in the tracts. Setons are fine drains inserted along the fistula tracts to allow continued drainage and avoid collections and recurrent infection and tissue damage. Anovaginal fistulae can also be a challenge, and understanding the potential of interposition flaps can improve fistula closure and lead to an improved quality of life (QOL) as these are often a problem in younger patients who are sexually active. Although current treatments using immunosuppressive agents can help contain progression, some patients will need an extended radical anorectal excision, removing the damaged tissue in the buttocks and perineum [1]. Similar challenges are found in patients with inflammatory bowel disease who have a failed restorative ileoanal pouch following proctectomy (removal of the rectum and retaining the anal canal to avoid a permanent stoma) [4]. In order to avoid a chronic perineal sinus, soft tissue reconstruction should be offered either at the time of excision or as soon as possible once the acute infection has been controlled.

1.9.1 Cysts

Cystic lesions that occur in the perianal region include epidermal and dermoid cysts and some cysts that are unique to this region, such as anal duct/gland cysts and sacrococcygeal teratomas. Epidermal cysts are slow-growing benign cystic lesions derived from the epidermis of the skin. They may develop following trauma or chronic hair follicle irritation. The patients present with perineal swelling [5]. Histologically, an epidermal cyst consists of a keratin-filled cystic space lined by squamous epithelium. They can be complicated by infection or rupture with secondary foreign body-type inflammatory reaction to the keratinous debris.

Cystic lesions can be drained and contents sent for cytology. Although drainage may result in improvement in symptoms, most will recur. Surgery will need to be aligned to the degree of symptoms versus risk of sphincter injury and must be customized to individual needs and desires.

1.10 Neoplastic Pathology

The neoplastic pathologies encountered in the perineum can be divided into those arising in the skin or from the anal glands. Noninvasive conditions including condylomata can become extensive if neglected where the sepsis and invasion of soft tissues can be challenging. Wherever possible, control is attempted by segmental repeated local resections and grafting. Up to 20% of condylomas show dysplastic changes on microscopic examination [6]. HPV is etiologically linked to anal and perianal cancer, and HPV type 16 is the most commonly detected subtype [7]. Squamous cell neoplasia in the anus and perineum can manifest as preinvasive anal intraepithelial neoplasia (AIN), graded 1 to 3 or invasive squamous cell cancer (SCC). In the WHO classification, a two-tier grading system (high-grade and low-grade) is favored, such that AIN1 corresponds to low-grade squamous intraepithelial lesion (LSIL) and AIN2 and AIN3 lesions correspond to high-grade squamous intraepithelial lesion (HSIL). Low-risk HPV subtypes are associated with low-risk lesions, and high-risk lesions are caused by high-risk HPV subtypes [8]. Diffuse en block staining for p16 immunostain can be helpful in identifying high-grade lesions (Fig. 1.4a, b). HPV subtyping can also be done using PCR.

Anal and perianal invasive squamous cell carcinomas present as mass lesions, which may be associated with pain or discomfort, ulceration, induration, hemorrhage, or discharge. SCCs are histologically heterogeneous, ranging from well-differentiated SCCs that closely resemble normal epithelium to basaloid SCCs and sarcomatoid SCCs that are poorly differentiated and non-keratinized (Fig. 1.5). Review of pathologies and treatments is summarized by Renehan [9]. Where there is invasive cancer, radical radiotherapy is current standard of care, but relapse/recurrence does occur in 20% of patients. For these patients, salvage surgery is offered where possible. Such surgery is challenging due to the changes in the soft tissues of the perianal area and buttocks. For these patients, reconstruction is essential to avoid nonhealing of the perineal wound [10].

While the majority of tumors of the perianal skin are SCCs, other types of cutaneous malignancies occur in this area. These include basal cell carcinoma, melanoma, and extramammary Paget's disease.

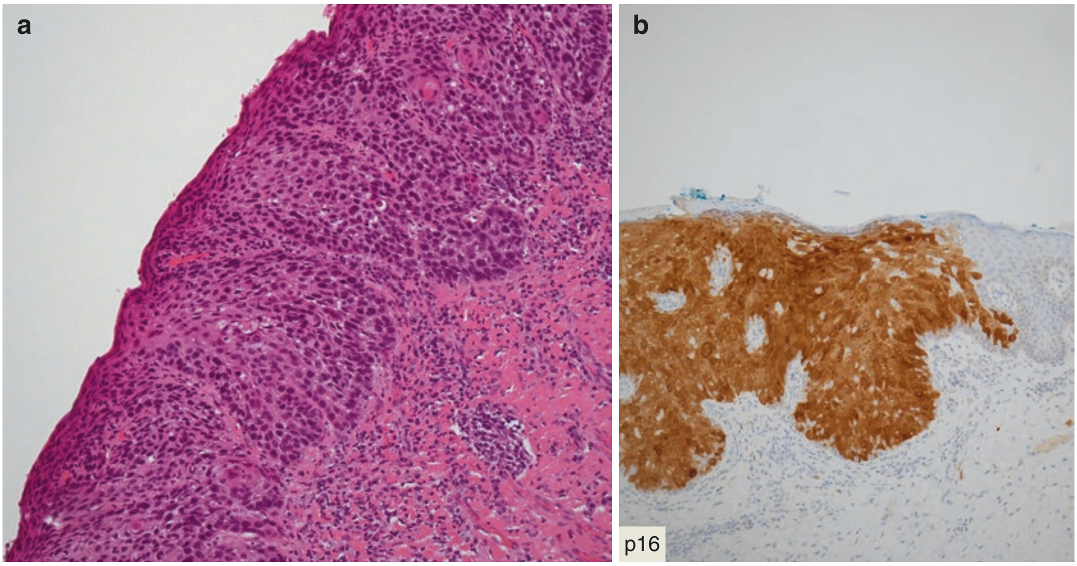

Fig. 1.4 (**a**) High-grade squamous intraepithelial lesion (HSIL)/anal intraepithelial neoplasia (AIN) grade 3. There is full-thickness dysplasia of the epidermis. (**b**) p16 stain in HSIL/AIN grade 3. There is full-thickness en block staining for p16 in the dysplastic epithelium. The normal part of the epidermis on one edge is negative for p16

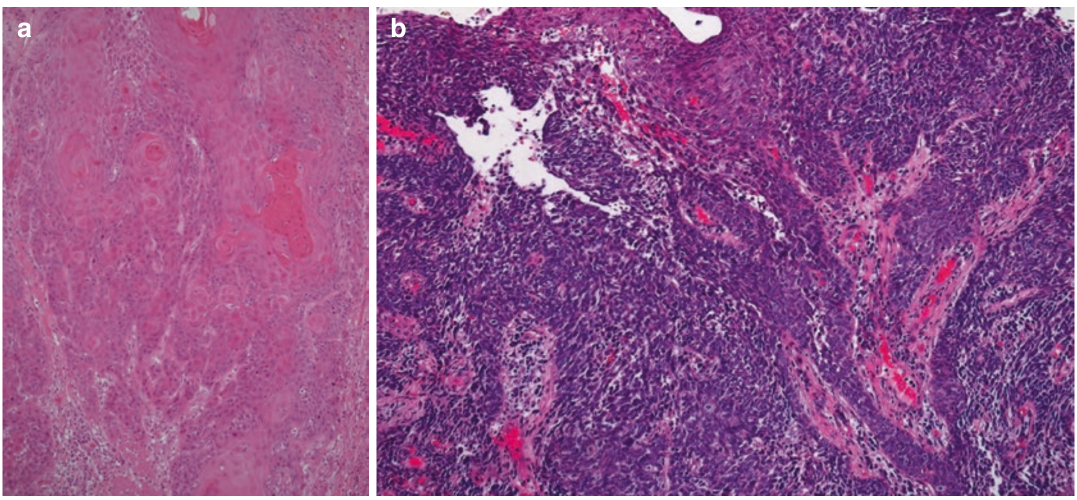

Fig. 1.5 (**a**) Invasive squamous cell carcinoma (SCC). Moderately differentiated SCC showing keratinization. (**b**) Invasive squamous cell carcinoma (SCC). Basaloid SCC showing basaloid features and is non-keratinized

1.11 Paget's Disease

This is an intraepithelial adenocarcinoma which can be either a primary cutaneous malignancy showing sweat gland differentiation or a result of secondary intraepidermal/intramucosal pagetoid extension from an underlying anal canal or rectal adenocarcinoma. The intraepithelial carcinoma may or may not be contiguous with the underlying tumor in cases of secondary Paget disease. The secondary Paget's disease may predate the underlying adenocarcinoma by up to several

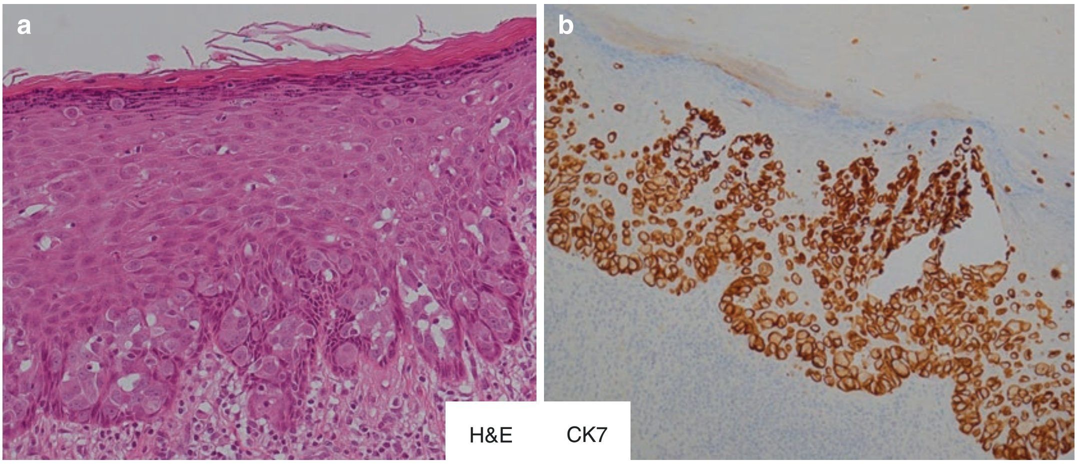

Fig. 1.6 (**a**) Extramammary Paget disease: There is intraepidermal proliferation of large atypical cells with abundant pale cytoplasm (Paget cells). (**b**) Extramammary Paget disease: Paget cells showing positivity for cytokeratin-7 (CK7) immunostain

years, and in some cases, it presents after the underlying disease [11].

Paget's disease presents as an erythematous, sometimes ulcerated lesion which clinically may resemble eczema or HSIL and is often pruritic. Histologically, it consists of intraepidermal large Paget cells with ample pale cytoplasm and large pleomorphic nuclei, which often contain prominent nucleoli. The cells are predominantly located in the epidermal basal layer, but some isolated cells and nests of cells may extend into the superficial epidermal layers. Dermal invasion, if present, is usually in the form of isolated individuals or small clusters of cells. Cells of primary Paget's disease typically show positivity for CK7, and they are also positive for CAM5.2, CEA, EMA, and GATA3 (Fig. 1.6a, b). The morphological appearance may resemble in situ melanoma and HSIL, and immunohistochemistry plays an important role in separating these two differential diagnoses from Paget's disease. Melanoma markers (S100, SOX10, HMB45, and melanoma) and HPV are negative in Paget's disease. p16 may, however, be diffusely positive [12].

Adenocarcinoma can arise from the mucosa or extramucosal anal glands and tends to have a poorer prognosis than SCC. A rare variant can arise in the perineal skin glands and can be multifocal on the skin without a true anal canal primary. The mucosal subtype arises from the luminal mucosa and is typically of intestinal type. The extramucosal subtype maybe of anal gland type, mucinous type, or intestinal type. The mucosal type clinically resembles anal squamous cell carcinoma and distal rectal adenocarcinoma. The extramucosal type shows a male preponderance and patients present with a painful mass or sensation of a mass, which may be associated with bleeding [13]. Both forms tend to require multimodal treatment involving chemoradiotherapy followed by surgery. The extent of skin loss will depend on the multifocal nature but must be as radical as necessary using multiple flaps to achieve soft tissue interposition and cover.

1.12 Melanoma

Mucosal melanoma of the anal canal and perianal tissues is extremely rare but often is diagnosed late when there is disease beyond the primary site in the form of nodal and organ metastases. Data from Public Health England (PHE) show that between 2010 and 2013, there were 437 cases of melanoma affecting anorectal and urogenital sites. Of these, 121 cases involved the vulva; 49 cases were vaginal melanoma; and 105 cases involved the anorectum

[14]. The median age at presentation is 61 years. Anorectal melanomas commonly present with rectal bleeding, pain, mass lesions, and change of bowel habits. These symptoms often result in the initial misdiagnosis of cases of anorectal melanoma as hemorrhoids. Histologically, the majority of tumors tend to be thick and ulcerated at the time of presentation, and in the perineum, the majority show invasion into the reticular dermis or beyond [15]. A decade ago, the surgical treatment would have been restricted to achieving local control, avoiding abdominoperineal anorectal resection (APR) with permanent stoma as the prognosis was less than 12 months following diagnosis. In the last 3 years, immunotherapies for melanoma have altered the natural history of metastatic melanoma with current guidelines recommending APR where metastatic disease has been controlled with systemic anticancer treatment [14]. Unlike SCC, these patients will not have had radiotherapy to the perineum; hence, wound healing following APR rarely requires a flap to achieve primary wound closure. Where local excision of lesions on the anal verge is undertaken, local rotation flap can be helpful to achieve optimal control.

1.12.1 Soft Tissue Tumors of the Perineum

Primary soft tissue tumors rarely occur in adult patients. The most commonly encountered and surgically important soft tissue tumors in this area are deep (aggressive) angiomyxoma, leiomyosarcoma, liposarcoma, and proximal variant of epithelioid sarcoma.

Deep (aggressive) angiomyxoma is a benign, but locally infiltrative tumor that occurs in the pelviperineal region. It most commonly occurs in women of child-bearing age, but rare cases can occur in males. Patients usually present with large deep-seated painless masses or diffuse, ill-defined swellings. The lesions are often slow growing, but rapid growth can be seen in pregnancy. The tumors are grossly poorly circumscribed, and the majority are greater than 10 cm in maximum dimension at the time of surgical excision. Histologically, they are paucicellular and consist of spindle- and stellate-shaped cells loosely arranged in a myxoid stroma containing medium-sized vessels, some with thick muscular walls. Some of the vessels have perivascular cuffs of myoid (smooth muscle) cells and collagen. The cells are typically positive for desmin, SMA, ER, and PR, with variable staining for CD34 (Fig. 1.7a, b). Deep angiomyxoma needs to be excised with a wide margin as extension into adjacent structures is often greater than appreciated on clinical assessment. Local recurrences occur in up to 40% of cases, sometimes decades after the initial excision [16]. Other similar benign soft tissue tumors that can occur in the perineal region

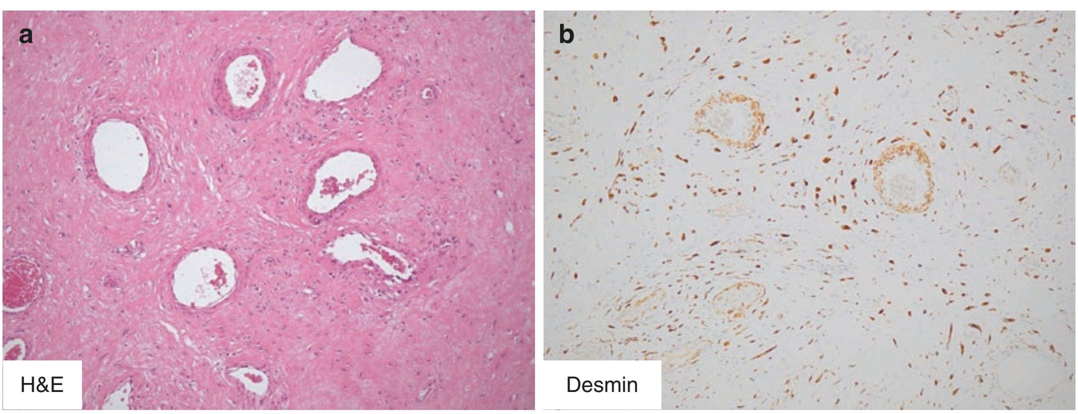

Fig. 1.7 (**a**) Deep (aggressive) angiomyxoma: Paucicellular tumor composed of spindle- and stellate-shaped cells lying in a myxoid and focally collagenous stroma containing prominent medium to large-sized vessels. (**b**) Deep (aggressive) angiomyxoma: The lesional cells are diffusely positive for desmin

include cellular angiofibroma and mammary-type myofibroblastoma.

1.13 Multimodality Treatments

As described above, radiotherapy is commonly employed as part of tumor control for a number of the pathologies encountered. As with other cancer treatment, radiotherapy has become refined over the last 5 years transforming from external beam to image-modulated radiotherapy allowing more focused beams with less scatter and injury beyond the tumor boundary [17]. For some patients who refuse surgical resection to avoid a colostomy, and in patients unfit for major surgery, additional topical intracavity radiotherapy can be offered [18]. Although these treatments may temporize relapse, most patients are not cured and unless elderly and frail will require surgical resection to achieve local control: In these patients, the degree of tissue damage can be extensive and reconstruction of the pelvic floor and perineum will be necessary [19].

1.14 Surgical Procedures

The range of procedures commonly performed in the perineum is listed in Table 1.1. Each procedure has a customized profile of consequences and complications that affect the extent of soft tissue and sphincter complex. Most of these cases will benefit from careful investigations with MR scanning of the pelvis and perineum, and many will benefit from a joint examination with a plastic reconstructive colleague either in the clinic or as an examination under anesthetic. The latter assists the team to evaluate the extent of tissue damage, the limits of attaining healthy tissue for reconstruction, and whether the procedure can be undertaken as a single or multiple staged procedures. Where extensive reconstruction is expected, wherever possible, prehabilitation with smoking cessation support is advised to optimize potential successful perineal wound healing.

Table 1.1 Common Perineal Colorectal Surgical Procedures

Fistulectomy: tissue and sphincter loss
Sphincter repair
Wide local excision perianal and perineal lesions
Transanal resection anal and rectal lesions
Proctectomy: chronic perineal sinus
Extended APER lateral, anterior, posterior
Total pelvic exenteration
Perineal hernia repairs

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2 Perineal Defects: A Colorectal Surgeon's Perspective

Omer Aziz

2.1 Introduction

Perineal defects are created for a wide range of indications in colorectal surgery, and their size, shape, and depth and the tissues they involve require significant tailoring to the patient. Relatively smaller perineal wounds involving only skin and subcutaneous incisions without surgery to remove the anal canal, low rectum, and pelvic floor are used to treat conditions such as anal intraepithelial neoplasia (AIN), very early squamous cell carcinomas of the skin, anal warts, and benign conditions such as chronic anal fissures. In such cases, a local advancement flap (such as a V-Y) may be used. The focus of this chapter, however, is the larger perineal wounds such as those created in abdominoperineal resections that involve the removal of the anus, anal canal, and rectum, with variable amounts of adjacent pelvic floor muscles, subcutaneous fat, and skin depending on the indication for surgery (tumor type and size).

Abdominoperineal resections comprise of an abdominal approach through either a midline laparotomy or a minimally invasive surgery (laparoscopic or robotic approaches) [1, 2]. Here, the blood supply of the sigmoid colon and mid-rectum (inferior mesenteric artery) is ligated alongside complete removal of the lymph node package around the rectum (total mesorectal excision or TME) to mobilize it for removal [3]. This is followed by a perineal approach to remove the anus, lower rectum, and adjacent pelvic floor [4]. The perineal approach is described in detail later in this chapter. In the case of advanced pelvic tumors, this may also involve the mobilization and ligation of the blood supply of organs such as the bladder, prostate, uterus, and ovaries. A commonly used nomenclature compartmentalizes the pelvis into

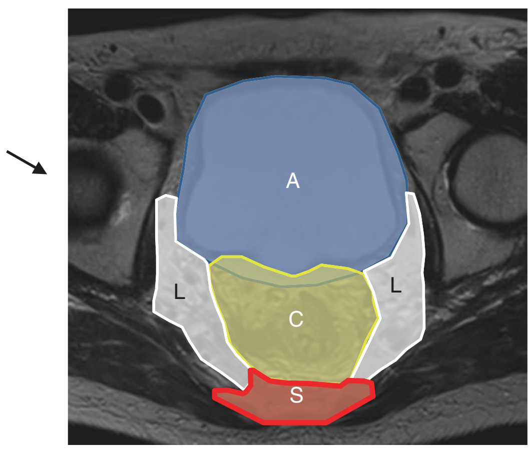

Fig. 2.1 An axial MRI scan demonstrating pelvic compartments: A—anterior compartment including bladder in a male and bladder and uterus in a female; C—central compartment containing rectum and mesorectum; L—lateral pelvic sidewall containing branches of the internal iliac arteries, veins, associated nodes, ureters, and nerves; S—sacral compartment

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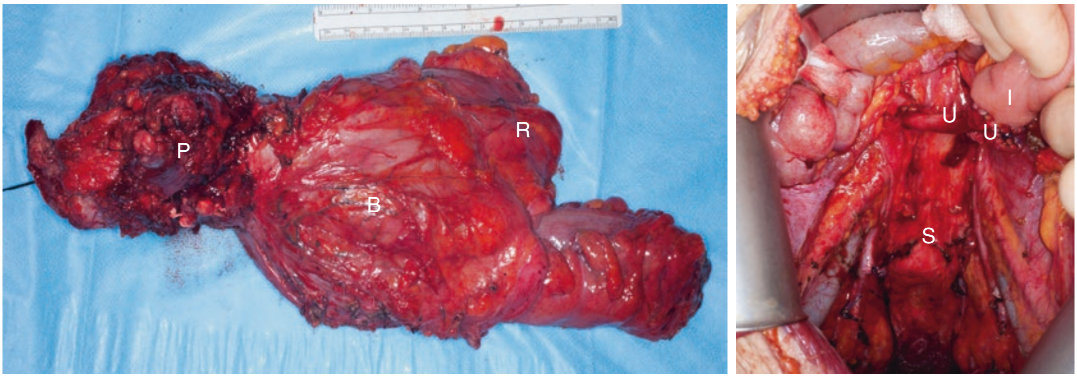

Fig. 2.2 A photograph of the components of the male pelvis (left) removed after a total pelvic clearance procedure with removal of the prostate (P), bladder (B), and rectum (R). The empty pelvis is shown on the right with both ureters (U) anastomosed onto a segment of ileum forming an ileal conduit (I) The sacrum is visible and marked (S)

anterior, central, lateral, and sacral compartments [5] as shown below in Fig. 2.1. An intraoperative image of a total pelvic clearance (removal of all compartments) is shown in Fig. 2.2.

The extent of the perineal defect that is created at abdominoperineal resection is dictated by the size and location of the lesion being removed, with the aim being to achieve an R0 margin (>1 mm from the tumor edge) [6]. Anteriorly defects can go on to involve the base of the penis in a male and the vagina and urethral opening in a female. This along with other factors mentioned later in this chapter then determines how this defect will be filled and closed. Reconstructive options for these challenging wounds need not only external closure of the wound through either primary closure or a flap, but also filling of the pelvic floor defect to prevent the entry of small bowel below the pelvic floor. The latter can result in tethering of small bowel loops causing postoperative small bowel obstruction or perineal hernias. Filling of the pelvic floor may be achieved through an omentoplasty and/or placing visceral organs in the pelvis such as the uterus, bladder, urachal ligament, and caecum. The use of biological mesh to reconstruct the pelvic floor has been evaluated with equivocal short-term benefits [7, 8], however the practice in the author's institution is to avoid this as there are limited tissues to attach the mesh to.

Perineal wounds are at higher risk of infection compared to other wound sites, and therefore, the consequences of any wound breakdown need to be considered. Factors such as prior radiotherapy, chemotherapy, diabetes, smoking, peripheral vascular disease, nutritional status, and steroid use are all important when deciding this [9]. Cancer patients with perineal defects often have a need to receive further adjuvant treatment such as chemotherapy within 12 weeks following surgery and therefore require planning of the type of wound closure, placement of drains, and postoperative patient mobilization, and specialist postoperative wound care. Any wound breakdown requiring healing by secondary intention may require active techniques such as negative pressure dressing to expedite closure. Complications from perineal reconstruction are covered elsewhere in this book.

Quality of life, sexual function, bladder function, and fertility are also important aspects to consider. Damage to pelvic autonomic nerves can result in significant sexual and bladder dysfunction [10]. Damage to the sympathetic hypogastric nerves can result in increased bladder tone and reduced bladder capacity, as well as impaired ejaculation in men. Damage to the parasympathetic system can result in voiding difficulties from increased tone in the bladder neck, as well as with erectile dysfunction in men and impaired vaginal lubrication in women. Patients with urinary complications may require prolonged bladder drainage with a Foley catheter, and all should be referred to urologist. Finally, vaginal reconstruction can be achieved with pedicled flaps, and intercourse is feasible for many women after this [11].

2.2 Indications for Perineal Reconstruction in Colorectal Surgery

Conditions that require surgery for which perineal reconstruction is considered are listed below:

- Abdominoperineal resection for "beyond total mesorectal excision (TME)" low rectal adenocarcinoma.
- Abdominoperineal resection for anal squamous cell carcinoma and anal Paget's disease.
- Abdominoperineal resection for recurrent rectal cancer (with or without previous reconstruction).
- Abdominoperineal resection for sarcoma.
- Abdominoperineal resection for anal melanoma.
- Perineal hernia.

Perineal hernias are a challenging pathology to treat and most commonly occur as a complication from a previous abdominoperineal resection where the pelvic floor is removed and the skin and subcutaneous tissues used to primarily close the defect. They can, however, occur even after a previous reconstructive procedure. Presented below is a case of a perineal hernia in a patient 6 months following an extralevator abdominoperineal resection with gluteal fold flap reconstruction. Figure 2.3 shows the perineal hernia itself with a CT scan demonstrating descent of small bowel into the deep pelvis, through the pelvic floor defect, sitting well below the coccyx. Options for perineal hernia repair involve placement of either a mesh or reconstruction with a flap. In the author's experience, the former is reserved for small defects where there are structures that the mesh can be attached to. In this case, however, the defect was significant and its repair required filling of the pelvis with a transverse rectus abdominis myocutaneous (TRAM) flap as well as an omentoplasty, mobilization of the urachal ligaments and placement in the pelvis, and finally mobilization and placement of caecum in the pelvis to prevent small bowel herniation (Fig. 2.4). The end result is shown in Fig. 2.5.

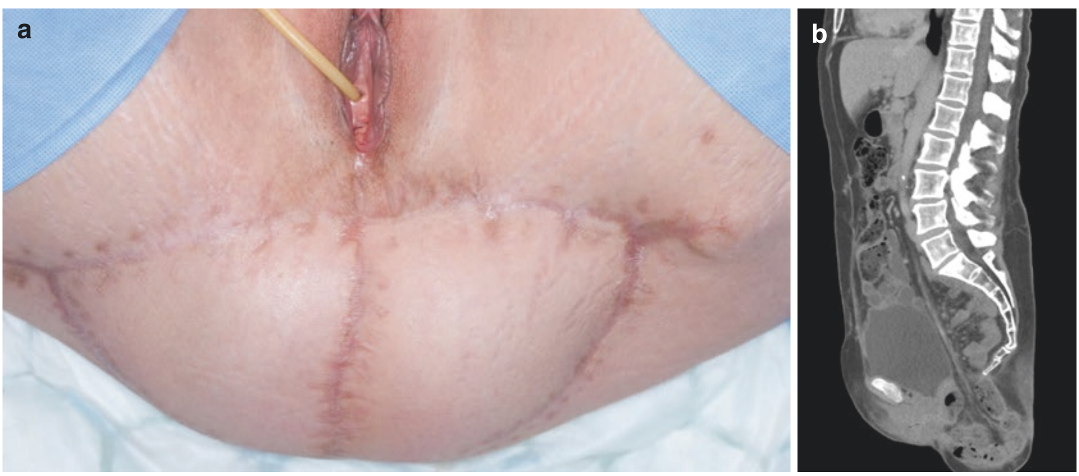

Fig. 2.3 A picture of perineal hernia after APR despite previous gluteal fold flap reconstruction (**a**) and CT scan showing descent of small bowel into the deep pelvis (**b**), through the pelvic floor defect, sitting below the coccyx

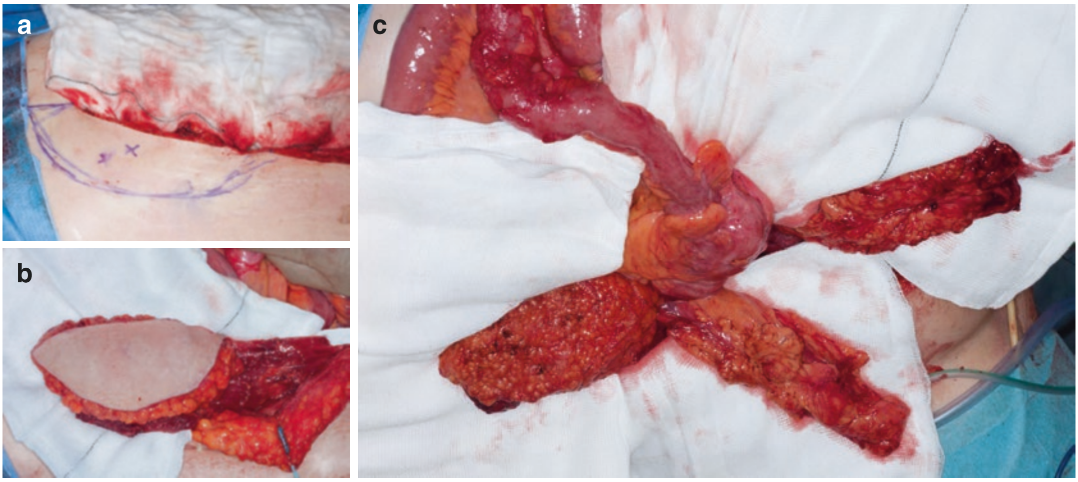

Fig. 2.4 Filling of the pelvic floor defect with a transverse rectus abdominis myocutaneous (TRAM) flap (**a** and **b**), as well as an omentoplasty, urachal ligaments, bladder, and finally mobilization and placement of caecum for placement to fill the pelvis (**c**)

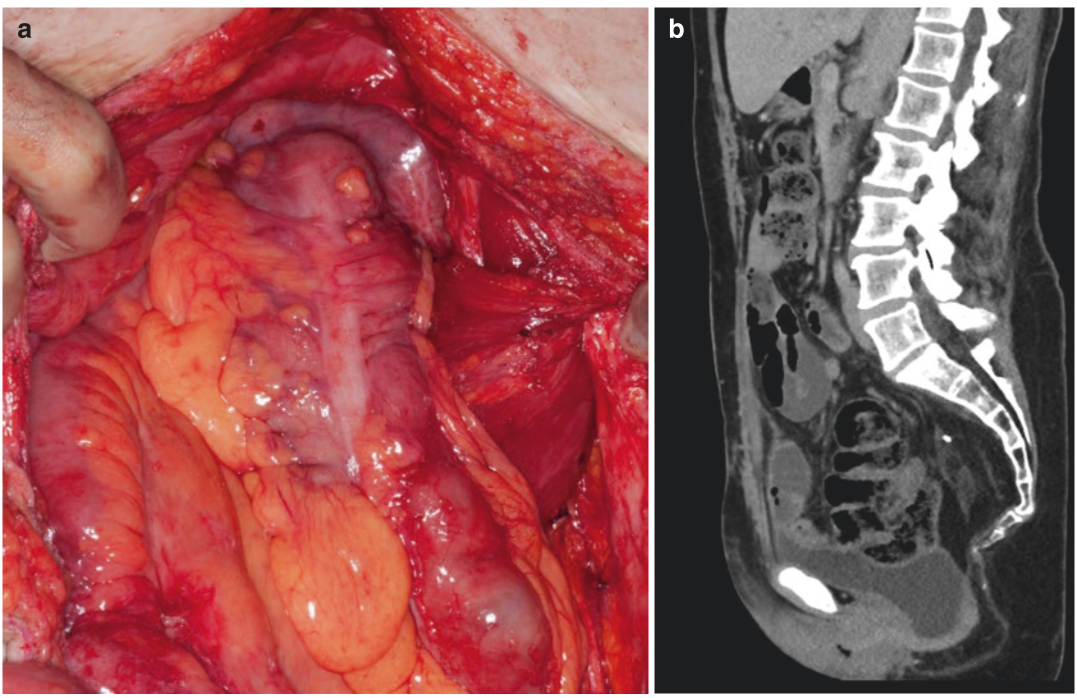

Fig. 2.5 Pelvic floor filled with TRAM flap, omentum and urachal ligaments, and bladder (**a**) and a 12-month postoperative CT scan showing the pelvis filled with these (**b**)

2.3 Radiology of Perineal Lesions

Imaging perineal lesions accurately is a key to surgical and reconstructive planning in these patients. Below are the key imaging modalities used.

Computer Tomography (CT) CT scanning of the thorax, abdomen, and pelvis with contrast is the gold standard investigation for disease staging and detection of liver and lung metastases, as well as surgical planning when considering lesions originating from or involving the abdominal cavity. CT angiography may also be used to identify vascular pedicles and flaps for patients having perineal reconstruction.

Magnetic Resonance Imaging (MRI) MRI is the imaging technique of choice for the pelvis and is also used for staging tumors involving the pelvis, sidewalls, anal canal, and floor. In locally advanced or recurrent rectal cancer, MRI is the most discriminatory test available to determine whether a complete (R0) resection is achievable. It also helps determine the planes of dissection that are required and decide which structures require removal. Examination under anesthesia of the pelvis can be used alongside MRI to determine resectability in locally advanced and recurrent rectal cancer.

Positron Emission Tomography (PET) PET is the investigation of choice for the detection of extrahepatic metastasis and local recurrence at the site of initial colorectal surgery, and although it has been shown by some to change management intent from curative to palliative in 30% of cases, others have suggested that its impact is much lower, affecting management in less than 8% of cases where it is used [12]. As a result, there is no consensus on its routine use, but it does have a role in selected cases where systemic disease is suspected or site of recurrence is not clear.

Ultrasonography (US) The role of endorectal ultrasonography (ERUS) in the context of staging locally advanced and recurrent rectal cancer is mainly achieved through MRI, and therefore, the role of ERUS is mainly to aid targeted biopsy. For the liver, contrast-enhanced US allows characterization of lesions, surgical planning, and biopsy and avoids repeated radiation exposure in serial imaging.

2.4 Multidisciplinary Team Decision Making

Multidisciplinary teams (MDT) specializing in colorectal conditions (e.g., cancer types) for which the surgery in undertaken should lead the decision-making process. These should include colorectal surgeons, clinical and medical oncologists, radiologists, pathologists, and clinical nurse specialists with experience in managing these patients. Furthermore, in centers undertaking pelvic exenterative surgery for locally advanced and recurrent rectal cancer, the MDTs should be supported by urologists, gynecological oncologists, plastic (reconstructive) surgeons, and if undertaking sacrectomy and pelvic bony excisions, spinal and orthopedic surgeons. There should also be a defined pathway to discuss patients with MDTs in peritoneal tumor, hepatobiliary, and thoracic specialist centers.

The role of advanced and recurrent cancer MDTs is to ensure appropriate diagnostic workup and establish the goals of treatment. This requires a personalized approach taking into account previous treatment. One of the first considerations is whether the patient's disease is potentially resectable with "R0" margins (complete resection with clear margins of at least 1 mm and no microscopic residual disease). If not, it must be considered whether neoadjuvant treatment such as chemotherapy and/or radiotherapy will make it resectable. If an R0 resection cannot be obtained, then the goal of any treatment is to strike a balance between quality of life and duration of disease control. In the case of chemotherapy, this involves taking into account toxicity and in the case or surgery the morbidity of the procedure. Symptom control (palliation) is important, and centers should have access specialist palliative care teams. Data on interventions and patient outcome should be collected prospectively with a view to obtaining long-term (10-year) follow-up outcomes. The author's institution suggests R0 resection rates, 3-year OS for R0 resections, and 30-day mortality as three quality indicators that should be used to benchmark results. These are 68%, 79%, and <1% for the author's institution, respectively.

In cases of oligometastatic disease (more than one distant metastatic site), while systemic chemotherapy is the standard of care, careful consideration has to be given to whether the sites are amenable to an R0 resection and if so whether this should be undertaken synchronously (multiple sites resected at the same time) or metachronously (staged resections). The latter is more common and requires careful consideration of the order in which these resections take place. It is important to note that despite the absence of high-quality data in this area, surgery has become the standard treatment approach for patients with resectable oligometastatic disease (most commonly liver and lung metastases). Local ablative techniques are being increasingly employed in the staged treatment of lung and liver metastases. These include thermal devices (radiofrequency ablation, cryoablation, or microwave ablation), nonthermal devices (brachytherapy and external body high-precision radiotherapy), embolic techniques (radioembolization with selective internal radiation therapy or transarterial chemoembolization), and locally delivered chemotherapy techniques [13].

2.5 Types of Perineal Excision

For low rectal cancers requiring removal of the anus, the concept of "extralevator abdominoperineal excision" (ELAPE) involves removal of a "cylindrical" specimen including the mesorectum and wide excision of the pelvic floor and ischiorectal fat. However, it is important to note that in the context of low locally advanced primary rectal cancers, there may be a need for an extended excision of the ischioanal fat akin to the approach taken in "salvage" surgery for recurrent anal cancers after chemoradiotherapy. Figure 2.6 illustrates the difference in these two procedures. Furthermore, readers should note that while the initial description of the ELAPE was with the patient in a prone "jack-knife" position, both this and the wider ischioanal excision procedure can also be undertaken with the patient in the Lloyd-Davies (lithotomy) position [14].

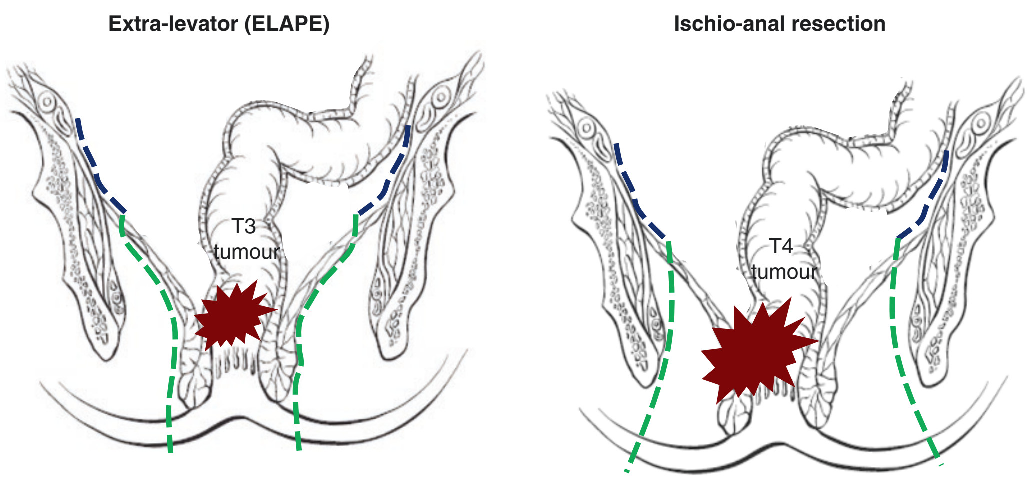

Fig. 2.6 Approaches to perineal excision. (Left) Standard extralevator abdominoperineal excision approach. (Right) A wider ischioanal approach for low, locally advanced T4 rectal cancers

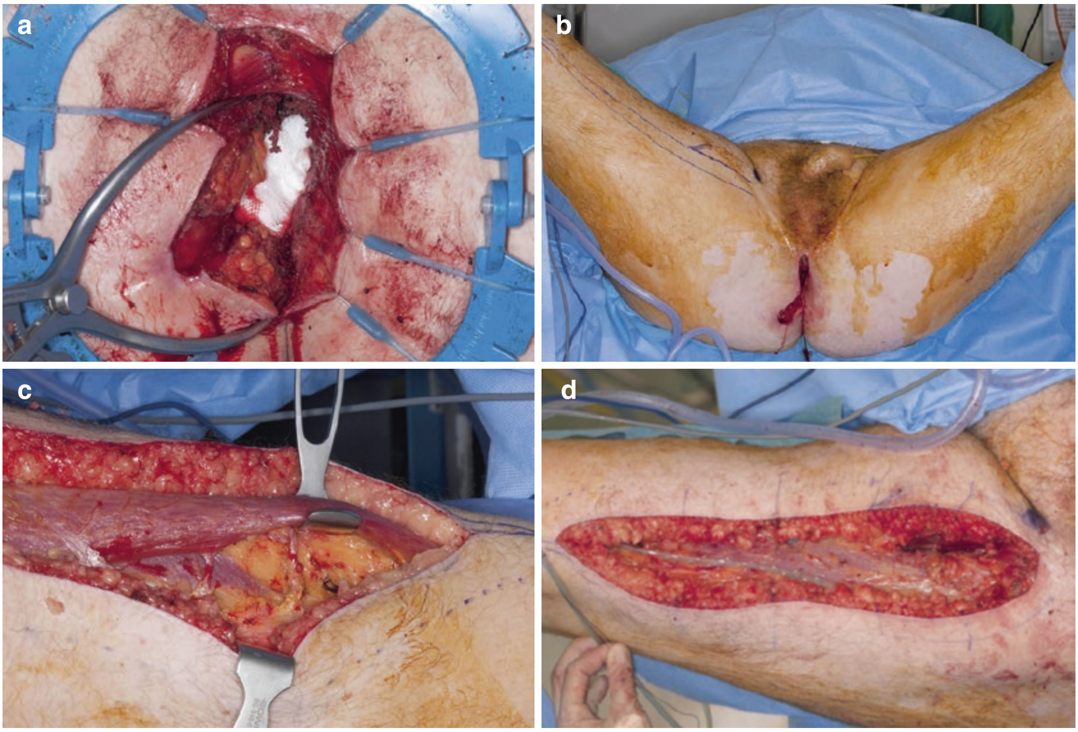

Fig. 2.7 A perineal defect after ELAPE (**a**) with a gracilis harvest site marked (**b**). The gracilis muscle and its perforators are shown (**c**) which are tunneled to fill the defect and the remaining harvest site (**d**) closed

In the case of ELAPE, an omentoplasty (mobilization and placement of an omental flap to fill the defect in the pelvic floor) and primary closure of the wound, biological mesh reconstruction and primary closure of the wound, and reconstruction with a pedicled or free flap are all options. The author's institutional practice is to avoid the use of meshes to close the pelvic floor as there is a lack of fixation points for the mesh and risk of infection. In the author's institution, either omentoplasty and primary closure or flap reconstruction is preferred closure techniques and biological mesh is not used for this purpose. Furthermore, perineal flaps are preferred to abdominal wall flaps due to the need to form one or two stomas in these cases. Figure 2.7 shows a gracilis flap in a perineal defect after ELAPE. In the case of ischioanal excision, the size of the defect necessitates reconstruction with a pedicled or free flap. Figure 2.8 demonstrates bilateral gluteal fold flaps after ischioanal resection.

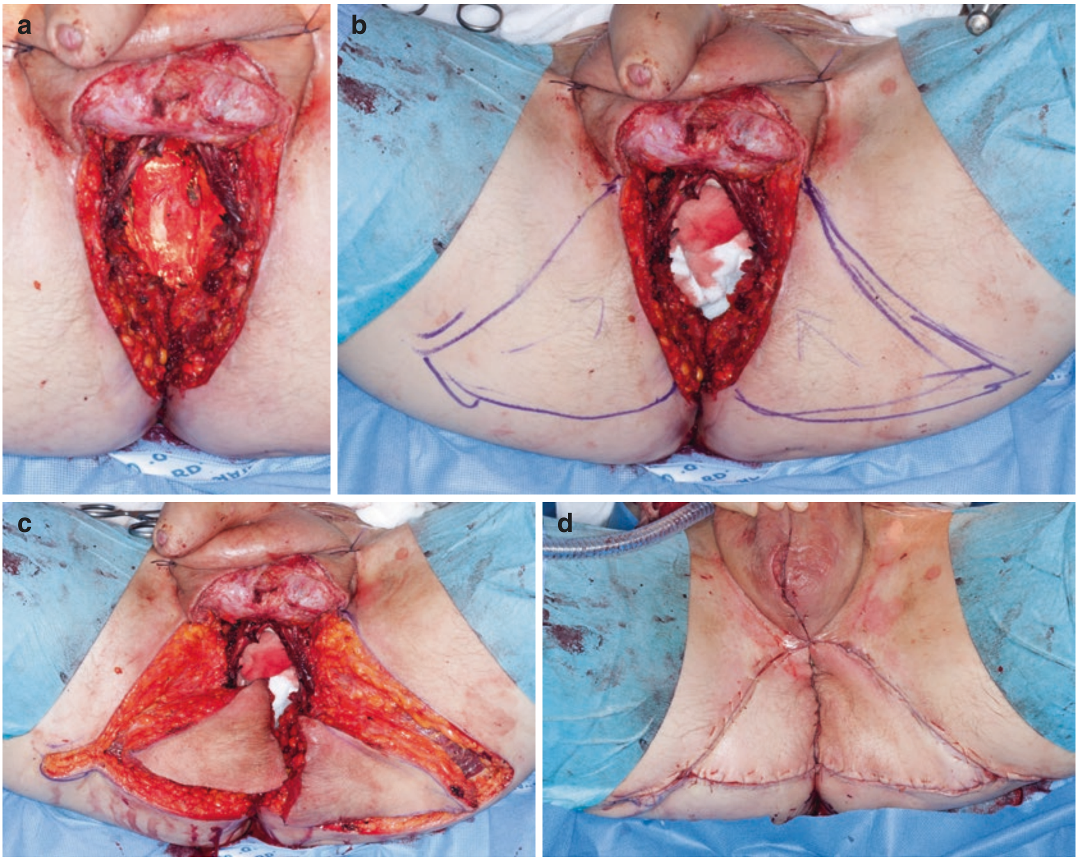

Fig. 2.8 Ischioanal resection in a male with resection of the penile base (**a**). The defect was closed with bilateral gluteal fold flaps (**b**–**d**)

2.6 Pelvic Multivisceral Exenteration

For locally advanced primary and recurrent rectal cancers, multivisceral resection is often required and should be undertaken with multispecialty surgical input within the context of a specialized complex cancer MDT, as has been discussed earlier in this chapter. Organs that require removal with the rectum may include structures anterior to it (including the bladder, prostate, seminal vesicles, urethra, uterus, vagina), posterior to it (including the presacral fascia, and sacrum), and lateral to it (including ovaries and associated structures, ureters, and pelvic sidewall vessels, nerves, and musculoskeletal structures).

2.6.1 Patterns of Rectal Cancer Recurrence

The following types of recurrences should be considered:

- *Central recurrences* (Fig. 2.9) most commonly arise at a previous rectal anastomotic site or in the residual mesorectum. These can go on to involve the anterior urogenital structures, which would need to be removed for an R0 resection. They can also extend posteriorly going up to the sacral fascia or periosteum only, in which case they may be resected en bloc for an R0 resection without sacrectomy.
- *Sacral recurrence* (Fig. 2.10) where bony invasion is present and an R0 resection is only

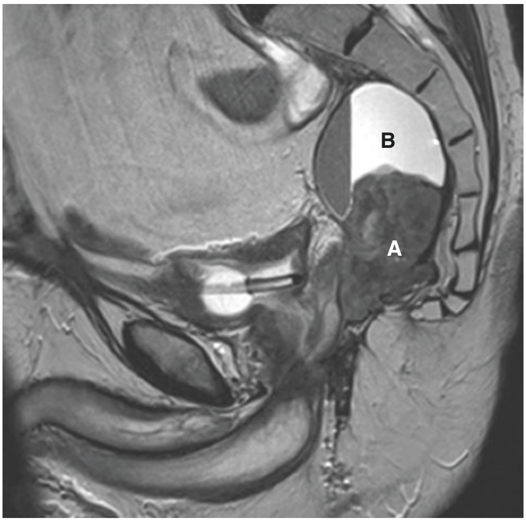

Fig. 2.9 MRI demonstrating central recurrence (A) at rectal stump following previous Hartmann's procedure with associated cystic cavity (B)

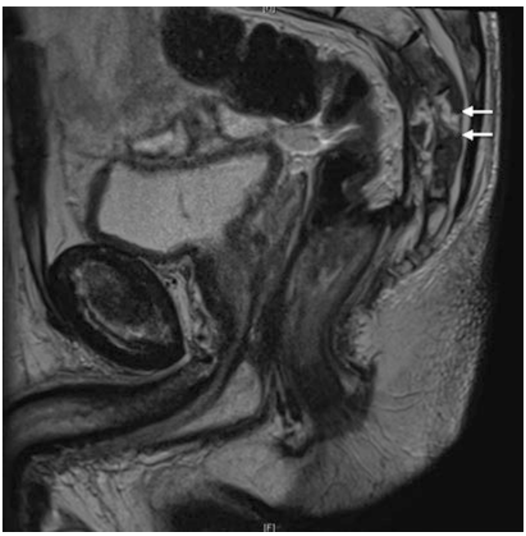

Fig. 2.10 MRI demonstrating sacral recurrence (arrows) extending up to the level of S3

possible with a sacral resection through a two-stage combined abdominosacral approach. Resection of the sacrum below S2–S3 level is an established technique with acceptable morbidity and established oncological and functional benefits. Involvement above S2–S3 required sacral fixation and while in the past had been considered a relative contraindication to surgery (the procedure involves ligation of the cauda equina and freeing the sacrum with sacrifice of sacral nerve roots below the level of resection); more recent data suggest that good survival outcomes can be achieved [15]. Sacrectomy should be undertaken in selected centers with the relevant experience and auditable outcomes. Figure 2.11 is an MRI scan demonstrating an S3–S5 sacrectomy.

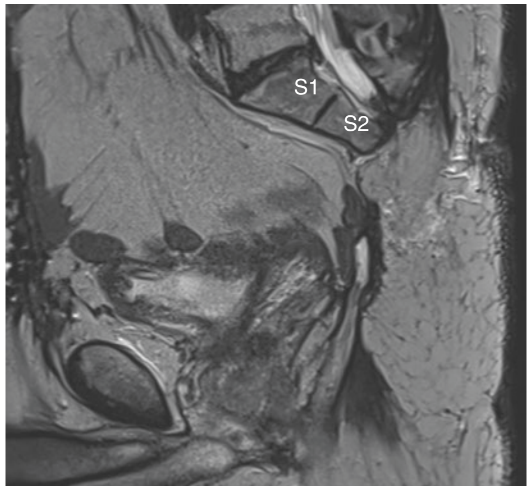

Fig. 2.11 Sagittal MRI scan of an S3–S5 sacrectomy. The remaining S1 and S2 sacral segments have been marked out

- *Lateral recurrence* (Fig. 2.12) involves the lateral pelvic sidewall encasing iliac vessels, pelvic autonomic nerves, and ureter and can extend through the greater sciatic foramen with or without invasion of the sciatic nerve. Of all the types of recurrence, this is the most difficult to achieve an R0 resection and is therefore associated with the poorest prognosis. Techniques to achieve clear lateral margins include en bloc resection of the iliac vessels and other sidewall structures and extended lateral pelvic sidewall excision.

2.6.2 Types of Pelvic Exenteration

Pelvic exenteration surgery needs to be tailored to each individual case; however, generally these procedures are as follows:

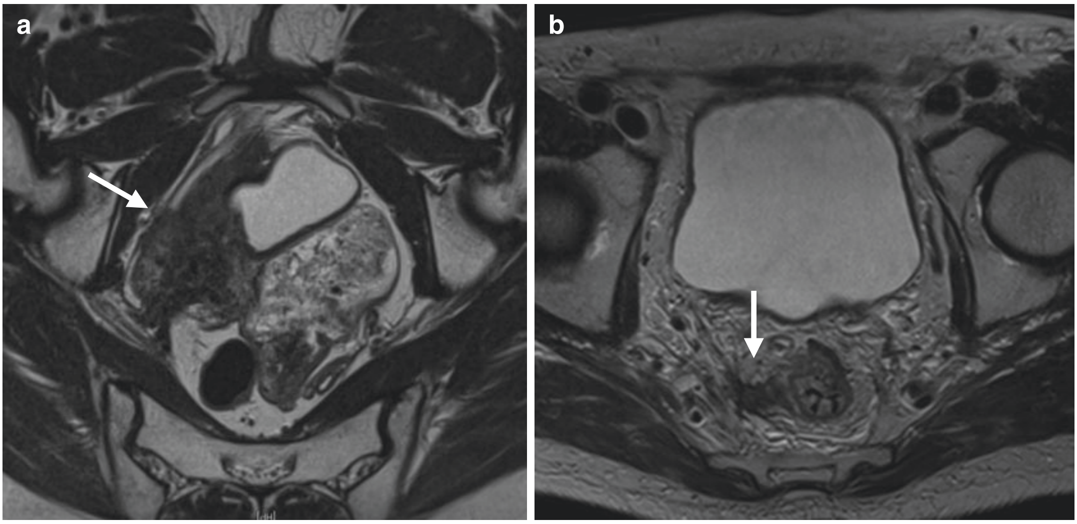

Fig. 2.12 Lateral recurrences of the left pelvic sidewall involving left internal iliac vessels and ureter (a and arrow) or abutting left internal iliac artery branches (b and arrow)

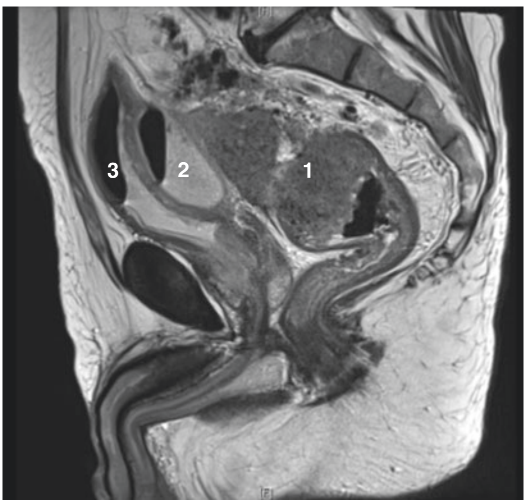

Fig. 2.13 MRI demonstrating locally advanced rectal cancer (1) with anterior perforation and associated abscess cavity (2) adjacent to bladder (3). The patient required total pelvic exenteration

- *Total pelvic exenteration* (or clearance) involves removal of the rectum, sigmoid colon, bladder, draining lymph nodes, pelvic peritoneum, and lower ureters. In males, the prostate and seminal vesicles are also resected. Figure 2.13 is an MRI scan demonstrating a rectal cancer requiring total pelvic clearance. In females, the uterus, ovaries, fallopian tubes, and required part of the vagina are removed. The patient has an end colostomy, and an ileal conduit is the most commonly used urinary reconstruction.
- *Anterior pelvic clearance* involves removal of the distal ureters, bladder, prostate, and seminal vesicles in a male and, in females, the uterus, ovaries, fallopian tubes, and the required part of the vagina. It is not a commonly performed operation for rectal cancer and is reserved mainly for tumors of the upper rectum and rectosigmoid that invades into anterior structures. This operation is more commonly used for the treatment of advanced urological and gynecological tumors. The distal rectum is spared and may be reanastomosed, and an ileal conduit is the most commonly used urinary reconstruction.
- *Posterior pelvic clearance* is a procedure performed in women, involving the removal of the rectum and uterus, required part of the vagina, ovaries, and Fallopian tubes. This may be with or without removal of the anus (perineal excision). The bladder is spared.

It is also important to appreciate that in the lateral dissection of the pelvic sidewall, depending on the extent of tumor invasion, there are

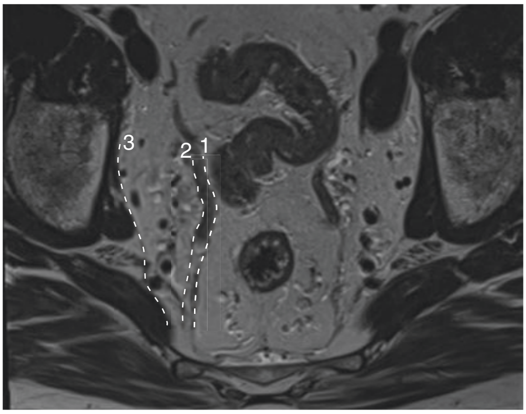

Fig. 2.14 MRI demonstrating planes of the right pelvic sidewall: mesorectal plane (1), ureteric plane (2), and bony plane lateral to internal iliac vessels (3)

three potential planes that the surgery may be undertaken in (Fig. 2.14):

- *The mesorectal fascial plane*—a continuation of the standard plane in which a TME is undertaken.
- *The ureteric plane*—a plane below the lateral pelvic peritoneum in which the ureter runs.
- *The bony plane lateral to the internal iliac vessels*—a plane along the obturator internus and piriformis muscles in the lateral pelvic compartments.

2.7 Stomas

Abdominoperineal resections involving removal of the anus, rectum, and pelvic floor result in a colostomy where the descending colon is brought out to the surface of the skin through a trephine wound as a "colostomy." This is most commonly placed in the left iliac fossa and is flush with the skin. Colostomies produce more formed stool and require emptying 1–2 times per day. If the entire colon has to be removed, the patient has their ileum brought out through a trephine wound in the right iliac fossa as an "ileostomy." These stomas are spouted to minimize contact of liquid stool with enzymes onto the adjacent skin which can cause painful excoriation. Ileostomies have to be emptied 4–6 times a day as they produce a larger quantity of more liquid stool. In cases where a total pelvic clearance is performed and the bladder is also removed, the two ureters are attached to a segment of the ileum and brought out to the surface of the skin as an ileal conduit most commonly in the right iliac fossa. This produces a constant amount of urine and requires regular emptying. In the author's institution, the use of perineal flaps is preferred to abdominal reconstructions for patients having stomas [16].

2.8 Conclusion

Perineal defects are created for a wide range of indications in colorectal surgery and their size, shape, depth and the tissues they involve require significant tailoring to the patient. Their management requires a multidisciplinary approach. This chapter has focused on larger perineal wounds such as those created in abdominoperineal resections that involve the removal of the anus, anal canal, and rectum, with variable amounts of adjacent pelvic floor muscles, subcutaneous fat, and skin depending on the indication for surgery (tumor type and size). It has also included patients undergoing perineal resections as part of total pelvic clearance procedures.

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3 Perineal Reconstruction in Gynecological Oncology: Indications and Insights

Brett Winter-Roach

There have been case series that report experience with many different types of reconstruction used in the closure of perineal wounds created in the treatment of different gynecological malignancies and that provide some rationale for the choice of one over the other approach [1, 2]. This chapter recognizes the importance of the technical considerations of flap reconstructions but seeks to discuss the gynecological oncology indications for perineal surgery with consideration of factors influencing decisions about wound closure techniques.

These decisions require an understanding of both the pathology being treated and importantly the aims of treatment. The surgical approach must as well consider various patient factors that influence wound healing. A sympathetic working relationship developed between the gynecological oncology surgeon and the plastic surgeon provides for the nuanced decision making that an algorithm cannot really match.

The indications for perineal surgery in gynecological malignancy are listed:

Vulval cancer primary and recurrent disease.
Vaginal cancer.
Exenterative surgery for gynecological disease involving the perineum.
VIN and lichen sclerosis.
Extramammary Paget's disease of the vulva.
Vulval sarcoma.
Vulval/vaginal melanoma.

3.1 Primary Vulval Squamous Cell Cancer

Plastic surgical approaches are sometimes necessary for the treatment of this condition.

The majority of perineal surgery done by gynecological oncologists is for squamous cell vulval cancer, which is primarily treated surgically with the aim to achieve a margin of 1.0 cm ideally in all dimensions, though a 7 mm margin is considered adequate [3, 4]. There are, however, other important factors that influence risk of recurrence including immunosuppression, concurrent multifocal preinvasive disease of the cervix or vagina, and age [5]. The challenge is simple in the majority of cases in which lesions are smaller and are lateral in location. In these instances, the defect can usually be closed primarily in layers with minimum tension without recourse to reconstructive surgical techniques.

Lesions that are larger than 4 cm in size are likely to leave defects that are larger than can be reasonably closed primarily. Defects larger than 5 cm are likely to be better closed with the use of advancement-type flap reconstruction.

Tumors that are within 2 cm of the midline come with the additional concern of the proximity

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of either the anus (sphincter) or the urethra. Both situations provide additional complexities for both the resection and reconstruction.

In the majority of cases, anterior vulval cancers will be centered on or very close to the clitoris. It will be necessary in these cases to remove the overlying skin of the clitoris and at times in order to ensure an adequate margin; the clitoral body will likewise need to be sacrificed. Attention will be needed to control the clitoral artery with a dedicated transfixing suture. Counseling the patient carefully about the consequences of the surgery with respect to body image and sexual function is essential, and the help of specialist nurses to support patients through this process is invaluable. With tumors extending to or within 1 cm of the external urethral meatus, it is necessary to excise the terminal urethra to achieve an adequate margin. The implications of this are a loss to some of the sensory feedback that is required for urinary continence. The reconstruction of the anterior perineum is challenging in these cases, and the support of plastic surgical colleagues is needed. If any more than 1 cm of the distal urethra is removed, it may be necessary to close the urethra and to rely on a permanent suprapubic catheter. Though this may be considered an extreme measure, it is preferable to cystectomy and the formation of an ileal conduit urinary diversion.

Posterior tumors involving the perineum are frequently encountered. It is often possible to achieve an adequate margin by incising within 1 cm of the anterior circumference of the anal verge. In pursuit of a deep margin, the anal sphincter is very often exposed and occasionally injured necessitating repair as would be undertaken with third-degree tears of the anal sphincter sustained in vaginal childbirth. Primary closure is sometimes possible in this situation though more often the size of the defect makes perineal flap reconstruction necessary (Fig. 3.1).

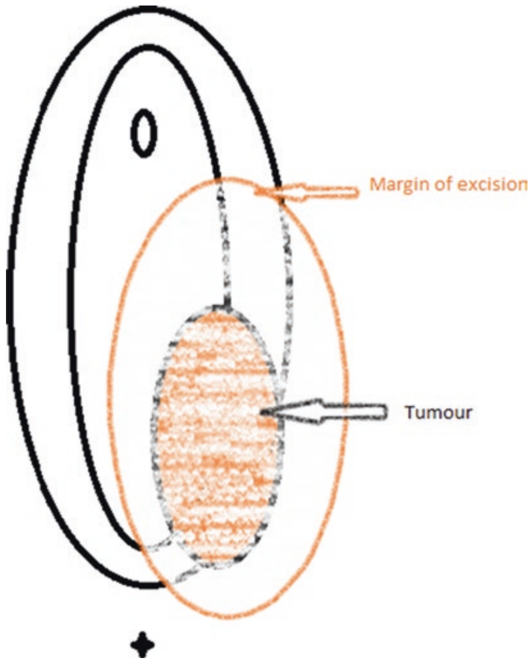

Fig. 3.1 Surgical incision margin influenced by proximity to either anus or urethra. The posterior margin is narrower to avoid injury of underlying anal sphincter complex

3.1.1 Primary Closure

The usual principles of good surgical practice pertain. Attention to hemostasis is very important. The author's preference is to use bipolar diathermy though arterial bleeding from branches of the pudendal arteries is better controlled with vascular ties after initial control with artery clips. Bleeding from the periclitoral vessels and paravaginal venous plexus can be troublesome, and the use of figure-of-8 sutures can be very effective in this regard. Inattention to hemostasis may result in the development of a hematoma in the subcutaneous space that is likely to result in poor wound healing, likely wound infection, and wound breakdown with resulting scar.

Occasionally, the use of small caliber suction drains is necessary though this is not the usual practice.

Interrupted mattress-type sutures with dyed 2/O vicryl are favored.

3.1.2 Advancement VY Flaps

The use of these transpositional advancement flaps raised from the gluteal folds is frequently used to close the typical posterior vulval wounds left by radical wide local excision. These flaps are based on branches of the deep pudendal artery and can be done on one or both sides to close quite large

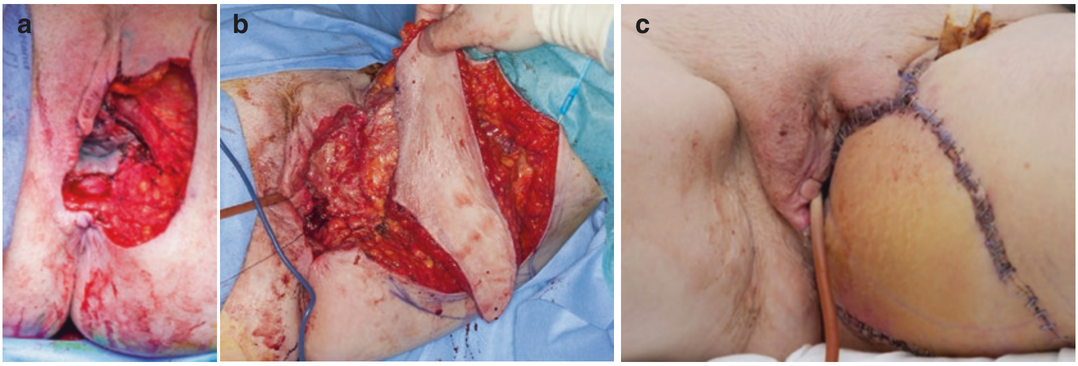

Fig. 3.2 (**a**–**c**) Partial left vulvovaginectomy and V-Y PAP-Flap reconstruction

defects. They can be used in patients who are having primary surgery and as well for patients who have had previous radiotherapy to the vulva. Certain patient characteristics are predictive of the success or failure of these flaps and must be considered in decision making. Smokers and diabetics are more vulnerable to wound breakdown and should be counseled appropriately. Deeper wounds that result from partial vaginectomy for example may be less suited to these flaps, and a myocutaneous tunneled flap may be considered (Fig. 3.2).

3.1.3 VIN-Vulval Intraepithelial Neoplasia

This premalignant HPV-driven condition can be unifocal or multifocal. The fundamentals of treatment recognize that this condition is premalignant so wide radical excision is not necessary. Excision with a narrow margin of 5 mm is acceptable [6]. Patients with involved margins are likely to recur and require further treatment, and long-term follow-up is required. It is necessary to map out the disease carefully to plan treatment taking into consideration characteristics of the patient and their past medical and previous perineal surgical history and considering important risk factors for recurrence [7] (Fig. 3.3).

In patients with one or a few isolated lesions that are small, it is possible to completely excise the disease and to close the wounds directly.

The treatment of multifocal disease or disease that is extensive is perhaps best done with the support of and collaboration with plastic surgical col-

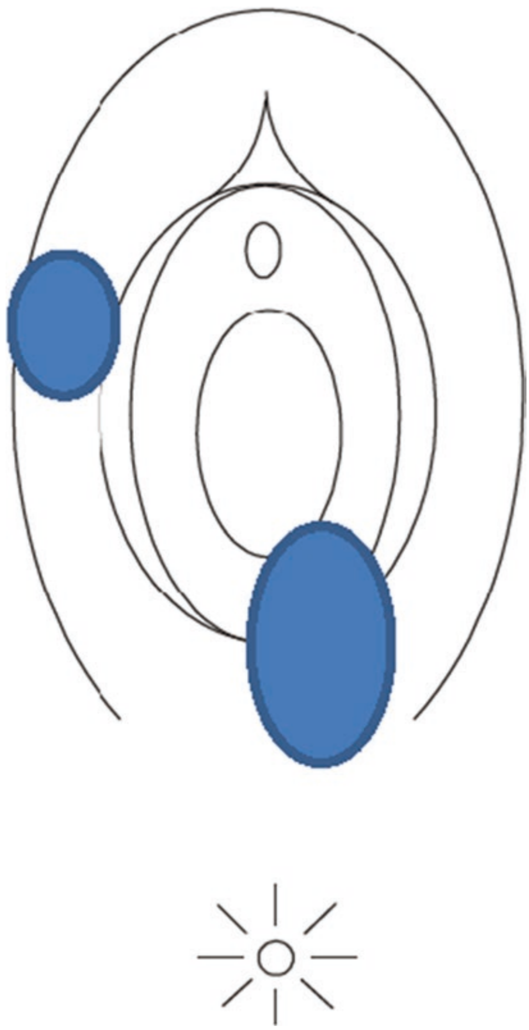

Fig. 3.3 Multifocal disease. Separate incisions are preferred to full vulvectomy for preinvasive disease

leagues. When the size of an excisional defect is such that primary closure cannot be achieved with minimum tension, it may be necessary to perform either a **partial or full-thickness skin graft** or alternatively to perform a **local flap reconstruction**. This approach, while within the technical remit of the experienced surgical gynecological oncologist, may be better handled by someone experienced with some of the subtleties of tissue handling in this area. Furthermore, the responsible clinician should be able to respond to and manage any complications that arise from a skin graft or at the donor site.

In any event, these approaches are often quite successful in removing VIN lesions, providing as well tissue samples that can be processed in the laboratory to exclude any malignancy.

The treatment of VIN with **laser ablation** is sometimes appropriate when the lesions are either very extensive, or where the aim is to avoid excisions. For lesions near the clitoris, in particular, it may be preferable to avoid excisions of tissue, which result in both functional loss, loss of sensation and distorted anatomy. It is possible to do a laser ablation to precisely target these areas, or lesions.

In the UK, gynecological oncology treatment centers with facilities for laser treatment are less common in current practice now, as the costs of CO2 laser machines can be prohibitive. Additionally, the need to maintain training in the safety aspects of the use of lasers is a limiting factor. Again, the support of colleagues in plastic surgery who are using this treatment modality for other disease types can be quite helpful. The use of laser treatment can also be helpful in multifocal disease, which is extending to a wide area or overlapping into the posterior perineum/perianal area or to the lower vagina. Laser ablation may be preferable to excision for this patient group as it can avoid very large incisions.

3.2 Extramammary Paget's Disease of the Vulva

Vulval Paget's disease is characterized by red or tender pruritic patches, which only hint at the true extent of disease, which microscopically could extend widely into the subdermal tissues of the vulval skin that appears normal to the naked eye. For this reason, the surgery for this condition can be problematic requiring extensive excisions and re-excisions in order to gain any surgical control [8]. Often, for this reason, topical immune modulation or photodynamic therapy is favored [9]. For those who are unable to tolerate the pain of photodynamic therapy, or for whom there is evidence of invasive Paget's on biopsy, excisional surgery remains appropriate. The wide local excision of these lesions can leave a defect, which is 10 or more centimeters wide, extending into the mons pubis or toward the buttocks.

If planned and performed with a plastic surgeon, flap reconstruction can afford a very good closure. Primary closure immediately after excision or delayed primary closure after histological confirmation of complete excision each have their relative merits. Direct primary closure following excisional surgery for vulval Paget's disease risks close or involved margins. With the latter approach of a delayed reconstruction, the wound needs to be packed and dressed with an occlusive dressing (if possible) for the days or even weeks required to get the histology reported and reschedule the reconstruction. This approach is likely to commit the patient to a longer period of in-patient care, is associated with a greater chance of wound infection, and has less appeal for patients who prefer more expedite care.

At times, in planning primary closure, it may be preferable to perform frozen section biopsies during the procedure in order to be more secure in determining a negative margin. This approach, though, with merit demands the support and buy-in of consultant histopathology colleagues who may not be as comfortable with reporting this histology on a frozen section biopsy.

The usual principles of care of advancement or rotational local flaps apply with the need to avoid direct pressure on the flap, at least in the first few days following surgery. The author's preference is for the use of subcutaneous drains for larger flap reconstructions in order to reduce the risk of problems related to wound hematoma.

3.3 Vaginal Cancer and VaIN

Most primary vaginal cancers are treated with radiotherapy and chemotherapy given concurrently.

This combination of treatment is less likely to result in the patient requiring exenterative type steps with removal of the rectum and bladder, which are the immediate posterior and anterior relations of the vagina itself.

The role of surgery for vaginal cancer and its premalignant precursor, VaIN, is limited to those tumors that are relatively small, superficial, and typically confined to the lower third of the vagina.

Vaginal cancers are predominantly squamous type malignancies though adenocarcinomas can be seen, arising in the glands of the lower vagina and vulva, such as Bartholin's gland or Skene's glands.

When surgery is performed for a low vaginal malignancy, the aim is to achieve an adequate negative margin of at least seven millimeters. If this is done after any radiotherapy, due to a persisting though smaller lesion, wound breakdown is inevitable and the input of a tissue viability nurse to support with the provision of advice about appropriate dressings is invaluable.

The challenge of surgery for vaginal tumors is greatest with respect to preserving or avoiding damage to the anal sphincters, both internal and external, which are all almost always involved in posterior lower vaginal tumors or vulval malignancies, encroaching on the midline posteriorly. The other concern is, of course, with anterior vulval or vaginal tumors related to the urethra, where the need to achieve an adequate margin of excision can mean sacrificing part of the urethra and risking urinary incontinence. Sometimes, it is necessary with anterior excisions to close the urethral meatus and accept a permanent suprapubic catheter for urinary diversion. This may be preferable to having cystectomy and urostomy.

The resulting perineal defect after radical excision of a lower vaginal or midline vulval lesion is thereby variable, with respect to both its size and geometry. Complex flap reconstructions of either petaloid rotational type or advancement flaps of the V to Y type based on the pudendal artery in the gluteal fold can be used successfully to meet this challenge.

When, as is often the case in younger women, the aim is to preserve vaginal function, the challenge is greater still. Anastomosing the flap to the remaining vagina, either anterior or posterior, is technically demanding, and requiring patience, and some considerable skill.

3.4 Exenteration for Recurrent Gynecological Cancer Involving Perineum, the Vulva, and Vagina

Surgery for these recurrent cancers of the endometrium, cervix, or vulva may be considered if there is no evidence of distant disease. Patients considered for these procedures will often have had previous radical radiotherapy. This challenge truly requires a multidisciplinary approach, incorporating the joint efforts of gynecological, colorectal, urological, and plastic surgical teams [10, 11]. The finding of an isolated pelvic recurrence of a cervical cancer can sometimes require removal of the entire vagina, together with the bladder and rectum, leaving a defect as well in the perineum.

When an infralevator exenteration is performed, it will be often necessary to close the vagina at the introitus or, at most, leaving very short vaginal stump. It may be possible to use omentum to try to fill the space left after this evisceration. This is not usually entirely satisfactory, and problems of pelvic floor herniation, occasionally with quite dangerous complications such as small bowel obstruction, can be seen. When the tumor is centered on the vulva or rather when recurrent tumor is centered on the vulva, particularly following radiotherapy, similar steps will be required, but the resulting defect in the perineum can be very large, and more determined efforts with plastic surgical input are required to close the wound. Locoregional advancement flaps from the gluteal folds may be possible. Alternatively, to provide more tissue bulk, a tunneled flap drawn from the thigh such as a gracilis flap can be performed. This approach may be preferred over the use of vertical rectus abdominis muscle (VRAM) tunneled flaps since the abdominal wall may be needed to host, either the colostomy or urostomy, required in the course of surgery.

In any event, this approach is very much a team effort. Since the patient will typically need to stay in hospital for a minimum of 2 weeks, there is usually ample time for the expert input of plastic surgeons and tissue viability nurses in the postoperative care (Figs. 3.4, 3.5, 3.6, 3.7, and 3.8).

Fig. 3.4 Multifocal malignancy involving perineum

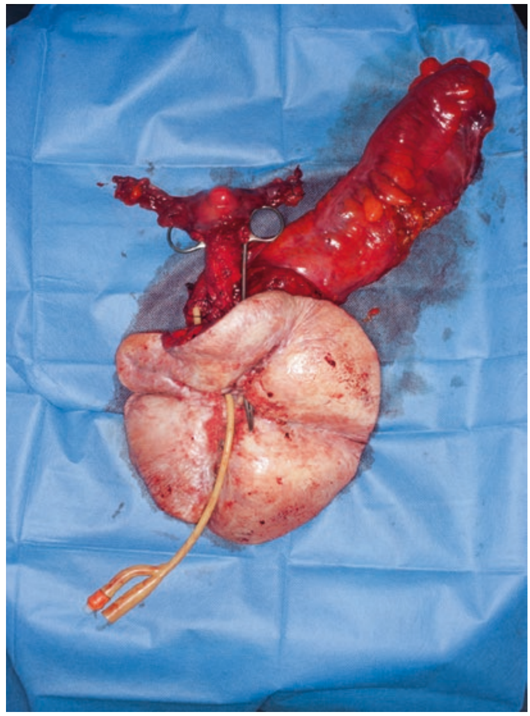

Fig. 3.6 Exenteration specimen - en bloc removal of uterus, bladder, rectosigmoid, and perineum

Fig. 3.5 Recurrence post radiotherapy and previous surgery with local V-Y flaps reconstruction (courtesy of mr Michael Smith/Consultant Gynecological/Oncological Surgeon)

Fig. 3.7 Extensive Perineal and pelvic wound (courtesy of mr Michael Smith and mr Damir Kosutic)

Fig. 3.8 Complex multi-flap reconstruction (courtesy of mr Damir Kosutic/Consultant Plastic and Reconstructive Surgeon)

3.5 Vulval Sarcoma

Primary vulval sarcomas are exceedingly rare. Such tumors can potentially arise in the stromal elements of the vulval glands or the connective tissue of the vulva. Such cases will be discussed by the sarcoma team and may require resections that involve orthopedic and oncoplastic surgeons.

Dermatofibrosarcoma Protuberans (DFSP).

This is an indolent low-grade sarcomatoid tumor, which rarely involves the vulva, mons, or perineum [12]. With this histology, the tumor can recur many years later despite quite generous margins of excision. The surgery is challenging and customized specific solutions with local flaps of different types may be required.

3.6 Malignant Melanoma of the Vulva or Vagina

This is a rare disease that even in a busy high-throughput service may be encountered no more than once a year [13]. The author has personal experience of no more than 5 such cases in a career now spanning 15 years.

Primary cutaneous malignant melanoma is approached like other vulval cancers with a careful documentation of disease extent by clinical examination and occasional examination under anesthesia. Pelvic MR scan will be required to explore the local disease extent and to determine if there is any size significant lymphadenopathy. PET CT scanning will complete the staging in this disease, which can be associated with distant metastasis. The traditional teaching has been that only if distant metastases are excluded, radical local treatment can be justified; however, immunotherapy can provide such sustained remissions of disease that this long-held rule is being challenged.

Local control of disease is best achieved with generous margins of excision exceeding 1 cm. A 2 cm margin of excision on resection is planned, which can lead to quite large defects needing reconstructive techniques as for other vulval cancers. The more problematic tumors are those with close relationships with the urethra or to the anus. For these tumors, it may be necessary to consider either cystourethrectomy with urinary diversion or possibly urethrectomy with permanent suprapubic catheterization. For tumors encroaching on the anus, it may be necessary to perform a colostomy to allow resection of the anus. As for recurrent squamous cancers or adenocarcinomas involving the perineum, the treatment of primary vulval melanomas can rarely require exenterative surgery leaving wide perineal defects and requiring reconstruction with either local advancement flaps (V to Y) or rotational lotus type flaps based around the pudendal artery. For anterior vulval lesions, the challenge can be somewhat different requiring the use of tunneled flaps making use of gracilis muscle or even VRAM flaps (though this would not be practical if both an ileal conduit and a colostomy were being done).

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4 Urological Aspects of Perineal Surgery and Reconstruction

Jeremy Oates

4.1 Introduction

The perineum is a key component of urological anatomy, with the urological functional outcomes of a wide variety of procedures being dependent on the maintenance and restitution of the perineum. Many of the pathologies described in other chapters in this book will have significant urological components; the importance of proper Multidisciplinary Team planning cannot be overstated in complex pelvic cases. All too frequently, involvement of key urological structures, particularly in the perineum, is overlooked with potentially significant and life-changing consequences to the patient. Awareness of these structures and careful planning are keys to the early identification and preservation of these structures.

Urological malignancies involving the perineum are uncommon, though centralization of urological cancers has meant that increasingly these are dealt with in higher volume centers [1, 2]. Occasionally though, these malignancies can present unexpectedly and benign urological conditions involving the perineum can present acutely requiring emergency intervention. More frequently, due to the close proximity of urological structures to other areas of the perineum, urological involvement in perineal surgery is common in nonurological pathologies and it is therefore important for all surgeons operating around the perineum to have an awareness of the potential for complications.

4.2 Key Urological Anatomical Considerations

Although most surgeons will have an awareness of the anatomy of the perineum and the pelvis, the proximity and relationship of certain key urological structures can be overlooked, with potential significant consequences. The urogenital triangle, representing the anterior half of the perineum is associated with the urological structures of the perineum. In females, the urethra, external sphincter, and vagina sit within the deep perineal pouch, formed by the deep fascia of the pelvic floor anteriorly and the perineal membrane inferiorly. In males, the deep perineal pouch contains the bulbourethral glands and deep perineal muscles. The superficial perineal pouch is separated from the deep by the perineal membrane, a tough fascia that acts as an attachment for the musculature of the external genitalia. The inferior border is formed by the superficial perineal fascia and it contains the erectile tissue of the penis and clitoris, along with the bulbospongiosus, ischiocavernosus, and super-

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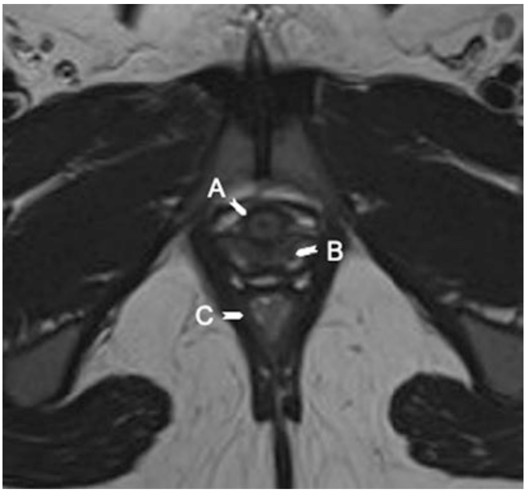

Fig. 4.1 Female perineum. Axial T2 MRI views of the female perineum. The uretha (A) can be seen anterior to and in close proximity with the anterior wall of the vagina (B). Posterior to the vagina is the rectum (C)

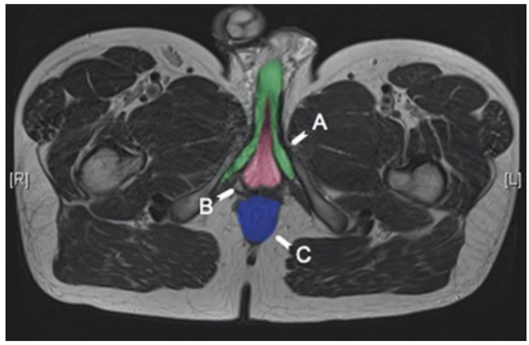

Fig. 4.2 Male perineum. The male perineum, showing the crus of the penis (A), the bulb of the penis (B) and the rectum (C). The crus is a continuation of the corpus cavernosa, which form the erectile bodies of the shaft of the penis; damage to these structures can result in erectile dysfunction. The bulb (B) contains the urethra and is covered by the bulbocavernosal muscle. Close proximity of the anorectum to the bulb results in vulnerability to damage during perineal surgery

ficial transverse perineal muscles. The posterior border is formed by the perineal body, a tough fibromuscular body at the center point of the perineum that divides the perineum in the urogenital and anorectal triangle.

In the female, the short nature of the urethra and the close proximity of the urethral sphincter to both the perineum and the anterior vaginal wall, means that there is a high risk of injury during perineal surgery (Fig. 4.1). Equally, any damage to the muscles of the superficial pouch or damage to the perineal body in particular can result in disruption to the support of the bladder neck. Either of these issues can result in significant problems with stress urinary incontinence, or even insentient, total incontinence. In the context of complex perineal wounds, this type of incontinence can have a huge impact on the patient and can be extremely challenging to manage, let alone treat definitively. Incontinence can also disrupt or prevent the healing of perineal wounds, compromising further care.

In the male, the external sphincter sits somewhat deeper than in the female and as such is less prone to injury (Fig. 4.2). However, the proximal penile and bulbar urethra sit more superficial that is often suspected, and as such are prone to injury. Incomplete urethral injuries can be managed conservatively with a Foley catheter, though often result in urethral stricture disease. More extensive injuries often require multistage repairs and will require the input from specialist urethral reconstruction teams. For this reason, at our institute we would strongly recommend the use of a urethral catheter to help facilitate the identification and localization of the urethra whenever perineal surgery is being considered.

The crus of the penis diverges and becomes more lateral, as it progresses posteriorly through the perineum (Fig. 4.3). As such, they are potentially susceptible to damage in the lateral perineum and damage can result in significant impairment to erectile function through disruption to the erectile mechanism. Similarly, the neurovascular bundles that are essential for erectile function are vulnerable as they enter the perineum adjacent to the bulb of the penis.

Sexual dysfunction in females following perineal and pelvic surgery is often overlooked and disregarded by surgeons, but can be significant and can have a major impact on quality of life postoperatively. Sexual dysfunction can occur in up to 60% of women undergoing low anterior resections or APRs, due to issues including loss of clitoral and distal vaginal sensation, vaginal dryness, and length loss. Radical Cystectomy for bladder cancer is associated with anorgasmia or reduced ability to orgasm in 45% [3]. Preservation of the lateral walls of the vagina can help pre-

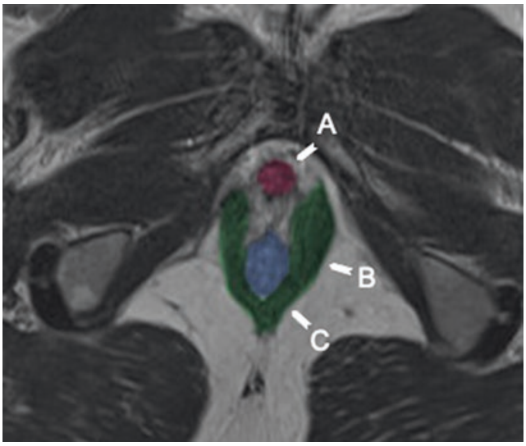

Fig. 4.3 Male Sphincters. Outlining the proximity of the urethra (A) and rectum (C) in the male as they pass through the pelvic floor. The puborectalis, part of the pelvic floor musculature, is marked (B)

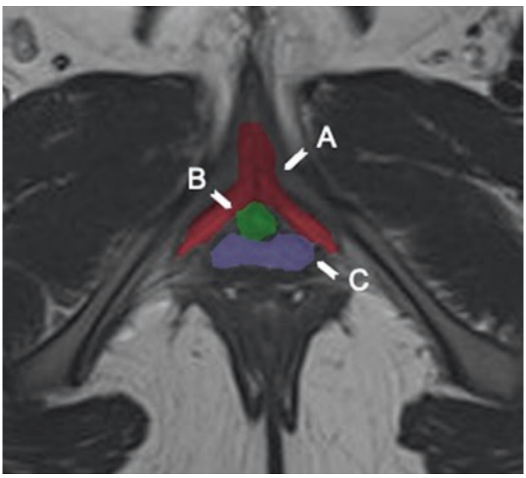

Fig. 4.4 Crus of clitoris. Showing intimate relationship of crus of the clitoris (A, in red) and its close relationship with then urethra (B, in green) and the vagina (C, in purple)

serve the plexus fibers supplying the distal urethra, which along with preservation of the neurovascular bundles in the pelvis can help maintain orgasmic function. Care must be taken whenever operating anterior to the vagina to preserve the crus of the clitoris and the bulb, which sits slightly superior and medial to the crus (Fig. 4.4). Unrecognized damage to either of these structures can result in sexual dysfunction postoperatively.

4.3 Urological Cancers and the Perineum

Despite the close proximity of urological structures to the perineum, the more common pelvic urological malignancies generally do not involve the pelvic floor and when they do, surgery is not normally a viable treatment option due to the inherent advance nature of the disease. However, there are situations when the management of these malignancies will require more extensive surgery, often involving the perineum.

4.3.1 Prostate Cancer

Prostate cancer is the most commonly encountered pelvic malignancy but disease progression into the pelvic floor and beyond is uncommon and surgical resection when there is involvement is unlikely to offer the patient long-term benefit. On rare occasions, there may be a palliative role for exenterative surgery (for example, in patients with impending rectal obstruction unable to receive radiotherapy). An example of such cases is given in Fig. 4.5, showing axial and sagittal views of a T4 prostate cancer infiltrating into the anterior rectum. Although radiotherapy to achieve local control is normally the treatment of choice, these patients occasionally require pelvic total exenteration, normally with the lower rectum and anus removed en-bloc with the bladder and prostate. The colorectal aspects of this procedure are broadly similar to Abdominoperineal resection (APR) and the perineal management aspects are as described in the chapter on colorectal surgery.

Although on occasions it may be technically possible to preserve the bladder in this setting, functional outcomes (particularly in terms of urinary incontinence) are poor due to likely involvement with the pelvic floor, urethral sphincter, and bladder neck. It is the practice of our institute to perform a urinary diversion in this situation, normally with an ileal conduit, which is generally associated with better quality of life outcomes as compared to attempts to perform bladder preservation.

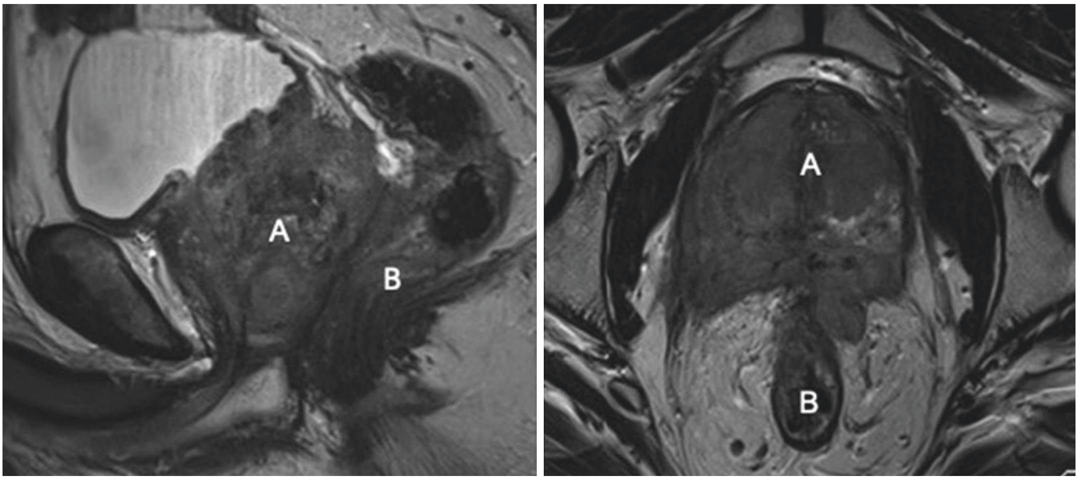

Fig. 4.5 T4 Prostate. Showing an advanced T4 Prostate cancer (A) infiltrating into the rectum (B), with clear tethering of the rectum at 12 o'clock on the axial views. In this case, the patient is known to have Lynch Syndrome, meaning that radiotherapy would result in a very high risk of malignant transformation in the rectum. Although it was felt that surgical resection of this gentleman's disease would be unlikely to cure his prostate cancer, it was felt by the MDT that due the very high risk of bowel and ureteric obstruction, a total pelvic exenteration would be his best option for long term disease control and maintenance of quality of life

4.3.2 Bladder and Urethral Cancer

The urinary tract is lined with transitional-cell epithelium (urothelium), which a specialized epithelial layer with waterproof and chemo-resistant properties to effectively store and transit urine. The transitional epithelium is frequently exposed to carcinogens resulting in urothelial cancers, particularly in the bladder where exposure is greatest due to its storage function [4]. A small percentage of tumors arise from or include the urethra, which can be of significance to the perineum, particularly in women due to the close proximity of the urethra and bladder neck to the perineum.

Superficial bladder cancer, which represents 65–75% of urothelial disease, is generally managed endoscopically and has a low risk of progression. Invasive disease affecting muscular layer is a very different and much more aggressive disease; more than 10% of patients present with a metastatic disease and even when localized and treated radically, 5-year survival is rarely more than 70% [5]. For those with metastatic disease, the prognosis from presentation is normally less than 12 months. Radical surgery involves the removal of the bladder and distal ureters, along with the prostate in a man due to the integral nature of the urothelium-lined prostatic urethra.

In women, cystectomy is normally performed as an anterior pelvic clearance due to the close proximity of gynecological structures to the female bladder. This would usually include excision of the anterior vaginal wall adjacent to the posterior bladder wall, along with the urethral meatus. Extensive involvement of the female urethra will therefore necessitate a much more extensive resection of the vagina and vulva, and this resultant defect may require a flap to achieve adequate closure.

This is also true of rare, primary urethral malignancies in females (such as urethral melanoma or malignancies arising from urethral diverticulum). In primary urethral malignancies, generally a wider resection of the vagina is required, resulting in a greater likelihood of a significant defect. However, in more distal urethral disease, it is not always necessary to perform a cystectomy/anterior clearance. In this situation, the urethra will be mobilized to the bladder neck via a laparotomy then divided and closed, with a suprapubic catheter left in situ for long-term bladder drainage. This is an often-used strategy in the elderly or frail as it avoids the significant morbidity associated with an anterior pelvic clearance, though at the cost of a slightly increased risk of positive resection margins. Flap closure of the defect is often required, both due to the likely wider resection of the anterior vaginal wall but also due to the need to ensure adequate separation of the defect from the suture line of the bladder neck. If the bladder neck closure is allowed to sit in close proximity to the vaginal wall, closure without the interposition of healthy, vitalized tissue, there is a high likelihood of the formation a vesicovaginal fistula. This can have a devastating impact on patient in terms of quality of life, particularly as it can prevent the healthy establishment of a flap or healing of the perineal wound. Moreover, closure of these fistulae is likely to require a complex pelvic procedure that many patients in this situation would not be fit enough to tolerate.

4.3.3 Penile Cancer

Penile cancer is predominantly a squamous carcinoma, mainly arising from the distal aspect of the phallus and is more common in uncircumcised men. Like cervical carcinoma, it is strongly associated with Human Papilloma Virus [6]. Penile cancer is a rare malignancy and although adequate oncological outcomes can be achieved with radical surgery, centralization of cancer services has led to a dramatic increase in organ preserving surgery. The management of nodal disease, particularly in the groins, is frequently required and high-volume expertize is essential to limit the complications associated with potentially morbid procedures.

When feasible, organ preservation can achieve good cosmetic and functional outcomes even when the glans penis or distal penis requires resection [7]. If a total penectomy is required, due to splitting of the crus of the penis within the perineum, it is often possible to preserve the proximal urethra and importantly the external urethral sphincter. It may be possible therefore to create a continent perineal urethrostomy, with the residual distal urethra spatulated onto the perineum in the midline. If the disease involved the bulb of the penis, resection may well compromise the integrity of the urethral sphincter and although in these situations it may be feasible to create an incontinent perineal urethrostomy, it would normally be preferable to insert a long-term suprapubic catheter as long-term perineal catheters are rarely well tolerated and often cause spatulation or "fish-slicing" of the perineum.

Although there has been an increasing move toward penile preserving surgery, due to patient self-neglect, there remains a significant number of patients who present with advanced disease, often involving the perineum [8]. Although surgery may not be curative in these situations, often radical debridements and extensive resections are required due to the symptomatic nature of these conditions. Large lesions often fungate, causing the patient discomfort but also can become infected and frequently present with sepsis. There is also the risk of metastatic nodal disease eroding into vital structures, including major vessels.

Management of defects left by these extensive resections can be challenging, more often than not due to the infective nature of the lesion at presentation, but also due to the need to preserve and protect the testes, as resection in these circumstances can often include the scrotal wall. If the defect is clean and healthy, the use of flaps for closure of these defects is often beneficial. If not, these defects often create long-term difficulties to manage problematic wounds, which could affect the timing of adjuvant or palliative cytotoxic regimens.

4.3.4 Pelvic Exenteration

The occasional need for pelvic exenteration has been discussed in the colorectal chapter and although main indications for this procedure are colorectal, there are instances where there is a Urological primary cancer. For example, a bladder tumor may be involving the sigmoid or rectum, though generally with locally advanced urological tumors, such resections are performed for palliative purposes as the chance of long-term cure is small.

From a urological perspective, total pelvic exenterations involves the anterior and lateral mobilization of the bladder (and prostate in a man) along with other pelvic organs. Urinary diversion is achieved normally with the creation of an ileal conduit, though occasionally other part of bowel, for example sigmoid colon, can be used depending on the clinical picture (Fig. 4.6).

Total pelvic exenteration is a complex procedure that requires specialized and experienced multidisciplinary input, from the planning stages to the operation itself. Other specialties often offer differing viewpoints, as well as identifying potential pitfalls and hazards that the primary specialty may not be aware of. Although a capable surgeon could perform each stage of multivisceral resections, it is the view of our institution and many similar units that multivisceral resections should be performed by multispecialist teams, to achieve the best possible outcome.

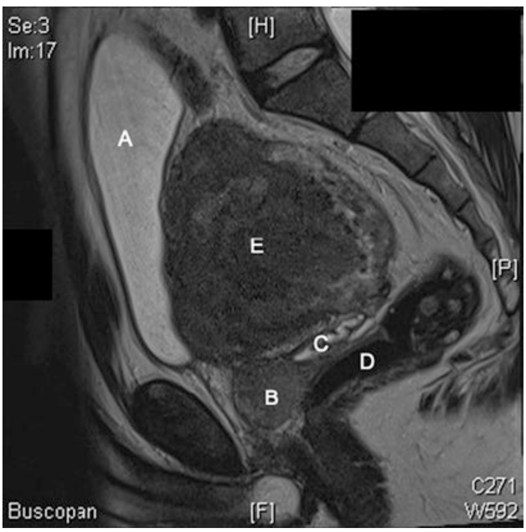

Fig. 4.6 Male pelvic mass. Showing the intimate relationship between pelvic structures and how a large mass can impact on them. In this case, a young male with a large benign retroperitoneal mass, the mass appears to be arising from the prostate (B), displacing the bladder (A) anteriorly as well as the seminal vesicles (C) posteriorly. Although the rectum (D) appears separate to the lesion, axial views reveal that the mesentry of the sigmoid is likely to be involved. In planning his case, it was felt that although surgical resection was feasible, there was however a high risk of rectal injury and complications which could have significant implications to the patient

4.4 Benign Conditions Affecting the Perineum

4.4.1 Infection

In most nonspecialized centers, the most common encounter with complex urological perineal issues occurs with infectious processes, most frequently Fournier's gangrene. Fournier's is a rare but a potentially catastrophic fulminant form of infective necrotizing fasciitis affecting the genital, perineal, and perianal tissues. It is frequently associated with diabetes or other immune-compromising conditions, though not exclusively so and Fournier's can present in otherwise healthy individuals [9].

Infective process normally originates from infected skin in the perineum, penis or scrotum, though occasionally, can occur after anorectal or urogenital trauma, or even through iatrogenic causes. The destructive, infective process progresses rapidly and requires immediate and aggressive intervention. Debridement is required to healthy uninfected tissue; although the infection tends to travel along, rather than through Bucks fascia, the lateral extent of the debridement can be very extensive. It is not uncommon to see the whole of the penoscrotal tissue involved, along with the anorectal and perineal skin. The anus may require circumscribing, and in this situation a defunctioning colostomy is required as defecation would be challenging and could compromise wound healing. Careful consideration of siting of the colostomy is required as occasionally the anterior abdominal wall may be involved (Fig. 4.7).

Normally, as the debridement tends to be relatively superficial, skin grafting alone is required for adequate wound management. However, if the ischiorectal fossa is involved, occasionally there may well be the need for filling of a defect in the perineum. In these situations, as the abdomen is unlikely to have been opened, the desir-

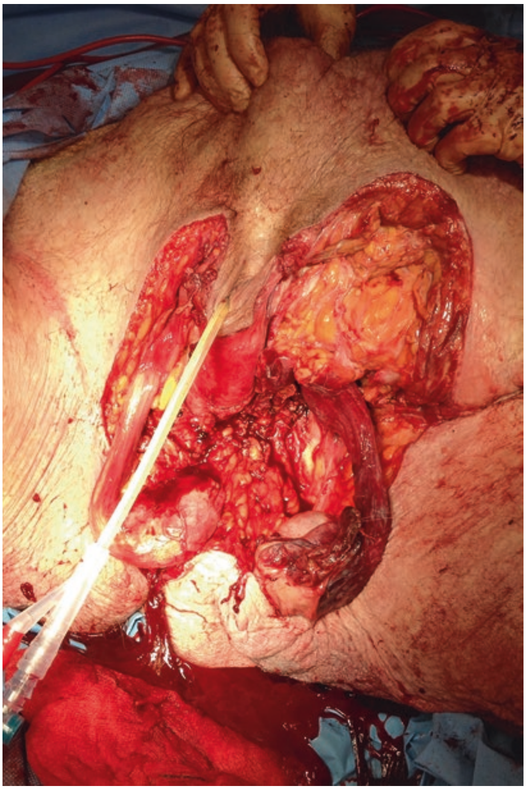

Fig. 4.7 Fournier's Gangrene. Views of the perineum after an aggressive debridement of a typical presentation of Fourneir's gangrene. The patient is characteristically obese with underlying poorly controlled diabetes mellitus. All that was visible externally was a small black lesion, though the subcutaneous extension was extensive, involving the scrotum, penis and perineum. On this occasion, the anus and perianal tissue was not involved, so defunctioning colostomy was not required

able management option would be a flap closure of the defect. However, as with skin grafting, this is likely to be performed in a delayed setting due to the frequent need for secondary debridements as there is often residual infected or necrotic tissue that needs removing on second or even third debridement, before definitive wound management can be achieved (Video 1).

Less commonly, the bulb of the penis or the corpora can be involved in an infective process, which can be an extremely challenging scenario and requires the early involvement of specialist penile surgical teams. If the corpora are involved, it is likely that erectile mechanism will be permanently compromised. Although it is unlikely that a specialist team would be able to preserve penile function in the case of gross infection, it may be possible if involvement is negligible or uncertain. If there is corporal destruction, early involvement of the penile team will aid the plans for further reconstructive plans including penile prosthesis or even phalloplasty, if there is substantial fascial destruction which prevents implants. In these situations, the specialist penile team's involvement can ensure that the patient is given the best chance of successful and functional reconstruction in the future.

4.4.1.1 Urethral Surgery

Masses in the female perineum and lower pelvis should always be carefully assessed to exclude potential involvement of the urinary tract. It is not uncommon to find benign lesions in the vulva and anterior vagina originating from the urethra; urethral diverticulum, for example, is often mistaken for simple cysts. Similarly, lesions identified within the pelvis can often originate from urethra at or even below the level of the pelvic floor. Figure 4.8 shows a urethral diverticulum, in close proximity to the urethral sphincter in a 25-year-old female [10]. This patient was planned for surgery to excise a "simple vulval cyst"; it is

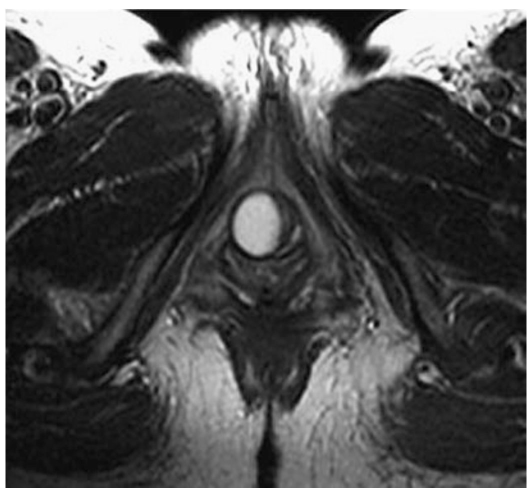

Fig. 4.8 Urethral Diverticulum. T2 weighted axial MRI, showing a fluid filled spherical lesion anterior to vaginal vault. Clinical and endoscopic examination revealed a small communication with the intra-sphincteric urethra, consistent with a urethral diverticulum

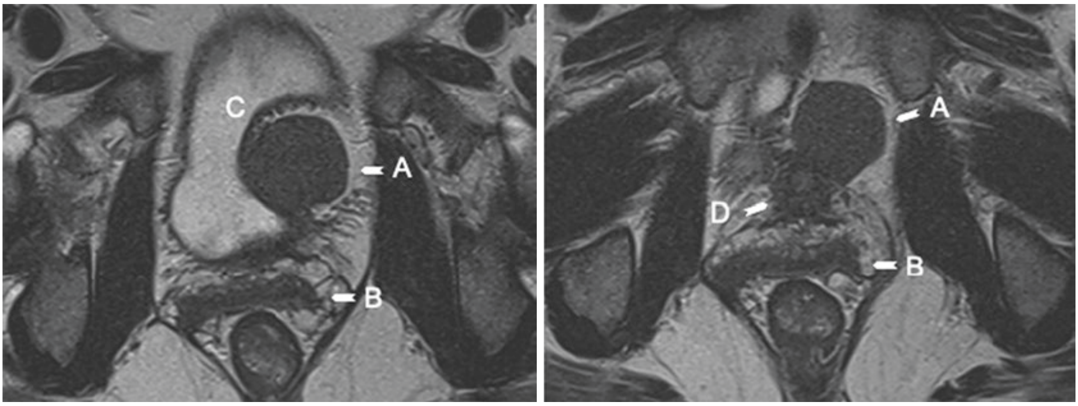

Fig. 4.9 Perivesical Mass. 37 year old female presenting with an incidental finding of a perivesical mass indenting the bladder. The left-hand image appears to suggest the mass (A) is located adjacent to the bladder (C) and superior to the perineal structures including the vagina (B). However, more caudal images reveal that the mass is in very close proximity to the urethra and urethral sphincter. Attempts to remove periurethral masses without careful planning and consideration of perineal structure often results in significant, and potentially life-changing, urinary incontinence. Excision of such lesions should only be undertaken by experienced teams and only after thorough work-up. In this case, an EUA was performed which reveal a well-defined, mobile mass and USS-guided biopsies reveal a leiomyoma. Given benign histology and the risks of damage to the urethral sphincter from resection, it was elected to offer this lady observation

likely that this would have resulted in sphincteric injury. Figure 4.9 shows what was initially thought to be a perivesical mass, though after careful assessment with examination under anesthesia, endoscopy, and MRI, it became apparent that the lesion was adherent to the urethra. Ultrasound-guided biopsies confirmed a benign leiomyoma which, given the risk associated with resection and asymptomatic status, was managed conservatively.

As described in other sections above, the key to managing such lesions is an appreciation of the structures of the perineum, then a comprehensive assessment prior to any management.

4.5 Conclusions

The key urological consideration for perineal surgery and reconstruction is the early identification of key structures to enable their preservation. Urological sequelae of perineal surgery are common and often unexpected, yet can have devastating impact on a patient's quality of life and the overall success of their treatment. Multidisciplinary decision making and planning can often prevent or mitigate these issues, and is key for successful outcomes to complex perineal surgery. Surgical approach and successful reconstruction also require careful planning to ensure that any risk of urinary leakage or fistulation is minimized, as the consequence to wound healing and overall quality of life can be profound.

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5 Radiotherapy of Perineal and Pelvic Malignancies

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Common primary malignancies involving the lower pelvis include malignancies of the lower genitourinary tract, gynecological and lower gastrointestinal tumors. Less common malignancies include those arising from the skin and mesenchymal tumors. All patients with cancer in the UK are staged and evaluated with a treatment plan via the appropriate site specialized multidisciplinary team (MDT). This allows optimum integration and timing of nonsurgical and surgical management.

The aim of radiotherapy is to deliver tumor-killing doses of radiotherapy to a defined target, while sparing adjacent normal tissues. Radiotherapy may be indicated adjuvantly (i.e., alongside surgery) preoperatively or postoperatively or definitively with curative intent but also in the palliative setting.

The term radiotherapy includes external beam radiotherapy and brachytherapy which are described later in the text. Traditional external beam radiotherapy (EBRT) is photon treatment, delivered daily, 5 days per week over between four and seven and a half weeks. Patients have a pretreatment CT scan in the treatment position, e.g., prone or supine, bladder, and bowel empty or full depending on local protocols.

5.1 Volume Definition for EBRT

1. The gross tumor volume (GTV) defines the tumor via optimal diagnostic imaging obtained prior to any intervention such as surgery or chemotherapy.
2. The clinical target volume (CTV) defines the area of microscopic risk beyond the GTV. It takes into account histological reports, surgical operation notes, or intentions and may include elective or definitive nodal groups.
3. The planning target volume (PTV) is center-dependent and is derived to include stability of patient setup and motion of target or surrounding organs, e.g., bladder filling. The PTV is the volume to receive at least 95% of the prescribed dose.
4. OARs: adjacent organs at risk, e.g., bladder, prostate, rectum, and ovaries delineated with constraints using international protocols.

The radiotherapy planning team sets about deciding on the optimum beam angles and techniques to achieve the required target dose while respecting the dose and volume constraints for the OARs.

This chapter is dedicated to our friend and colleague Dr Jac Livsey.

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Improving technology has allowed more conformal techniques with shaping of multiple radiotherapy beams to cover the target but more effective shielding of adjacent normal organs. Intensity-modulated radiotherapy (IMRT) or volumetric arc radiotherapy (VMAT) are examples of high-precision external beam radiotherapy delivered over a matter of minutes via multiple beam angles with the patient in a comfortable stable position. The ability to perform cone beam CT on the linear accelerator assures positioning and relative stability of adjacent OARs such as the bladder and bowel. Such image-guided radiotherapy (IGRT) is current standard of care.

Other modalities of external beam radiotherapy include electron beam, which is limited to superficial tumors and proton beam therapy (PBT).

Proton beam therapy delivers high doses to the target, but the dose then drops off dramatically beyond because of physical property called the Bragg peak.

There are two main indications for proton beam therapy.

1. Late toxicity reduction: Decrease in the exit dose means less dose to other organs beyond the tumor which could lead to less risk of second malignancies particularly in children and teenagers or young adults. Therefore, it may be advised in pelvic Ewing's sarcomas or rhabdomyosarcomas. Both malignancies have high metastatic risk also necessitating chemotherapy. PBT is indicated for local control, either as definitive treatment or in conjunction with surgery, preoperatively or postoperatively. Surgeons with experience of pelvic PBT irradiation preoperatively report visible significant radiotherapy tissue change within the irradiated area, but a sharp demarcation to normal tissue planes immediately beyond.
2. Proton beam therapy may allow dose escalation for less radiation-sensitive tumors and thus may be advised in pelvic primary bone sarcomas or sacral chordomas. In sacral chordomas, it may be offered as a definitive treatment, as a mixture of preoperative and postoperative treatment or exclusively postoperatively. The highest local control is reported by the Boston group using combined preoperative and postoperative PBT. This requires involvement of reconstructive surgeons from the outset.

Brachytherapy is a type of radiotherapy using sealed radioactive sources. It may be permanent, such as low-dose rate iodine 125 seeds inserted transperineally for low-risk prostate cancer or more commonly a temporary implant via inserted needles or placed in body cavities with a high-dose-rate source such as iridium 192. Note the terminology of low or high dose refers to rate of delivery not to the overall dose. Brachytherapy is the ultimate conformal radiotherapy with a very high dose over a small volume and rapid fall off of dose with distance. It may be indicated as a sole treatment or along with EBRT. In the perineum, brachytherapy may be used in prostate cancer, penile cancer, and endometrial, cervical, vaginal, and vulval cancers, including for rhabdomyosarcomas, and anal cancer. As organ-preserving surgical expertise expands, however, the technical demands of brachytherapy have made its use less common and expertise is concentrated in fewer centers.

5.2 Radiobiology

Radiation works by damaging the DNA in cells and stopping their ability to reproduce. It affects both tumor and normal cells but exploits the impaired ability of tumor cells to repair, leading to cell death. Radiotherapy straddles the balance between tumor control probability and normal tissue tolerance or normal tissue complication probability. The curve for increasing tumor control with increasing dose is sigmoid, meaning that at some point there is little gain by just increasing dose. Radiobiological modeling which is most commonly the linear quadratic model tries to take into account not just total dose but also dose per fraction, overall treatment time, and tissue radiosensitivity. Another way of increasing dose effect but without increasing the late radiation complication probability, although the acute toxicity may increase, is to combine radiotherapy with concurrent chemotherapy. This allows spatial cooperation and the simple addition of antitumor effects while protecting normal tissues and enhancing the tumor response.

5.2.1 Acute Radiation Effects

The acute side effects of radiotherapy in the perineum are considerable and include skin and mucosal reactions, starting in the first half of the radiotherapy and extending several weeks beyond completion. They are a result of cell damage and resultant-free radical release, with upregulation of inflammatory cells including pro-inflammatory cytokines. The resultant signaling amplification leads to ulceration and inflammation with secondary infection. However, epithelial proliferation and cellular and tissues differentiation will restore epithelial integrity in due course. If radiotherapy is planned preoperatively, there are advantages in terms of lower dose and smaller volume of irradiated tissue. However, there is undoubtedly a small increase in wound complications. It is therefore important that reconstructive surgeons are involved from the outset in the MDT discussions. Generally, surgery is planned around 6–8 weeks following preoperative radiotherapy when the acute side effects such as erythema, edema, and mucositis have abated, but before the more fibrotic late effects arise.

5.2.2 Late Radiation Effects

This can manifest itself from several months to many years following radiotherapy and is the dose-limiting step, even if a degree of repair has occurred over the subsequent years.

Factors which affect late toxicity in radiotherapy include:

5.2.2.1 Patient Factors

Age, smoker, diabetic, autoimmune disorders, inflammatory bowel disease, and intrinsic radiation sensitivity.

5.2.2.2 Radiotherapy Factors

Total dose, dose per fraction, volume of tissue irradiated, quality of radiation, concomitant or pre-exposure chemotherapy, previous surgery, organ-type irradiated and amount irradiated, previous radiotherapy.

Examples of late toxicity are as follows:

- Fibrosis—fibroblastic proliferation, secondary to growth factor stimulation.
- Vascular damage—small vessel constriction or dilatation such as telangiectasia, ischemic bowel, and perforation.
- Atrophy—collagen loss and fibrocyte loss leading to poor healing and wound breakdown.
- Radiation-induced malignancies.
- Loss of fertility.

Acute and late radiation toxicities are graded and reported via a number of systems including the common toxicity criteria CTC or the RTOG/EORTC classifications [1] (Table 5.1).

The quantitative analysis of normal tissue effects in the clinic (QUANTEC) [2–4] recommendations are used to guide radiotherapy dose and volume constraints to adjacent OARs. They are based on the risk of at least grade 2 toxicities. Of course, patient-reported outcomes may be substantially different to clinician reported.

As a response to increased referrals, the British Society of Gastroenterology produced guidelines to investigate and treat cancer treatment-related bowel toxicities. The Royal Marsden [5, 6] has developed a complex but practical algorithm. An initial holistic assessment takes place as well as a risk of recurrence assessment. If no recurrence then a view on whether the symptoms are related to radiotherapy or exacerbation by radiotherapy of preexisting problems. Objective grading and bother impact may lead to investigation with often a wide differential diagnosis. If radiation related, for instance bleeding from rectal telangiectasia, management may range from simple explanation, reassurance and dietary advice to in severe cases interventions such as hyperbaric oxygen, Argon coagulation or formalin therapy. These

Table 5.1 RTOG/EORTC late radiation toxicity for pelvic organs

Tissue	Grade 1	Grade 2	Grade 3	Grade 4
Skin	Slight atrophy; pigmentation change; some hair loss	Patch atrophy; moderate telangiectasia; total hair loss	Marked atrophy; gross telangiectasia	Ulceration
Subcutaneous tissues	Slight induration (fibrosis) and loss of subcutaneous fat	Moderate fibrosis but asymptomatic; slight field contracture; <10% linear reduction	Severe induration and loss of subcutaneous tissue; field contracture >10% linear measurement	Necrosis
Mucous membrane	Slight atrophy and dryness	Moderate atrophy and telangiectasia; little mucous	Marked atrophy with complete dryness	Ulceration
Spinal cord	Mild Lhermitte's syndrome	Severe Lhermitte's syndrome	Objective neurological findings at or below cord level treated	Mono, para, quadriplegia
Small/large intestine	Mild diarrhea; mild cramping; bowel movement 5times daily; slight rectal discharge or bleeding	Moderate diarrhea and colic; bowel movement >5 times daily; excessive rectal mucus or intermittent bleeding	Obstruction or bleeding, requiring surgery	Necrosis/ perforation fistula
Kidney	Transient albuminuria; no hypertension; mild impairment of renal function; urea 25–35 mg/dL; creatinine 1.5–2.0 mg/dL; creatinine clearance >75%	Persistent moderate albuminuria (2+); mild hypertension; no related anemia; moderate impairment of renal function; urea >36–60; 50–74%	Severe albuminuria; severe hypertension; persistent anemia (<10); severe renal failure; urea >60; creatinine >4.0; creatinine clearance <50%	Malignant hypertension; uremic coma; urea >100
Bladder	Slight epithelial atrophy; minor telangiectasia (microscopic hematuria)	Moderate frequency; generalized telangiectasia; intermittent macroscopic hematuria	Severe frequency and dysuria; severe telangiectasia (often with petechiae); frequent hematuria; reduction in bladder capacity (<150 cm^3)	Necrosis/ contracted bladder (capacity <100 cc); severe hemorrhagic cystitis
Bone	Asymptomatic; no growth retardation; reduced bone density	Moderate pain or tenderness; growth retardation; irregular bone sclerosis	Severe pain or tenderness; complete arrest of bone growth; dense bone sclerosis	Necrosis/ spontaneous fracture
Joint	Mild joint stiffness; slight limitation of movement	Moderate stiffness; intermittent or moderate joint pain; moderate limitation of movement	Severe joint stiffness; pain with severe limitation of movement	Necrosis/ complete fixation

Grade 5 for all = death directly related to radiation event

interventions can carry significant risks, particularly argon, and should ideally be done in specialist centers.

With improved survival outcomes, quality of life and survivorship issues are increasingly important. A variety of strategies to reduce late toxicities have been used, but the concept of personalized pretreatment tumor and normal tissues radiosensitivity evaluation remains the holy grail. If subsequent surgery is required, bringing in fresh vascularized tissue is often required for healing. Thus, the reconstructive pelvic surgeon plays an important role in the complex management of patients who have late radiotherapy toxicity, recurrence postradical treatment, and/or second malignancies.

5.3 Prostate Cancer Radiotherapy

5.3.1 Introduction

One in eight men is diagnosed with prostate cancer in the UK. This translates into over 42,000 cases per year in England and Wales with over 13,000 undergoing radical radiotherapy [7]. Conventional staging with PSA and digital rectal examination followed by transrectal ultrasound-guided biopsies classifies patients into low, intermediate, locally advanced, or advanced prostate cancer.

- Low Risk:
  – T1-T2a and Gleason score 6 and PSA < 10 ng/mL.
- Intermediate Risk:
  – T2b-T2c or Gleason score 7 or PSA 10–20.
- High Risk:
  – T3a or Gleason score 8–10 or PSA > 20.

There has been a move toward earlier prebiopsy MR scans, [8] greater access to transperineal biopsies, and more use of PET-CT plus the availability of a greater range of active agents in advanced disease.

5.3.2 Evolution of the Treatment of Prostate Cancer

The role of radiotherapy has been tested in a number of UK-led trials.

– The MRC trial RT01 [9] confirmed improved PSA control with dose escalation from 64 Gy to 74 Gy.
– The CHHIP trial [10] established a slightly hypofractionated schedule of 60 Gy in 20 fractions over 4 weeks as the new standard. Hypofractionation means that the dose per fraction is higher than previous convention of 2 Gy per day. The trial also defined organ at risk (OAR) dose constraints, i.e., bladder, bowel, penile bulb, femoral heads and described acute and late toxicities with modern radiotherapy techniques (Fig. 5.1). Just over 10 % of patients have grade 2 bowel toxicity. Fewer than 4% have grade 3 bowel or bladder toxicity.
– The Radicals trial [11] saw an agreement on how to define postprostatectomy radiotherapy volumes and dose fractionation. The primary trial endpoints are not yet reported, although some early results released at ESMO 2019.
– The Stampede trial [12] showed some benefits of prostate radiotherapy in selected patients with low-volume metastatic disease.

Areas of continued interest include prostate and nodal radiotherapy, the use of rectal spacers, stereotactic ablative radiotherapy-delivering tumoricidal radiotherapy safely over ultra-hypofractionated schedules such as over 5 or 7 fractions, and the sequencing and integration of newer agents in advanced disease.

Prostate brachytherapy [13] can be used as monotherapy in early disease, either by permanent iodine 125 seed implantation or multifraction high-dose rate temporary implant (Figs. 5.2 and 5.3). The ideal patient has a gland of less than 50 cc with good urinary function and favorable tumor parameters, i.e., organ-confined disease and PSA of less than 10 ng/mL and Gleason 3+3 disease on biopsies. In more locally advanced disease, a combination of external beam radiotherapy and high-dose rate brachytherapy [14] or external beam radiotherapy is offered along with androgen deprivation therapy. The high dose over

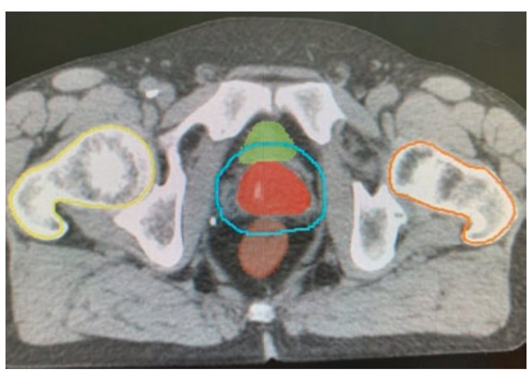

Fig. 5.1 Example of prostate GTV in red with CTV in blue and OARs

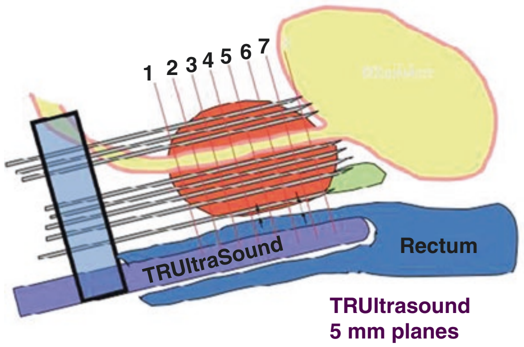

Fig. 5.2 Diagram showing needles position for brachytherapy. (Courtesy of Dr D Ash)

Fig. 5.3 I 125 Seed insertion under USS control—Dr Dan Ash UK brachytherapy pioneer. (Picture courtesy of Dr D Ash)

a concentrated area can result in anterior rectal wall telangiectasia. Unless cancer is suspected, this should not be biopsied as there is a 2% risk of fistulation.

The risk of radiation-induced second primary cancers of the bladder or rectum from radical radiotherapy to the prostate is difficult to define because of multiple confounding factors [15]. It is estimated to be around 1 in 220–290 patients and increases with time. Most studies reviewed older radiation techniques.

The advent of robotic prostatectomy [16] has reduced the in-patient recovery period and is an attractive option for many patients. The use of multimodality treatment, i.e., surgery and post-operative radiotherapy, in more locally advanced disease is growing. However, initial radiotherapy followed by surgery at a later date for relapse remains a challenge in terms of functional outcomes including continence and rectal damage and is practiced in selected patients in a small number of interested centers.

5.4 Anal Cancer Radiotherapy

5.4.1 Introduction

There are approximately 1000 new cases of anal cancer diagnosed each year in the UK. While this is much less common than colon or rectal cancer, morbidity from the disease and its treatment is high. Incidence has been steadily rising by 2.2% on average per year over the last decade [17]. Squamous cell carcinoma comprises more than 70% of cases. There is a clear association with the human papilloma virus (in particular HPV-16), and this can be detected in 80–90% of cases [18]. Risk factors are therefore those associated with the acquisition and persistence of HPV infection including HIV, high-risk sexual behavior, receptive anal intercourse, and immunosuppression [19]. In addition, tobacco exposure is a significant risk factor.

Anal intraepithelial neoplasia (AIN) is a pre-malignant condition which presents with anorectal discomfort or itching. The rates of progression of AIN3 to invasive cancer are relatively low with studies suggesting progression rates of 8–11% over time periods of 3–4 years [19]. There is also evidence of spontaneous regression in some individuals. AIN can be treated using topical therapies such as imiquimod or 5-flurouracil or with ablative therapies such as laser or electrocautery.

5.4.2 Evolution of the Treatment of Anal Cancer

Until the 1980s, standard treatment for invasive anal cancer was surgical resection and permanent colostomy. This carried significant morbidity, and radiotherapy as an alternative treatment strategy to allow an organ-sparing approach was explored. There were a number of trials in the late 1980s designed to improve locoregional control rates with the addition of chemotherapy to radiotherapy. The largest of these, the ACT1 trial demonstrated significantly reduced locoregional failure (36% vs. 59%) in patients treated with concurrent mitomycin C and 5FU and radiotherapy compared to radiotherapy alone [20]. The trial included almost 600 patients, and the benefit was maintained after a median follow-up of 13 years [21].

The early trials used basic radiotherapy techniques with irradiation of the whole pelvis to 45 Gy given over 25 fractions followed by a 6-week gap for response assessment. In patients whose disease was responding, a further boost to the primary disease was administered (15 Gy in 6 fractions external boost or an Iridium implant to 25 Gy). The ACT2 trial examined the effect of changing the chemotherapy backbone (replacing mitomycin C with cisplatin) and showed no significant benefit to this. However, the radiotherapy schedule removed the gap in treatment and utilized a shrinking field technique in which the whole pelvis received 30.6 Gy in 17 fractions and macroscopic disease received a further 19.8 Gy in 11 fractions. Cancer outcomes were better than in the ACT1 trial with a 90% complete response rate and 75% patients achieving local control and avoiding colostomy [22]. This radiotherapy schedule was subsequently adopted as standard of care.

Further developments in technical radiotherapy have led to the introduction of intensity-modulated radiotherapy (IMRT) or volumetric arc therapy (VMAT) for anal cancers. These techniques allow more precise, conformal treatment of nodal areas, and the primary tumor with significant sparing of normal tissues. The nodal areas in the elective treatment volume include internal and external iliac, obturator, and inguinal lymph nodes. Superiorly, this extends 2.5 cm superior to the inferior aspect of the sacroiliac joints and inferiorly to the inferior most part of the lesser trochanter of the femur. The ischiorectal fossa and mesorectum are also included in the field if there is evidence of infiltration of these. In 2014, 21 of 25 centers treating anal cancer in the UK had implemented IMRT or VMAT techniques in routine clinical practice for at least a proportion of radically treated anal cancer patients [23].

Table 5.2 Acute and late toxicity from radical chemoradiation for anal cancer

	Acute	Late
Common	Fatigue Diarrhea Skin reaction—dry/moist desquamation Cystitis Hematological toxicity	Erectile dysfunction or vaginal stenosis Infertility Chronic diarrhea/fecal incontinence
Less common	Nausea Cardiac complications (1%) Enteritis/colitis	Bowel fistula Telangiectasia of bladder/rectum causing bleeding

Despite advances in radiation techniques, treatment still carries significant acute and late toxicity (Fig. 5.6) (Table 5.2)

More conformal and precise techniques raise the possibility of dose escalation to further improve local control. The national “personalizing anal cancer radiotherapy dose” (PLATO) trial is looking at optimizing radiotherapy dose according to risk stratification and includes three separate trials. For high-risk disease (T3/4 N any or T2 N1–3), there are radiotherapy dose escalation arms (ACT5). It is also recognized that there may be considerable over treatment of early-stage disease (T1/2 N0), and for such patients, there is a separate trial examining dose de-escalation (ACT4) with the aim of reducing toxicity. For patients with locally excised T1 tumors, the ACT3 trial evaluates observation for those with clear margins (>1 mm) or low-dose local chemoradiation for those with involved margins [24]. All arms of the PLATO trial are currently open to recruitment in the UK (Fig. 5.4).

Following treatment, patients have a response assessment pelvic MRI and PET-CT at 3 and 6 months. If there is evidence of residual disease at 6 months, the option of salvage surgery is discussed. For patients with a complete response, follow-up is stratified according to risk with MRI scans every 6–12 months for up to 3 years. CT thorax, abdomen, and pelvis are performed to

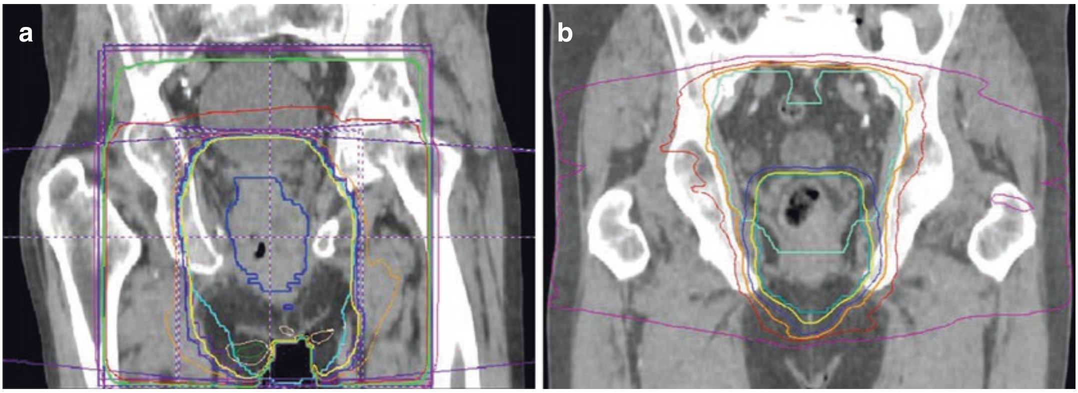

Fig. 5.4 (**a**) Coronal section of historical radiotherapy plan demonstrating anterior and posterior field for elective nodal irradiation of the whole pelvis with 3D conformal boost to primary tumor. (**b**) Coronal section of VMAT radiotherapy plan demonstrating conformal elective nodal irradiation with synchronous boost to primary tumor

assess distant metastatic disease annually for 3 years. Clinical follow-up continues for a total of 5 years [25].

5.5 Rectal Cancer Radiotherapy

Radiotherapy with or without chemotherapy is also recommended preoperatively for rectal adenocarcinomas. For tumors which do not threaten the circumferential resection margin (CRM) but have high-risk features, short course radiotherapy (25 Gy in five fractions) followed by immediate surgery (within 7 days of completion) is given with the aim of reducing the risk of local recurrence. The Swedish rectal cancer trial (1997) demonstrated a local recurrence rate of 11% in patients receiving preoperative radiotherapy compared to 27% in patients going straight to surgery ($p < 0.001$) [26].

For rectal tumors with involvement of the CRM or sphincters, treatment is given with the aim of downstaging disease prior to definitive surgery. In this scenario, long-course chemoradiation, 45 Gy in 25 fractions with oral capecitabine followed by reassessment after 8–10 weeks, is the treatment of choice. Following such treatment, 10–15% of patients achieve a complete clinical response (cCR). In recent years, there has been a move to adopt a “watch-and-wait” strategy in these patients offering them the opportunity to avoid major resection surgery and stoma formation. This requires an intensive follow-up program, and recent data have suggested local recurrence rates of 33% in the first 3 years [27]. Strategies to enhance cCR rates and achieve durable responses to allow organ preservation are under investigation in a number of clinical trials.

5.6 Radiotherapy for Endometrial Cancer

Endometrial cancer is the most common gynecological malignancy in the UK.

Surgery is the main primary treatment for endometrial cancer; however, both radiotherapy and chemotherapy are used in the adjuvant setting [28]. Radiotherapy can also be used in patients with early-stage disease who are unfit for surgery and also in the palliative setting [29].

Adjuvant treatment is recommended based on risk categories; these vary slightly between different studies but are broadly based on grade, histology, and stage. The most common histology is endometrioid adenocarcinoma, with serous or clear cell histology seen in a minority of patients [30].

Low risk—stage 1A (disease confined to inner half of myometrium), grade 1–2, endometrioid histology.

Intermediate risk—stage 1A, grade 3 disease, or stage 1B, grade 1–2 without additional risk factors.

High intermediate risk—stage 1B with additional risk factors; age > 60, multifocal LVSI or grade 3, stage 2.

High risk—stage 3 disease, serous or clear cell histology.

Patients with low-risk disease have an excellent prognosis and do not require adjuvant treatment [28].

The PORTEC studies have defined adjuvant treatment for patients with high and intermediate-risk disease. The PORTEC 1 study showed that for intermediate to high intermediate-risk disease, external beam radiotherapy reduced the risk of local recurrence with no difference in overall survival [31]. PORTEC 2 compared external beam radiotherapy with vaginal brachytherapy with no differences seen in overall survival but a reduction in toxicity [32].

In intermediate- to high-risk patients, PORTEC 3 showed an overall survival benefit with the addition of chemotherapy to radiotherapy, but the majority of benefit was seen in those with stage 3 or serous tumors. Estimated five-year overall survival for patients receiving chemoradiotherapy was just over 80% [33]. The GOG 258 study showed no overall survival benefit for chemotherapy and radiotherapy compared to chemotherapy alone, but the addition of radiotherapy reduced local recurrence [34].

In patients with intermediate-risk disease, vault brachytherapy is used, and for high intermediate-risk disease, either brachytherapy or external beam radiotherapy is used, depending on local practice [28]. For high-risk patients with stage 3 disease, both chemotherapy and external beam radiotherapy are generally recommended [35].

Vaginal brachytherapy is generally delivered on an outpatient basis and uses a standard cylinder to deliver high-dose rate brachytherapy in 2–4 sessions (Fig. 5.5).

Fig. 5.5 (**a**) Pretreatment image of extensive perineal SCC with fistulous tract and right gluteal abscess. (**b**) Appearances 3 months post radical chemoradiation with seton still in situ. (Images used with kind permission from the patient)

Treatment is well tolerated and is as efficacious as external beam radiotherapy in reducing vaginal recurrence. The main late toxicity is vaginal stenosis, which can be reduced with the use of dilators. Other late effects include bowel and bladder toxicity, but these are rare [36].

The standard external beam radiotherapy regimen is 45 Gy/25 fractions over 5 weeks; chemotherapy (cisplatin) may also be added. The area treated includes the vaginal vault and pelvic lymph nodes. Acute toxicity includes fatigue, nausea, diarrhea and urgency, urinary frequency, urgency, and cystitis. These effects are common but settle within the first year following radiotherapy. Late effects include bowel and bladder dysfunction including urgency and bleeding, vaginal stenosis, and pelvic bone changes [37]. In the majority of cases, only the upper portion of the vagina is included in the radiotherapy field, so perineal toxicity is very unlikely.

5.7 Radiotherapy for Cervical Cancer

Cervical cancer is rare, with just over 3000 new cases of invasive disease each year in the UK. The rates of invasive disease have declined due to screening, and the impact of HPV vaccination will also be seen in the future [38]. Around 80% of cases are squamous cell, with adenocarcinoma, representing the second most common histology [39].

For patients with early disease, confined to the cervix with a size less than 4 cm and no lymph node involvement on imaging, surgery is recommended. Adjuvant treatment, with chemoradiotherapy, is recommended for patients with involved margins or positive lymph nodes [40].

Concurrent chemoradiotherapy followed by brachytherapy is the standard of care for patients with locally advanced cervical cancer. The EMBRACE collaborative research group has defined an evidence-based approach with their prospective cohort studies [41]. 5-year overall survival for all patients is 67%, increasing to 87% for those with node-negative early-stage disease [41].

Treatment comprises of external beam radiotherapy (45 Gy/25 fractions) over 5 weeks with weekly cisplatin 40 mg/m^2. The radiotherapy field encompasses the uterine corpus and cervix, parametrium, and upper vagina as well as elective nodal volumes [41].

This is followed by 4 sessions of high-dose rate brachytherapy with a temporary implant inserted in theater, often under general anesthetic. Over the last 10 years, brachytherapy techniques have improved, with MRI guidance and the use of interstitial needles improving target coverage and reducing dose to normal tissue (Figs. 5.6 and 5.7).

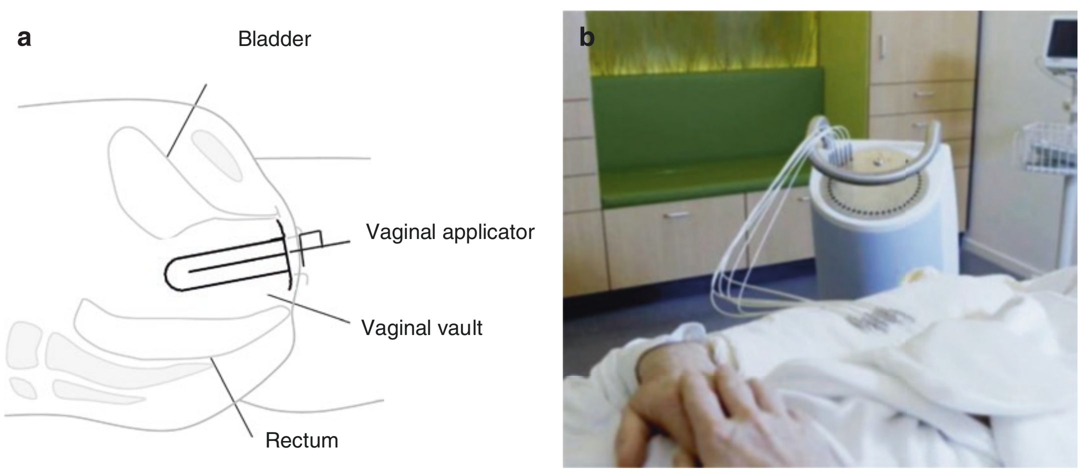

Fig. 5.6 (**a**) Schematic showing position of vaginal applicator in the vaginal vault. (**b**) Image of a Brachytherapy afterloader. The tubes are connected to the applicator and radioactive sources are automatically loaded into the applicator for a prespecified period of time then removed. (Image used with kind permission from Elekta Instrument AB Stockholm)

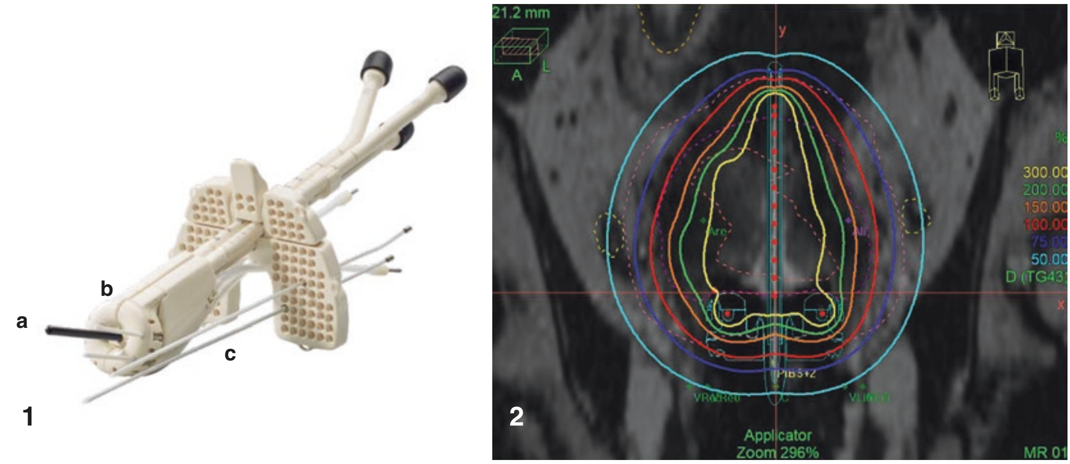

Fig. 5.7 (*1*) Cervical applicator, with central uterine tube (**a**), ring (**b**) positioned below the cervix and interstitial needles (**c**). This is used in combination with the after loader shown in Fig. 5.6. (*2*) Coronal MR scan of pelvis, with applicator in situ (outlined in blue), showing tumor (dashed orange) and the dwell position of the radioactive sources (shown in red). The bold lines show the radiotherapy dose distribution with the yellow line showing 300% of the total dose and light blue line showing 50% of the dose. The use of the needles shapes the radiotherapy field, increasing dose to the tumor and reducing dose to normal tissues like the bladder. (Images used with kind permission from Elekta Instrument AB Stockholm)

This, in combination with modern external beam radiotherapy techniques, has led to improved outcomes and reduced toxicity [42].

Vaginal cancer is very rare and is managed in a similar fashion to cervical cancer. However, brachytherapy may not be possible, and in that case, an external beam radiotherapy boost to the tumor is delivered, usually over 2 weeks.

Toxicity is similar to treatment for endometrial cancer with short- and long-term bladder, bowel, vaginal, and pelvic bone toxicity. All patients are rendered infertile and postmenopausal. The retroEMBRACE study reported rates of late grade 3 urinary toxicity of 7% and bowel toxicity of 5% [41].

In patients with extensive disease, requiring treatment of the inguinal region and vagina often develops skin toxicity similar to patients with vulvar cancer.

5.8 Vulval Cancer

Vulval cancer is a rare cancer, generally squamous cell carcinoma, with 1300 people diagnosed each year in the UK. The incidence increases with age, and there is often a field change affect with patients developing multiple lesions. The majority of evidence for the role of radiotherapy particularly in the radical setting comes from small, mainly retrospective studies.

The standard treatment for early vulval cancer is surgery, with radical wide local excision preferred if possible. Inguinal lymph node involvement is common, and surgical management, either with sentinel lymph node biopsy, for tumors less than 4 cm, without clinical nodal involvement or inguinofemoral lymph node dissection (IFL), is recommended. In the case of a positive sentinel node biopsy, IFL should be performed; however, in the case of micrometastases (less than 2 mm), the GROINSS-V II study suggests that radiotherapy is an acceptable alternative [43].

Adjuvant radiotherapy is recommended for patients with close, less than 8 mm margins, and those with positive lymph nodes, with the strongest evidence for those with 2 or more nodes involved. Although there has been limited direct evidence to support the use of concurrent chemotherapy, it is commonly used based on data from sites such as cervical and anal cancer. The most common regimen is concurrent cisplatin [44]. There is no standard dose or fractionation regimen, although it is recommended that areas of gross disease receive at least 60–70 Gy [45].

Locally advanced tumors, especially those close to the anus or ureter, may be treated with primary radiotherapy (with concurrent chemotherapy if possible) to avoid radical surgery. Primary radiotherapy can also be used in patients who are unfit for surgery. If there is a complete response, surgery can be avoided, and in other cases, a more limited procedure can be carried out [46]. A small phase 2 study reported clinical complete response rates of 64%, with pathological confirmation in 50% of patients. It appears that increasing the dose to areas of gross disease increases response rate [47]. Brachytherapy can also be used, either alone for small tumors or in combination with external beam radiotherapy [48].

Acute toxicity rates are high, with the majority of patients experiencing skin desquamation (Fig. 5.8). This usually peaks at the end of radiotherapy and then recovers over 4–6 weeks although a minority of patients have delayed healing. Management is mainly symptomatic, although absorptive dressings may be helpful, and there is weak evidence supporting the use of silver sulfadiazine cream [47].

Fig. 5.8 A moderate acute radiotherapy skin reaction, showing erythema and skin breakdown in the perivulval area. (Used with kind permission of the patient)

Fig. 5.9 Late radiotherapy side effects, showing skin telangiectasia. (Used with kind permission of the patient)

Long-term skin changes with telangiectasia are common (Fig. 5.9). Other side effects include bowel and bladder toxicity. There is limited data about the impact of previous radiotherapy on the rates of surgical complications.

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6 Classification of Perineal Defects

Damir Kosutic

Despite a number of attempts to classify perineal defects, widely accepted classification related to oncological/resectional defects does not exist. Existing classifications describe either defects related to obstetric trauma, injuries, or anorectal malformations [1–4]. This is in part, due to the fact that oncological perineal surgery is a multispecialty affair, where none of the involved parties usually perform surgery themselves from start to finish. A simple yet informative classification system would be desirable, as it would allow better preoperative planning between surgeons of different specialties from both resectional and reconstructive points of view. In our experience, reconstructive plastic surgeons often find themselves in difficult situations simply because resectional surgeons underestimated or even downplayed the extent of resection and its consequences on reconstructive options. This can have profound consequences on the choice of reconstructive technique, flap availability, successful wound healing, and overall outcomes—all ultimately related to subsequent quality of life for the patient.

Based on our experience, I propose the following classification of perineal defects:

Type 1: Defect involves areas/organs anterior to anus and up to pubis with anus spared.
- Type 1a—anterior to anus with preservation of urethra (Fig. 6.1).
- Type 1b—anterior to anus with resection of urethra (Fig. 6.2).

Type 2: Defect involves anus and areas posterior to it toward the natal cleft, while perineum anterior to anal defect is spared (Fig. 6.3).
- Type 2a—anal resection without pelvic clearance.
- Type 2b—anal resection with pelvic clearance.

Type 3: Combined defects including most of or entire perineum with total pelvic exenteration performed (Figs. 6.4 and 6.5).

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Fig. 6.1 Type 1a perineal defect following resection of recurrent sarcoma

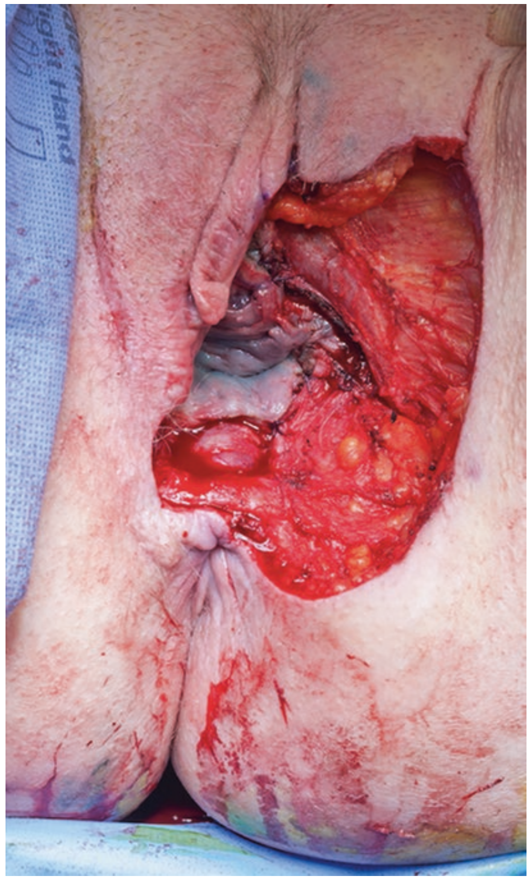
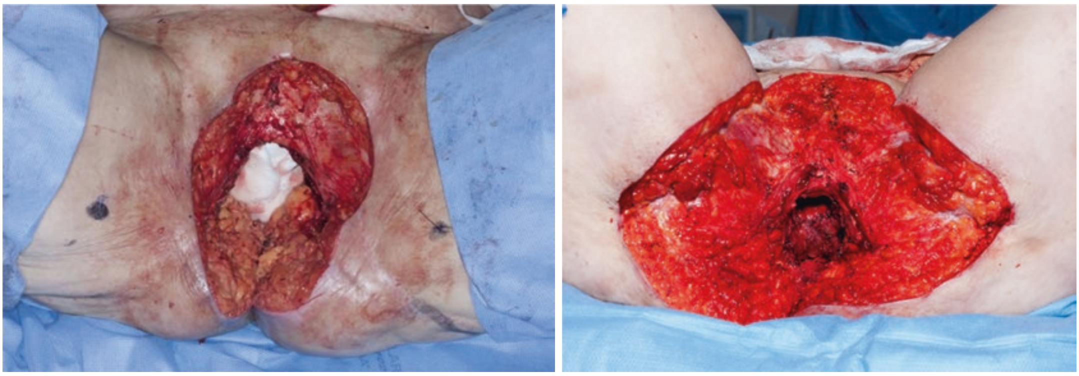


Fig. 6.2 Type 1b defect following partial vulvectomy

Fig. 6.3 Type 2 defect including resection of anus and pelvic exenteration



Figs. 6.4 and 6.5 Type 3 defects including entire perineum, gluteal and pubic areas, and pelvic clearance

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7 Anesthetic Considerations for Perineal Reconstructive Surgery

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7.1 Introduction

It is important for the surgeon to have a broad understanding of what is required perioperatively to achieve safe and effective anesthesia for whichever operation he or she performs on patients. We aim to give you an overview of the conduct of anesthesia for patients undergoing perineal reconstruction surgery in this chapter. It is by no means an exhaustive account.

In general terms anesthesia for this type of surgery, where flap reconstructions tend to be rotational, is of itself less challenging than anesthesia for free flap work. This is because the need to maintain physiological or supraphysiological cardiac output to optimize flap perfusion is less critical. However, such operations often form a part of a larger gynecological, urological or colorectal resection, and patients may be in theater for 10 h or more in total. This places them at a significantly greater risk of complications related to the anesthetic, surgery, and prolonged immobility, and requires careful attention to positioning, protection of vulnerable pressure areas, fluid management, temperature control, and analgesia.

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7.2 Preoperative Management

7.2.1 The Preoperative Assessment

The anesthetist will follow the traditional structure of history, examination, and investigations when performing a preoperative assessment. The purposes of it are as follows:

1. Evaluate physiological fitness for the proposed procedure.
2. Optimize fitness as much as possible.
3. Identify, quantify, and discuss risks.
4. Formulate and agree a perioperative anesthetic management plan.
5. Anticipate any difficulties in executing this plan.
6. Consent for anesthetic procedures.
7. Establish rapport between anesthetist and patient.
8. Prescription and administration of any necessary premedication.

7.2.1.1 The Surgical Stress Response

Patients undergoing surgery are placed at risk. This may take the form of generally unpredictable events, such as anaphylaxis or pulmonary embolism, but risk also arises predictably from the physiological response to surgical trauma.

Any patient undergoing significant surgery is exposed to tissue trauma. Pain, even if not consciously felt, results in sympathetic activation and catecholamine release. This has a myriad of poten-

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tially deleterious effects, including tachycardia, hypertension, hyperglycemia, and reduced gut perfusion. Additionally, the renin-angiotensin-aldosterone system is activated, exacerbating hypertension, causing sodium and fluid retention and reducing urine output. Cortisol is released from the adrenal cortex, resulting in tissue catabolism, further hypertension, and hyperglycemia. Local inflammatory cytokines released in response to cellular trauma and death may in sufficient quantities give rise to a systemic inflammatory response and generalized microvascular injury, compromising major organ function such as the lungs and kidneys.

This multisystemic, neurohumoral response necessitates an increase in global oxygen consumption for several postoperative days [1]. This is readily measurable, and in patients having undergone major body cavity surgery with reconstruction, may be in the region of 5 mL/kg/min—a rise of almost 50% compared to the usual baseline of 3.5 mL/kg/min. Patients with poor physiological reserve may have insufficient ability to meet these demands by virtue of chronic respiratory or cardiovascular disease. Such patients incur an oxygen debt, and are as a result at a much higher risk of organ dysfunction, infection, poor wound healing, and cardiorespiratory complications such as chest infections or myocardial infarction.

7.2.1.2 Evaluation of Physiological Fitness for Major Surgery

Evaluating physiological fitness is of clear paramount importance. This not only serves to inform risk, and therefore decision making, but potentially allows this risk to be mitigated and perioperative care planned.

Comorbidities, particularly chronic cardiovascular and respiratory compromise, have significant potential to impede a patient's ability to withstand the physiological stress that surgery and anesthesia bring. The anesthetist will take a thorough history, establishing existing diagnoses as well as screening for any undiagnosed symptoms.

Self-reported exercise tolerance is useful, if sometimes not completely reliable. Ability to exercise is quantified in metabolic equivalents (METS—see Table 7.1), with 1 MET representing the amount of oxygen uptake required to sustain life at rest (3.5 mL/kg/min)—this is roughly equivalent to 1 kcal/kg/h. As a rule of thumb, patients who are able to increase their oxygen uptake to 4 METS (14 mL/kg/min oxygen uptake—this would be required to climb a flight of stairs without stopping) are often considered to be in a lower risk category than patients who cannot.

Relevant investigations can help to identify pathology and quantify its severity. These may include electrocardiography, echocardiography, stress echocardiography, pulmonary function tests, and arterial or venous blood gases.

Physiological fitness itself can be more formally quantified using an array of validated tools. These include:

(a) Cardiopulmonary exercise testing (CPET)
This is an investigation involving the measurement of oxygen uptake and carbon

Table 7.1 Quantification of activity intensity using metabolic equivalents [2, 3]

Activity	Metabolic equivalents (METS)
At rest	1
Slow walking	2.5
Walking at moderate pace (3 km/h)	3
Housework	3.5
Climbing 1 flight of stairs	4
Brisk walking (6 km/h)	5
Vigorous sexual activity	5.8
Running 8 km/h	8
Running 11 km/h	11.5

dioxide production during exercise on a cycle ergometer. Maximum oxygen uptake (VO_2) can be measured, as can the point at which anaerobic respiration begins (the anaerobic threshold—AT), as at this point carbon dioxide production increases disproportionately to oxygen uptake. Given that the surgical stress response requires a sustained oxygen uptake of 5 mL/kg/min for several days, and given that subjects are only able to sustain prolonged exercise at 30–40% of peak, a maximum VO_2 of 15 mL/kg/min during exercise is considered to be the threshold at which patients are deemed to be low or high risk (just over 4 METS—[1]). Additionally, an anaerobic threshold of 11 mL/kg/min of oxygen uptake is also a predictor of risk, and is less effort-dependent than maximal VO_2.

(b) Incremental shuttle walk test

The patient is asked to walk to a series of recorded beeps around two cones placed 9 m apart. The beeps get incrementally faster, and the test ends when the patient can no longer keep up. Patients able to cover more than 360 m in total are considered low risk [4].

(c) Duke's Status Activity Index

This is a self-reported questionnaire of exercise capacity. It has only been validated in patients with cardiovascular disease, but nonetheless shows good correlation with CPET results in other patients.

(d) The American Society of Anesthesiology (ASA) Score

Most healthcare professionals working in a theater environment will have heard of the ASA score. It is not in fact a standalone risk prediction tool, but can be used in conjunction with other predictive factors to give a broad estimate of risk. ASA 1 patients are fit and healthy; ASA 2 have mild systemic disease; ASA 3 severe systemic disease; ASA 4 systemic disease that is a constant threat to life; ASA 5 patients are moribund and not expected to survive without the operation; and ASA 6 are patients who have already died but are having organs removed for donation purposes.

7.2.1.3 Optimizing Fitness

Simple measures such as stopping smoking, dietary advice, and encouragement of regular exercise may improve fitness for surgery. More formal exercise programs are provided in some institutions under the guise of "prehabilitation", which ideally also includes psychosocial interventions to address anxiety, dietetics, and smoking cessation [5].

Individual pathologies may require medical optimization prior to surgery. Examples include medical, interventional or surgical treatment of cardiovascular disease such as severe ischemic heart disease or valvular dysfunction, or medical management of respiratory disease such as inhaler optimization in patients with chronic obstructive pulmonary disease.

7.2.1.4 Discussion of Risk and Consent for Anesthesia

Risk is an abstract concept comprising of the likelihood of an adverse event occurring and the impact of it should actually occur. For example, the risk of a sore throat after an anesthetic with airway instrumentation is approximately 10%. The risk of paralysis after epidural insertion is approximately 0.001%. Both are materially important to most patients because the former is very common with minimal impact but the latter is an extremely rare catastrophe. United Kingdom General Medical Council guidance states that patients must be informed of these risks in a clear, simple, and unbiased way so that they can make their own assessment as to whether these risks are acceptable to them and therefore whether they wish to proceed. Please see Table 7.2 for approximate risks of complications associated with anesthesia.

Consent is usually in verbal form for anesthesia, although written consent is sometimes used. In the same way that consent for surgery requires mental capacity, consent for anesthesia mandates that the patient is able to:

1. Understand the information given.
2. Retain the information given.
3. Use it to weigh up the benefits and risks to come to a decision about whether to proceed.
4. Communicate that decision.

Table 7.2 Approximate risks of anesthetic-related complications and side effects [6]

Likelihood of occurring	Adverse event
1 in 10 or more	Sore throat, shivering, nausea/vomiting
Between 1 in 10 and 1 in 100	Minor lip or tongue injury, pain at intravenous cannula site
Between 1 in 100 and 1 in 1000	Minor nerve injury
Between 1 in 1000 and 1 in 10,000	Permanent minor peripheral nerve injury (1:1000) Corneal abrasion (1:2800) Dental injury needing treatment (1:4500) Anaphylaxis (1:10,000)
Between 1 in 10, 000 and 1 in 100,000	Accidental awareness (1:20,000) Loss of vision (1:100,000) Death (1:100,000)

The Mental Capacity Act (2005) obliges healthcare professionals to do everything within their power to help patients meet the above criteria, including (for example), the use of interpreters, the provision of information in a variety of forms that patients are able to understand (e.g., Braille) and the provision of sufficient time. Where patients lack capacity and are not likely to regain capacity in a reasonable timeframe (this will vary depending on the urgency of the surgery), the Mental Capacity Act is prescriptive in terms of the steps that must subsequently be taken. A detailed discussion of this is outside of the scope of this chapter, but may take the form of seeking opinions from the patient's family and friends, second opinions, involving other healthcare professionals, appointing an independent mental capacity advocate, and in exceptional cases, asking the Court of Protection for help.

7.2.1.5 Anticipating Specific Problems with Anesthesia

Airway management is a fundamental cornerstone of anesthetic practice. A "difficult airway" is defined as an airway that a conventionally trained consultant anesthetist will encounter difficulty with bag-mask ventilation, tracheal intubation or both. Difficult bag-mask ventilation occurs in about 1 in 1500 anesthetics, and difficult tracheal intubation 1 in 1–2000 [7]. For the most part, these can be predicted in the preoperative phase with a careful airway assessment. In particular, a history of previous airway problems during anesthesia, known abnormality of the airway (e.g., tumor) or obstructive sleep apnea are of paramount importance. Clinical examination may reveal poor mouth opening (less than 3 cm), restricted neck extension, poor view of the oropharynx on mouth opening or an underbite. In exceptional cases, investigations may be required, such as cross-sectional airway imaging, cervical spine flexion/extension views or flexible nasendoscopy.

If a neuraxial technique is indicated, such as spinal or epidural analgesia, history and examination during the preoperative assessment will be undertaken to anticipate any issues and establish the presence of any absolute or relative contraindications. These may include local or systemic sepsis, known structural spinal problems, coagulopathy, abnormalities of platelet structure or function or severe aortic valvular stenosis. If procedure or patient mandates central and arterial lines, the anesthetist will briefly assess peripheral pulses and examine the proposed site of central access.

Cardiopulmonary instability can be predicted to some extent. Elderly, dehydrated patients with known structural heart disease, severe lung disease with pulmonary hypertension, spinal cord injury, autonomic neuropathy (such as in patients with diabetes) or adrenal insufficiency are at higher risk.

7.2.1.6 Premedication

Anesthetic premedication is sometimes required for the following reasons:

(a) Anxiolysis

A variety of agents are available preoperatively for this purpose. Benzodiazepines such as oral midazolam, lorazepam or diazepam are used most commonly. These act on $GABA_A$ receptors in the central nervous system to open chloride channels and hence reduce neuronal excitability. Alpha-adrenoceptor agonists, including clonidine and dexmedetomidine can also be administered, and rarely oral ketamine may be required in poorly cooperative children or adults with learning difficulties.

(b) Drying of secretions

Antisialagogues such as glycopyrrolate or hyoscine may be required in the context of advanced airway maneuvers such as awake fiberoptic tracheal intubation, where they improve the view obtained from the fiberscope, but are rarely used outside of this context.

(c) Treatment of symptomatic reflux

Pulmonary aspiration of gastric contents under anesthesia is the most common serious adverse event during anesthesia and airway management. In patients with hyperacidity syndromes or an incompetent lower esophageal sphincter, oral proton pump inhibitors such as omeprazole are highly effective in reducing the acidity of gastric secretions, thereby reducing potential damage to lung tissue should aspiration occur. H_2 inhibitors like ranitidine are also sometimes given for the same reason.

(d) Acceleration of gastric emptying

Patients with delayed gastric emptying due to diabetic autonomic neuropathy or structural gastroduodenal lesion may require pharmacological assistance to ensure adequate gastric emptying has occurred prior to induction of anesthesia. Dopamine inhibitors such as metoclopramide or domperidone are used for this.

(e) Optimization of cardiopulmonary disease

Patients with asthma or chronic obstructive pulmonary disease are at risk of bronchospasm in response to painful stimulation or airway manipulation under anesthesia. The administration of preoperative β_2-agonists such as salbutamol (via inhaler or nebulizer) may help to partially mitigate this.

Patients with heart disease on long-term β blockade should continue this medication throughout the perioperative period, but β blockers should not be started de-novo preoperatively in an attempt to prevent cardiovascular complications. Management of anticoagulants and antiplatelets perioperatively is often the subject of debate, and the risk of stopping these medicines must be balanced against the risk of exacerbating blood loss during surgery. This risk calculation is sometimes complex and varies between patients—as such specialist advice may need to be sought.

(f) Reduce or prevent pain from intravenous cannulation

This is of particular relevance in pediatric anesthetic practice, although needle-phobic adults may also benefit. Topical local anesthetic agents include EMLA 5% cream (this is a mixture of 2.5% lignocaine and 2.5% prilocaine) or amethocaine 4%. Amethocaine causes local histamine release and hence vasodilatation, potentially making cannulation easier. Following a 45-min application, the local anesthetic effect lasts for 4–6 h. EMLA cream may cause slight vasoconstriction, and requires a local application time of 1 h [8].

7.3 Intraoperative Management

7.3.1 Patient Monitoring

The following are the basic physiological monitoring modalities recommended by the Association of Anesthetists of Great Britain and Ireland (AAGBI) in 2015 during surgery [9]. Their collective use is universally accepted practice, and without them general anesthesia cannot proceed. They include (as demonstrated in Figs. 7.1 and 7.2):

Fig. 7.1 Intraoperative monitoring. This monitor shows the recording of ECG, BP (invasive), O_2 saturations, central venous pressure, and temperature

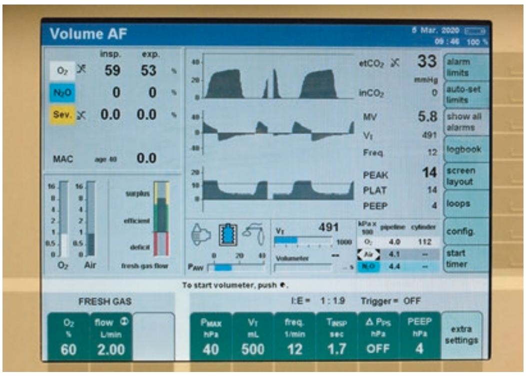

Fig. 7.2 Intraoperative invasive ventilation settings. The ventilator has been set to deliver a specified tidal volume with each breath (so-called "volume control" ventilation). Also showns are airway pressures required to deliver the specified tidal volume, the CO_2 trace measured throughout the respiratory cycle, and inspired and expired concentrations of gases and volatile anesthetic agents

Electrocardiogram (ECG).
Non-invasive blood pressure (NIBP).
Pulse oximeter.
Inspired and expired oxygen concentration.
Airway gas analysis, including capnography and volatile agent (if used).
Airway pressure.
Peripheral nerve stimulator if muscle relaxants are administered.

Other monitoring devices may be required depending on the clinical situation. These include depth of anesthesia devices (such as Bispectal Index (BIS) and Entropy) when patients are concurrently administered total intravenous anesthesia (TIVA) and neuromuscular blocking agents

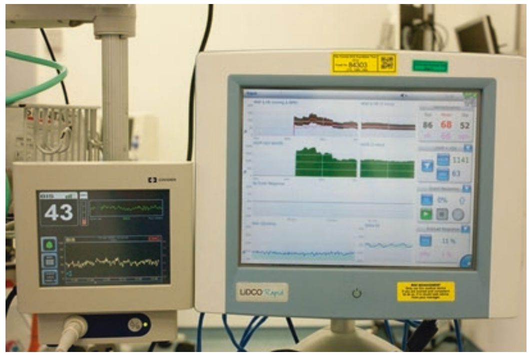

Fig. 7.3 Intraoperative monitoring of depth of anesthesia and cardiac output. The depth of anesthesia is measured in this case using Bi spectral Index (BIS) which displays a real-time electroencephalographic trace and analyses this uses validated computer algorithms to indicate anesthetic depth and likelihood of accidental awareness. The cardiac output is measured by LiDCO Rapide, which is a minimally invasive hemodynamic monitor and derives cardiac output by analysing contours of the invasive blood pressure waveform

[10]. Use of BIS is shown in Fig. 7.3. Additionally, most patients undergoing perineal reconstruction will have invasive arterial and central venous pressure monitoring (please see Figs. 7.4 and 7.5).

Peripheral oxygen delivery is the single most important determinant of peripheral and flap tissue oxygen status and physiological wellbeing. This is determined by blood flow and blood oxygen content. The latter is largely determined by arterial oxygen saturations at atmospheric pressure. Blood pressure is often used a surrogate for blood flow, but in reality forms only a single variable of its determination. Total blood flow is governed by the Hagen-Poiseuille equation, thus:

$$\text{Blood flow} = (P_1 - P_2)\pi r^4 / 8\eta l.$$

P_1 = arterial pressure.
P_2 = venous pressure.
r = vessel radius.
η = blood viscosity.
l = vessel length.

From the above equation, it can be seen that the radius of blood vessels is a much more important determinant of flow than the driving pressure (arterial—venous pressure, or $P_1 - P_2$ above). Anesthetists will therefore attempt to optimize flow as far as possible, with pressure a secondary

Fig. 7.4 Invasive blood pressure monitoring. The arterial line is a catheter which here is inserted into the radial artery. This gives continuous beat-to-beat monitoring of the blood pressure and also allows frequent arterial blood gas sampling

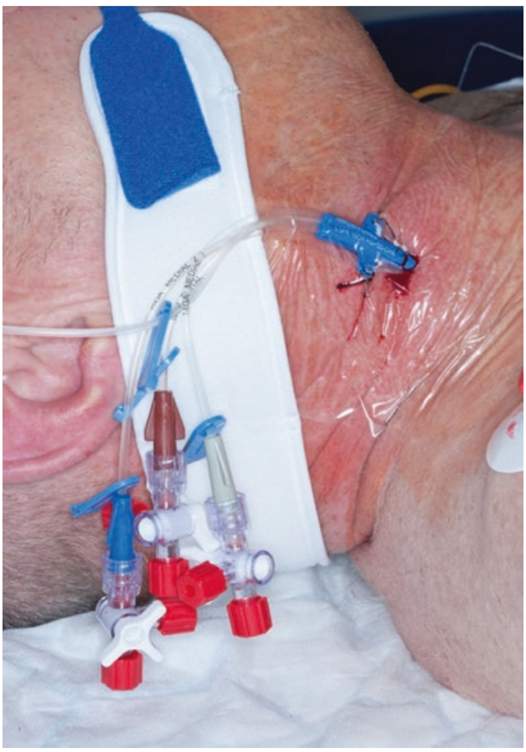

Fig. 7.5 Central venous pressure monitoring. Central venous pressure (CVP) is the pressure recorded from the right atrium or superior vena cava, and is representative of the filling pressure of the right side of the heart. Here a four-lumen catheter is inserted into the right internal jugular vein. These catheters are used to administer fluids, blood, and medications, for blood sampling, and for hemodynamic monitoring

consideration. Cardiac output (CO) monitors generate an estimate of blood flow by various means. In our institution we use the esophageal doppler, which measures blood velocity in the descending thoracic aorta, to derive flow measurements. Pulse contour analysis is also in widespread use—this involves the mathematical analysis of the arterial pressure waveform to derive flow estimates as demonstrated in Fig. 7.3.

Core temperature also needs to be accurately measured. Patients undergoing general anesthesia are at high risk of hypothermia, as anesthetic-induced peripheral vasodilatation increases heat loss, and this together with the loss of behavioral ability to regulate temperature, will result in profound hypothermia by the end of a long operation unless active steps are taken. Hypothermia, apart from being generally unpleasant for the patient following emergence, has physiologically deleterious effects, including coagulopathy, retained secretions, cardiovascular instability, arrhythmias, and a higher risk of wound infection.

Urine output is the only direct measure of tissue perfusion available, and is monitored routinely via a urinary catheter and urometer on an hourly basis. An approximate guide for adequacy of urine output is 0.5 mL/kg/h, although in the context of the surgical stress response, sometimes a slightly lower figure, such as 0.3 mL/kg/h may be accepted to avoid excessive fluid administration, which may itself be harmful.

7.3.2 Epidural Placement and Anesthetic Induction

Following the establishment of AAGBI monitoring and peripheral intravenous access, for many perineal reconstructive operations, an epidural is sited for postoperative pain relief. In our institution, the vast majority of these involve a full midline laparotomy as part of a major cancer resection, and therefore the epidural is sited at the thoracic level. Major contraindications include patient refusal, local or systemic sepsis, coagulopathy, and thrombocytopenia or abnormalities of platelet function (including drug-induced, such as clopidogrel, which should be stopped 7 days beforehand). Following this, induction of anesthesia is usually performed with an intravenous anesthetic agent such as propofol, https://www.sciencedirect.com/topics/medicine-and-dentistry/propofol combined with an opioid and a muscle relaxant. Inhalational induction can also be performed in some circumstances, such as profound needle phobia, difficult peripheral venous access, and where significant hemodynamic instability is expected.

7.3.3 Airway Management

Following anesthetic induction, the airway is supported with simple airway-opening maneuvers such as head tilt, chin lift and jaw thrust. An oro- or nasopharyngeal airway may be inserted to facilitate airway patency. A period of apnea following induction agent and muscle relaxant administration will supervene. This initially requires bag-valve mask or supraglottic airway ventilation until such time as the muscle relaxant has had sufficient time to work (usually 2–3 min for routine surgery), whereupon an endotracheal tube is placed and invasive mechanical ventilation commenced.

7.3.4 Maintenance of Anesthesia

Maintenance of anesthesia can be done in two ways:

1. *Continuous intravenous anesthetic infusion* (total intravenous anesthesia or TIVA): This commonly involves propofol and remifentanil, although other agents are occasionally used depending on the clinical situation and anesthetist preference; or
2. *Volatile anesthetic agents*: These are added to the patient breathing circuit by the anesthetic machine, and concentrations are continuously measured using airway gas analysis.

TIVA may result in less postoperative nausea and vomiting, and may be required when anesthetizing patients with the rare condition of malignant hyperthermia, where volatile anesthetic agents will trigger a life-threatening hyperthermic response. There is some evidence that TIVA may reduce cancer recurrence risk when compared with volatile anesthetic agents, but this remains controversial [10]. TIVA is associated with a greater risk of accidental awareness during general anesthesia—this mandates the use of a depth of anesthesia monitors when administered concurrently with muscle relaxants.

7.3.5 Invasive Mechanical Ventilation Via the Endotracheal Tube

Patients are artificially ventilated using positive pressure. A variety of modes of machine ventilation are available, which broadly differ in terms of delivering a fixed tidal volume (volume control ventilation—with delivered pressure dependent on lung compliance) or fixed pressure (pressure control ventilation—with delivered tidal volume dependent on lung compliance). Some modes of ventilation allow spontaneous breathing on top of ventilator-delivered breaths throughout the respiratory cycle, although for perineal reconstruction most patients will have received muscle relaxants and therefore will be unable to do so.

7.3.6 Antibiotic Prophylaxis

Local protocols usually mandate antibiotic administration within 1 h of skin incision to prevent surgical site infection.

7.3.7 Preventing Pressure Ulceration

Key strategies to prevent perioperative pressure ulcers during prolonged procedures include [11]:

1. Risk assessment

   Validated scores such as the Waterlow score are available for this purpose.
2. Pressure redistribution

Bony prominences should be protected using foam or gel pads to prevent pressure ulcers.

Skin and other pressure areas should be regularly inspected, and where possible patients should be periodically moved or repositioned throughout the procedure to prevent pressure build up over at-risk areas. Some institutions may perform regular passive limb movements at regular intervals.

The eyes should be lubricated with ointment and closed with tape to prevent corneal injury.

At our institution the endotracheal tube is secured using pressure relieving tape. Nasogastric tubes (if used) should be secured and carefully padded.

3. Prevention of hypothermia (see below).

7.3.8 Positioning

For this procedure the patient may be either prone or in the lithotomy position.

7.3.8.1 Prone

Prone positioning is associated with a range of pitfalls, risks, and complications. The act of proning an anesthetized patient requires significant skill and personnel. During proning, routine anesthetic monitoring largely requires removal, and therefore a potential delay in the detection of patient deterioration. Vascular access devices and the endotracheal tube itself are at risk of displacement, and patients with significant cardiovascular comorbidity may become hemodynamically unstable. Injury to facial structures, particularly the eyes and nose, is possible, and careful attention must be paid to limb positioning and pressure areas to prevent pressure sores and neurological injuries during prolonged procedures. The chest and abdomen should be as free as possible to avoid inhibiting ventilation, and the vulnerable female breasts and male genitalia should be protected.

7.3.8.2 Lithotomy

This position has been associated with common peroneal, saphenous, and sciatic nerve palsies. Compartment syndrome is a serious complication of prolonged procedures in the lithotomy position.

7.3.9 Temperature Management

Active warming devices during perineal reconstruction include warmed fluids and forced air warmers.

7.3.10 Fluids

Fluid administration is guided intraoperatively by the need to:

- Replace pre-existing fluid deficit

  Most patients will be fluid depleted to some extent before the operation starts. This is due to preoperative starvation guidelines (6 h prior to anesthetic induction for all but clear fluids that can be taken until 2 h) and bowel preparation that induces enteric fluid losses.
- Meet the need for ongoing baseline fluid maintenance

  Baseline fluid requirements are 4 mL/kg/h for the first 10 kg body weight, 2 mL/kg/h for the second 10 kg, and 1 mL/kg/h for the remainder. As an example, a 50 kg patient will require 40 mL + 20 mL + 30 mL = 90 mL/h (2160 mL/day). In the absence of oral intake, this will need to be replaced intraoperatively.
- Replace surgically-induced fluid losses

  Evaporative losses from surgical wounds are significant. An open laparotomy wound as a benchmark results in approximately 10 mL/kg/h water loss, and although smaller wounds might be expected to make a lesser impact, nonetheless they will need to be factored into fluid replacement calculations.
- Replace blood losses

Blood is largely replaced with non-blood intravenous fluid until the hemoglobin concentration falls below 80 g/L in most cases. Total blood volume in an adult is approximately 70 mL/kg (4.9 L in a 70 kg adult). If the starting hemoglobin concentration is 140 g/L, this would theoretically mean that (140–80)/140 × 4.9 = 2.1 L blood loss before transfusion is required.

7.3.11 Analgesia

Multimodal, opioid-sparing analgesia is important to help control pain for patients undergoing reconstructive surgery.

Systemic analgesic agents include paracetamol, non-steroidal anti-inflammatory drugs (if not contraindicated by the surgery), and opioids. Occasionally ketamine, intravenous lignocaine or clonidine may also be administered. Regional techniques include epidural or spinal analgesia, and simple local anesthetic infiltration. In the postoperative period, *patient-controlled analgesia* devices are designed to administer a preset bolus of intravenous opioid in response to a button press by the patient, followed by a lockout time to prevent overdose.

7.3.11.1 Antiemesis

A multimodal approach to postoperative nausea and vomiting (PONV) prophylaxis should be considered in all patients based on individual risk factors. The etiology of PONV is complex and multifactorial. The Apfel simplified score for risk stratification includes female gender, history of PONV and/or motion sickness, nonsmoking status, and postoperative use of opioids. When 0, 1, 2, 3, or 4 factors are present, the risk of PONV is 10%, 20%, 40%, 60%, or 80%, respectively [12].

First line antiemetic drugs are serotonin antagonists (e.g., ondansetron), corticosteroids (e.g., dexamethasone), and dopamine antagonists (e.g., droperidol). These have a similar efficacy against PONV, with a relative risk reduction of ~25% per drug class administered. Others include antidopaminergic (e.g., metoclopramide), anticholinergic (e.g., scopolamine), and antihistaminic (e.g., cyclizine).

Please see Table 7.3 for a suggested PONV prevention and management strategy.

7.3.12 Emergence

Emergence from anesthesia is achieved simply by discontinuation of the volatile or intravenous anesthetic agent. As consciousness returns, the endotracheal tube is safely removed. It may be also be removed or substituted for an alternative airway device during deep anesthesia to help prevent coughing and hypertensive responses during emergence.

Table 7.3 A suggested management strategy for the prevention and treatment of postoperative nausea and vomiting [12]

Assess baseline risk	Inform the patient Number of risk factors-predictive incidence	Decrease the baseline risk	Prevent	Treat
Female	0–10%	Use regional instead of GA	1–2 first line antiemetics for patient at moderate risk	Ondansetron or palonosetron
Nonsmoker	1–20%	Avoid volatile/ nitrous oxide	3–4 first line antiemetics and/or TIVA for high-risk patients	Consider second line antiemetics if 5HT3 antagonist is used for prophylaxis
h/o motion sickness and /or PONV	2–40%	Limit opioids		
Postoperative use of opioids	3–60%			
	4–80%			

7.4 Postoperative Considerations

Emergence from anesthesia takes a variable length of time, and is dependent on:

(a) *Anesthetic factors*, such as the agents used,
(b) *Patient factors*, such as age, body habitus, and renal or liver impairment and,
(c) *Surgical factors*, particularly duration of surgery.

Once consciousness is regained, and airway reflexes and respiratory drive returned, the tracheal tube is removed, and supplementary oxygen applied as required, usually via a Hudson mask.

7.4.1 Postanesthetic Care Unit

In the UK, postanesthesia care is standardized by the Association of Anesthetists of Great Britain and Ireland [13]. It should only take place in designated areas, and patients should be closely monitored by a trained recovery practitioner or anesthetist on a one-to-one basis. This level of care should continue until the patient meets the following discharge criteria:

- fully alert,
- spontaneously maintains own airway,
- adequate respiratory function,
- cardiovascular stability with no persistent bleeding,
- pain score 4 or less,
- other symptoms such as nausea and vomiting are adequately controlled,
- temperature over 36 °C, and
- vascular access devices flushed and patent.

Physiological monitoring should take the same form as that applied intraoperatively as described above.

7.4.1.1 Pain Control

Choice of pain relief is dictated by patient, surgical and anesthetic factors. Most patients undergoing prolonged procedures receive epidural analgesia intra- and postoperatively, and usually experience good pain control as a result. At our institution, it is usual practice to continuously infuse 0.125% bupivacaine with fentanyl 2 μg/mL with a patient-controlled bolus function. Analgesic partial or complete failure is nonetheless relatively common in the immediate postoperative period.

Please see Fig. 7.6 for the approach taken at our institution to treat this.

Alternatives to epidural analgesia include intravenous patient-controlled analgesia and multimodal analgesia including paracetamol and NSAIDs if not contraindicated. On occasion, more specialized forms of pain relief such as ketamine and lignocaine infusions can be administered [14].

7.4.1.2 Postoperative Nausea and Vomiting (PONV)

Further antiemetics may be required in the postoperative period using the algorithm described above [15, 16].

7.4.1.3 Other Aspects of Immediate Postoperative Recovery

Central venous catheters, if placed intraoperatively, require radiological verification of correct placement and exclusion of complications related to insertion, most notably pneumothorax [17].

7.4.2 Critical Care/High Dependency Phase

Once recovery discharge criteria have been met, the patient is transferred to level 2 (high dependency) or level 1 (ward) as appropriate. The principle difference between level 2 and level 1 care is the nurse: patient ratio—at 1:2 for level 2 but potentially 1:6 or more for level 1. Level 2 care thus allows for much closer patient monitoring (including flap observations and pain relief) than would be realistically achievable in a level 1 environment. Length of stay in a level 2 bed is patient-dependent, but rarely exceeds 48 h [18].

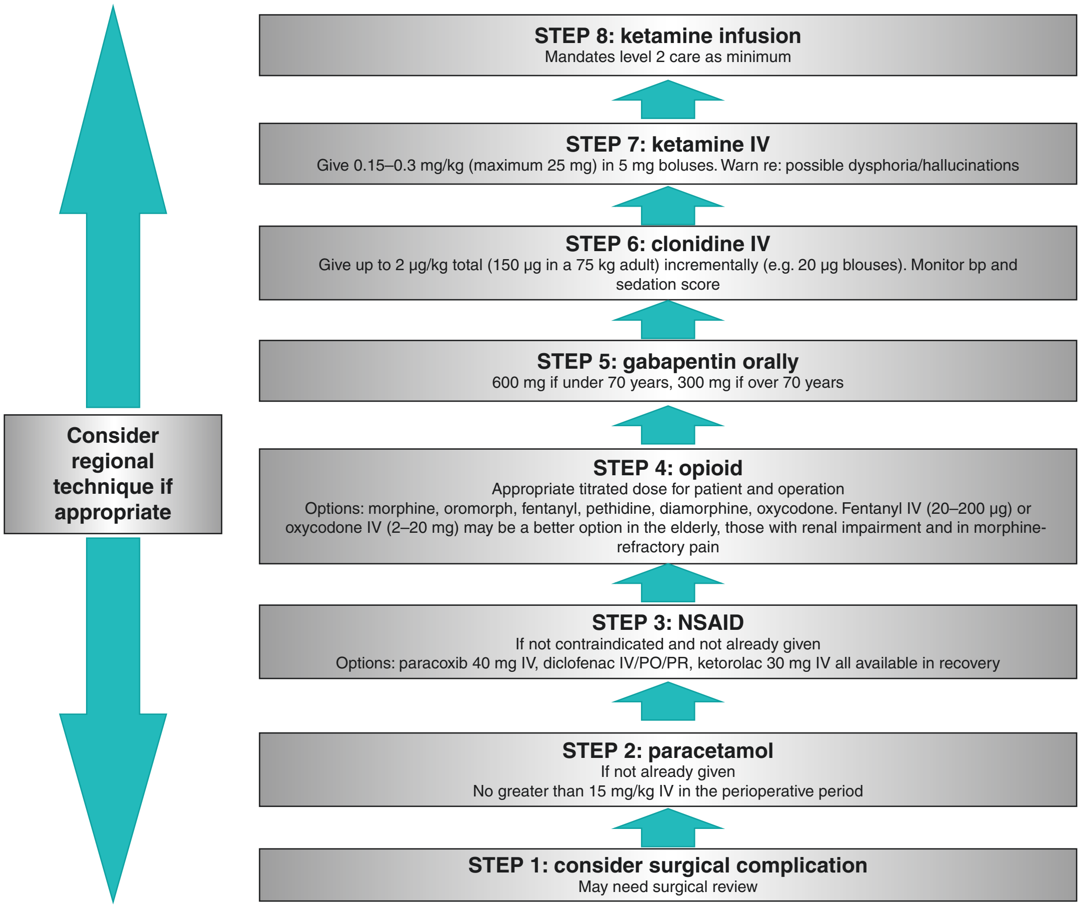

Fig. 7.6 Rescue analgesia guideline for use in the postanesthetic care unit

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8 Lotus Petal and V-Y Advancement Flaps

Charles Yuen Yung Loh and N. S. Niranjan

8.1 Introduction

Perineal defects can occur for a variety of reasons and in particular, management of pelvic malignancy can be challenging. A multidisciplinary approach should be taken with a plastic surgeon, abdominal-colorectal surgeon, urological surgeon, gynecological-oncological surgeon, oncologist, radiologist, specialist nurse practitioner, physiotherapist, and psychologist as part of the team involved. The involvement of various specialists in the care of such patients is key in improving outcomes where each specialty brings their experience and expertise to the table, working for a better outcome in these patients. In our experience, the management of this group of patients depends on general condition of the patient and any comorbidities (such as smoking, age, history of diabetes, atherosclerosis, high BMI, nutritional status) and the likely defect following resection (skin, pelvic contents, sphincter muscles). Some patients had previous surgery and/or radiotherapy and for them, the local surgical option would have either already been used or may not possible, because of previous scars or radiotherapy damage to soft tissues. The patient should be well informed about the extent of surgical treatment, likely outcomes, complications, and possible major life changes postoperatively (for example loss of sexual function, control of sphincters, colostomy, and urinary conduit). Consultant Anesthetist who is regularly involved in these procedures should assess the patient *preoperatively*. In total pelvic exenteration, the defect includes both skin and pelvic viscera. Varying components resected will determine the volume loss and type of flaps chosen to reconstruct the defect. In perineal skin or soft tissue loss alone following extensive infection like necrotizing fasciitis, burns or trauma, the defect again may be soft tissue where lotus petal or V-Y flaps may be employed.

A "clock face" approach to assessing the defect is our approach in formulating a reconstructive plan. There are numerous perforator-based or myocutaneous flaps available beyond the clock-face territory of the lotus petal flaps [1] and extended lotus petal flaps, which serve this purpose [2, 3]. These flaps are a distance away from zone of trauma/disease or irradiation and allow for harvesting of fresh vascularized tissue to reconstruct the defect. The goal of reconstruction would be to get the patient healed and allow mobilization as soon as possible.

The perineum has a rich vascular plexus, supplied by both the femoral and the iliac arteries. Branches from these vessels anastomose with each other around the urogenital and anal orifices. It is this plexus of vessels and perforators

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that supply the overlying skin through which we are able to raise fasciocutaneous flaps, such as the lotus petal or V-Y flaps.

Perineal reconstruction is very challenging both in terms of function and cosmesis. Local perforator flaps are very useful as they replace the defect with tissue of similar qualities. They allow for a thin and supple reconstruction of a defect and can be bulked up to a degree, when de-epithelialized and tucked into a defect to obliterate the dead space.

8.2 Anatomical Blood Supply of the Perineum (Fig. 8.1)

Carl Manchot (1889) [4] contributed to our understanding of the blood supply of the perineum and also divided the perineum in the anterior and posterior regions. The femoral and internal iliac arteries contribute branches that supply the perineum. The anterior region is supplied by the superficial external pudendal artery and deep external pudendal artery, whereas the posterior half of the perineum is supplied by the obturator artery, internal pudendal artery, and branches of the inferior gluteal artery.

The penile/clitoral branch and the perineal artery are branches of the internal pudendal artery. The perineal artery on both sides forms anastomoses that supply the labial/scrotal part of the perineum. The medial branch of the perineal artery supplies the perianal region and the lateral branch supplies an area on the posterior surface of the upper thigh. A rich plexus is formed by the interconnections and anastomoses from these named vessels which allow us to raise fasciocutaneous perforator flaps (Fig. 8.1).

8.3 The Lotus Petal Flap for Perineal Reconstruction

The ideal flap for a perineal defect should be pliable, reliable, not be too thick, and have protective sensation to a crucial area. It should be robust to withstand shearing and pressure as the patient is often lying down on it. Donor site morbidity should also be kept to a minimum. A line drawn between the ischial tuberosity divides the perineum into anterior and posterior regions. A central defect is usually seen after resection of vulvar/vaginal or anal neoplasia (Fig. 8.2). Other indications for flap reconstruction in the perineum are congenital malformations and severe infections requiring debridement and excision of the affected area such as hidradenitis suppurativa or necrotizing soft tissue infections. In upper quadrant defects, donor skin flaps could be harvested from the groin and/or mons pubis area, whilst lower quadrant defects can be reconstructed from the gluteal fold and/or gluteal area. Local perforator flaps can be categorized based on type of movement required as rotation flaps (lotus petal flaps, Fig. 8.3), V-Y advancement flaps and transposition (pudendal, mons pubis flaps, Fig. 8.4).

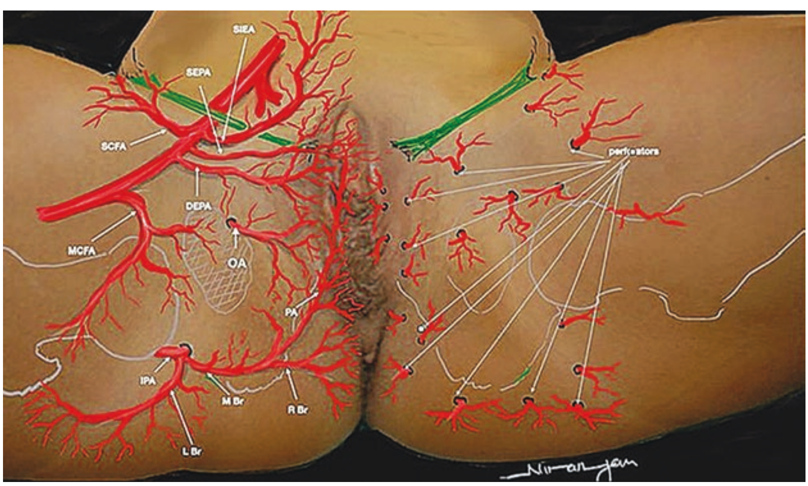

Fig. 8.1 Arterial network and perforators of the perineum. *SIEA* superficial inferior epigastric artery, *SEPA* superficial external pudendal artery, *SCFA* superficial circumflex femoral artery, *MCFA* medial circumflex artery, *DEPA* deep external pudendal artery, *OA* obturator artery, *IPA* internal pudendal artery, *L Br.* Lateral branch, *M Br.* medial branch, *R Br.* rectal branch, *PA* perineal artery

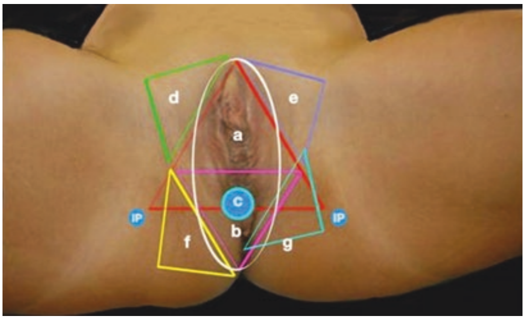

Fig. 8.2 Regions of the perineum. (**a**) anterior triangle; (**b**) posterior triangle; (**c**) Perineal body; (**d**) Right upper groin; (**e**) left upper; (**f**) Right lower; (**g**) left lower

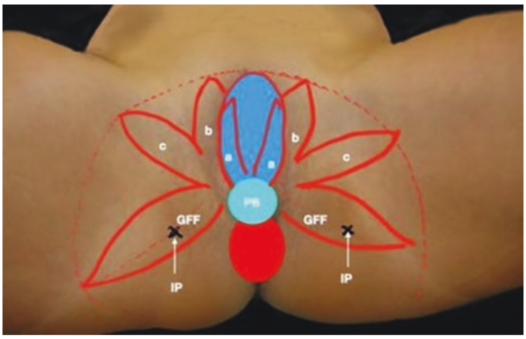

Fig. 8.3 The Lotus petal flap design. (**a**) labia minora flaps; (**b**) labia majora flaps; (**c**) intermediate petal flaps; *GFF* gluteal fold flaps, *IP* Ischial tuberosity

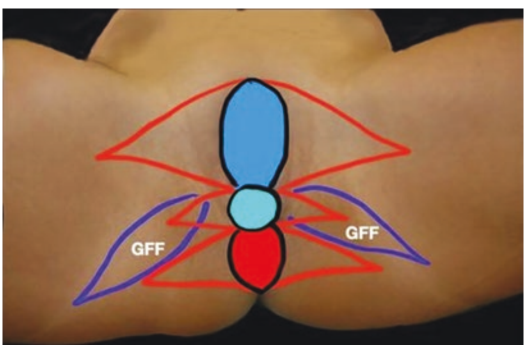

Fig. 8.4 V-Y flap design for perineum. *GFF* gluteal fold flaps

Horton et al. (1973) [5] reported local random pattern flaps designed around the genital area. Other types of skin flaps used during the 1970s and 1980s were mostly myocutaneous flaps [6]. Wee and Joseph (1989) [7] described a pudendal thigh flap with an intact nerve supply for vaginal reconstruction. The senior author prefers local perforator fasciocutaneous flaps in the form of a lotus petal as first described when reconstructing the perineum.

A Lloyd Davies' position is preferred whilst the patient is under a general anethesia or a spinal block. Prophylactic antibiotics are administered during induction and for 48 h postoperatively. The defect is measured, and a template is created. The template can be used to design the amount of tissue required to be harvested from the donor area. A swab connected to the template is swung toward the defect to ensure it reaches and allows for planning of the flap inset route. Perforators (vessels) are mapped using a hand-held Ultrasound Doppler device preoperatively and can be confirmed intraoperatively. Several perforators are mapped out to allow for versatility in planning of the flap. An exploratory incision is performed along one side of the flap, through the fascia and down to the muscle. The flap is raised in a subfascial approach until the perforating vessel is reached. The perforator is assessed for size and ensuring that there is an arterial and venous component to the perforator. When designing rotation or transposition flaps, perforators should be chosen closer to the defect. However, for V-Y advancement flaps harvest, perforators included can be anywhere in and around the mid-axis of the V-Y flap.

8.4 The Perineal Body

The perineal body, described by MacAlister (1889) [8, 9], is a complex fibromuscular mass which separates the perineum in anal and urogenital regions. It is delineated by the rectovaginal septum (Denonvilliers' fascia), perineal skin, posterior wall of the vagina, anterior wall of the anorectum, and the ischial rami.

The perineal body has an important role in maintaining urinary and fecal continence. Any injury to the perineal body has long-lasting effects and patients may then suffer from pain, dyspareunia, an open external vaginal orifice causing fecal/urinary urgency or incontinence. It should hence be given due consideration when repairing the area to reduce physical and psychological sequelae. As plastic surgeons, we perform scar revisions and reconstruct defects over the perineal body using local perforator flaps such as the lotus petal flap, recreating that tissue barrier between the vagina and anorectum.

8.5 Planning V-Y Flaps for Perineal Reconstruction

Gluteus maximus is the largest muscle within the buttock area. It is a type III muscle (having two dominant blood supplies). Superior and inferior gluteal arteries arise as branches of the internal iliac artery. They emerge on either side of the piriformis muscles (Fig. 8.5). Superior gluteal artery supplies the cranial part of the gluteus maximus muscle and the inferior gluteal artery supplies the inferior half. The inferior gluteal artery is a direct continuation of the internal iliac artery, emerging below the pirifomis muscle. It is accompanied by the sciatic nerve, inferior gluteal nerve, internal pudendal vessels, and posterior femoral cutaneous nerves. The cutaneous perforators of the inferior gluteal artery, about 8 of them (+/−) 4, are concentrated in the middle third of the gluteal region, parallel to the gluteal crease. A V-Y flap can be planned and raised based on these perforating vessels as well.

The principle of V-Y advancement and the concept of the perforator flap have changed perineal reconstruction in plastic surgery.

When faced with a defect over the posterior triangle of the perineum, the reconstructing surgeon should consider three factors:

1. The skin defect.
2. The dead space.
3. The pelvic floor.

We recommend a V-Y flap design that preserves the gluteal fold flap area on both sides.

If it is only skin that is to be reconstructed, a V-Y flap from one side would generally be sufficient for a small to moderate defect. Larger skin defects, however, would generally require bilateral V-Y flaps.

If dead space reconstruction is required, a de-epithelialized gluteal flap can be used as well. In our practice we have used a V-Y flap from one side and a gluteal fold flap from the opposite side—this keeps additional similar flaps available for future use.

In an abdominoperineal resection, the initial resection is performed by the colorectal surgeons with the patient supine. The patient is then positioned in a prone, jack-knife position for reconstruction. With either a rotation-type or transposition-type of flap, a perforator close to the defect should be selected whereas with a V-Y advancement flap the selected perforators can be anywhere in and around the mid-axis of the flap. The flap is islanded by incising the deep fascia around the island whilst preserving the perforators from the muscle under the flap. Islanding the flap allows it to be maneuvered into the defect although there is a risk of venous congestion, particularly if the flap is rotated and is based on a single perforator. This can be ameliorated by preserving a degree of subcutaneous tissue at the pivot point.

Once the flap is transposed or rotated and advanced into the defect, the donor site is usually directly closed with a suction drain inserted at both donor and the recipient sites. Once the operation is completed, the perineum is protected with Gamgee (cotton wool sandwiched between

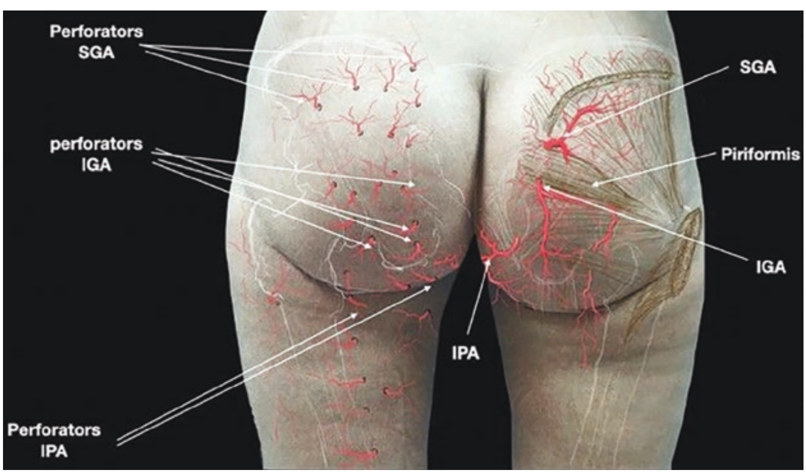

Fig. 8.5 Arterial network of the gluteal region. *SGA* superior gluteal artery, *IGA* inferior gluteal artery, *IPA* internal pudendal artery clinical cases

dressing gauze). This dressing keeps the area warm in order to encourage vasodilatation.

Patient controlled and/or regional analgesia is often required for the first 48 h. The use of lotus petal flaps requires the patient is kept in a position that minimizes pressure over the flap, with thighs abducted and knees are slightly flexed and supported by a pillow. In contrast, patients who have had V-Y flaps from the gluteal region require nursing in the prone position.

Most patients can be mobilized after 24 h and their urinary catheter can usually be removed within 4–5 days with discharge home after a week.

Patients with a gluteal fold flap may feel uncomfortable sitting for the first few weeks. They should be given soft cushions and advised not to sit for too long.

Clinical cases of the various examples of perineal reconstruction in either a lotus petal or V-Y flap fashion are shown in Figs. 8.6, 8.7, 8.8, 8.9, and 8.10.

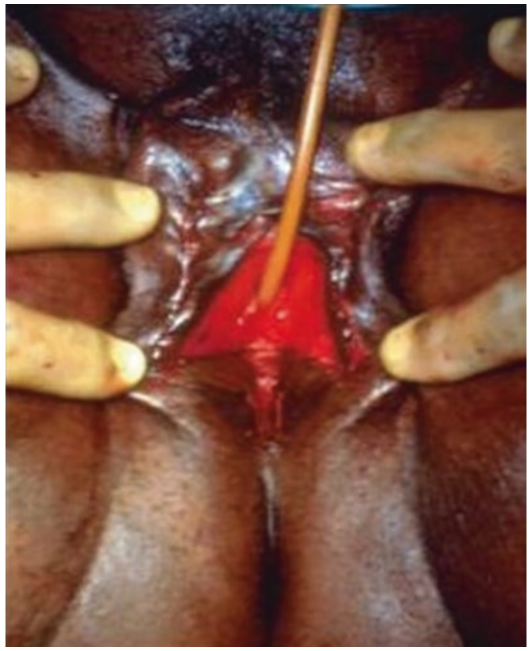

Fig. 8.6 Labia minora flaps for vaginal stenosis

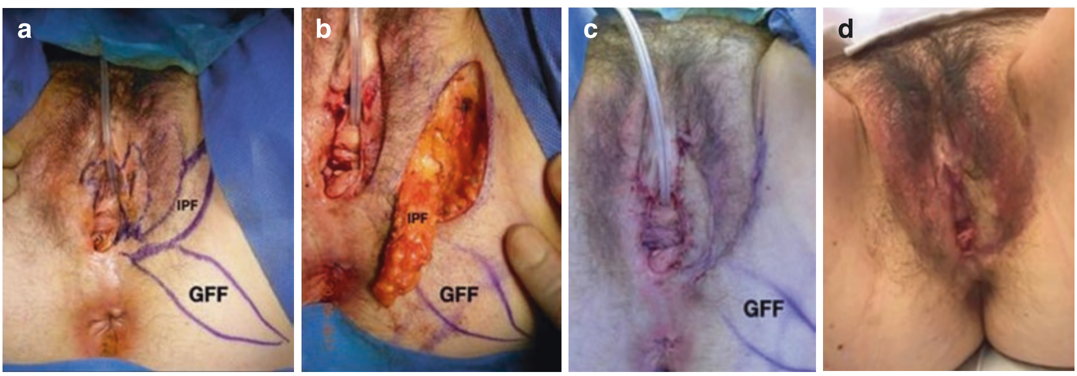

Fig. 8.7 Excision of SCC of the left vulva and reconstruction with a left intermediate petal flap. *IPF* intermediate petal flap, *GFF* gluteal fold flap, (**a**, **b**) intraoperative photographs of the left on the left vulva with the defect and IPF raised, (**c**) IPF inset and direct closure of secondary defect, (**d**) 4-months postoperative photograph at follow-up

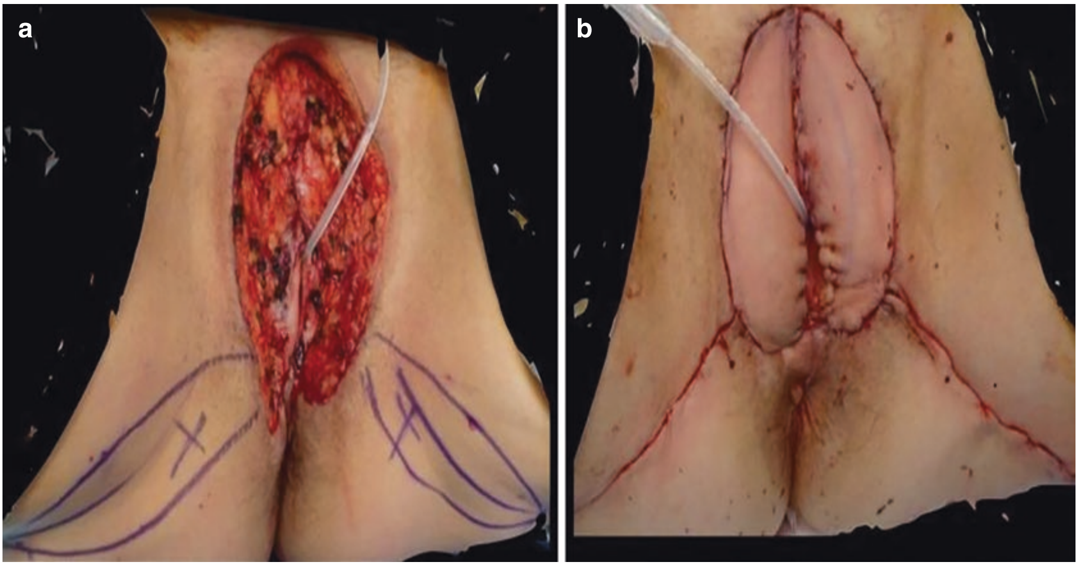

Fig. 8.8 Gluteal fold flap (Lower petal of lotus petal flap) for radical vulvectomy. (**a**) Gluteal fold flap for Radical Vulvectomy (**b**) Lower Petal of Lotus Petal Flap

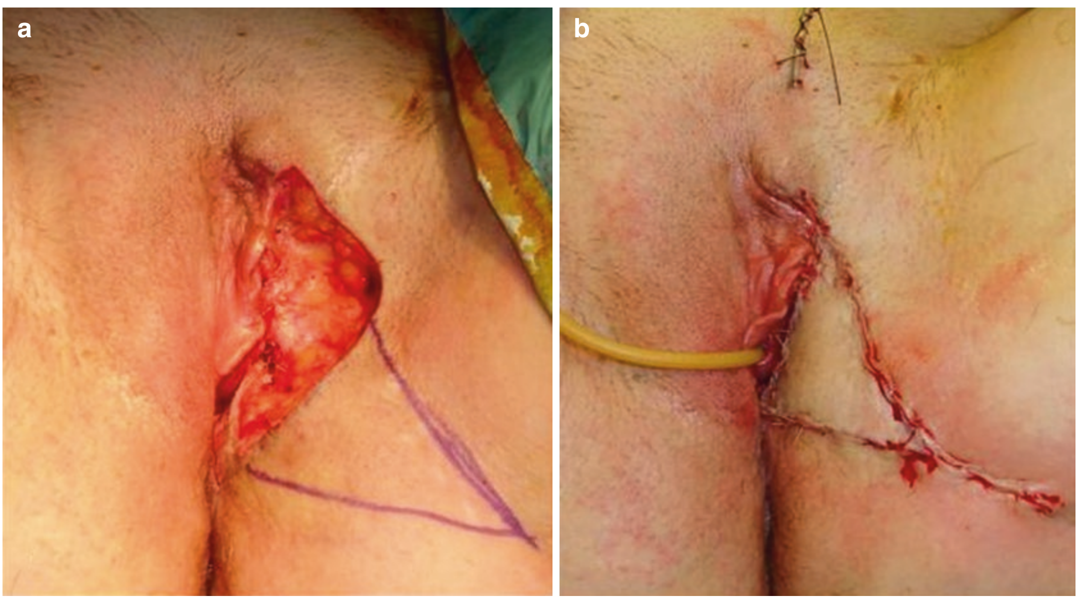

Fig. 8.9 V-Y flap reconstruction of the defect over left vulva. (**a**) V-Flap before reconstruction (**b**) V-Y flap reconstruction of the defect over left vulva

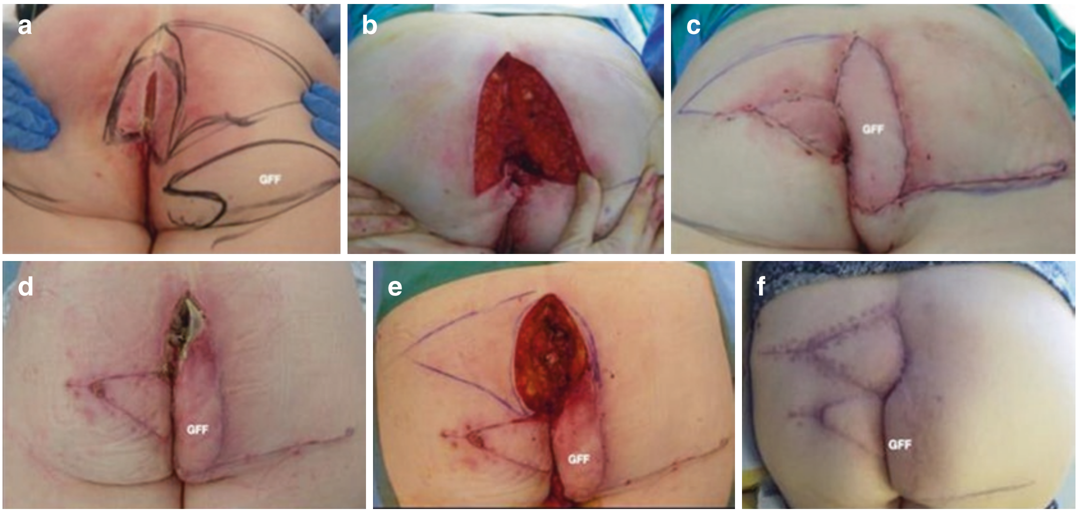

Fig. 8.10 V-Y flaps with gluteal fold lotus petal flaps for perineum reconstruction. (**a**) post radiation ulcer over posterior triangle of the perineum; (**b**) Defect; (**c**) reconstruction with right gluteal fold flap and left V-Y flap; (**d**) wound dehiscence; (**e**) further debridement with defect reconstruction with a gluteal fasciocutaneous V-Y flap (GFF); (**f**) 6-week postoperative result

8.6 Discussion

Perineal reconstruction is highly complex and should be managed within a multidisciplinary team. Defects and surgery in this area are associated with psychological and physical changes for the patients which are permanent. Basic reconstructive surgery principles should ensure a water tight, reliable reconstruction, which offers patients the best route for early recovery and have low donor site morbidity. The lotus petal flap and the V-Y perforator fasciocutaneous flaps are workhorse flaps in perineal reconstruction. In cases where up to one half of the perineum has to be reconstructed, any one of the petals of lotus petal flap would be sufficient. When entire perineum needs to be reconstructed, an extended petal of lotus petal flap should be the reconstructive choice [10], depending on the required size and volume. There are three components to consider when reconstructing the perineum - pelvic floor, dead space, and skin cover. The first can be reconstructed either by Acellular Dermal Matrix or de-epithelialized skin flaps. Dead space requires bulk to obliterate, which can be achieved by a vascularized muscle or a de-epithelialized myocutaneous or fasciocutaneous flap. Skin cover is best provided with flaps mobilized with a skin component.

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Gracilis Flap

9

Maija Kolehmainen and Sinikka Suominen

9.1 Introduction

The need for pelvic and perineal reconstruction is increasing due to larger resections. Better oncological therapies allow longer life expectancy, and safer anesthesia has made operative treatment possible for patients who were previously considered inoperable due to comorbidities or metastatic cancer. In previously irradiated patients, reconstruction with healthy, well-vascularized tissue may be necessary for successful wound healing.

The medial thigh is a logical tissue source in perineogenital and pelvic reconstructions. The pedicled gracilis muscle has been used for almost 100 years for several indications, for example in the filling of large cavities, fistula corrections, sphincter reconstructions for urinary or anal incontinence, and genital reconstructions [1–7]. In 1976, Harii reported the first free gracilis muscle transplantation for dynamic reconstruction of facial paralysis with a microneurovascular gracilis flap [8].

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The myocutaneous gracilis flap was traditionally harvested with a vertical skin island. However, the distal third of this skin island has insecure vascularity with an increased risk of partial necrosis. In 1992, Yousif et al. demonstrated in cadaver studies that the skin island of gracilis has a horizontal orientation in vascularity, and presented two cases of reconstruction with the transverse gracilis musculocutaneous flap, one post mastectomy and one heel defect [9]. This information enabled the development and use of more viable myocutaneous gracilis flaps for microsurgery by the end of the 1990s.

The myocutaneous gracilis flap with a horizontal skin island has two established names in use. These are Transverse Upper Gracilis (TUG) flap by Arnez, who started microvascular breast reconstructions in Ljubljana in 2002 [10] and Transverse Myocutaneous Gracilis (TMG) flap [11] by the Innsbruck team, which started the use of the flap in lower limb reconstructions in 1996 and later popularized the use of the TMG flap in microvascular breast reconstructions in the 2000s [12–14].

Pedicled flaps from the lower abdomen or a microvascular latissimus dorsi flap were long considered superior in the reconstruction of the pelvic floor and the vagina [15–18]. The skin island of the myocutaneous gracilis flap was regarded as unpredictable and the vertically designed flap could not reach the deeper pelvic defects. After the transversal orientation of the skin island proved to be viable, a myocutaneous

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gracilis flap became a versatile option as it permits a larger arc of motion to the flap and reaches the pelvic floor. In 2007, Kolehmainen initiated the use of the pedicled TMG flap in the reconstructions of the pelvic floor and the vagina in Helsinki [19, 20].

9.2 Anatomy of the Flap

The gracilis muscle is the weakest of the hip adductors and participates in flexion and medial rotation of the hip. It lies medially to a long adductor muscle, originates from the outer surface of the ischiopubic ramus in the pubic bone, and attaches to the medial condyle of the tibia.

The transversal skin island for the musculocutaneous flap (TMG or TUG) lies proximally in the thigh. Its upper border follows the inguinal-infragluteal crease, from the crossing with femoral vessels anteriorly to the lateral point of gluteal fold (25–30 cm in width) posteriorly. The crescent-shaped skin island has its maximum height on the top of the gracilis muscle (8–12 cm). A reliable vertical skin island of a myocutaneous gracilis of 10 × 15 cm can be harvested from the proximal half of the thigh.

The muscle is innervated by the obturator nerve (L2–L4) from the lumbosacral plexus. According to our clinical phalloplasty experience, the obturator nerve also brings sensation to the muscle, as our patients report sensation of pain in their thighs during bed side wound revisions in the early postoperative days and a deep sensation in the neophallus later on.

A small cutaneous branch from the anterior obturator nerve gives sensation to the skin above the gracilis muscle, while most of the upper medial thigh is innervated by the anterior medial cutaneous nerve (L2–L3). The posterior region of a transverse skin island is innervated by the posterior femoral cutaneous nerve (S1–3).

The circulation pattern is Mathes Nahai type II [21]. The main pedicle (length 6–8 cm), ascending branch of medial circumflex femoral artery, and venae comitantes, have its entry point to the muscle in the junction of the proximal and middle thirds of the thigh. The secondary pedicle from the superficial femoral artery and vein enters the muscle in the distal third of the muscle.

The cutaneous blood supply to the horizontal skin island comes via a perforator in the proximal gracilis muscle. However, the same skin island is vascularized also directly from the medial circumflex femoral vessels, profunda perforators, and inferior gluteal vessels. Therefore, the exactly same skin island can also be harvested on the pedicles of the Inferior Gluteal Artery Perforator (I-GAP) Flap or the Profunda Arterial Perforator (PAP) Flap. This is an important consideration if the gracilis pedicle has a small diameter [13, 22–24].

9.3 Flap Elevation

9.3.1 Gracilis Muscle

9.3.1.1 Preoperative Markings (Fig. 9.1)

The gracilis muscle lies behind the long adductor muscle. Its tendon is the most prominent and palpable structure of the medial proximal thigh, when the lower limb is abducted and flexed to a frog-like position. Thus, a vertical line for incision is drawn 3–5 cm behind the adductor longus tendon, starting approximately 6–8 cm from the origin of the muscle, continuing inferiorly.

Fig. 9.1 Donor site of the gracilis muscle flap

9.3.1.2 Position

The flap can be elevated while the patient is either in the supine or lithotomy position. The lithotomy position is more ergonomic for the surgeon and allows a multi-team approach, if laparotomy is performed simultaneously.

9.3.1.3 Operation

The skin is incised according to the preoperative markings, vertically behind the adductor longus muscle. An approximately 10–12 cm long incision, centered on the edge of the proximal and middle third of the muscle is made. The gracilis muscle then is bluntly dissected free from surrounding structures. The secondary vascular pedicle to the superficial femoral vessels in the distal third of the muscle is clipped, if possible. Tendinous insertion of the muscle is divided with scissors under a palpation control. Care must be taken not to cut bluntly more tissue than the tendon, as the saphenous vein and nerve run across the insertion in a more superficial layer. Saphenous nerve injury can lead to permanent numbness of the upper medial calf. An additional, shorter incision is sometimes useful for easier access to the tendon.

The side branches of the medial circumflex femoral vessels are clipped until the main trunks of the deep femoral vessels. Careful dissection of the pedicle is important, and the sensory cutaneous branch of the anterior obturator nerve crossing over it should be saved whenever possible. The motor branch of the obturatory nerve to the gracilis muscle is either cut sharply and allowed to retract inside a muscle or mobilized and left intact for functional reconstruction. The proximal attachment of the gracilis muscle in the pubic bone is usually preserved.

A tunnel of two to three finger breadths is created on the suprafascial plane, below scrotal or labial fat. The flap is pulled through to perineum. A meticulous hemostasis is performed. We often prefer to leave a suction drain to the donor site with a distal outflow channel. The donor site wound is closed in two layers.

9.3.1.4 Postoperative Treatment

We recommend avoiding outer rotation and strong abduction (>30°) of the thigh and extreme flexion (>90°) of the hip and the knee within the first few days. We also recommend avoiding sitting with full weight for 2 weeks or until the superficial wounds have healed.

9.3.2 Myocutaneous Gracilis Flap (TMG, i.e., Transverse Myocutaneous Gracilis Flap or TUG, i.e., Transverse Upper Gracilis)

9.3.2.1 Preoperative Markings (Fig. 9.2)

The TMG flap is harvested from the superomedial aspect of the thigh. The size of the skin flap varies between 8–12 and 25–30 cm. Pinch grip reveals the available amount of skin and subcutaneous tissue, i.e., the width and thus the lower border of the flap.

The superior edge of the skin island is marked with a line along the inguinal and the infragluteal fold. The anterior tip is drawn medial to the femoral vessels and the posterior tip to the point where infragluteal fold ends laterally. Although the skin island lateral from this point is viable and can be included if a bigger flap is needed, the scar will be more visible.

The gracilis muscle lies behind the long adductor muscle. Its tendon is the most prominent and

Fig. 9.2 Donor site of the myocutaneous gracilis flap

palpable structure of the proximal thigh when the lower limb is abducted and flexed to a frog-like position. Thus, a vertical line to mark the gracilis muscle is drawn 3–5 cm behind the adductor longus tendon. The broadest part of the skin island should be centered on the top of the muscle. A posterior skin island with strong vascularity can be drawn almost as broad with just the tip rounded. A skin island situated anteriorly from the muscle is outlined as a small triangle, because it has only a small volume and thin skin. There is also a potential risk of damaging lymphatic vessels if large mobilization of the tissue is performed in that direction. To avoid harming the lymphatic drainage of the extremity, we especially recommend against extending the anterior tip of the flap on the lateral side of the femoral vessels.

9.3.2.2 Position

The flap can be elevated while the patient is in the supine or lithotomy position. The lithotomy position is more ergonomic for the surgeon and allows a multiteam approach if laparotomy is performed simultaneously.

9.3.2.3 Operation (Figs. 9.3 and 9.4a, b)

The dissection begins suprafascially from the anterior tip of the skin island until the adductor longus tendon. There, the fascia is incised vertically along the tendon, to protect the gracilis pedicle and the obturator nerve. Connection between the gracilis muscle and the skin island must stay intact. Temporary fixation sutures between the skin edge and the gracilis muscle help to avoid distension of the perforator vessels during the flap harvest and inset. The posterior part of the skin island behind the gracilis muscle can be harvested suprafascially, leaving most branches of posterior femoral cutaneous nerve intact. This is especially important in the lateral half of the skin island in the posterior thigh. However, we recommend to include the posterior fascia into the flap if the patient has significant comorbidities (e.g., atherosclerosis or pulmonary disease) and in cases where the skin island is planned to cover superficial defects. Sutures in the fascia may relieve tension from the skin and thus enhance circulation of the flap.

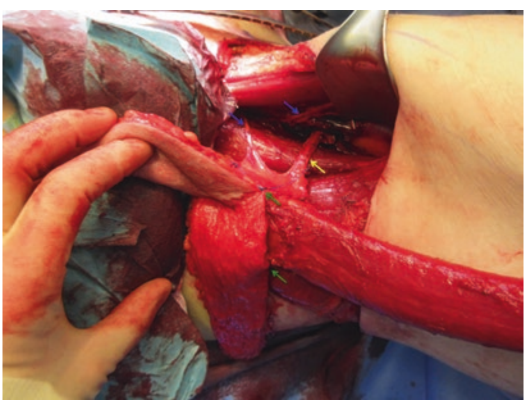

Fig. 9.3 Myocutaneous gracilis flap harvested on its pedicle and nerve. The origin of the muscle is intact; skin island is partly de-epithelialized. Arrows: main pedicle of the gracilis flap (yellow), branches of the obturator nerve (blue), fixation sutures between the skin island and the muscle (green)

After dissection of the skin island, the subcutaneous fascia of the thigh is opened with long scissors vertically over the length of the gracilis muscle. This releases space for additional blunt dissection and makes the donor site closure easier. The gracilis muscle, distally from the main pedicle, is released under the skin from surrounding structures. The secondary vascular pedicle to the superficial femoral vessels in the distal third of the muscle is clipped if possible. Tendinous insertion of the muscle is divided with scissors under palpation control. Care must be taken not to cut bluntly more tissue than the tendon, as the saphenous vein and the nerve run across the insertion in a more superficial layer. Saphenous nerve injury can lead to permanent numbness of the upper medial calf.

The side branches of the medial circumflex femoral vessels are clipped until the main trunks of the deep femoral vessels. Careful dissection of the pedicle is important, and the sensory cutaneous branch of the anterior obturator nerve crossing over it should be saved whenever possible. The motor branch of the obturatory nerve to the gracilis muscle is either cut sharply and allowed to retract inside a muscle or mobilized and left intact for functional reconstruction. The proximal attachment of the gracilis muscle in the pubic bone is usually preserved.

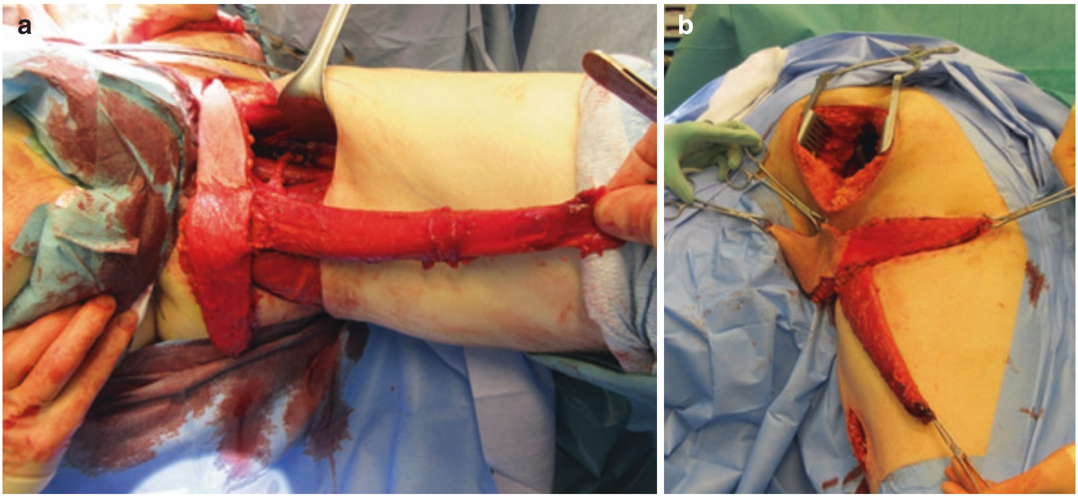

Fig. 9.4 Myocutaneous gracilis flap anteromedial (**a**) and posterior view (**b**)

A tunnel of two to three finger breadths is created on the suprafascial plane, below scrotal or labial fat. The flap is pulled through to perineum. A meticulous hemostasis is performed. We often prefer to leave a suction drain to the donor site with a distal outflow channel. The donor site wound is closed in two layers.

9.3.2.4 Postoperative Treatment

We recommend avoiding outer rotation and strong abduction (>30°) of the thigh and extreme flexion (>90°) of the hip and the knee within the first few days. We also recommend avoiding sitting with full weight for 2 weeks or until the superficial wounds have healed.

9.4 Indications and Techniques in Reconstructions (Fig. 9.5)

9.4.1 Filling of a Cavity and Coverage of Contaminated Wounds or Large Perineal Defects

One gracilis muscle flap is often adequate, as it is able to expand and fill even a large pelvic cavity after tumor excision or necrotizing infection. Closure of the dead space resists infection, as richly vascularized tissue tolerates the contaminated environment well.

The gracilis muscle can cover a superficial area (approximately 7 × 20 cm in size), especially if the muscle fascia is scored, which allows spreading of the muscle as a lining for a skin graft. A myocutaneous flap is an option in large superficial defects, where it is beneficial to position the skin island to a weight-bearing area, for example the ischial tubercle.

9.4.2 Fistula Corrections (Fig. 9.6a–d)

As a narrow and flat muscle, gracilis has an optimal shape in fistula corrections. However, some higher fistulas at the level of bladder, uterus, and proximal rectum are outside its range of motion. Preoperative radiography or MRI, perioperative palpation, and use of blue dye or hydrogen peroxide usually reveal the location of the fistula. After careful debridement, the injured tissues are anatomically separated from each other and both the mucous lining and the wall of the injured structure (bladder, urethra, bowel, or vagina) are closed with sutures. The gracilis muscle is pulled through to midline and fixed carefully to protect the sutured defect and spread to separate the anatomical layers from each other.

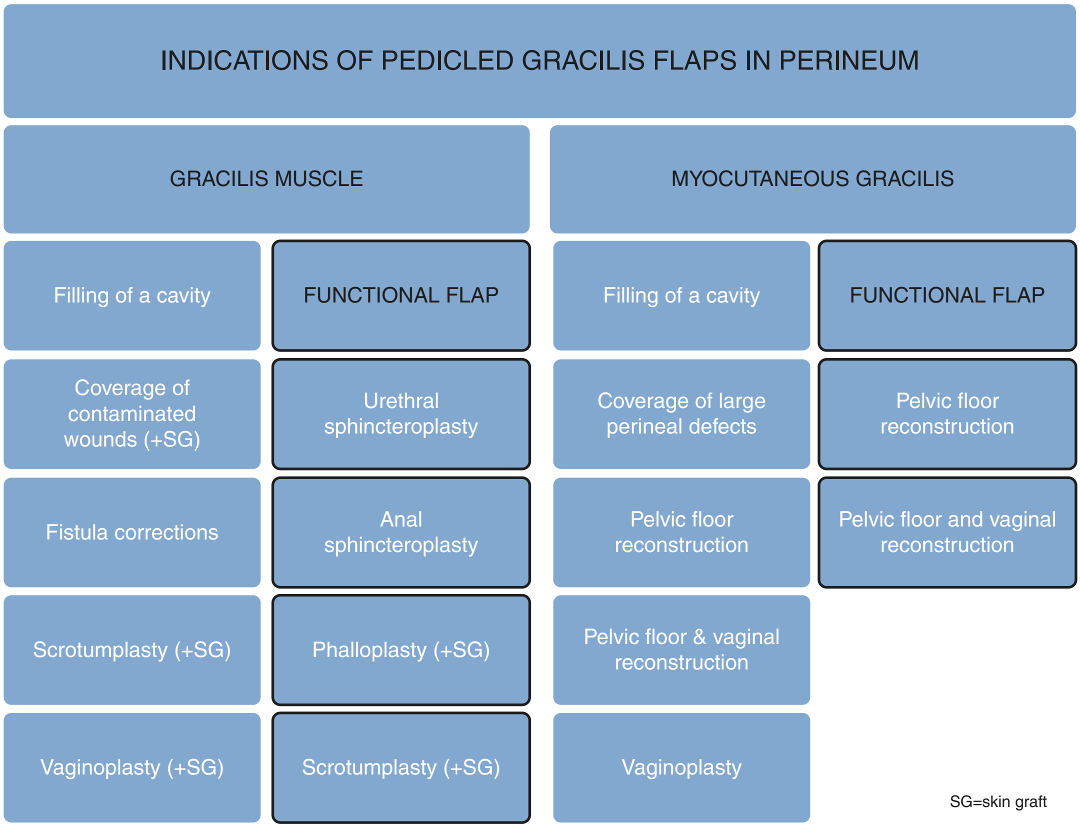

Fig. 9.5 Indications of pedicled gracilis flaps in perineum

9.4.3 Reconstructions of Urethral and Anal Sphincters

A functional gracilis muscle flap has been used in urethral and anal sphincter corrections. Several authors have described promising results in restoration of sphincter function by wrapping a functional gracilis flap, either a pedicled or a microvascular flap, around either a urethral or a rectal sphincter. Electrical stimulation by a programmable pulse generator has been used to reinforce the tone of the muscle [25, 26]. Thus far, both postoperative wound healing problems and relatively modest functional results have limited the use of these techniques to carefully selected patients. This treatment method may have a larger role in the future.

9.4.4 Scrotoplasty (Fig. 9.7a–c)

The most common etiology for a major tissue loss of the scrotum is gangrenous infection. Reconstruction with a flap is necessary if over half of the scrotum is lost. Although myocutaneous flaps bring buffering fat tissue to shelter testicles, these flaps may be too bulky and heal slowly if the patient is obese or has comorbidities. Necrotizing infection and debridement can injure the circulation to the skin flaps. Reconstruction with a gracilis muscle flap heals well even in compromised patients. Many authors propose reconstruction with a bilateral gracilis muscle. However, a unilateral gracilis muscle flap is sufficiently large for the reconstruction, as it is possible to spread wider by performing excision or scoring the muscle fascia.

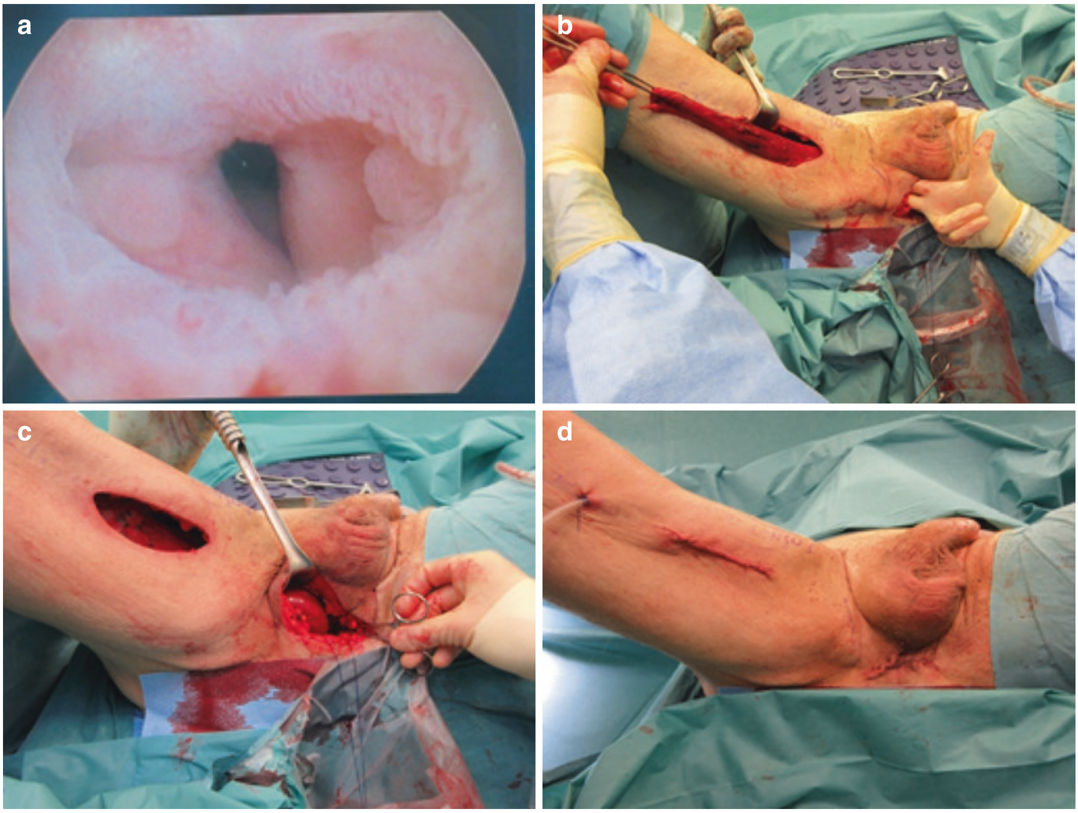

Fig. 9.6 (**a**) Urethrorectal fistula: endoscopic view from urethra. (**b**) Reconstruction with a gracilis muscle flap: before subcutaneous tunneling of the flap. (**c**) Gracilis muscle pulled to the recipient site; fixation sutures for the flap have been inserted around the defect prior to the flap mobilization. (**d**) After the closure

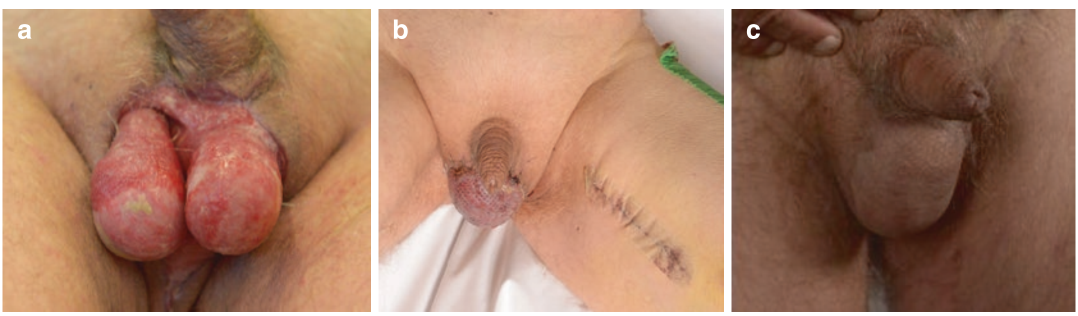

Fig. 9.7 Missing scrotum after necrosis due to Fournier's gangrene. (**a**) After debridement. (**b**) After reconstruction with the left gracilis muscle and a split skin graft. (**c**) Six months postoperatively

The gracilis muscle is mobilized from a vertical incision and leaves the pedicle, origin, and optionally also the motor nerve intact. The muscle is pulled through to midline. The insertion of the muscle is fixed to the contralateral pubic periosteum, fasciectomy of the muscle is performed, and the muscle is spread on the top of the testicles and fixed to the wound edges. The obturator nerve branch can be left intact if function is needed. The muscle is covered with skin graft. A vacuum device secures tight bandaging and may promote graft take.

9.4.5 Pelvic Floor Reconstruction

The TMG flap is elevated, if possible, simultaneously with laparotomy. Only the muscle origin, medial circumflex femoris pedicle, and obturator nerve are left intact; everything else is mobilized. The flap is left hidden to the donor site and the wound is closed permanently from the anterior and posterior tips and temporarily in the middle region. The wound is covered temporarily, for example with a membrane to prevent contamination during the perineal excision of the tumor.

New scrubbing and sterile sheets are placed after excision and possible turning of the patient to the jack-knife position. Sutures are placed around the defect using the parachute technique to the remnants of the levator muscles, the edges of the resected vagina, the coccyx, and the pubic periosteum, at an approximate 1-cm distance to each other (Parachute technique: Figs. 9.8a, b and 9.9a, b). The flap is exposed and tunneled on the suprafascial plane to the midline wound.

The threads are tied only after all of them are positioned first, as eye contact with the defect is lost after the first suture is finished. In difficult circumstances, it is advisable to fix some hold sutures from laparotomy access, as they aid in positioning the remaining sutures.

The defect of the pelvic floor is closed with the dermis from the posterolateral tip of the myocutaneous gracilis flap. De-epithelialized dermis is facing toward the abdominal cavity. The ipsilateral (cranial) edge of the dermis is sutured first. The posterolateral tip of the skin island is fixed to the coccyx and the contralateral edge of the defect is fixed to the caudal edge of the flap dermis.

Tying of the sutures proceeds from the ipsilateral edge to the inferior (either coccyx or symphysis, depending on the position of the patient), the contralateral, and finally to the superior edge of the defect (either symphysis or coccyx) (Fig. 9.10). After the pelvic floor defect is closed, the middle region of the skin island is used as a lining for the posterior (and lateral) walls of the vagina if needed (Fig. 9.11a, b). If the patient has been turned to the jack-knife position, the reconstruction of the posterior vaginal wall is performed before patching of the levator defect (sutures between the skin island and vaginal mucosa first, then sutures between the dermis and the vaginal wall).

The remaining subcutaneous flap is de-epithelialized and left to fill the cavity. The anterior tip of the skin island can be used for perineal skin defects. Below the reconstructed pelvic floor, the gracilis muscle is fixed to the lateral walls of the pelvis, thus supporting the dermal and subcutaneous parts of the flap, and filling the cavity. The obturator nerve can be left intact to create a functional pelvic floor reconstruction. The origin of the muscle is usually left intact, as its division does not increase the mobility of the flap. In atherosclerotic patients, collateral circulation via the origo might have a role in the vascularization of the flap.

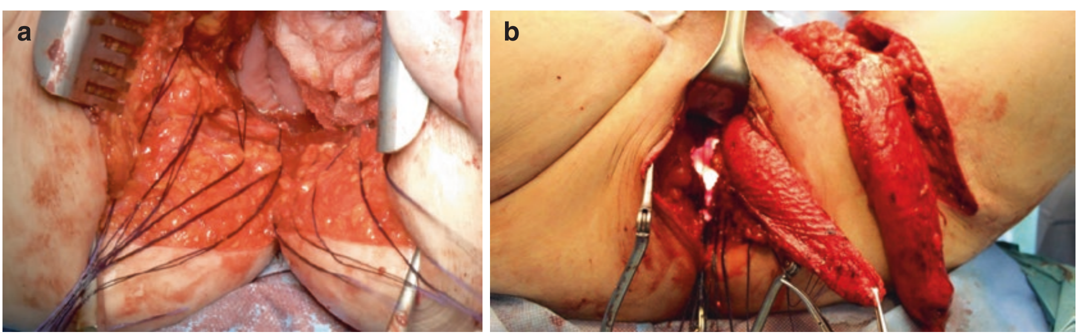

Fig. 9.8 Patient in gynecological/lithotomy position. Parachute technique secures tight closure of the defect in the pelvic floor. Sutures are first inserted around the defect (**a**) and then to the ipsilateral edge of the flap (**b**)

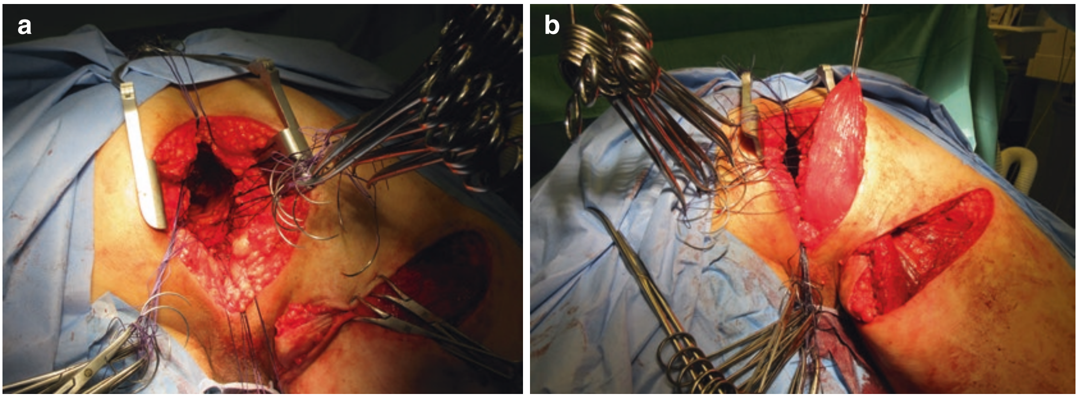

Fig. 9.9 Patient in prone/jack-knife position. Parachute technique secures tight closure of the defect in the pelvic floor. Sutures are first inserted around the defect (**a**) and then to the ipsilateral edge of the flap (**b**)

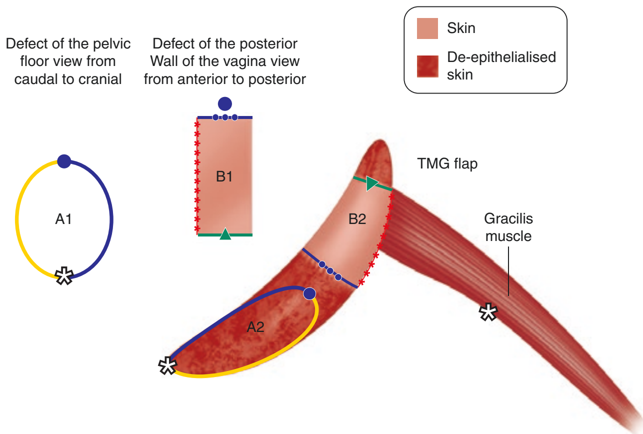

Fig. 9.10 Schematic drawing of the left TMG flap and its positioning to cover the defects of the pelvic floor (**A1**), view from caudal to cranial and the posterior vaginal wall (**B1**), view from anterior to posterior. Orientation points: Coccyx (white star), Symphysis (blue ball), Introitus (green triangle). (**A1**) Defect of the pelvic floor. (**A2**) De-epithelized skin island of the flap for the reconstruction of the pelvic floor. Blue line: Posterocranial edge of the flap is sutured to the ipsilateral side of the defect. Yellow line: Posterocaudal edge of the flap is sutured to the contralateral side of the defect. (**B1**) Defect of the posterior vaginal wall. (**B2**) Skin island of the flap for the reconstruction of the posterior vagina. Blue line with dots: Middle part of the flap is sutured to the proximal part of the vaginal defect. Green line: anterior part of the flap is sutured to the distal part of the vaginal defect

One myocutaneous flap is usually sufficient for coverage of the pelvic floor. In very large defects, the flap can be combined with a contralateral myocutaneous flap, a muscle flap, or a skin flap, depending on the location of the additional defect.

9.4.6 Vaginoplasty

One TMG flap is usually adequate to cover the defects of both the pelvic floor and vagina, if less than three quarters of its circumference has been resected. In larger or total vaginal resections, an

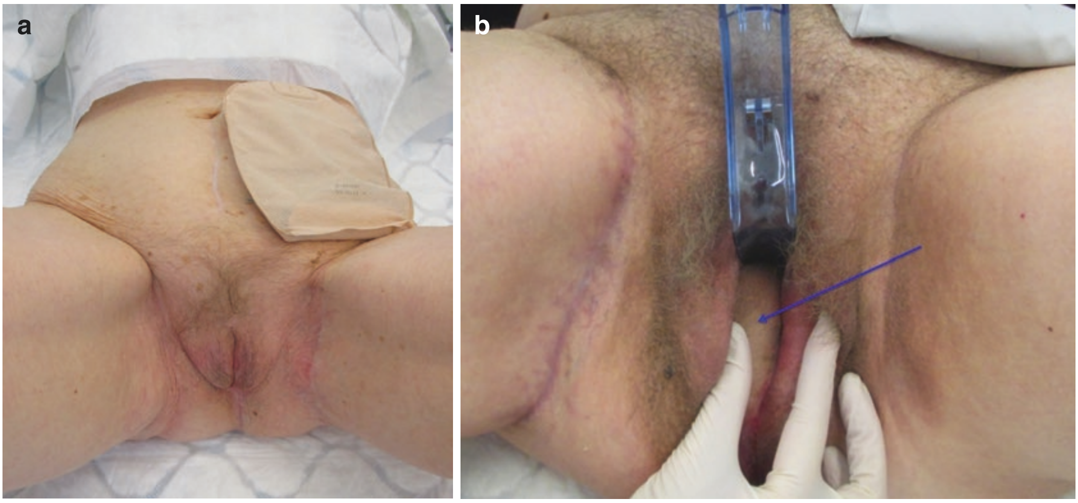

Fig. 9.11 Three months after total mesorectal excision and reconstruction of the pelvic floor and posterior vagina with a transverse myocutaneous gracilis flap (**a**). Arrow indicates the skin island of the TMG flap in the posterior vagina (**b**)

additional flap, usually Singapore or contralateral gluteal fold flap or sometimes even the contralateral myocutaneous gracilis flap, can be harvested for the reconstruction [27–29]. Bilateral TMG is, however, very bulky. The anterior wall of the vagina should be thinner than TMG and sensate if possible. Therefore, it is often advisable to reconstruct only the lateral and posterior walls of the vagina with a TMG flap and the anterior defect with a thinner local sensate skin flap (e.g., Singapore flap). If skin flaps are not an option, contralateral gracilis muscle with a skin graft may yield a more functional result.

9.4.7 Phalloplasty (Fig. 9.12a, b)

Local flaps were used in phalloplasties until the era of microsurgery, when the radial forearm flap became the most popular option for penile reconstructions [30]. Orticochaea (1972) described a case report using a myocutaneous gracilis flap for penis reconstruction [5]. Inspired by the work of Vesely on the innervated myocutaneous latissimus flap for phalloplasty, Kolehmainen and Suominen have developed a phalloplasty technique using bilateral, functional motor innervated gracilis flaps in combination with a pedicled extended groin flap/superficial circumflex iliac perforator (SCIP) flap [31, 32]. Since 2010, we have used the functional bilateral gracilis phalloplasty mainly in gender confirming surgery, but this technique is also versatile after penis amputation.

The neourethra is created with a pedicled SCIP flap or an extended groin flap. The skin flap is tubularized and sutured, end to end, to the remaining proximal urethra. In female-to-male patients, the urethra is first lengthened with the skin from labia minora, then the tubularized skin flap is sutured to it at the level of the clitoral tip.

Functional gracilis muscles are mobilized bilaterally via incisions in the inguinal crease and extend if necessary until the midline of the infragluteal crease (same as the superior incision in the skin island of a TMG flap). If the thigh is very long, an additional 2–5 cm vertical incision at the lower third of the thigh can be helpful in the division of the tendinous insertion. The functional gracilis muscle flaps are brought to the midline, wrapped around the neourethra, and fixed to each other with sutures. The neopenis is finally covered with split thickness skin grafts. In female-to-male patients, clitoral foreskin or labial skin can also be used.

The postoperative period requires meticulous wound care, but the final color match of the foreskin and skin graft can provide an acceptably

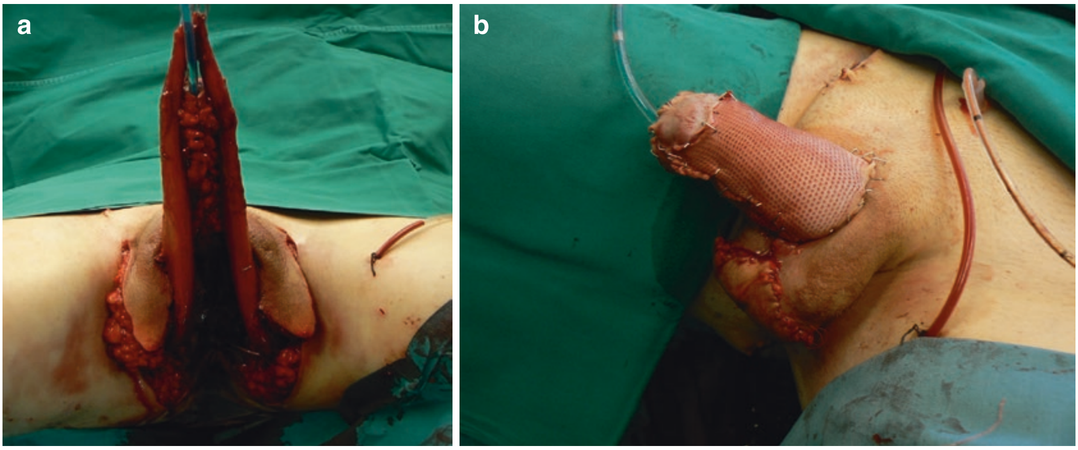

Fig. 9.12 Functional gracilis phalloplasty. (**a**) Bilateral functional gracilis flaps are wrapped around the neourethra (groin/SCIP flap) and sutured together in the midline; proximal parts augment the neoscrotum. (**b**) Neophallos and neoscrotum. Gracilis muscle flaps are covered with a split skin graft. Glans is created from the tip of the flaps

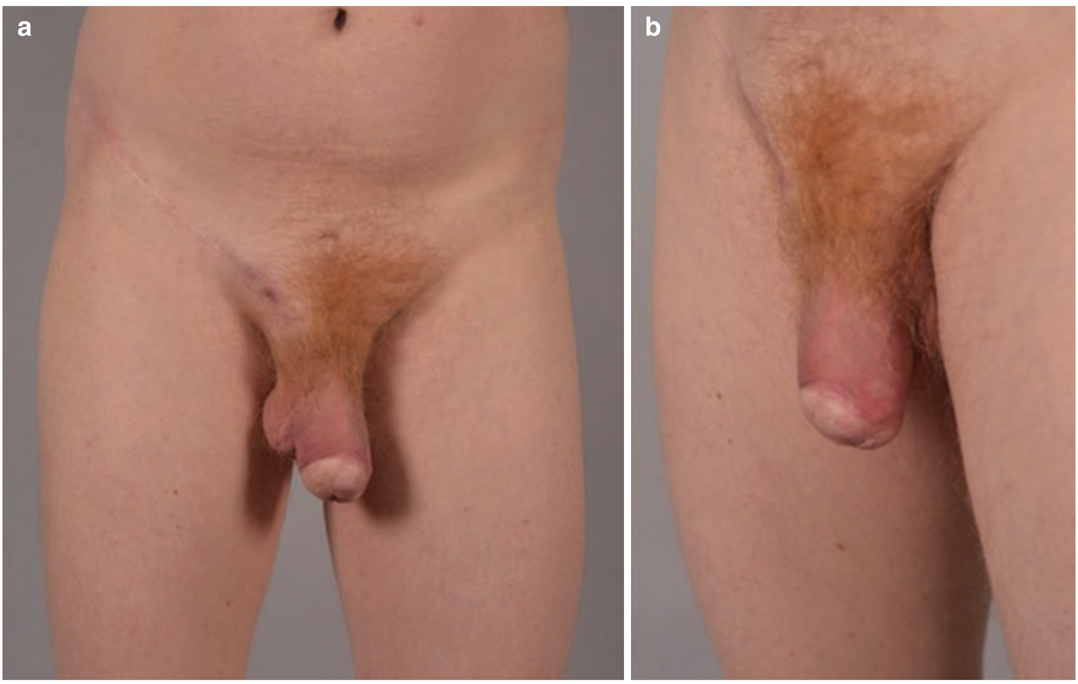

Fig. 9.13 Two years after phalloplasty with bilateral gracilis flaps and a groin/SCIP flap. (**a**) Front view. (**b**) Side view

natural result. The main benefit of this technique is both the motor and the sensory innervation. The neopenis has sensitivity immediately after the operation, and the gracilis muscles can be contracted voluntarily to provide a "paradoxal erection". This provides enough stiffness for many patients to be able to perform intercourse without an erection implant. The final length of the neopenis is in relation to the length of the patient's thigh (Fig. 9.13a, b and Video 9.1).

9.5 Benefits of Gracilis Flaps

A myocutaneous gracilis flap has all the necessary components for perineal reconstruction. These include skin to cover superficial defects, muscle to fill a cavity or to confer function, subcutaneous fat with buffering properties, autologous dermis to patch the pelvic floor, and well-vascularized tissue outside of the radiation field for oncologic reconstructions.

Immediate reconstruction is necessary after pelvic exenteration. In particular, vaginal reconstruction may prove impossible in a delayed operation. Large pelvic operations and their postoperative observation occur usually in a colorectal, urological, or gynecological unit, often remote from the reconstructive unit. This favors the use of pedicled gracilis flaps as a simple and safe reconstruction method with minimal need for postoperative observation.

Large resections last for several hours. Adopting a multi-team approach reduces the total duration of the operation. The patient is usually positioned in the lithotomy (i.e., gynecological) position and laparotomy or laparoscopy is performed. Simultaneous flap harvest is possible if the medial thigh is used as the donor site; even a bilateral flap harvest can be easily performed. Another benefit is that abdominal wall, with possible ostomies, is not further compromised due to the flap donor site in the thigh. The gracilis donor site is available even if the patient is turned to the jack-knife position during the operation. Additional risks related to microsurgery are eliminated when using a pedicled flap.

9.6 Drawbacks and Problems with Gracilis Flaps and Their Donor Sites

The short pedicle of the gracilis flap may prevent the muscle from properly reaching over a large defect of the pelvic floor, but the transverse skin island of a myocutaneous flap reaches well. However, the flap positioning due to the short pedicle is somewhat challenging at the beginning; there is thus a learning curve for this technique.

Postoperative edema or tension of either the skin island or the pedicle risks the viability of the flap. It is therefore important to avoid outer rotation of the thigh within the first few postoperative days. Careful prevention of decubital ulcers and prophylaxis of thrombosis are also important for the viability of the flap.

In most reconstructions, division of the origin of the muscle is not necessary. Leaving the origin intact may even enhance flap circulation as small collaterals enter the muscle through the origin. If an island flap is not necessary for the reconstruction, leaving the skin bridged is advisable.

In our unpublished patient series, patients with poor oxygenation of the tissues (due to pulmonary deficiencies, such as COPD, pulmonary edema, or metastases) in particular seem to develop wound healing problems both in the reconstruction site and the donor area. There is also a greater risk for a partial or even a total loss of the skin island. Supplementary oxygen and careful treatment of comorbidities is useful in this patient group. For very morbid patients, a muscle flap without a skin island may be a better option.

External pressure and shearing forces are directed to a perineal defect. Gluteal and perineal skin is thick, whereas skin from the anterior tip of the TMG flap is very thin. Accordingly, perineal reconstruction is most safely performed with the posterior or middle part of the skin island. If the flap is planned to resist hard friction, it is advisable to elevate the fascia together with the whole breadth of the skin island.

In perianal defects, a skin flap can restrict the distension of the anus during defecation. This can result in anal stenosis, especially if perianal scars are circular. A gracilis muscle flap covered with a skin graft can produce a more pliable result. In small lesions near the anus, bare muscle without a skin graft will epithelialize secondarily and may provide a reasonable reconstruction.

Cancer patients often gain weight after the reconstruction, which can lead to fat prolapse in the posterior introitus after reconstruction of the vaginal wall. Debulking of the flap or liposuction can be performed under local anesthesia.

Postoperative lymphoedema of the thigh is infrequent if the inguinal lymph nodes are left intact during the elevation of a TMG flap. However, wound healing of the donor site may be compromised by lymphoedema after a simultaneous inguinal lymphadenectomy.

Tension of deep scars in the reconstruction and the donor sites can be prevented by early and active mobilization of the patient. Numbness or cold sensitivity in the posterior thigh can be reduced, by elevating the lateral half of the posterior TMG flap suprafascially, leaving branches of posterior cutaneous femoral nerve intact. Numbness of the medial thigh along the gracilis muscle donor site can be avoided by careful dissection of the pedicle, leaving the sensory anterior branch of the obturator nerve intact.

Positioning of the superior edge of the skin island to the groin and the infragluteal crease and harvesting of a moderate size skin island enable invisible donor sites. This also helps prevent the aesthetically undesirable descending of scars and harmful tension, which would open the vestibule of the vulva and lead to discomfort or pain and repeated urinary tract infections.

9.7 Complications of Gracilis Flaps

9.7.1 Muscle Flap

A pedicled gracilis muscle flap with an intact proximal attachment in the pubic bone has reliable circulation. Flap necrosis is rare, only in a phalloplasty indication, minor necrosis in the distal flap is relatively common. However, in our experience intense exercise of the thigh muscles (e.g., body building) within few weeks prior to the operation might lead to massive postoperative muscle edema and hypoxia leading to a bigger distal flap loss. Therefore, hard work-up of the lower limbs is advisable to be interrupted before the operation.

Hemorrhage from the distal perforators is possible due to blind dissection. Usually, it is recognized and hemosthasis is performed intraoperatively. Postoperative bleeding is exceptional. Seroma formation or wound infection is possible, but luckily rare. Acute postoperative pain is sporadic and usually relieved by drain removal. Chronic pain is exceptional. Tension of the deep scars can be avoided by rapid mobilization.

9.7.2 Myocutaneous Gracilis Flap

A pedicled myocutaneous gracilis flap with an intact proximal attachment in the pubic bone has reliable circulation. Partial or even total necrosis of the skin island is however possible. To our experience, systemic postoperative edema due to cardiac insufficiency or poor pulmonary function increases the risk for partial or complete flap loss of a pedicled flap. In coverage of a superficial perineal defect, viability of the thin skin may be compromised due to excess tension from the surrounding tissues, where the skin is thicker and possibly scarred.

Hemorrhage from the distal perforators is possible due to blind dissection. Usually, it is recognized and hemostasis is performed intraoperatively, via an additional distal incision. Postoperative bleeding from subcutaneous fat seldom leads to a reoperation. Seroma formation may sometimes require aspiration with a needle, but chronic seromas are rare. Lymphedema can develop if inguinal lymph vessels are injured due to too lateral or deep dissection near the femoral vessels. Minor suture fistulas may appear. Wound infection is a risk in smokers or if the preoperative condition of the inguinal skin is compromised for example due to hidradenitis. Acute postoperative pain is sporadic and usually relieved by drain removal; chronic pain is exceptional. Tension of deep scars can be avoided by rapid mobilization.

9.8 Conclusion

The range of gracilis flaps offers a rich variety of reconstructive options to the perineal region from the vicinity. Multiple components for different needs are available. Microsurgery is usually not required. The donor site enables a multi-team approach. Easy access to bilateral donor sites guarantees a relatively quick and safe reconstruction even for the most morbid patients.

Bilateral use of gracilis flaps in perineal reconstructions is common in the literature. However, bilateral flap elevation should be restricted only to cases where two flaps are necessary, as no donor sites of flaps are completely symptomless. In addition, use of bilateral myocutaneous flaps may easily result in bulkiness, especially when the patient gains weight after convalescence from cancer. In our experience, a unilateral myocutaneous gracilis flap is often sufficient to cover most of the reconstructional needs inside the pelvis or in scrotal reconstruction. A new reconstruction may become necessary if the etiological disease recurs, if the reconstruction fails or if a new disease affects the perineal region. Therefore, we recommend economical use of the flaps and respect for the healthy tissues of the patient.

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10 Profunda Artery Perforator Flap for Perineal Reconstruction

Damir Kosutic

10.1 Introduction

Perineal reconstruction following large and mutilating resections for recurrent or advanced gynecological and colorectal malignancies remains a challenging task, despite a number of flaps already in use by reconstructive surgeons. Indeed, a variety of reconstructive techniques have been described for defects in the perineum and pelvis, each having different properties that make them more or less suitable for a given defect. Apart from 3-dimensional anatomical complexity of perineal and pelvic defects following abdominoperineal resection or radical vulvectomies, often combined with bilateral groin dissections limiting the use of tissues from the abdomen, previous surgeries and/or radiotherapy with subsequent extensive scarring presents a real challenge for the reconstructive surgeon. This is true for both decision making and technical execution as to where to harvest sufficient amount of tissue from, while maintaining adequate blood supply in previously radiotherapy/surgery-damaged scarred environment. Recently, the profunda artery perforator (PAP) flap has been described [1] as a reliable donor site in microvascular perforator-based breast reconstruction. This gave us an idea to utilize the same area based on the same blood supply for reconstruction of perineal/pelvic defects, which we performed for the first time in 2014 and published the following year [2]. Since then, technique and its modifications proved successful in both colorectal and particularly gynecological oncological defect reconstructions [3, 4]. Benefits and excellent outcomes of PAP-flap in perineal/pelvic reconstruction have been presented worldwide by the author and became standard in our Department.

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10.2 Surgical Anatomy and Preoperative Planning

Profunda artery gives medial and lateral row perforators, which can be found on posterior upper thigh, below gluteal crease. These vessels have different origin and course. Medial row perforators are direct branches of profunda femoris, supplying and traveling through adductor magnus muscle and emerging in most cases posterior/below gracilis muscle in the upper medial third of the thigh. These vessels are the ones we can use to harvest PAP flap. Occasionally, perforator can travel through semitendinosus or semimembranosus. In contrast, lateral row PAP perforators either belong to first perforating branch of profunda femoris or are continuation of medial circumflex femoral artery. These vessels are too

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lateral from perineum and cannot be used for perineal reconstruction [5] (Fig. 10.1a, b). Anatomical [1] and radiological [6] studies suggest an average of 3 perforators found per thigh with an average caliber of 1.9 mm. The most common perforator and the one we can use for perineal reconstruction is found to be medial in over 85% of cases [6], near adductor magnus, on average 5 cm below inferior gluteal crease and 4 cm off the midline. The second most common perforator is lateral; however, this vessel is too far away from the perineal defects and cannot be used to base pedicled or propeller perforator flaps for perineal reconstruction.

Similar to PAP flap utilized in breast reconstruction, PAP flap for perineal/pelvic reconstruction is based on a medially positioned profunda artery perforator (Fig. 10.2). Indeed, in our own experience, a sizeable medial PAP perforator can be found in majority of patients within 8 cm below the gluteal crease. This is considered to be a safe width of the flap to be able to close the donor site directly, which is important from the wound-healing point of view. In approximately half the patients, perforator has septocutaneous course, in other half course is intramuscular. Location of PAP perforator can be found with Doppler ultrasound only [7], though our preference whenever possible is to utilize CT angiogram (Fig. 10.3) or MR angiogram (Fig. 10.4), which if properly interpreted, will provide a very important information on size and course of the PAP flap feeding vessel. This is crucial for success of surgical technique as PAP perforator courses away from the perineal defect and its position and length may be detrimental in deci-

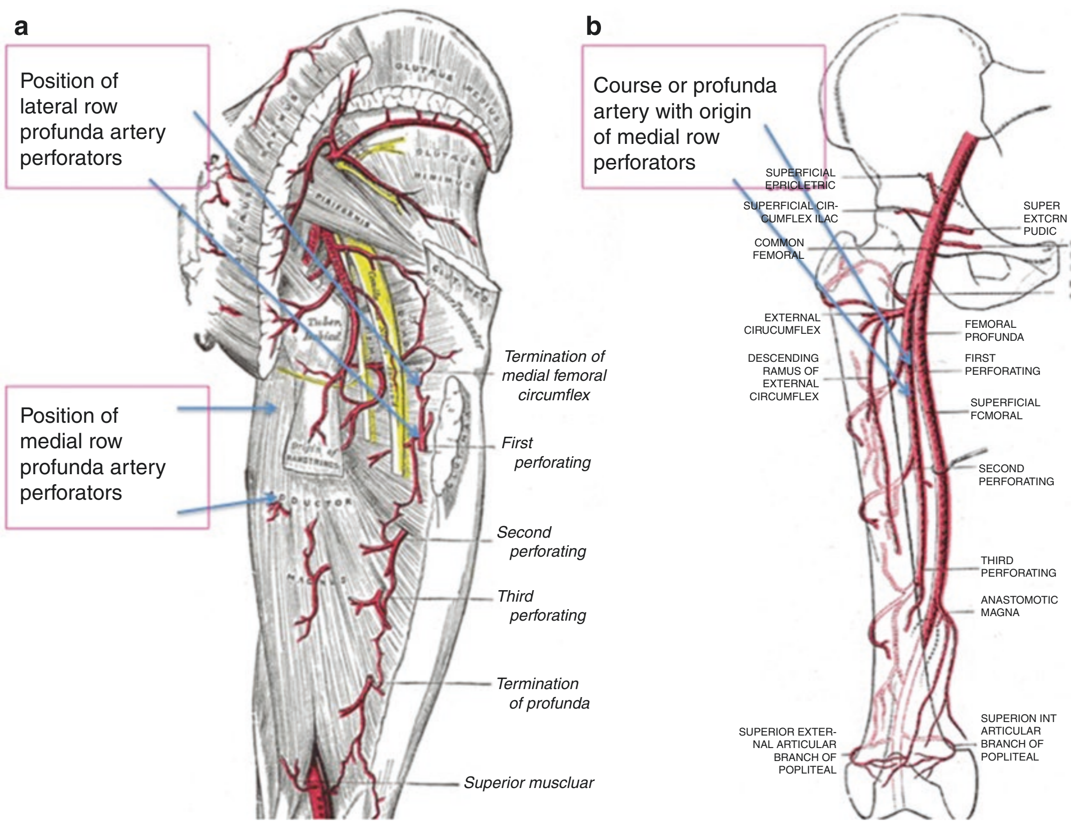


Fig. 10.1 (**a**, **b**) Profunda artery gives medial row perforators, which are direct muscular branches supplying musculus adductor magnus in the medial upper third of the thigh. Vessel usually emerges posterior to gracilis muscle. Lateral row perforators belong to either first perforating artery or medial circumflex femoral artery

sion making whether the flap would reach into lower pelvis to address the 3-dimensional aspect of some defects. Even better imaging can be obtained using MRA scan, though this may not be applicable in all patients due to implanted metalwork or length of the study required.

Fig. 10.2 Profunda artery perforator preoperative markings for perineal reconstruction on a posteromedial thigh aspect with patient in a standing position facing away from the surgeon. Dominant perforator usually found within 8 cm below inferior gluteal fold and several centimeters lateral to the midline

Fig. 10.3 CT angiogram can determine position of best profunda artery perforator and increase reliability of flap harvest as well as reduce complication rates

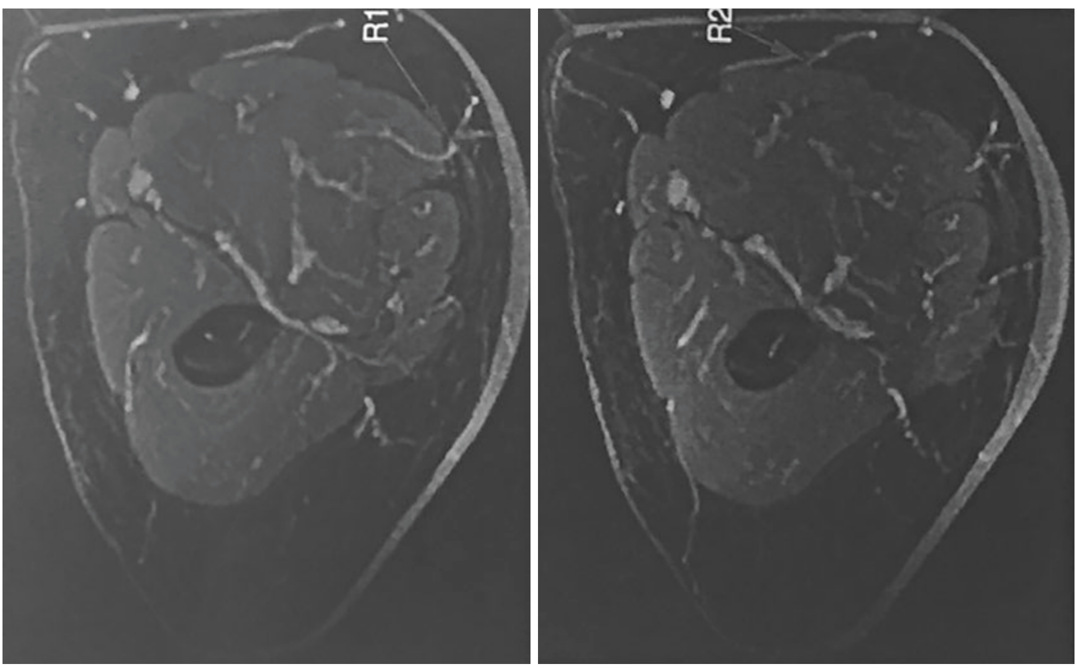


Fig. 10.4 MRA provides greater quality images of PAP course, though may not be applicable in patients with implanted metalwork or those with claustrophobia

10.3 Surgical Technique

Patient is marked in a standing position showing back to the surgeon. The upper border of PAP flap is marked within the gluteal crease, while lower edge of the flap is created by drawing a parallel line to the one within gluteal crease but 6–9 cm below. Width of the flap is best kept at 8 cm to allow primary closure of donor site and avoid wound breakdowns and delayed healing in this area, otherwise very frequent in perineal reconstructions anyway. It is recommended that surgeon uses pinch test to check the maximum width of the flap that would still allow tension-free closure of donor site at the time of preoperative markings (see Video 10.1). If larger surface area requires coverage in a thin patient or part of pelvic defect needs to be filled, bilateral PAP flaps can be utilized with one being completely or partially de-epithelialized. Dominant medial PAP perforator, previously located by CT angiogram or Doppler US, is marked, and flap is designed around it, respecting the above mentioned boundaries. Length of the flap can be extended all the way toward the most lateral point of gluteal crease. This is to avoid "dog ear" on the edge of donor-site scar but even more so to recruit more tissues by designing a longer flap that could better address certain pelvic defects. In most patients, it is desirable to mark bilateral flaps preoperatively (Figs. 10.2 and 10.5), in case unilateral reconstruction is insufficient, depending on the size and depth of perineal/pelvic defect. Preoperative markings are preferential as width and anatomical boundaries (e.g., inferior gluteal crease) would change once patient is fixed in lithotomy position (Fig. 10.5), which is often the case in gynecological and rectal malignancies (Fig. 10.6). Flap harvest can be performed in prone position too, though this is rarely utilized as it would be very difficult to reconstruct gynecological defects in this way. Next, superior incision is performed first, dissecting through skin, fat, and fascia where multiple smaller perforators can be found and divided. Dissection proceeds inferiorly and subfascially until dominant perforator is visualized (Fig. 10.7). Perforator dissection then continues, first along muscle fibers and then intramuscularly (Fig. 10.8). It is important to understand that PAP (profunda artery) perforator usually courses away laterally from the defect, which sometimes can reduce the useful range of motion of the flap in case propeller type of

Fig. 10.5 It is desirable to mark bilateral flaps preoperatively in case unilateral reconstruction is insufficient, depending on the size and depth of perineal/pelvic defect

Fig. 10.6 Preoperative markings are preferential, as width of the flap/s would change once patient is fixed in lithotomy position—usually required for colorectal and gynecological malignancies

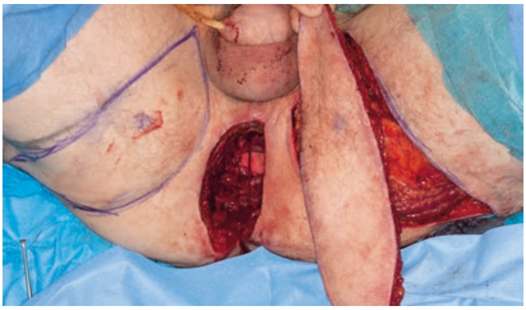


Fig. 10.7 Subfascial PAP flap dissection until dominant perforator is visualized

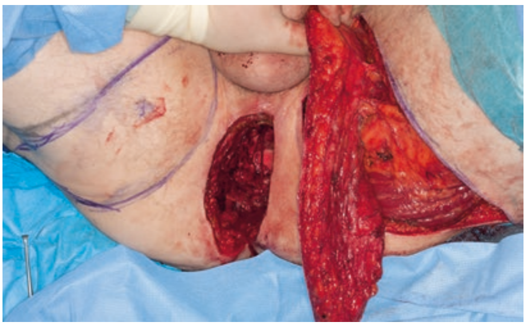


Fig. 10.8 Flap completely raised on a profunda artery perforator. Perforator dissected first along muscle fibers and then intramuscularly until desired flap movement achieved to allow defect coverage

reconstruction was planned (Fig. 10.9). In these situations, it may be useful to combine the PAP flap on one side with a different type of flap on the opposite side (V–Y, pudendal artery perforator, IGAP) or perform bilateral reconstruction (Figs. 10.10, 10.11 and 10.12). In thinner patients, when third dimension of the pelvic defect needs to be addressed and single PAP flap can only resurface perineum, gracilis muscle pedicled flap could be used in addition with minimal morbidity (Fig. 10.13). If desired range of motion required for reconstruction cannot be achieved utilizing propeller technique or flap advancement, perforator PAP flap can be converted to a pedicled PAP flap (Fig. 10.14), by dissecting entire length of the perforator up to and beyond the origin-vessel, profunda artery.

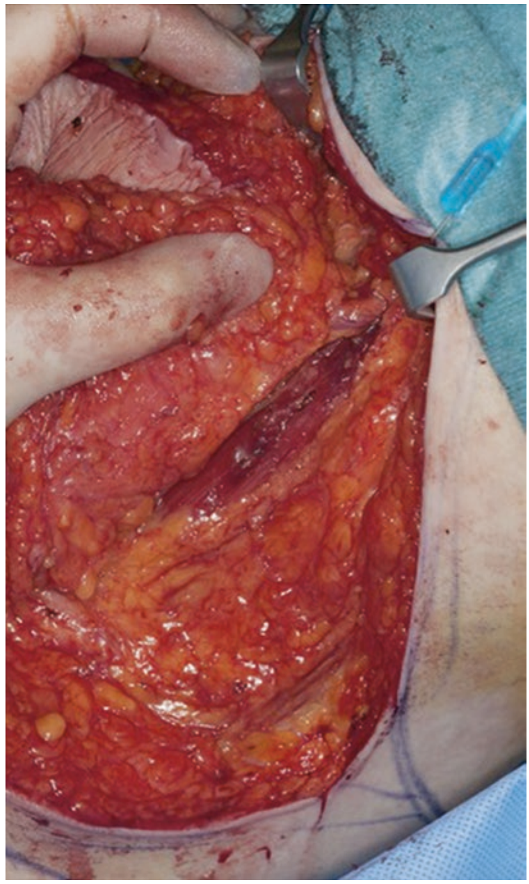
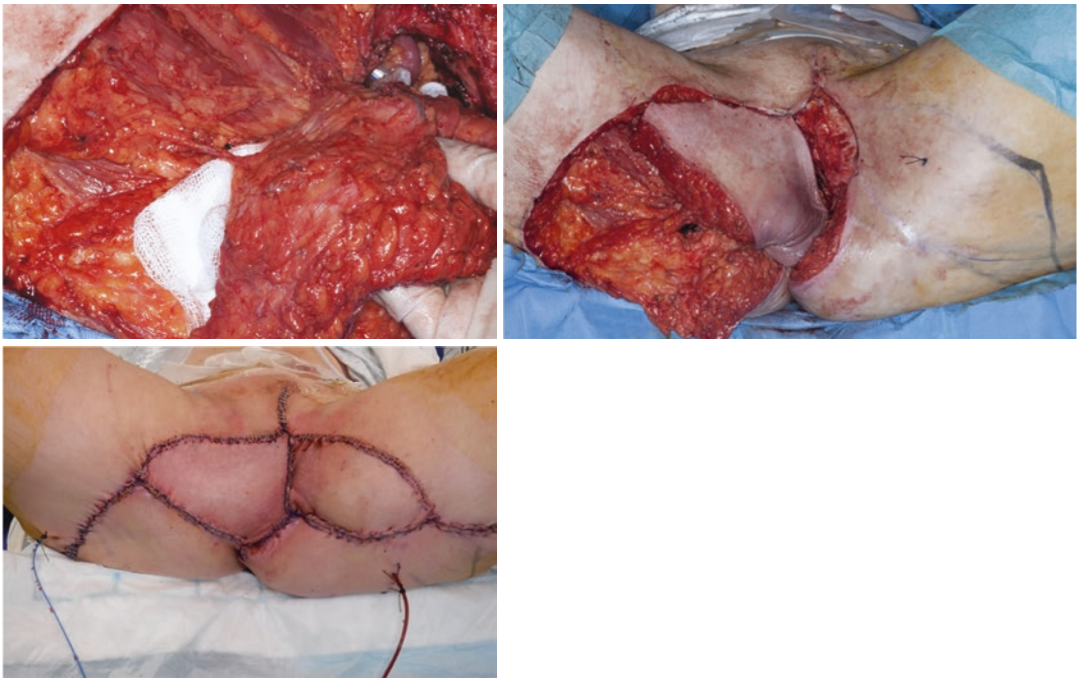


Fig. 10.9 PAP (profunda artery perforator) usually courses away laterally from the defect, which can reduce useful range of motion of the flap

Inferior incision is made once most of the perforator dissection is completed, to avoid the flap "hanging" on a perforator with patient in lithotomy position. At that stage, it is important to partially fix the flap temporarily (sutures or staples) or have an assistant to hold it until adequate release is completed to allow reconstruction of the perineal/pelvic defect without tension (Fig. 10.15). In unilateral reconstructions flap can be partially de-epithelialized at the distal 1/3 or half and this area fixed into pelvis with interrupted resorbable sutures (usually 2-0 PDS or 2-0 vicryl). This will hold the distal end of the flap in position and address pelvic



Figs. 10.10, 10.11 and 10.12 Bilateral PAP flaps used for resurfacing large perineal defect following resection of advanced gynecological malignancy involving bladder, which had to be removed. One PAP flap partially de-epithelialized and pushed into pelvis where it was anchored to periosteum. Flaps moved in a V–Y fashion. Note significant distance right PAP flap was moved from, based on intramuscular dissection of the single dominant perforator

defect. In cases where one sizeable flap or bilateral flaps are harvested, sufficient amount of soft tissue can be fixed with sutures onto pelvic walls which can prevent herniation of abdominal contents in case colorectal surgeons were unable to cover the pelvic opening with omentum or uterus (in selected cases). Flap is then sutured from inside out in 3 layers, including fascia with fat, dermis, and epidermis. Our preference is to use staples with skin glue (fibrin sealant) in between as they cause less local skin ischemia, less infections, and reactions to suture material (Fig. 10.16). Indeed, perineal area is notoriously difficult to maintain any dressing, so this technique in our hands has proven beneficial for wound care in perineal patients over the years. In case of bilateral PAP flaps or combination of PAP flap and a different flap, same principles of fixing the flap and suturing from inside out in layers apply; however, it is necessary to suture flaps together as well. When one partially de-epithelialized flap needs to be connected onto another, one should use stronger silk sutures rather than staples for the outermost layer, to better accommodate a small step between flaps. One or two suction drains (bilateral cases) are inserted in such a way that exit point is lateral and inferior to most lateral aspect of either flap, which is in most cases in posterolateral thigh/gluteal area.

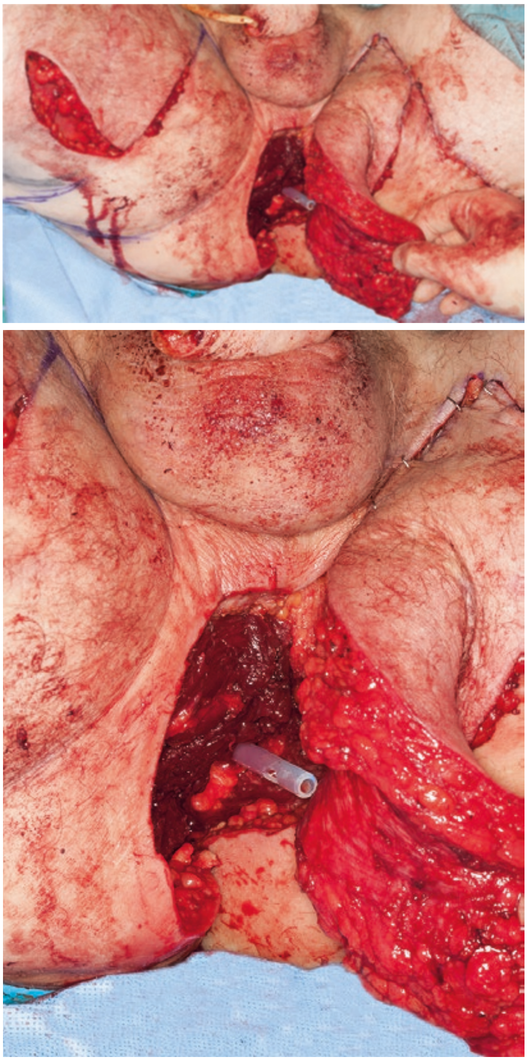


Fig. 10.13 Combination of unilateral PAP flap to resurface perineal skin defect and contralateral muscle-only gracilis flap to address a third dimension—pelvic defect in a thin patient after total pelvic clearance for recurrent advanced colorectal malignancy post-previous surgeries and RT (radiotherapy)

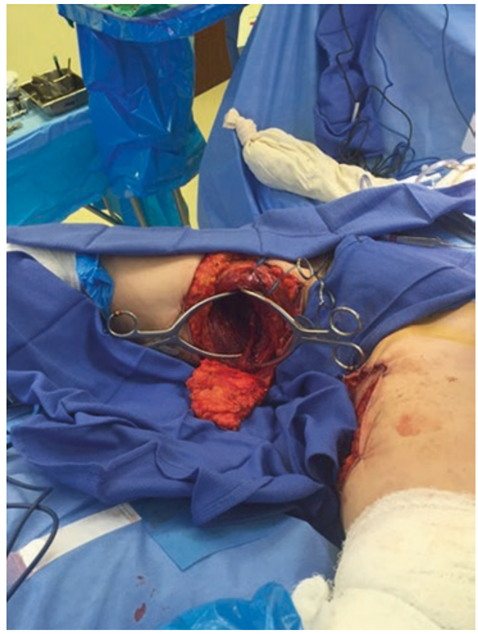


Fig. 10.14 If desired range of motion required for reconstruction cannot be achieved utilizing propeller technique or flap advancement, perforator PAP flap can be converted to a pedicled PAP flap, by dissecting entire length of the perforator up to and beyond the origin-vessel, profunda artery

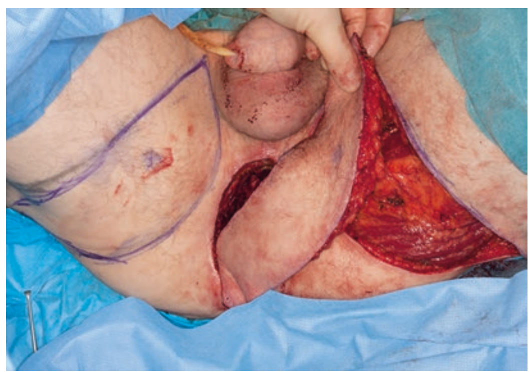


Fig. 10.15 Tension-free unilateral PAP propeller flap reconstruction for large perineal defect following resection of recurrent rectal cancer

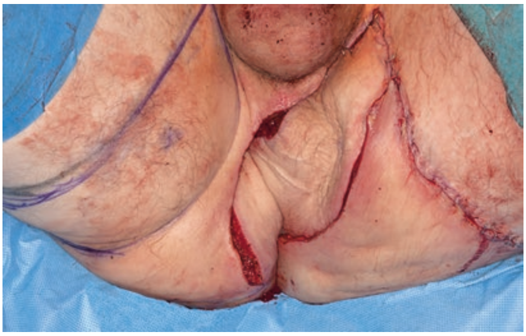


Fig. 10.16 Preferential use of staples and skin glue for perineal reconstruction to reduce infection rates and avoid unnecessary use of dressings, difficult to maintain in this location. Both flap and donor site are outside the area where most of the pressure is while patient is in a sitting position

10.4 Postoperative Management

Patients are nursed in a lateral position, which should be started as soon as patient is extubated. The reason for this is to avoid excessive pressure on the suture line, which could easily cause wound breakdown and prolonged healing by secondary intention. One should remember that forces per square centimeter of skin surface in inferior gluteal area are so high that no closure could withstand sustained pressure if patient would sit longer, while wounds are still healing. This is usually somewhat less problematic in most gynecological–oncological resections, where defect and subsequent flaps are above the area where most of the pressure is while patient in a sitting position (Fig. 10.17). In addition, surgeon should understand that following major resections and particularly pelvic clearance with flap reconstruction, sensory nerve damage to perineal and gluteal area is very likely. Sensory stimulus is protective and would under normal circumstances, after a period of sitting, cause discomfort and pain, which would trigger change in position and natural relief of pressure. Due to either transection of sensory nerves during surgery or a combination of preoperative radiotherapy and surgery, most patients requiring flap reconstruction would not have the ability to recognize when the pressure exceeds what could

Fig. 10.17 Postoperative outcome in the same patient 18 months after surgery. Donor-site scar is maintained within or just below inferior gluteal crease, which is important for primary wound healing, due to less pressure on tissues while patient sitting. The lateral end of the scar can still be visible in longer flaps, especially in male patients

cause tissue damage. Therefore, particularly in patients following abdominoperineal resections for colorectal malignancies, patient should be advised preoperatively on avoiding pressure on the flap/s for number of weeks. Immediately postoperatively, patients are turned between left and right lateral positions every 2–3 h. This could be extended after first 4–5 days to 4–6 h. Patient is allowed to stand and walk, but sitting can only be done if a special cushion with the hollow center is utilized, as normal pillow would cause too much pressure on the flap and potential partial/total flap necrosis or wound breakdown that would require many months to heal by secondary intention. Surgeon should educate both patients and staff about importance of this regime for success of surgery and avoidance of significant above-described complications. Compliance is often problematic, as patients lack protective sensation and/or feel relatively weak after extensive surgeries and longer general anesthetic. Often compliance needs to be enforced by nursing staff and surgical team on a daily basis as patient would want to rotate their chest anteriorly, which in turn causes loss of true lateral position and exerts excessive pressure on the flap and donor site. Stapled/sutured wounds in perineum are managed in the similar manner as pressure sore flaps. In majority of patients, alternate staples/sutures are removed in 2 weeks of time and remaining ones in 3 weeks of time. In addition, drains should remain longer than usual or until drainage per 24 h is 30 mL or less. In most patients, drains are only removed when patients are fully mobile. In authors' experience, general recommendation for patients with colorectal resections and flap reconstructions is to avoid sitting and direct pressure on the flap/flaps for 6 weeks, while in gynecological patients this can be shorter (up to 4 weeks). Though some colorectal surgeons believe this is excessive, in authors extensive experience with not only PAP flap, but all other forms of perineal reconstructions, best results, and lower complication rates can be achieved if above protocol is utilized. Plastic surgeon should ensure both patient and flaps receive sufficient oxygen and nutrients necessary for wound healing. Therefore, correction of postoperative anemia and high-protein diet is necessary during recovery as inpatient as well as after discharge.

10.5 Complications

As in other types of perineal reconstructions, wound breakdown could happen, more frequently as a result of noncompliance with the above-described postoperative regime than infection or partial flap failure. In our experience, wound breakdowns in PAP flap-based perineal reconstructions are significantly less common than in other flaps used for this area. One of the reasons behind this is that PAP flap skin island is located inferior to inferior gluteal crease, i.e., below the area where most of the pressure is while patient in a sitting position. This means that there are better chances for primary wound healing than in, for example, IGAP flaps. Another advantage in this respect is the use of propeller technique, which in PAP flap often allows avoidance of suture lines being positioned within the area of highest tissue pressure in sitting position. Sometimes, however, this cannot be avoided, especially if bilateral flaps are utilized for larger defects requiring filling of pelvic defect at the same time. Wound breakdowns are usually managed conservatively, rarely with the VAC dressing as it is very difficult to obtain a good seal in the perineum. Infections are in authors' experience very rare, as are dehiscences in flap donor sites. Occasionally, in certain patients following total pelvic clearance with resection of perineum and anus, a pelvic hernia may occur as a result of inability to close the pelvic opening by abdominal/urological/gynecological surgeon after tumor resections, as PAP flaps are usually not reaching far enough or are usually too narrow distally, to fill entire pelvis. Rarely, a partial flap necrosis occurs which can contribute to a wound breakdown and delayed healing. Blood supply is robust, and we have not encountered total flap failure with PAP flap for perineum since we performed the first case in June 2014.

10.6 Technical Pitfalls and Pearls

PAP flap is by its design and blood supply fasciocutaneous flap with largest width/size medially and progressively more narrow toward its lateral end. In this fashion, donor-site scar is maintained within or just below inferior gluteal crease, which is important for primary wound healing, due to less pressure on tissues while patient in a sitting position. It also hides most of the scar well in the gluteal crease, though lateral end of the scar in longer flaps can still be visible, especially in male patients. The reason why flap should be kept wider medially is in its vascular anatomy, as dominant perforator usually enters the fascia in this region. Perforator, however, when dissected, courses laterally away from the defect, so to ease and minimize dissection, one should choose one or two perforators relatively close to perineal defect to be able to execute propeller technique. It is possible to perform propeller technique based on two perforators if these are relatively close to each other, as previously described by the author [8, 9]. This is sometimes insufficient and flap cannot reach medially enough. In these situations, one can either continue dissecting the perforator to the main vessel and perform a pedicled PAP flap or harvest contralateral flap as either PAP, IGAP, gracilis, or simple V–Y flap and utilize combination flaps to address the defect adequately. Similarly, in very thin patients with large defects, one should primarily aim for bilateral flap reconstruction simply to recruit more tissue as per defect requirements. PAP flap is particularly useful as it is usually outside the area where previous flaps were performed and outside the previous radiotherapy field, this being frequently utilized in patients with recurrences, as a "salvage reconstruction."

10.7 Editors Comments

Profunda artery perforator flap is a relatively newly described flap for perineal/pelvic reconstructions [2]. Unlike most other flaps frequently utilized for this indication, it can often be performed as a propeller flap, based on a single or several perforators close to each other which reduces operating time as, apart from some perforator dissection, there is no need to dissect the pedicle in many cases to move the tissue into the defect. Another great advantage of this flap is the position of its skin island away from previous surgeries and/or radiotherapy fields. In addition, subsequent donor-site scar lies outside the area where most of the pressure is while patient is sitting. I believe this is the main reason for significantly less wound-healing problems observed in patients with the PAP flap, compared to other more popular flaps for this area in author's experience. Technique still needs to acquire greater recognition among reconstructive surgeons, as it requires perforator dissection skills and careful planning.

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11 Anterolateral Thigh Perforator Flap

Stefano Gentileschi, Damir Kosutic, and Marzia Salgarello

11.1 Historical Background

The anterolateral thigh (ALT) flap is one of the most popular flaps for variety of soft-tissue reconstructions. However, its use for perineal reconstruction has been rarely reported in the literature.

In 2000, Luo et al. [1] described the use of ALT fasciocutaneous flap to cover a complicated perineogenital defect after a previous reconstruction with bilateral gracilis myocutaneous flap, complicated by infection and dehiscence. The authors highlighted the low donor-site morbidity of this novel technique.

Then, Huang et al. [2] reported their preliminary experience with the use of an ALT—vastus lateralis (VL) myocutaneous flap for vulvar reconstruction after radical vulvectomy. They emphasized that the advantages of this technique were relatively normal appearance of neovulva, with satisfactory sensation and function, and the donor-site defect was minimal.

Wong et al. [3] published in 2009 their experience with the use of the ALT-VL flap for pelvic exenteration defect reconstruction in 18 patients. In this case series, abdominal flaps were contraindicated because of bilateral anterior abdominal wall stomal openings. When the perineal defect could be closed primarily, the vastus lateralis muscle was tunneled over the inguinal ligament into the pelvis (inguinal route, 6 patients). For concomitant perineal–vaginal reconstruction, the ALT-VL flap was tunneled over the medial thigh to the defect (perineal route, 10 patients). For 2 patients both routes were employed, one for each side. Authors reported low complication rate, but suggested that this technique may not be ideal for obese patients with short thighs.

In 2010, Friji et al. [4] reported their experience with 85 pedicled ALT flaps done in 78 patients for post-oncological excisional defects, 13 of which were perineal. Authors reported satisfactory coverage in all patients and observed no functional deficit of knee extension in any case.

In 2011, Van Bommel et al. [5] reported a case of a patient with a recurrence of vulvar carcinoma, in an irradiated area, undergone total en bloc pelvic exenteration and immediate reconstruction with a pedicled left rectus abdominis muscle flap, to prevent the bowel from herniation into the pelvis, while perineal defect was repaired with a large pedicled right-sided ALT flap. In the

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case reported, the colostomy was placed at the left side, next to the place where the rectus muscle was harvested. The Bricker-type urostomy was placed on the right side of the abdomen.

The paper by Zeng et al. [6], published in 2011, is the first to report the outcome of ALT flap-based vulvar reconstruction and to develop an operative strategy based on the experience of 11 patients operated for vulvar carcinoma. The authors described four possible different conditions: unilateral defects, reconstructed with unilateral ALT flap, asymmetric bilateral defects, reconstructed by unilateral ALT flap executed in the side of the wider defect, and local advancement flap for the contralateral side, large bilateral defects, reconstructed employing a fenestrated ALT flap, and combined vulvar and vaginal defects, reconstructed by employing a chimeric flaps with two separate skin paddles. The authors concluded that ALT flap is reliable for vulvoperineal reconstruction with good outcomes and minimal donor-site morbidity.

Filobbos et al. [7] described in 2012 the first case of a split free ALT flap anastomosed to the superficial femoral artery and saphenous vein to reconstruct a vulvar defect following excision of recurrent tumor. The authors concluded that splitting the ALT increases the versatility yet further without compromising flap vascularity.

In 2015, Contedini et al. [8] reported the case of a patient affected by an anal carcinoma who underwent a pelvic exenteration and reconstruction of the pelvic–perineal area by pedicled ALT flap combined with bilateral lotus petal flaps. The final result was good, and there were no major postoperative complications. Authors concluded that bilateral lotus petal flaps, combined with a pedicled ALT flap, may represent a valid option in pelvic–perineal reconstruction following a wide oncological resection. Zhang et al. [9] in 2015 reported outcomes of 24 patients following vulvar reconstruction utilizing ALT flaps. Four patients were affected by advanced stage primary vulvar cancer, while 20 had a recurrent vulvar malignancy. The main focus of this study was the quality of life and prognosis.

Complications after surgery were classed as major and minor [10]. Major complications encountered were total or partial flap necrosis, wound breakdowns (more than one-third of the length), and persistent cavity (dead space). Minor complications included minor breakdowns (defined as less than one-third of the length of the incision) [10].

Wound breakdown was defined as the separation of the surgical margins (dehiscence) [11].

None of patients of this study suffered a complete flap loss. Eight patients (33.33%) developed postoperative complications, with five patients (20.83%) having major complications and three (12.5%) developing minor complications. Partial necrosis patients underwent debridement and skin grafting of residual defects. Both major and minor wounds dehiscence healed after conservative treatment.

The authors concluded that ALT flap-based vulvar reconstruction method can improve the quality of life and might be considered as an appropriate option for reconstructing the vulvar defects in patients with advanced or recurrent vulvar malignancy.

In 2016, Gentileschi et al. [12], described the quality of life, surgical, and oncological outcomes of 15 patients affected by complex postoncologic gynecological defects for vulvar cancer, reconstructed with 16 pedicled ALT flaps. In two cases, authors harvested the skin island with VL (vastus lateralis) muscle as a chimeric flap, to fill the empty space (3-dimensional defect) after pelvic clearance. No flap necrosis was reported and partial dehiscence occurred in 3 flaps. Patients' performance and pain improved after surgery. Authors concluded that ALT flap should be considered a useful option for perineal reconstruction following vulvar cancer surgery, due to its reliability and versatility.

11.2 Surgical Anatomy

The ALT flap is designed on the skin of the anterolateral surface of the thigh. Its vascularization is based on the perforators of the descending branch of the lateral circumflex femoral artery that courses in the septum between the vastus lateralis muscle and the rectus femoris muscle. Usually, its perforators pierce the deep fascia within 6-cm-diameter circle, centered over the midpoint of a line connecting the anterior superior iliac spine and the upper lateral border of the patella [13]. In vulvoperineal reconstruction, ALT flap is practically always used as a pedicled flap. Therefore, another very important landmark is the pivot point. This point is the origin of the descending branch from the lateral circumflex femoral artery. To find the pivot point, a line is marked between the middle point of the line that connects anterior superior iliac spine and superior–lateral border of the patella and the midpoint of the line extending from the anterior superior iliac spine and the pubic tubercle. The resulting line should mimic the course of the descending branch of the lateral circumflex femoral artery (Fig. 11.1). A point on this line located approximately 3 cm under the groin crease represents the likely origin of LCFA and therefore the pivot point of the pedicled ALT flap. The ALT flap can be raised and transferred as a sensate flap [12, 14–18], even if including the nerve reduces the arc of rotation. The dominant sensory nerve of the ALT flap is the lateral femoral cutaneous nerve arising from the dorsal divisions of the second and third lumbar nerves. It emerges near the anterior superior iliac spine and continues down in the deep subcutaneous layer of the thigh dividing into an anterior and a posterior branch [17, 18].

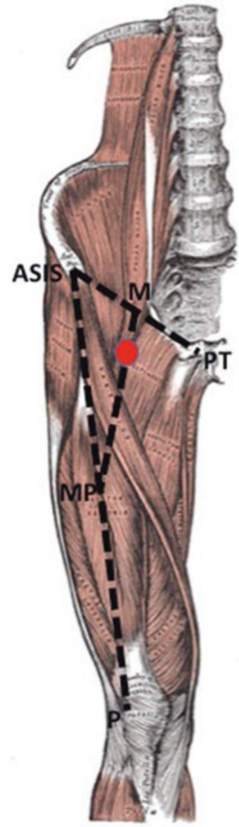

Fig. 11.1 This drawing represents the landmarks to assess the pivot point of the pedicled ALT flap. The midpoint (MP) of a line connecting the anterior superior iliac spine (ASIS) and the upper lateral edge of the patella (P) is marked. The midpoint (M) of a line connecting the anterior superior iliac spine (ASIS) with the pubic tubercle (PT) is marked too. Following the line connecting these two points (MP-M), 2–3 cm caudally to the inguinal groove, we can establish the pivot point of the pedicled ALT flap (red circle)

11.3 Indications

ALT flap is usually employed for perineal reconstruction after vulvar, anorectal, vaginal, and urethral cancer ablative surgery.

Fig. 11.2 ALT–vastus myocutaneous flap in combined pubic–suprapubic and vulvar sarcoma reconstruction. (**a**) Recurrent DFSP (dermatofibrosarcoma protuberans) affecting right pubic area. Planned 2–3 cm wide resection down to pubic bone as per sarcoma guidelines. (**b**) Resection performed jointly by plastic surgeon and gynecological oncological surgeon including pubic/suprapubic and vulvar areas, exposing pubic bone. (**c**) Combined chimeric pedicled ALT-VL flap raised and tunneled under the rectus muscle and skin into the defect, donor-site closed combining local flap and direct closure. (**d**) Stable postoperative result at follow-up 18 months postoperatively. (Reproduced from *Kosutic D, Mulh R, Apostolos V, Solinc M. 360° of Freedom in Chimeric Pedicled Vastus Lateralis - ALT Perforator Flap for Reconstruction in Patients with Advanced or Recurrent Malignancies. Clin Surg. 2017; 2: 1401*)

The ALT flap can virtually reach any point from the groin to the perineal area, according to the position of the perforators and to the geometry of the defect. The distal perforators increase the arc of rotation.

ALT flap covers very well the groin area, repairing possible skin defects but also filling subcutaneous dead space, can reach mons pubis (Fig. 11.2a–d) and even repair abdominal wall or inguinal ligament, achieving the closure of the deep structures with its fascia lata component.

The geometry of the defect is important as well. In fact, it is easier to inset an ALT flap into a homolateral defect of the anterior, medium, and posterior perineum rather than attempting to reconstruct a solely posterior defect, in which the skin island of the flap has to get through the residual perineal skin.

This flap is ideal for covering asymmetric perineal defects, with one side wider than the other, including dead space or skin defect in the mons pubis or groin area. Secondly, this flap should be chosen, including VL muscle (vastus lateralis), as a chimeric or myocutaneous flap, in the presence of pelvic exenteration if a VRAM flap is contraindicated. The skin island of ALT flap can be used to repair the external defect, while the muscular tissue is employed to fill the dead space and close the passage of the bowel inside the pelvic floor. When pelvic exenteration is performed, often the patient already had previous surgeries and underwent radiation therapy. Under those circumstances, it is very important to fill the dead space to avoid infections. In these cases, the VRAM flap with an endopelvic course is surely the best choice, but it is not always feasible. This is particularly true in presence of previous extensive surgical abdominal scars or if bilateral stomas are needed. In these patients, according to the position of urostomy and colostomy, the VRAM flap can be contraindicated to avoid excessive impairment of the abdominal wall.

Abdominal flaps can also be contraindicated in presence of abdominal weakness or hernia.

Finally, in rare cases in which the ablative surgery involves an abdominal wall resection, ALT flap can repair the abdominal fascial layer with fascia lata and the external layer with the skin island.

11.4 Surgical Technique

Before surgery, perforators are detected along the line previously described, by Doppler or color Doppler ultrasound, and marked on the skin. Once ablative surgery is completed, the reconstruction begins by making a template of the defect. The thigh chosen for the flap harvesting is the one on the side where the oncologic defect is wider. In case of symmetric defects, the surgeon should choose the side with the most distal suitable perforators, according to the preoperative Doppler ultrasound information. The template is placed on the selected thigh, according to the position of the pivot point and of the perforators previously marked, to locate the exploratory incision. Once the exploratory incision has been deepened till the deep fascia, the perforators can be searched with a subfascial or a suprafascial approach, according to the need to include or not the fascia lata in the flap. Whenever possible, it is better to include at least 2 perforators, particularly in cases of larger flaps or obese patients. The perforator is dissected in a retrograde fashion until its origin, and then, the dissection proceeds to the origin of the descending branch from the lateral circumflex femoral artery. When dissection of the pedicle is completed, its length is definitively established according to the position of the perforator and of the pivot point. Then, the exploratory incision is temporarily approximated, and the final skin island of the flap is marked on the thigh skin considering the position, size, and shape of the defect. This flap can be raised with or without underlying fascia lata, or with only a part of it, depending on the reconstructive requirements. In case of pelvic clearance, VL (vastus lateralis) muscle can be included with the flap to fill the pelvic cavity and close the pelvic floor. In order to transfer the ALT flap into the recipient site, it is mandatory to create a tunnel under the rectus femoris and inguinal skin, with careful preservation of saphenous vein (unless it was already ligated during groin dissection) [12]. For medially positioned defects, a tunnel under sartorius muscle is sometimes necessary as well (Fig. 11.3a–c).

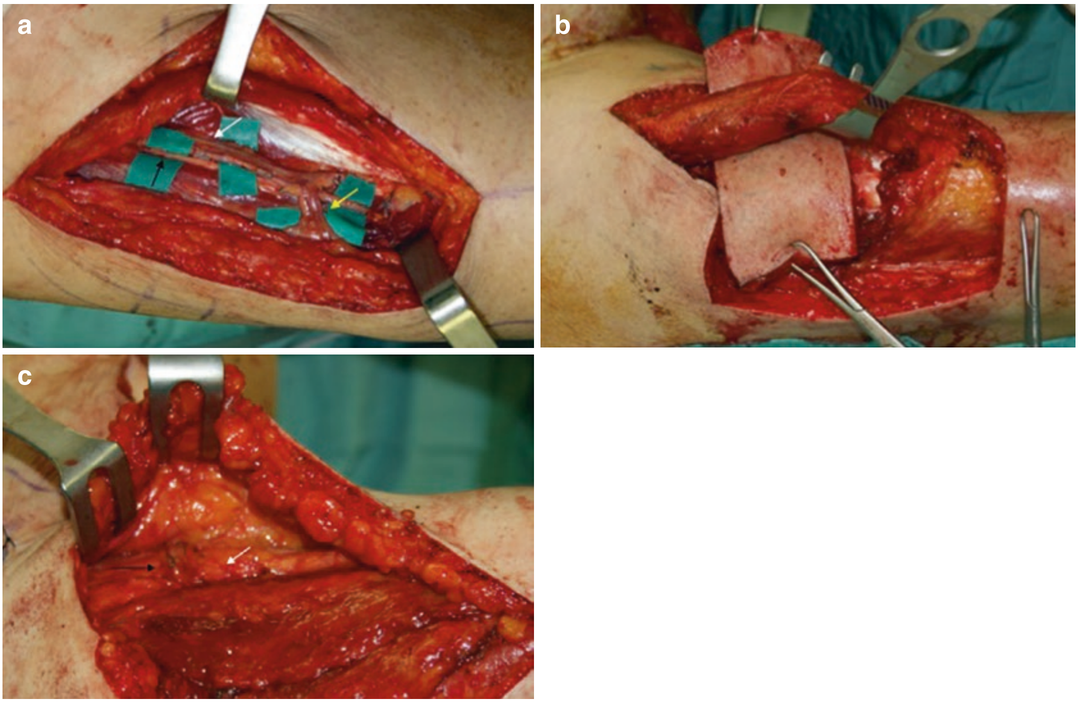

Fig. 11.3 These pictures show the intraoperative sequence followed when ALT flap is used for perineal reconstruction. (**a**) By an exploratory incision, the position of the perforator (yellow arrow) previously marked with preoperative color Doppler ultrasound is confirmed. The pedicle (white arrow) is dissected, till the origin of the descending branch of the lateral circumflex femoral artery, sparing the motor nerve for the vastus lateralis muscle (black arrow). (**b**) After incising and undermining the flap, a tunnel is made under the rectus femoris muscle and the inguinal skin, to transpose the flap into the perineal area. Care must be taken to not severe the pedicle of the rectus femoris muscle, to avoid its devascularization. (**c**) Once the flap is transposed into the perineal defect, its vascular pedicle (black arrow) lays on the sartorius muscle. When the perineal defect is posterior and more arc of rotation is required or if some compression by the sartorius is observed, the sartorius muscle can be undermined, and the flap can be passed under the sartorius muscle. During the undermining of the sartorius muscle, care must be taken to avoid damaging femoral vessels and saphenous vein that are on its medial edge

11.5 Tips and Tricks

Preoperative color Doppler ultrasound is always advisable to ensure the presence and the suitability of the distal perforators that provide the maximum possible length to the pedicle. Often, the distal perforators are smaller, and with a longer intramuscular course if compared to the proximal perforators. Dissection of these distal perforators is often more technically challenging, but can provide a longer pedicle.

If only proximal perforators are detected, it is possible to harvest a long flap, in eccentric fashion in relation to the perforator, to reach the perineal region. In these cases, it could be required to inset the flaps' proximal part into the groin area. Hence, only when a proximal adequate perforator is present, the ALT flap is indicated in the presence of perineal defect with concomitant inguinal defect. The groin defect can be cutaneous or only subcutaneous dead space, such as in case of extensive groin dissection [19, 20], where the proximal part of the ALT flap can be buried, and the distal part can be used for perineal reconstruction.

Before planning and incising the skin island of the flap, an anteromedial exploratory incision provides the most convenient approach to identify the position and course of perforators and precise location of the pivot point. This medial incision is also the same that subsequently allows the surgeon to create the subcutaneous and submuscular tunnel on the thigh and the groin. Therefore, it should be slightly more medial than in a classic free ALT flap harvest, to shorten the length of the tunnel. Whenever possible, two or more perforators should be included in the flap, particularly in obese patients. In fact, for these patients, it is difficult to keep the position with somewhat opened and flexed thighs during the immediate postoperative period in the bed [21]. Thus, when flap needs to be inset in the perineum, this could cause folding/kinking of the skin island, with the risk of impairing the vascularization. The presence of two perforators reduces this risk.

Vascular skin territory that can be harvested with a pedicled ALT flap is surprisingly wide, extending from the greater trochanter to the area above the anterior and lateral aspects of patella, and the skin island can be strongly decentralized, with respect to the perforator position, to further lengthen the arc of rotation.

The ALT flap can be longitudinally split in the distal part, according to the reconstructive needs, without increasing the risk of necrosis to the tip of the flap.

To transpose the flap to the perineum, a tunnel has to be formed under the rectus femoris muscle. Therefore, it is more convenient to complete the dissection of the descending branch at its origin from a medial approach, after the creation of this tunnel and the lateral displacement of rectus femoris muscle. This maneuver allows a better visualization of the origin of the descending branch. During the "tunnelization" of the rectus femoris muscle, attention should be paid to avoid severing the pedicle of this muscle, to prevent its partial devascularization.

Sometimes, after transposition of the flap into the perineum, the pedicle could get under pressure by sartorius muscle. In this case, a little V-shaped incision can be created by cautery, in the muscle belly of the sartorius, to release any pressure on the vascular pedicle.

Including the sensory nerve in the flap severely reduces the pedicle length, forcing the surgeon to inset the proximal part of the flap into the groin region. This is usually done only in cases of simultaneous inguinal reconstruction [22].

If during surgery, it emerges that ALT flap is not feasible, possible backup plans can be V-Y advancement flap, gracilis myocutaneous flap, DIEP flap, VRAM flap, or SCIP flap [23–25].

In some cases, with dead space, it is better to include vastus lateralis muscle or part of it with the ALT skin island without dissecting individual perforators. This would not only provide the necessary bulk, required to fill the dead space in pelvis/perineum or groin, but also improve blood supply to flaps' skin island by adding more perforators including very small ones, otherwise normally not suitable for intramuscular dissection. In rare cases of critically sized defects [26], where extremely large flap is required, it is advisable to include both vastus and rectus muscle to maximize blood supply to the flap and increase the bulk, as described by Kosutic et al. (Fig. 11.4a–j). Though this may sound extreme and would seemingly produce mobility issues, it has not done so in authors' experience (Video 11.1).

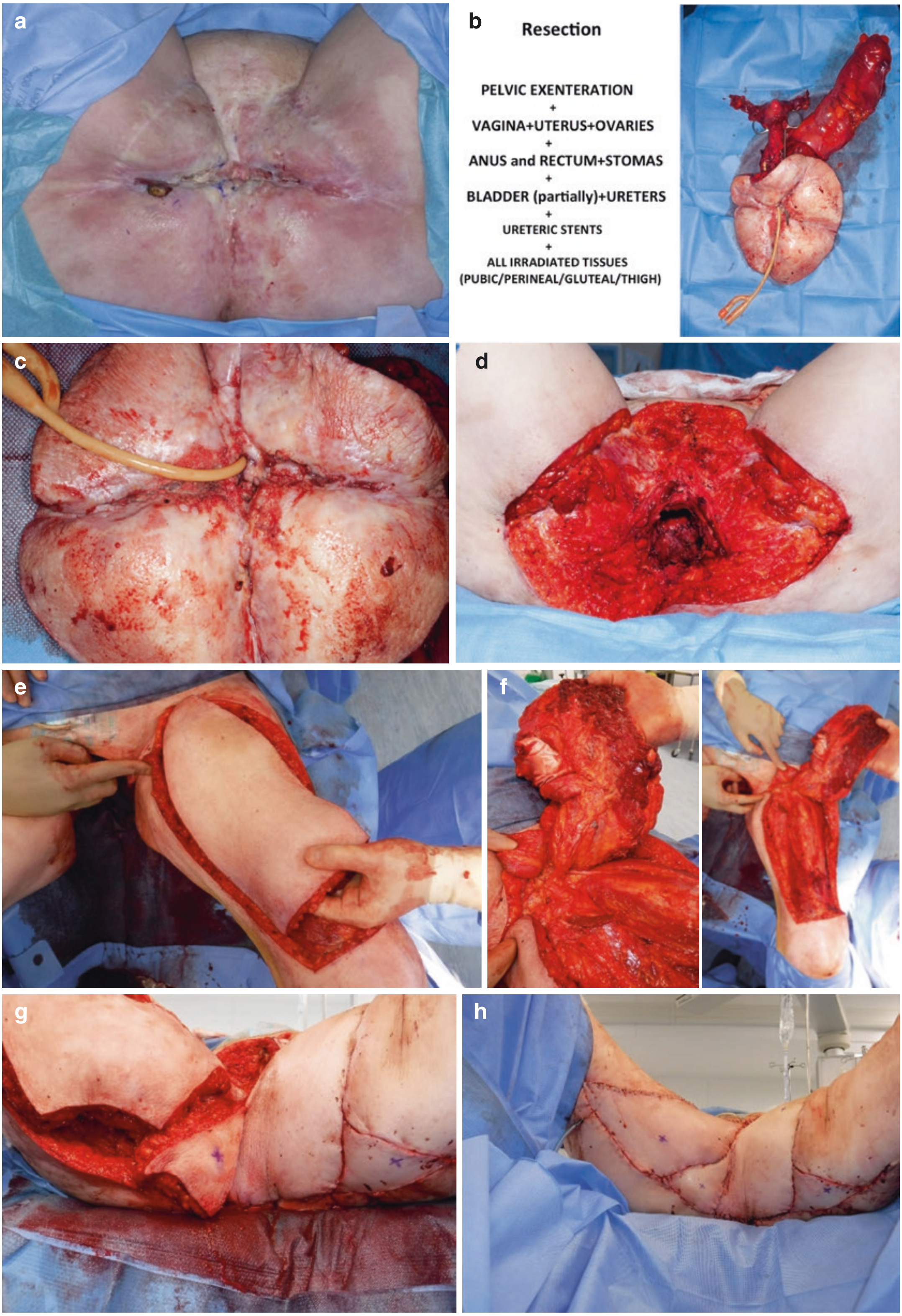
a
b
Resection
PELVIC EXENTERATION
+
VAGINA+UTERUS+OVARIES
+
ANUS and RECTUM+STOMAS
+
BLADDER (partially)+URETERS
+
URETERIC STENTS
+
ALL IRRADIATED TISSUES
(PUBIC/PERINEAL/GLUTEAL/THIGH)
c
d
e
f
g
h

Fig. 11.4 Extremely large defect following total pelvic clearance including removal of vagina, uterus, ovaries, anus, rectum, partial excision of urinary bladder, ureters with ureteric stents as well as large area of pubic, perineal, gluteal, and thigh soft tissues which were previously irradiated for recurrent vulvar cancer. (Reproduced from Kosutic D, Tsapralis N, Gubbala P, Smith M. Reconstruction of critically-sized perineal defect with perforator flap puzzle technique: a case report. Case Reports Plast Surg Hand Surg. 2019 Mar 1;6(1):38–42.) (**a**) Recurrent vulvar cancer following previous multiple surgeries with V-Y local flaps and radiotherapy. Extensive radiotherapy-related damage to soft tissues of perineum, pubic, thigh, and gluteal areas bilaterally. (**b**) Resected specimen includes anus, rectum, uterus, ovaries, vulva, urethra, part of urinary bladder with ureters, and perineal soft tissues. (**c**) Extensive soft-tissue specimen including entire perineum, pubic, thigh, and parts of gluteal areas bilaterally. (**d**) Subsequent 3-dimensional soft-tissue defect with empty pelvis and sutured remains of urinary bladder inside. (**e**) Mega-ALT–vastus–rectus flap harvested from left anterior, medial, and lateral left thigh. (**f**) Inclusion of both rectus and vastus muscles allows very robust blood supply to entire surface area of the flap. (**g**) ALT–vastus–rectus large enough to cover only 50% of the defect so flap combined with chimeric-blood supply mega-PAP (profunda artery perforator) and myocutaneous gracilis flap to cover pubic area and part of perineum. Two "free-style" IGAP (inferior gluteal artery perforator) flaps performed in addition, to address the last 10% of the required surface area. (**h**) Completed reconstruction with a "perforator puzzle technique." (Reproduced from Kosutic D, Tsapralis N, Gubbala P, Smith M. Reconstruction of critically-sized perineal defect with perforator flap puzzle technique: a case report. Case Reports Plast Surg Hand Surg. 2019 Mar 1;6(1):38–42.) (**i**) Stable result 14 months postoperatively with all flaps fully healed and patient recovered with practically full function, pain-free, and mobile with no evidence of cancer. (**j**) Healed skin-grafted left thigh donor site

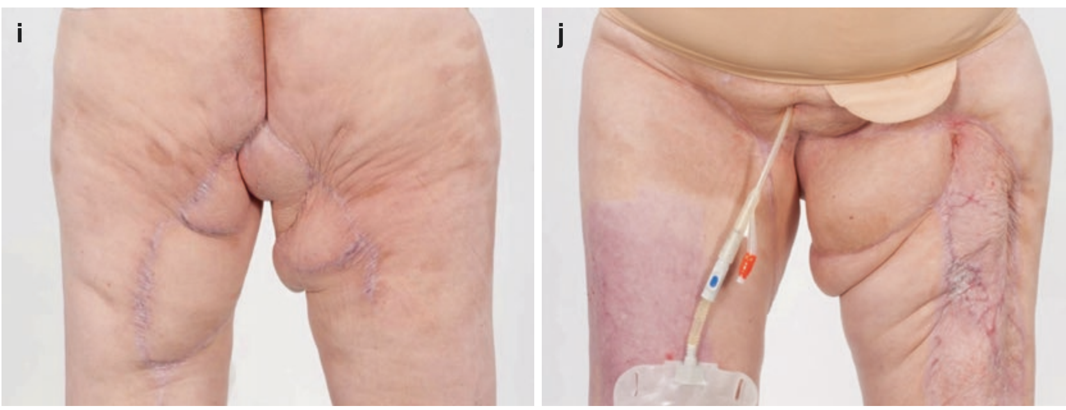

Fig. 11.4 (continued)

11.6 Conclusion

Thanks to its strong longitudinal vascularization, the ALT flap has a great versatility for perineal reconstruction, allowing the surgeon many possibilities of tridimensional tailoring.

For this reason, in presence of complex defects, it could be considered as the first choice for perineal reconstruction, particularly in defects not limited to vulvoperineal edges but also including other anatomical subunits such as mons pubis, groin, or pelvis. Under such circumstances, ALT flap has the advantage to avoid the significant donor-site morbidity of traditional VRAM flap.

The possibility to harvest the fascia lata and the VL muscle is useful when a defect involves the pelvic floor.

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12 Abdominal Flaps

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12.1 Introduction

The pelvic and perineal area is a challenging region for soft tissue reconstruction. Defects are mainly encountered in oncological settings and many aspects need to be taken into consideration when deciding on soft tissue reconstruction. The objectives of surgical reconstruction are preservation of function and restoration of aesthetic appearance, while minimizing morbidity. Specifically, in perineal reconstruction, adequate tissue is required to fill the dead space postresection of tumor with minimal fecal and urinary contamination [1]. Primary closure of the perineum without flap reconstruction leads to higher rates of complications due to the creation of "dead space" postresection. Complications include formation of seroma, abscess, hematoma that may contribute to postoperative infections and formation of fistulas or hernias. During abdominoperineal resection, the pelvic floor is breached and inadequate repair leaves a defect through which abdominal contents can herniate leading to perineal hernia and potentially bowel obstruction [1–5].

Factors that need to be carefully assessed prior to reconstruction are:

Location of defect

Location of defect can determine the type of flap to use as reconstruction. If adjacent tissue is healthy and vascularity not compromised from debulking surgery or irradiation, then local flaps can be considered for reconstruction, otherwise, and more commonly regional pedicled flaps are required for reconstruction as nonirradiated tissue decreases morbidity [1, 2, 6].

Expected size of defect

Careful preoperative planning and consideration of defect size can establish type of flap reconstruction. Flap selection will depend on size and shape of the defect, available donor sites, patient choice, and surgeon expertise [1, 6, 7]. Large-volume defects would require large volumes of tissue to fill and cover the defect. Noncollapsible dead space from wide resections contributes to wound healing complications and pelvic infections [8]. In cases of more sizable defects, local flap lengths are not adequate; therefore, regional pedicled or free flaps are required [9].

Preoperative tissue quality

Reconstruction with healthy viable tissue reduces the risk of infection and problems with postoperative wound healing. Genitoperineal or pelvic irradiation can severely compromise surrounding tissue and vital structures, leading to compromised skin vascularity and necrosis. The development of rectovaginal and vesicovaginal fistulas as a consequence of radiation also increases morbidity [2, 3].

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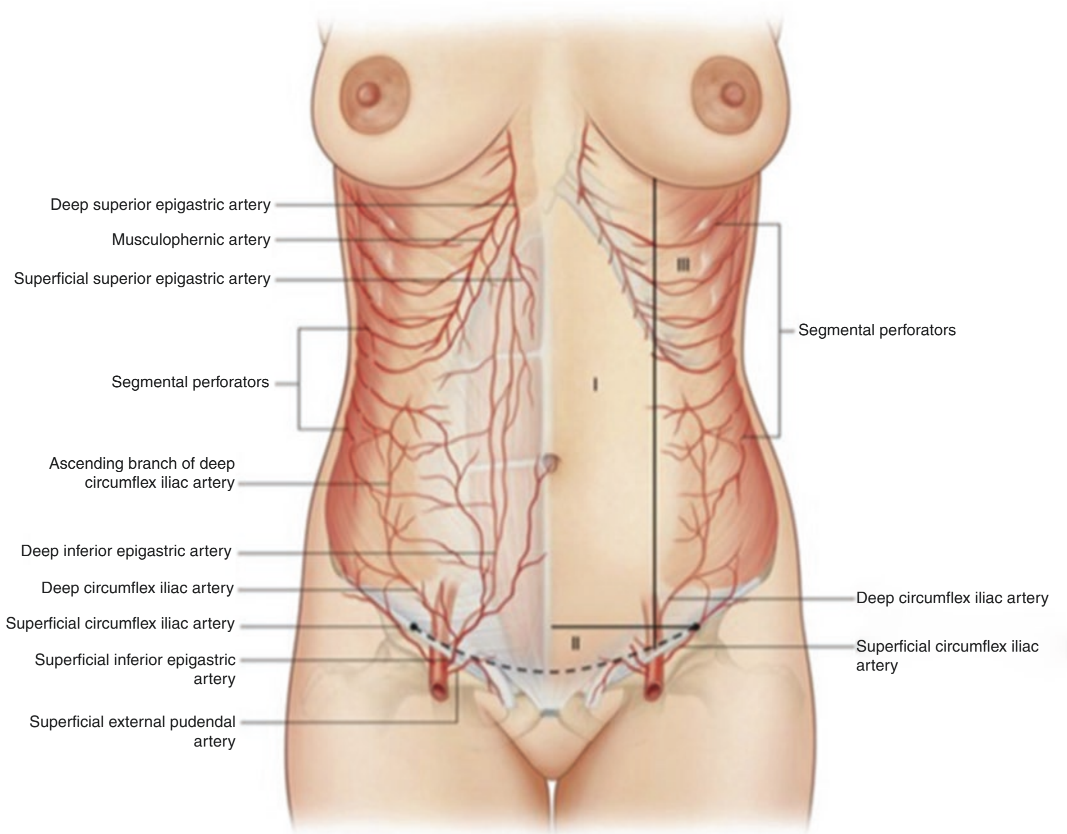

Fig. 12.1 Demonstrating the Huger zones of abdominal wall perfusion

Previous abdominal surgery

Blood supply to the abdominal wall can be divided into three zones according to Huger [10]. Perfusion to zone I is via superior and inferior epigastric systems, to zone II circumflex iliac and external pudendal systems, and zone III intercostals and external pudendal systems (Fig. 12.1). Previous abdominal incisions and consequent scarring can compromise the vascular architecture of the abdominal pannus and compromise flap tissue. Scarring also contributes to lengthier operational time due to altered anatomy impeding dissection. The most common abdominal incision in women is the Pfannenstiel incision, which traditionally undermines the abdominal tissue to approximately umbilical level, severing perforator vessels. Potential disrupted vasculature needs to be taken into consideration when planning surgery, and appropriate radiological investigations carried out preoperatively [11]. Other factors to consider are mobility of the patient, wound status and current infection, adjuvant therapies, and technical expertise of the operating surgeon.

12.2 Abdominal Flaps

Abdominal-based flaps for perineal reconstruction can be transferred either as pedicled or free flaps. Pedicled flaps are largely recognized as an effective and suitable reconstructive option for perineal defects.

12.2.1 Rectus Abdominis Myocutaneous Flap

The rectus abdominis muscle was first described in 1977 by Mathes and Boswick, and then modified by Shukla and Hughes in 1984 [4, 12]. It is a myocutaneous flap that receives its blood supply from the superior epigastric artery superiorly and inferior epigastric artery inferiorly, with numerous perforating and anastomosing branches that supply the muscle and skin [4]. The inferior epigastric artery is the larger and more well-defined vessel of the two that can be found 4–5 cm above the pubis and entering the muscle laterally. Inferior to the vessel entry point, the rectus muscle is divided in full thickness to form the flap. The rectus abdominis flap can have an oblique or vertical pattern skin flap up to 10 × 20 cm that can be used to fill the perineal defect, becoming a vertical rectus abdominis muscle flap (VRAM) or oblique rectus abdominis flap (ORAM, Fig. 12.2) [4, 13].

A marked skin paddle is incised starting at the level of the umbilicus and extending superiorly to the costal margin. The width of the skin paddle is determined by a combination of the size of the perineal defect to be filled and the mobility of the abdominal wall so that the resultant defect can be primarily closed. The subcutaneous fat is incised to the anterior rectus sheath. The rectus sheath is incised as an ellipse. The muscle is divided at its superior limit. The flap is then raised leaving the posterior rectus sheath behind and taking care not to damage the superior epigastric vessels continuing as the deep inferior vessels inferiorly on the posterior aspect of the muscle. The attachment of the rectus muscle to the symphysis pubis is generally left intact to add support to the deep inferior epigastric vessels, which carry the blood supply to the flap. Following abdominoperineal resection (APER), the flap is rotated 270° and tunneled through to reach the perineum taking care not to kink the pedicle. Its cutaneous aspect is sutured to the perineum [1, 12]. In immediate flap reconstruction of the perineum, ORAM (Fig. 12.3a–e) and VRAM flaps have shown to have no significant difference in complication rates [14].

Fig. 12.2 Demonstrating design of an ORAM flap

12.2.1.1 Advantages

RAM flaps are a widely used method of flap reconstruction with ease of harvest and enough bulk for filling defects with good reliability and outcomes. RAM has a long pedicle and provides adequate volume of tissue for large perineal defects. In larger defects where larger tissue is needed for reconstruction, ORAM flaps can provide this extra tissue [7]. VRAM flaps in comparison to thigh flaps have been shown to have lower wound complication rates such as wound dehiscence, as well as lower rates of pelvic abscesses, presumably due to better filling of the "dead space" [15].

12.2.1.2 Disadvantages

Flap harvest results in abdominal wall morbidity, which includes fascial dehiscence, abdominal wall hernias, weakness in truncal core strength. Uses of abdominal mesh may be considered for additional support [16].

12.2.2 Deep Inferior Epigastric Perforator Flap

The Deep inferior epigastric perforator flap (DIEP) was first described as a free perforator-based flap sparing the rectus abdominis muscle in 1989 by Koshima and Soeda and is routinely used as the flap of choice in breast reconstruction surgery [17]. In abdominoperineal reconstruction,

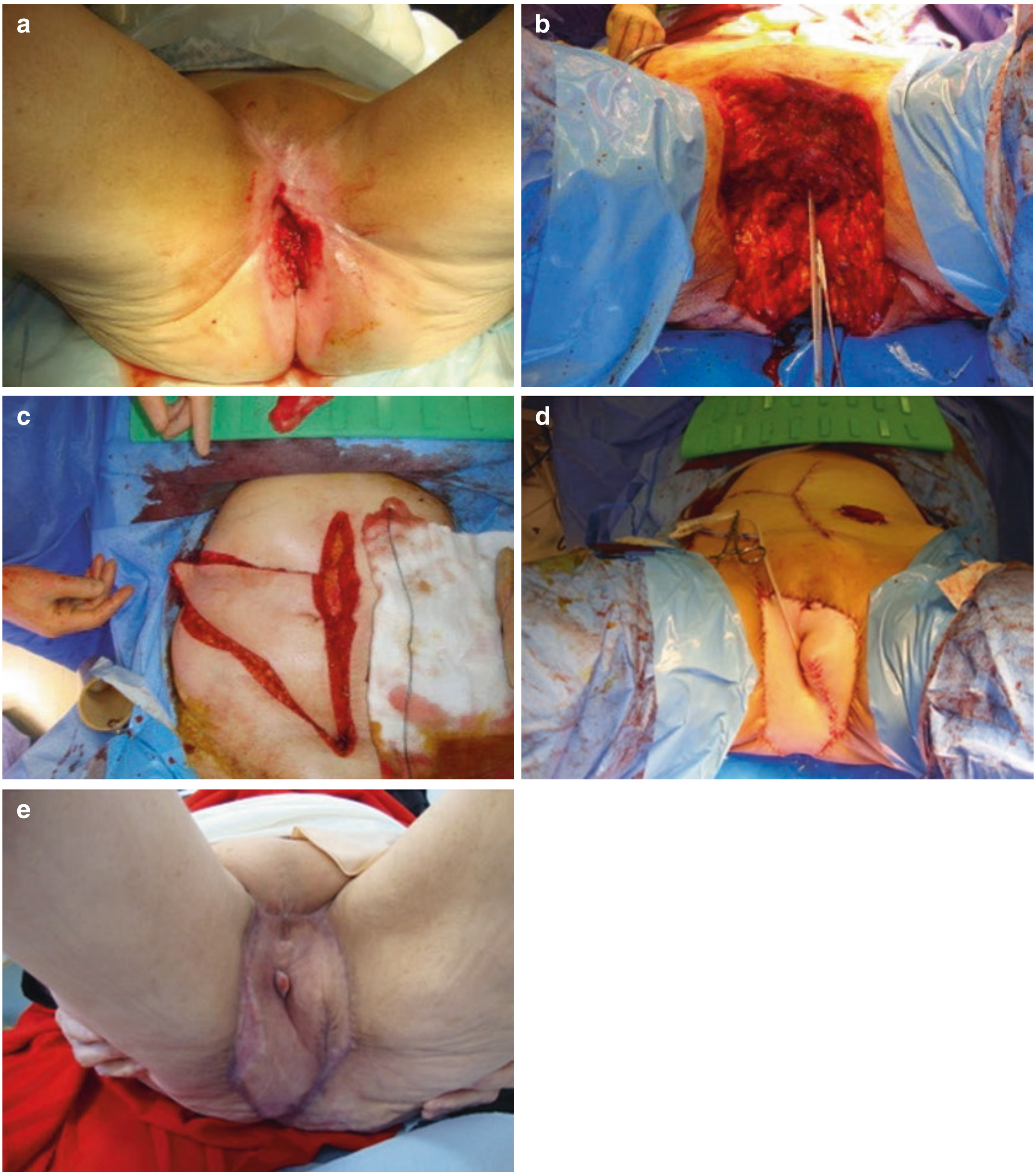

Fig. 12.3 (**a**–**e**) Patient presenting with recurrent vulval carcinoma. ORAM flap is raised and transposed to reconstruct defect. The ORAM flap was folded to increase its width (**d**). Long-term result with a stable reconstruction (**e**)

DIEP flap can be used as a free flap or more commonly, as a pedicled flap. The choice of skin paddle, transverse, vertical, or rhomboid will rely on surgeons' choice as well as the patients' reconstructive needs [18, 19].

The DIEP flap is based on the deep inferior epigastric vessels, the same vessels that supply the RAM. The skin paddle of DIEP flap is often similar to the RAM flaps, but is more likely to depend on the location and anatomy of the perforator vessels. The flap is raised based on the perforators of DIE vessels, which are carefully dissected through the anterior rectus sheath and rectus muscle to the main vessel. As such, the anterior rectus sheath and rectus muscle are left behind.

Preoperative planning for abdominal-based flaps would require thorough history and relevant

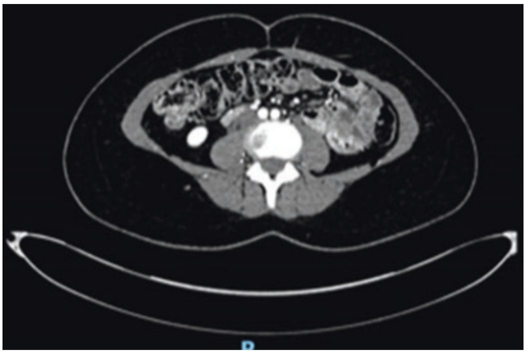

Fig. 12.4 Axial CT scan revealing a left paraumbilical perforator suitable for a DIEP flap

examination, identifying factors that may have compromised blood vessels supplying the abdominal tissue, such as previous surgery. Radiological angiographic imaging, such as CT or MR angiogram, helps identify adequate perforators, which can aid preoperative planning (Fig. 12.4).

12.2.2.1 Advantages

DIEP flap has a long pedicle and robust blood supply. The main advantage of using the DIEP flap is the muscle sparing aspect of it, carrying a lower donor site morbidity rate in comparison to RAM flaps with less postoperative pain as muscle is left intact and a lower risk of abdominal hernias [6, 7, 17–19].

12.2.2.2 Disadvantage

Lengthier operative time, absence of muscle bulk to fill "dead space", and potentially greater risk of torsion/damage to pedicle.

12.2.3 Omental Flap

The greater omentum has a reliable blood supply, rich lymphatic network, and large surface area. The greater omentum is typically separated from the transverse colon and greater curvature of the stomach and is commonly based on the right gastroepiploic vessel and arcades to the stomach. The pedicled flap is brought down to the perineum from the retrocolic and retroperitoneal plane through the mesentery of the transverse colon. The flap is then secured to its final position by placing across the sacral promontory to pelvic floor and secured to the perineum. The vascularized flap provides sufficient bulk, which is used to fill the perineal defect; however, it does not provide primary healing of large skin defects. In that case, it is either used in conjunction with fasciocutaneous flaps or covered with split-thickness skin graft [12, 20, 21].

12.2.3.1 Advantages

Omental flaps are a suitable option for perineal defects providing adequate surface area and volume, and improving lymphatic drainage from pelvic sidewalls. The bulk provided by the flap to the base of the pelvis helps prevent perineal herniation [5].

12.2.3.2 Disadvantage

If omental flaps are used as primary flaps, then split thickness skin grafts are typically required for wound healing. This in turn prolongs the duration of wound healing and poses the risk of potential graft failure.

12.2.4 Postoperative Care

Postoperative care and correct nursing on wards following flap reconstruction to the perineum are important to avoid flap compromise. For successful outcomes, pressure on the flap must be avoided for the first few days postoperatively; therefore, patient must adopt positions that relieve pressure on the flap, being nursed either in lateral positions or directly supine. Appropriate air mattresses must be used to avoid pressure sores until patient is mobile. A standard protocol for postoperative care currently does not exist. Bed rest duration ranges from 2 days to 2 weeks after which patients can mobilize. Sitting on the flap from 30° to 90° is gradually built up starting from 10 min an hour, from 3 days to 3 weeks postoperatively depending on surgeon instructions [22].

12.3 Conclusion

There is a range of reconstructive options available for reconstruction of abdominoperineal defects. These range from local flap options to various regional and free flaps. The rectus abdominis muscle flap in particular has proven to be simple, robust, and versatile in its use. The use of nonirradiated tissue for reconstruction with its healthy blood supply has been shown to decrease wound complications normally seen in primary closure [6]. The main problem faced in RAM flap reconstruction remains abdominal wall weakness in the form of fascial dehiscence and incisional hernias [1, 6, 16]. There can be significant anatomical variation in vasculature, especially following previous abdominal surgery; therefore, the use of preoperative radiological angiographic imaging is recommended to evaluate blood supply and promote safe and efficient operative planning.

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13 Pudendal Artery Perforator Flap and Other Reconstructive Options in Perineal–Pelvic Reconstruction

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13.1 Introduction

Perineal reconstruction can pose a functional and aesthetic challenge for the plastic surgeon due to a complex regional anatomy, with variations in soft tissue thickness, color, texture, and tension [1]. The perineum plays a role in many bodily functions, and disruption in this area can have a profound effect on quality of life. The appropriate choice of reconstruction in the region may be influenced by many factors such as patient age, sexual function, and personal wishes [2].

Most defects in the region arise secondary to abdominoperineal resection (APR) for colorectal, urological, or gynecological carcinomas. Treatment of pelvic malignancies generally favors an aggressive, radical resection, which may involve removal of associated viscera, muscle, bone, ligaments, and blood vessels [3]. Wide excisions produce larger defects, with a greater probability of microscopically negative margins, but which may also be associated with increased wound complications [4]. In the perineal region, wide excision can also be used for management of necrotizing soft tissue infections, as can be found in cases of Fournier's gangrene, for severe inflammation, often encountered in advanced hidradenitis suppurativa or Crohn's disease, for burns, and traumatic wounds [5]. In each of these scenarios, addressing the postsurgical defect may require recruitment of bulky soft tissue and skin for resurfacing.

A locoregional or distant soft tissue flap can be utilized when options such as healing by secondary intention, primary closure, or the use of skin grafts are inadequate. Flaps allow for a robust reconstruction, first by providing volume that can fill empty space, and second by providing functional skin coverage with its own blood supply. Historically, the Vertical Rectus Abdominis Myocutaneous (VRAM) flap has been the workhorse flap in this region; however, if the abdominal donor site is unavailable, other donor sites such as the thigh may be used, especially for larger defects. Other local flaps from the groin and buttock may be ideal for the resurfacing of more superficial perineal defects that do not require substitution of extensive soft tissue.

Sound planning by a multidisciplinary team, which include the patient in the decision-making process, is necessary to optimize the timing and execution of surgical resection, adjuvant therapy, the choice of reconstructive procedure(s), and ongoing clinical monitoring. This chapter describes the options and general

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guidelines for the reconstruction of perineopelvic defects based on location and the principles of skin coverage, volume requirement, and minimization of donor site morbidity as outlined by the senior author M.S.C. Specific emphasis will be placed on the Pudendal Artery Perforator (PAP) flap.

13.2 Regional Considerations

The perineum is an anatomically complex area, involved with various bodily functions including sexuality, reproduction, and the elimination of waste. Ablative procedures in this region may lead to extensive functional deficits that can have profound effects on patient quality of life [3]. Management of defects in this region should consider the unique characteristics of anatomical structures such as the vagina, vulva, penis, and scrotum, and avoid excessive bulk that can produce discomfort and poor cosmesis. Optimal wound healing may be challenged by locoregional factors such as pressure placed on dependent regions, extensive intrapelvic or peritoneal empty space that can result from extirpative procedures, and the unique microbial environment [6]. When selecting a perineal reconstructive procedure, the plastic surgeon should strive to ensure a tension-free closure with adequate blood supply and enough bulk to ablate the empty space, thereby preventing complications such as seroma or delayed wound healing. A vascular assessment by color Doppler can be used to monitor blood flow to the flap and identify multiple perforators, aiding in flap design and long-term viability. Where possible, protective sensation should be preserved during reconstruction. Care should be taken by the extirpative surgeon during resection to avoid bladder or bowel invasion, and stool or urine leakage [6]. Fecal diversion may be necessary in patients whose wounds involve the anal canal, to avoid contamination. Some studies have advocated the use of laparoscopic or extralevator resections to minimize perineal wound complications; however, to date there is no consistent evidence supporting these claims [7–9].

13.3 Reconstructive Options

Many options are available for management of perineal defects, the most basic of which is to allow healing by secondary intention. Dermal matrices provide the added benefit of coverage and can include growth factors that promote wound healing. Alternatively, an allograft can be utilized to cover wounds that have a healthy, granulating tissue base and an adequate blood supply [4]. Primary closure with or without the aid of an incisional negative pressure wound therapy (iNPWT) device is sufficient for some patients [10]. A retrospective analysis of a cohort of patients managed with primary perineal wound closure combined with 5 days of iNPWT after APR, found that these patients were less likely to have perineal surgical site infection (SSI) than those with gauze dressing alone ($p = 0.04$) [11]. However, other studies have shown that primary closure may lead to a higher risk of perineal herniation after APR [7]. Moreover, no significant cost-savings benefit has been observed in management healing by secondary intention versus primary closure [12].

Perineal reconstruction with a myocutaneous flap after APR may have significant benefits over primary closure. While at least one study has reported that flap reconstruction ($p = 0.03$) may be associated with higher rates of delayed wound healing after APR ($p = 0.03$) [13], multiple meta-analyses have demonstrated a reduction in total, and major perineal wound complications when compared to primary closure [14, 15]. Still, it should be noted that a flap-based reconstruction can prolong operation time, which may not be ideal for high-risk patients, especially where time under anesthesia is a concern.

Axial pattern flaps (Fig. 13.1), based on known, constant vessels have been traditionally utilized for more complex reconstructions. Over the past few decades, however, there has been a gradual shift toward perforator flaps (arterial branches perforating through fascia or muscle to the skin) (Fig. 13.1) due to the increased versatility in flap design, improved arc of rotation, shorter dissection times, reduced bleeding, decreased pain, preservation of muscle and func-

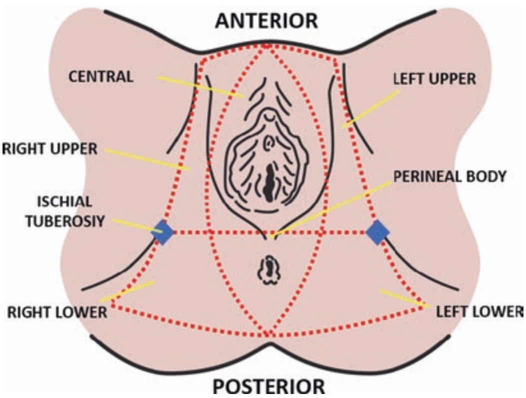


Fig. 13.1 Perineal defects can be described according to the diagram below, including the central upper (urogenital canal) and lower (anal canal), right upper and lower, or left upper and lower regions

tion, minimized contour deformity, and over all decreased donor site morbidity [1, 16–18]. Random pattern perforator flap designs are based on an artery and venae comitantes that perforate the deep fascia to supply an area of tissue. Both axial and random flaps may be employed as local, regional, or free flaps [5].

For the purposes of reconstructive planning, the perineum can be divided into three parts, each with an upper and lower region. With the patient in lithotomy position, a horizontal line is drawn between the ischial tuberosities at the level of the perineal body, dividing the perineum into an upper and lower region. This line is then bisected in the midline by a vertical ellipse, incorporating the urogenital and anal orifices, and separating the right and left regions. In this manner, perineal defects can be described as central upper and lower, right upper and lower, or left upper and lower [5] (Fig. 13.1). Generally, for superficial defects, the groin and/or mons flaps are the ideal donor site for defects in the upper quadrants. Groin and gluteal donor sites are ideal for superficial defects in the lower quadrant. The thigh or abdomen may function as alternative donor sites, especially when greater soft tissue bulk is necessary. Any of the above options can be considered for reconstruction in the central area of the perineum [5], and multiple pedicled perforators can be used when multiple regions are involved [1].

The above rules are based on perforasome theory [1], utilizing perforator flap(s) more proximal to the location of the defect, and should serve as guidelines which may be amended based on the size, shape, and location of the defect, the need for skin coverage, and the minimization of donor site morbidity. Further considerations for donor site selection include the patient's previous medical and surgical history, donor site availability, BMI, aesthetic and functional preferences, and provider expertise. A thorough physical exam should assess the quality of the tissue in each potential donor site, and the patient history should elicit any prior radiation therapy, which has been linked to a significant increase wound complication rates after/following APR [7]. Abdominal, thigh, groin, and gluteal donor sites, offer varying amounts of tissue bulk and perineal resurfacing. The amount of tissue bulk in specific regions can vary between patients, particularly in terms of adipose tissue and lean muscle mass. Low lean muscle mass has been shown to be associated with higher rates of infections following flap-based perineal reconstruction after extirpative procedures [19]. In appropriate candidates, it is important for the plastic surgeon to have multiple donor sites available and prepped, in the event that one or multiple sites are unavailable or are suboptimal for use. In select cases, the reconstruction may be reinforced with the addition of a biologic mesh, although there is minimal evidence to support advantages over non-mesh repair [7, 20–22]. Many algorithmic approaches to pelvic reconstruction have been described and continue to evolve, generally preferring the use of local flaps for smaller perineal defects and the VRAM or alternative regional flaps for larger defects [1, 23–25]. This approach favors the reconstructive elevator, which posits that the optimal functional perineal reconstruction technique is not necessarily the simplest [26].

13.4 Abdominally-Based Reconstruction

See Table 13.1.

Table 13.1 Flap options for perineal reconstruction

Location	Type	Vascular Supply
Abdomen	DIEP,PUP, TRAM, VRAM	Inferior Epigastric Artery
Thigh	ALT, Gracilis, RF, TFL, VL PAP IPAP	Lateral Circumflex Femoral Artery Profunda Femoris Artery Internal Pudendal Artery
Groin	Singapore/IPAP Lotus SCIP	Pudendal Artery Superficial Perineal Artery Superficial Circumflex Iliac Artery
Gluteal	SGAP IGAP GA, Propeller GF	Superior Gluteal Artery Inferior Gluteal Artery Gluteal Arteries Internal Pudendal Artery
Other	LD SA/PA Omental Combination	Thoracodorsal Artery Circumflex Scapular Artery Gastroepiploic Arteries N/A

ALT anterolateral thigh, *DIEP* deep inferior epigastric perforator, *GA* gluteal advancement, *GF* gluteal fold, *IGAP* inferior gluteal artery perforator, *IPAP* internal pudendal artery perforator, *LD* latissimus dorsi, *PA* parascapular artery, *PAP* profunda artery perforator, *RF* rectus femoris, *SA* serratus anterior, *SCIP* superficial circumflex iliac perforator, *SGAP* superior gluteal artery perforator, *TFL* tensor fascia lata, *VL* vastus lateralis

Abdominally-based reconstruction of perineopelvic defects typically involves the rectus abdominis muscle, most commonly the VRAM flap (Fig. 13.2). The VRAM is the primary workhorse flap following ablative surgeries in this region and was modified by Shukla and Hughes in 1984 to have an inferior pedicle and vertical or oblique orientation, for use in reconstruction of perineal defects [27]. Variations of the flap based on perforators can also be utilized, including the muscle-sparing (ms-VRAM) version and the deep inferior epigastric artery perforator (DIEP) flap [28]. The rectus abdominis flap is a well-vascularized, composite soft tissue Mathes/Nahai type III flap, with the dominant blood supply coming from the inferior epigastric artery caudally, and secondary blood supply from the superior epigastric artery cephalad. The VRAM flap is well suited for the deep, irregularly contoured defects that often present after APR [29], and has demonstrated fewer complication rates than other commonly utilized flaps for large defects [30–33]. One study described a protective effect of the VRAM versus non-VRAM perineal reconstruction against the development of pelvic abscesses (10 vs. 26.9%) ($p < 0.01$) and delayed perineal wound healing at 3 months (10.4 vs. 31.5%) ($p < 0.01$), in patients with a history of APR and neoadjuvant radiotherapy [30]. Moreover, when meta-analyzed, patients undergoing perineal reconstruction with a VRAM (35.8%) ($P = 0.041$) had significantly fewer complications than other commonly used flaps, such as the gracilis (43.7%) and gluteal-based flaps (52.9%) [32]. The robust, pedicled blood supply to a large muscle bed makes the VRAM an excellent reconstructive solution in irradiated surgical fields, and the VRAM has been shown to decrease costs associated with perineal wound complications, compared to primary closure [12].

Traditionally, the skin paddles of the VRAM are designed in a plane paramedian to the mid-

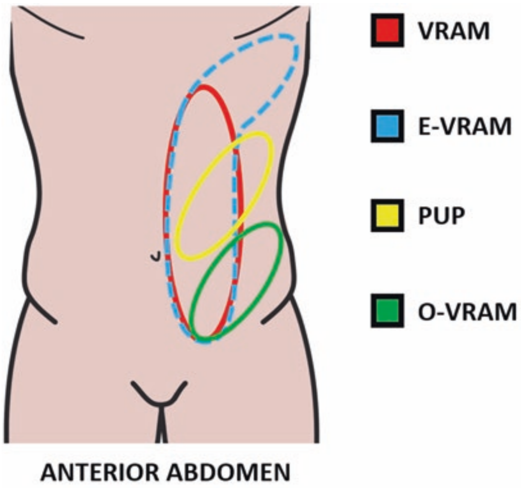


Fig. 13.2 The main abdominally-based, workhorse flap for perineal reconstruction, especially after extirpative procedures, is the vertical rectus abdominis myocutaneous (VRAM) flap that has an extended (E-VRAM), oblique (O-VRAM), and paraumbilical perforator (PUP) variations. This pedicled flap is dissected, tunneled into the pelvis, and delivered through the perineal defect, where it is inset. Due to violation of the rectus sheath, there is a significant risk for ventral hernias after this procedure. The deep inferior epigastric perforator (DIEP) flap can also be utilized by harvesting the skin and subcutaneous tissues of the abdomen, sparing the rectus muscle. *E-VRAM* extended vertical rectus myocutaneous, *VRAM* vertical rectus abdominus myocutaneous, *PUP* periumbilical perforator, *O-VRAM* oblique vertical rectus abdominus

line laparotomy incision, but variations such as an oblique (O-VRAM) (Fig. 13.2) or periumbilical perforator (PUP) (Fig. 13.2) flap orientations are possible. The dissection is carried down to the rectus, which is divided at its cephalic extent. The vascular pedicle of the inferior epigastric vessels is further dissected, and the flap is then mobilized into the pelvis. An extended version of the flap (E-VRAM) (Fig. 13.2) expands superolaterally, incorporating tissue along the inframammary crease and lateral thorax. An extra-abdominal approach to the VRAM flap dissection and insetting has also been described [34], which may be necessary in cases where external beam radiation has left the abdomen with difficult tissue planes. In addition to the soft tissue bulk, the VRAM provides a large skin paddle that can be rotated and inset for durable skin coverage and can even be folded to form a functional epithelial lining in vaginal reconstruction [29]. VRAM reconstruction has been perceived as too bulky by some patients [29], and revision surgeries may be necessary. Violation of the rectus sheath, as a result of VRAM dissection, presents the potential for significant donor site morbidity, especially in obese patient [33], commonly leading to reduced core strength and the potential for ventral herniation. Early reports suggest that minimally invasive robotic dissection of the rectus abdominis muscle can preserve the anterior rectus sheath, reducing the risk of abdominal hernia after flap harvest [35]. More research is necessary to refine such techniques that will play a part in the future of abdominally-based flap harvest. The surgeon can reduce the risk of donor site complications with the use of a muscle-sparing technique or a mesh [36]. The DIEP (Case 13.1) flap spares the muscle and offers an array of flap orientations; however, a lengthy dissection can increase surgery time. The muscle-sparing VRAM has the potential benefit of decreasing morbidity in conjunction with decreasing dissection time [37]. Similarly, the Superficial Inferior Epigastric Perforator (SIEP) flap has also been described as a muscle-sparing, abdominally-based, pedicled flap for perineal reconstruction, especially for use in combination with other flaps when greater skin coverage is necessary [1]. However, its short pedicle can limit the reach of this flap and a lack of muscular bulk makes other flaps more ideal for usage, particularly for extirpative pelvic defects.

13.5 Thigh-Based Reconstruction

Thigh-based flaps can be used for large, complex perineopelvic defects as an alternative to abdominally-based flaps, when abdominal flaps are contraindicated. Thigh-based flaps are primarily used for patients who wish to avoid abdominal scars, when less soft tissue bulk is necessary, in cases of robot-assisted APR, when tumor extirpation does not require laparotomy, when diversion of both urinary and lower gastrointestinal tract/patients requiring two ostomies, and in patients wishing to avoid the morbidity of a VRAM harvest [29, 38]. The availability of fasciocutaneous and myocutaneous perforator variants has increased the utility of these flaps; however, many of the vascular pedicles located outside of the perineum may be subject to distal necrosis [39, 40].

The gracilis (Fig. 13.3) (Cases 13.2, 13.3, and 13.7), described by Becker et al. in 1976, is the main workhorse flap in the thigh and can be harvested as a myocutaneous flap or as the muscle alone. A Mathes/Nahai type II flap, the gracilis is fed primarily by the ascending branch of the medial circumflex femoral artery, branching from the profunda femoris, and secondarily by distal branches of the superficial femoral artery. A less bulky short variant gracilis flap, based off the terminal branch of the obturator artery, has also been described [41]. The vertically oriented skin paddle, along the long axis of the muscle is commonly used, which has the benefit of an optimal, tension-free closure, and a less noticeable donor site. Several other orientations of the skin paddle have been reported, including diagonal, L-shaped, S-shaped or tri-lobed patterns, allowing for larger skin paddles and tissue recruitment. The distal extent of the gracilis skin paddle is prone to poor cutaneous perfusion and epidermolysis or necrosis is common. This area is generally excised prior to flap insetting. The flap may be tunneled by its pedicle under the adductor longus muscle, allowing for a greater reach [42]. This flap can also be raised unilaterally or bilaterally for larger defects requiring greater soft tissue bulk. Bilateral gracilis flaps can be inset in a side-to-side fashion, providing a robust, functional vaginal reconstruction with durable epithelium [29]. The gracilis muscle alone can also be utilized to fill pelvic soft tissue defects, when there is adequate perineal skin for primary closure. In a retrospective analysis of 16 consecutive patients who received neoadjuvant chemoradiation therapy and then underwent APRs (ten with concomitant

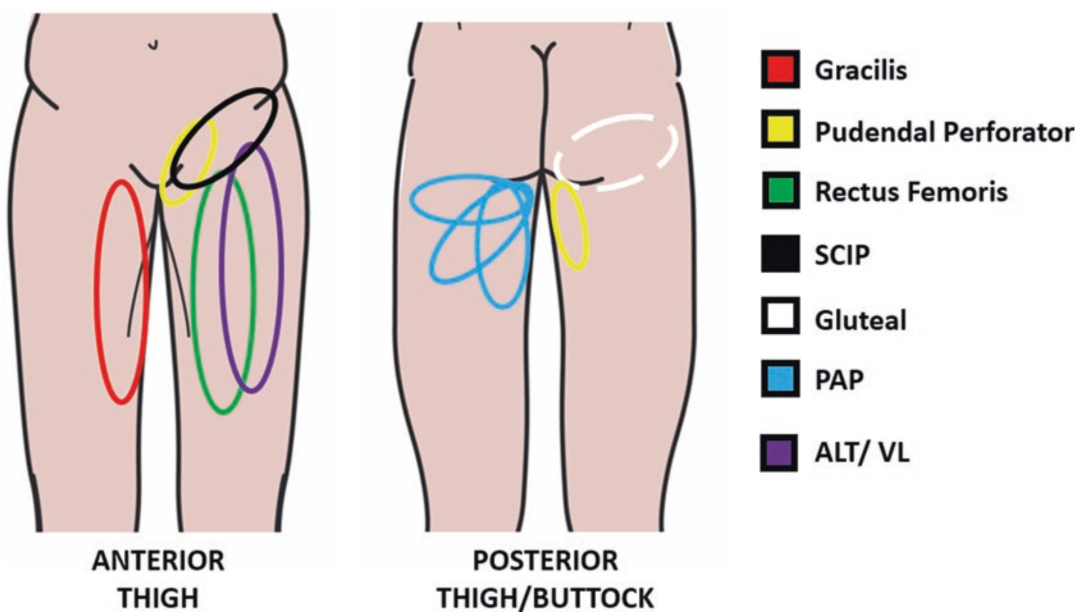


Fig. 13.3 Local and regional thigh-based, perineal and groin flap options for pelvic reconstruction. *ALT* anterolateral thigh, *PAP* profunda artery perforator, *SCIP* superficial circumflex iliac perforator, *VL* vastus lateralis

pelvic exenterations), empty space ablation with gracilis muscle flaps (six bilateral flaps), and primary skin closure, only one patient experienced a major wound separation, which was managed conservatively. No patients required operative debridement. Three patients had minor wound separations and no perineal hernias or gross skin dehiscence was noted [38].

A host of other perforator options are available in the anterior and posterior thigh for perineopelvic reconstruction. The anterolateral thigh (ALT) flap (Fig. 13.3) (Cases 13.4, 13.5, 13.6 and 13.7) was first described by Song in 1984 [43] and has been utilized for perineal reconstruction since 1992 [44]. The ALT is perfused most commonly by perforators from the descending branch of the lateral circumflex femoral artery. The ALT can be raised as a fasciocutaneous, myocutaneous, or adipofascial flap. In patients that might pose a healing risk, the sartorius muscle can be rotated as a flap to protect the vasculature in a "sartorial switch" [45]. The ALT flap offers long vascular pedicle and good arc of rotation allowing for a tension-free flap insetting, which may be extended further by including distal perforator(s), ligating the arterial branch to the rectus femoris (RF) when an adequate secondary blood supply has been confirmed, and/or tunneling the flap below RF and sartorius, the course of which can vary depending on the location of the recipient site [46]. A study by Tamai et al. demonstrated that the ALT can reach as far as the umbilicus in up to a third of patients studied [47]. The ALT is a reliable option for perineopelvic reconstruction with broad applicability, providing both soft tissue bulk and skin for resurfacing, and is increasingly used in conjunction with the RF and VRAM [48–50]. Thigh muscles, such as the RF (Fig. 13.4), vastus lateralis (VL) (Fig. 13.3), or tensor fascia lata (TFL) can be included, based on reconstructive needs, or raised on their own for empty space obliteration. High BMI patients with pelvic empty space fill requirements and no significant skin coverage requirement can consider a VL muscle-only variant of the pedicled ALT flap with primary perineal skin closure over the muscle flap. The ALT flap may also be harvested as a free flap and can include a sensory component when indicated. A single center, retrospective review of 19 consecutive patients who underwent ALT or VRAM flap reconstruction for perineal defects secondary to extirpative procedures found no flap failures and no significant differences in the rate of bleeding, hematoma, infection, or necrosis at 183 days follow-up [51].

Perforator-based flaps, such as the profunda artery perforator (PAP) (Fig. 13.4), supplied by posteromedial perforators of profunda artery, have also been used for thigh-based perineal reconstruction. The PAP flap has a robust blood supply and recruits a large amount of skin, removes the concern for abdominal wall hernias associated with abdominally-based flaps [52]. The consistent vascular anat-

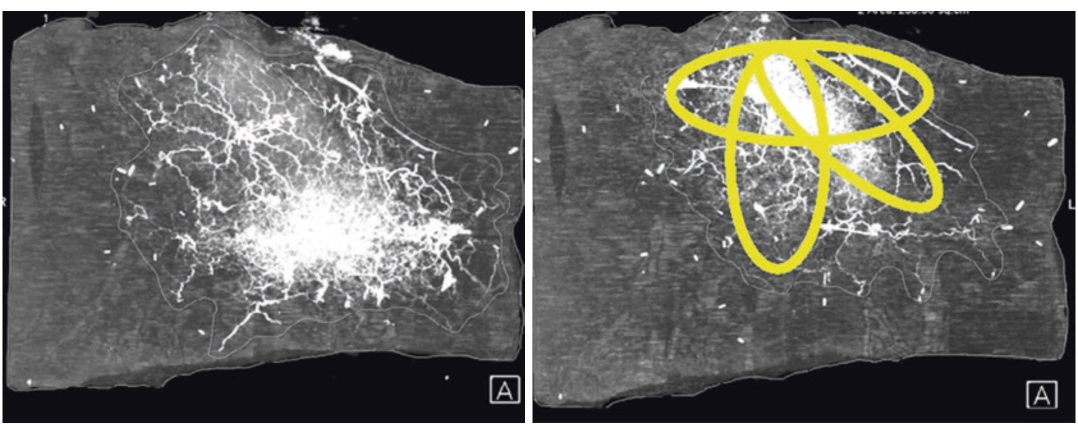


Fig. 13.4 Anatomical study using 3D-rendered computed tomographic angiography to demonstrate the vascular territory of the profunda artery perforasome in a human cadaver. Proximal is superior and distal is inferior in these images. The large perforasome allows for various flap modification and orientations (yellow ellipses)

omy, long pedicle, and multiple perforators (Fig. 13.4) allow for versatility of flap design and ease of flap harvesting and transfer [53]. Bilateral PAP flaps can also be harvested, for larger defects.

A drawback of thigh-based flaps is the potential for deep venous thromboembolism (DVT), particularly in the limb involving the donor site. In a study of 126 patients who underwent unilateral lower extremity flap harvest for abdominal or perineal reconstruction for an oncologic defect, 9% developed deep venous thromboses in one or both legs, and had a tenfold higher odds of venous thromboembolism when compared to 60 comorbidity-matched controls who did not have flap reconstruction (OR: 10.64; CI: 95%, 1.11–102.34; $p = 0.041$) [54]. Patient mobility status and other risks for DVT should be considered when assessing the suitability of donor sites for perineal reconstruction. Early postoperative ambulation should be encouraged when possible to minimize this risk.

13.6 Groin- and Gluteal-Based Reconstruction

13.6.1 Pudendal Flaps

The mainstay of groin-based flaps is the Singapore fasciocutaneous flap, a Mathes/Nahai type I flap, based on the internal pudendal artery (IPA) and its perforators (Fig. 13.3) (Cases 13.8 and 13.9). The flap was first described by Wee and Joseph in 1989 and is noted for a relative ease of dissection and reliable blood supply [29]. Cadaveric studies highlighting consistent circulation of the internal pudendal artery perforators (IPAP) feeding the groin, gluteal fold, and thigh regions have led to wide use of these flaps in perineal reconstruction [24, 55–59]. Freestyle flaps, where a shape is superimposed upon the skin perforator region, have also gained popularity for reconstruction in the perineum [60]. Flaps based in the groin tend to be more favorable for the resurfacing of superficial perineal defects [29], but may also offer some soft tissue bulk for small- to moderate-sized defects in the perineum or ischium [55, 56].

The perineal region was first divided into anterior and posterior regions by Marchot in 1889 [5] (Fig. 13.2). Later studies by Salmon in 1936, and Taylor and Palmer in 1987, gave detailed accounts of angiosomes within the region [61, 62]. The rich blood supply in the perineum arises from branches of the femoral and internal iliac arteries to form circles of anastomoses around the urogenital and anal orifice [5], offering multiple perforating vessels to use in perineal reconstruction flaps.

The posterior region of the perineum is supplied by the internal pudendal artery (IPA) and branches of the inferior gluteal artery (IGA), while the anterior region is supplied by the superficial and deep external pudendal arteries. The IPA runs deep to the sacrotuberous ligament, toward the ischial tuberosity where it emerges and branches in the direction of the ischiorectal fossa. The first terminal branch of the IPA is the perineal artery that supplies the labia and scrotum. The perineal artery also supplies the perianal region via the medial branch, and the posterior surface of the upper thigh, via the lateral branch. The second terminal branch of the IPA is the clitoral/penile branch. A system of anastomoses from contralateral branches create a rich network of vessels around the perineal orifices and are the bases for perforator flaps within the region.

The anatomical studies by Hashimoto and colleagues went into detail to shed light on the vascular territory of the IPA and its skin perforators, and further inform IPAP flap design and dissection [57, 58]. Perforators branching from the IPA to the perineal skin are typically encountered within the ischiorectal fossa, located in the highly vascular, anatomical triangle formed by ischial tuberosity, coccygeal apex, and scrotum or vaginal orifice (Fig. 13.2) [55]. There are typically 3–5 perforating vessels in this region. Three important landmarks should be identified to aid in surgical dissection. The posterior boundary of the urogenital diaphragm is identified by a line drawn from the ischial tuberosity to the scrotum or vaginal orifice. Similarly, the margin of the gluteal maximus muscle is identified by drawing a line from the ischial tuberosity to the coccygeal apex. Finally, anococcygeal ligament may be identified by drawing a line from the scrotum or vaginal apex to the coccyx.

Starting within the vascular triangle, which contains a high concentration of perforators [55] (Case 13.9), a handheld Doppler may be used to identify audible signals of arterial flow to aid in flap design. This area has a robust vascular network, which according to perforasome theory, links via communicating branches within the adipose layer. The linking vessels spread out over the entire groin and into the gluteal and thigh regions. Preservation of the fatty tissue between the ischiorectal fossa and the flap base can ensure adequate survival and blood flow to the flap, even when much of the skin base has been resected. Because the skin flaps within this region have a direct blood supply from perforating vessels, the flap can be thinned according to flap volume needs [55].

The skin paddles for the IPAP flap are designed in a freestyle fashion, tailored on the unique structural needs of the perineal defect. Perforators can be identified via ultrasonography. Dissection begins in distal portion of the flap toward the vascular pedicles [55]. As the fascia is identified, the flap can continue to be raised in either a suprafascial or subfascial plane, taking care to avoid the region of the ischiorectal fossa, where the fascia dives deep toward the levator ani and sphincter ani muscle [55]. In this area, the fascia may not be found in the usual plane. Perforators are identified within the fatty tissues of the ischiorectal fossa and the soft tissues around the pedicle are cleared with blunt dissection. Prior to inset, adequate length of the pedicle should be ascertained to ensure a tension-free closure [55].

Variations in flap design, based on the IPAP blood supply, include propeller flaps (Type I-1), transposition flaps (Type I-2), and V–Y advancement flaps (Type II). Propeller flaps, such as the lotus flap, described by Yii and Niranjan [63] offer the benefits of multiple axes and greater ease of rotation compared to the other options, especially when the required arc or rotation is greater than 90°. When arrayed together, flap options appear as "petals" in a "lotus flower" configuration (Fig. 13.5). The deep fascia layer can be excluded for increased flap thinness and pliability [64]. This technique can minimize problems with flap reach and dog ear formation around the pedicle. The transposition flap is ideal for rotations less than 90°. Finally, V–Y advancement flap can be designed to encompass a large area of tissue and is suitable for coverage of wide, shallow perineal defects [55]. The Singapore flap can be raised bilaterally for vaginal reconstruction; although, the quality of skin can vary [29]. Moreover, a bilobed flap design may extend the arc of flap rotation for the Singapore flap, improving coverage of deep defects and preserving the unique characteristics of both the middle upper (urogenital) and middle lower (anal) triangles [65].

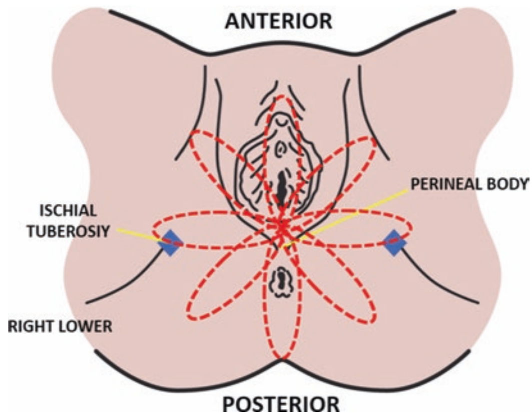


Fig. 13.5 The petals of the lotus flap, when rotated about a focal point, form a "lotus flower" configuration. The lotus flap is ideal for the reconstruction of superficial perineal defects

The superficial circumflex iliac perforator (SCIP) flap (Fig. 13.4) first described by Koshima et al. is another reliable, thin option perineal reconstruction, especially for the scrotum [66]. The flap can be defatted to further minimize the bulk, which is carried out mostly in the distal flap to prevent vascular pedicle injury [67].

Complications after perineal reconstruction with an IPAP flap are uncommon but when they do occur, they typically arise from issues with vascular outflow, the results of which may range from partial to complete flap loss [5]. Patients with comorbidities such as diabetes, obesity, and tobacco use, or those with a history of radiation to the perineal region, are at greatest risk for complications [5]. Small areas of dehiscence can appear in the postoperative period. Small wounds may be left open to heal by secondary intention, while larger wounds with complete flap loss may require the use of a second perforator flap. Therefore, it is important for the reconstructive surgeon not to burn bridges to potential secondary options when designing flaps for the initial procedure. In the case of infection, debridement down to healthy wound margins may be required prior to placement of a second flap [5].

The IPAP flap and its variations are safe and reliable, with significant advantages over alternative donor sites, including minimal donor-site morbidity, preservation of posterior thigh skin, buttock-line integrity, and reliable vascularity [68]. They may be used for defects located throughout the perineopelvic region. Most patients are completely healed by the 3-month mark, even those who have received radiation therapy. Longer healing times may be associated with higher BMI, larger extirpative defects, and the presence of comorbidities [69].

13.6.2 Gluteal Flaps

If a posteriorly located donor site is closest to the defect, gluteal flaps (Fig. 13.3) fed by either the superior gluteal artery or inferior gluteal artery can be used, with the lower border placed along the buttock crease extending laterally toward the greater trochanter. Computed tomographic angiography may be used to identify which artery is optimal for flap design. Gluteal flaps have been expanded upon since first described by Fujino et al. in 1975 [70]. They can be raised as rotational flaps, island flaps, large, frequently bilateral V–Y advancement (Case 13.10), or free flaps and can be muscle-sparing or include part of the gluteus maximus muscle. Perforator variations include the superior gluteal artery perforator (SGAP) flap, which have been advanced by the works of Bloondeel [71] and Allen [72], and the inferior gluteal artery perforator (IGAP) flap, described by Le-Quang [73]. The gluteal fold flap (Case 13.11), as described by Knol et al. [74] in 1997, is another perforator flap that incorporates the skin along to gluteal fold, which can be rotated along an arc, like the lotus flap in groin, for posterior perineal reconstruction. Finally, gluteal propeller flap variants based on internal pudendal artery perforators may also be used to address more superficial perineal defects.

The gluteal flap tends to get easily raised and is reliable, causing only minimal discomfort within the donor site, with the added benefit of concealment of the donor site within the gluteal fold. The gluteal flaps require lateral decubitus patient positioning for unilateral harvest or prone positioning for bilateral harvest, which must be taken into account if other donor sites in the abdomen or thigh are also being planned. Postoperatively, patients should avoid placing direct pressure on the flap for up to 2 weeks to prevent necrosis [36]. Selective use of the gluteal flap in patients with adequate soft tissue, requiring perineal reconstruction, care can yield good results [22, 75]. A portion of the gluteus maximus muscle may be incorporated for added soft tissue bulk with minimal morbidity. One study of a series of six consecutive male patients who underwent neoadjuvant chemoradiotherapy followed by APR and immediate reconstruction with inferior gluteal artery myocutaneous (IGAM) flap demonstrated no donor site morbidity, flap failures, partial flap losses, postoperative hernias, or major wound complications. One high BMI patient did have a superficial breakdown treated with dressings changes alone [76].

13.7 Other Flaps

Sometimes during extirpative procedures, damage can occur to branches of the internal iliac artery, including the superior and the inferior gluteal arteries. Vessel injury during tissue resection may eliminate the gluteal-based flaps from consideration in perineopelvic reconstruction. If other common locoregional flap options in the abdomen, thighs, groin are not available, reconstruction via free tissue transfer may be indicated. The free latissimus dorsi (LD) flap, is a reliable myocutaneous flap based on the thoracodorsal artery, which can provide generous bulk to obliterate the large empty space created extirpative procedures. The free LD flap can be combined with the adjacent serratus anterior (SA) muscle during harvest, providing even more volume [77–80].

For extensive superficial defects, covering a large surface area, as can be found in Fournier's gangrene, extramammary Paget's disease, hidradenitis suppurativa, and in some skin cancers, a combination of multiple flaps can be used to achieve a tension-free closure [1, 81–84]. The authors of a single center retrospective review of 16 patients requiring multiple pedicled perforator flap reconstruction (37 flaps) for extensive perineal defects employed a simple algorithmic approach to perineopelvic reconstruction. The nearest anatomical perforator(s) based on perforasome theory, were utilized. The study reported the achievement of tension-free primary closure in all patients, without partial/total loss or donor site complications, with an average of 2.31 flaps per patient. Temporary flap congestion was reported in three cases and minor wound dehiscence occurred in one patient [1]. Stacked flaps have demonstrated reliability when more tissue is necessary for coverage of extensive defects.

The greater omentum can be used as a pedicled flap for added bulk in filling deep empty spaces. The omentum has a rich blood supply coming from the left and right gastroepiploic arteries, which anastomose to become the gastroepiploic arch, along the greater curvature of the stomach. Depending on omental tissue length, volume, and mobility, which can vary from patient to patient, a piece of omentum may be dissected from the transverse colon and greater curvature of the stomach, then tunneled in a retrocolic or paracolic fashion, to fill pelvic defects created after APR [85]. One disadvantage of this method is the lack of skin for perineal resurfacing. Perineal skin resurfacing is especially important in an irradiated, poorly vascularized wound bed that may be prone to increased wound complications [86–89]. Bisecting the omentum takes advantage of the rich omental blood supply, and can allow the tissue to reach the deeper into the pelvis. It should be noted, however, that omental flaps, used alone or in conjunction with other flaps after APR, have been shown to be associated with significantly higher rates of postoperative organ space infections (10.4% vs. 6.5%, $p = 0.04$) [90] and complications for omental flaps have been reported as high as 20% [88, 89].

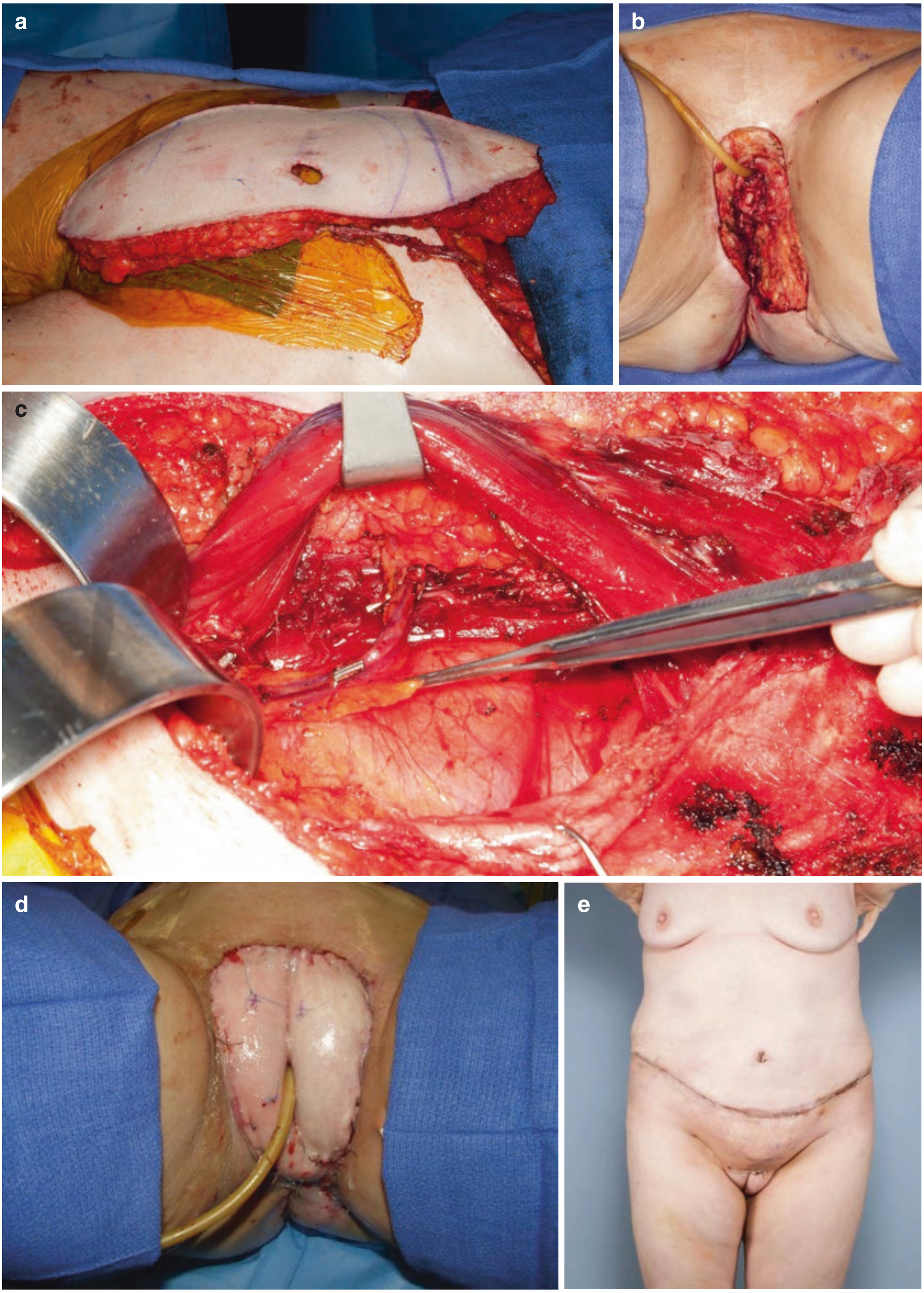
13.8 Conclusion

There are many reconstructive options for perineal and pelvic defects that can be used to optimize the functional and aesthetic outcomes within this region. Advances in perforator flap technique and design, with donor sites in the abdomen, thigh, groin, and gluteal region, make these flaps favorable reconstructive options, that accomplish the goals of adequate skin coverage, appropriate volume requirement, and minimal donor site morbidity. Locoregional perforator flaps such as the IPAP are excellent first options for locoregional reconstruction of smaller perineal defects with robust and well-preserved vascular supply and low complication rate. The VRAM remains the most utilized flap for reconstruction after extirpative perineopelvic procedures. Minimally invasive robotic dissection techniques hold promise for further decreasing donor site morbidity after rectus muscle harvest. Ultimately, multiple potential donor sites can be explored for perineopelvic reconstruction, and appropriate flap selection should consider factors such as soft tissue bulk and skin resurfacing requirements, patient health status, and patient preference. Generally, local flaps can be used to reconstruct more superficial defects and regional/distant flaps can be used to recruit more tissue to fill larger defects.

13.9 Cases

Case 13.1

This case illustrates a 47-year-old female who underwent complete vulvar resection with residual perineal defect for squamous cell carcinoma in combination with neoadjuvant radiation therapy. (**a**) Reconstruction was accomplished with a pedicled deep inferior epigastric perforator (DIEP) flap, containing two periumbilical perforators, and a 15-cm pedicle. (**b**) View of vulvar defect in lithotomy position. The flap was inset within the subcutaneous tissue above the inguinal ligament. (**c**) Intraoperative view of the DIEP flap pedicle with rectus muscle retracted anteriorly. Progressive tension sutures with 2-0 vicryl were used to minimize tension over the pedicle during the final closure. (**d**) The flap was partially bisected into two hemi-flaps, each based on their individual periumbilical perforator to maintain perfusion. This allowed for recreation of the vulva and room for passage of the urethra, as well as complete coverage of the perineal defect. (**e**) An anterior view of the patient, as seen 6 weeks postoperatively, with no signs of infection or wound breakdown.


a
b
c
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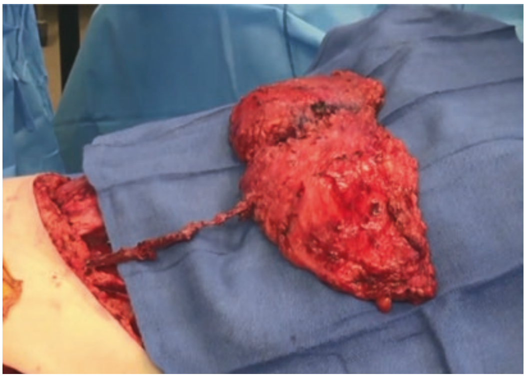
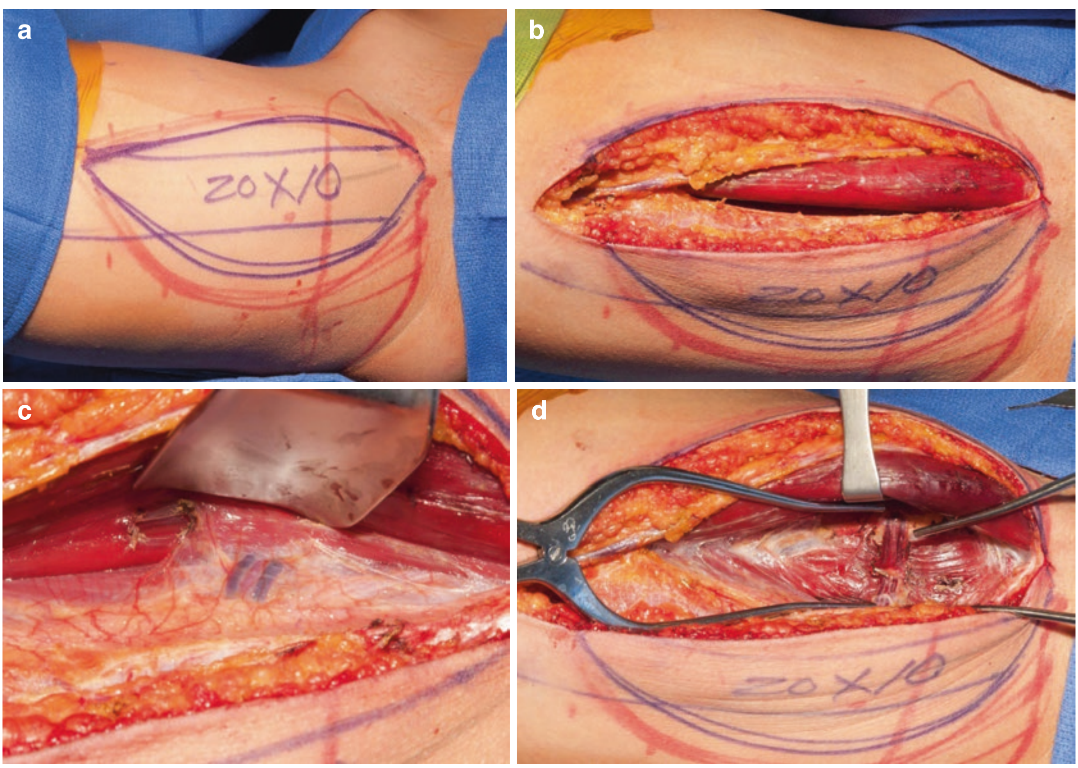
e

Intraoperative view of pedicled deep inferior epigastric perforator (DIEP) flap.



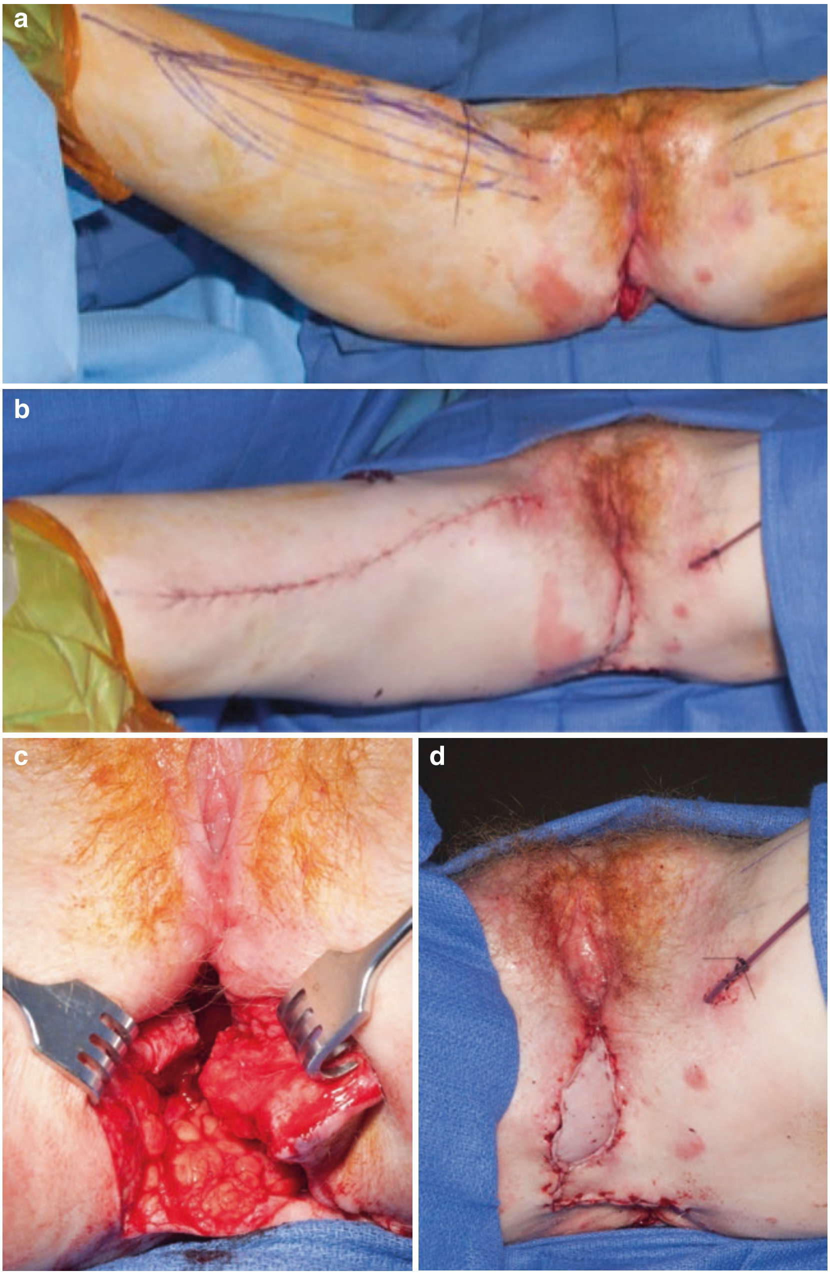
Case 13.2

(**a**) Intraoperative view of skin paddle marking overlying the gracilis muscle. Right is proximal and left is distal. The gracilis muscle can be palpated just posterior and medial to the adductor longus on forced abduction of the thigh. The skin paddle is designed with its anterior border one-third anterior to the anterior border of the gracilis muscle and two-thirds posterior to the posterior border of the gracilis muscle. Vascularity can be maintained by limiting the caudle portion of the flap to not pass the midpoint of the thigh. (**b**) The initial anterior incision with preservation of the greater saphenous veins as well as all collaterals. The adductor longus is identified, with the gracilis lying just lateral to the muscle. (**c**) After retraction of the adductor longus medially, this exposes the medial circumflex femoral artery and two venae comitantes, which represent the pedicle of the gracilis muscle. The septum between the adductor longus and the gracilis is opened in order to provide access for further dissection of the pedicle. (**d**) Two self-retainers provide tension between the adductor longus and gracilis. Dissection of the pedicle continues underneath the adductor longus, and the small muscle branches are dissected away to increase pedicle length. The pedicle is dissected all the way up to its origin at the profunda artery. A circumferential incision is then made along the posterior border of the skin paddle. The gracilis muscle is then detached distally. Tacking sutures are placed between the muscle and the fascia to minimize the shearing forces, and the flap is then ready for tunneling and inset.



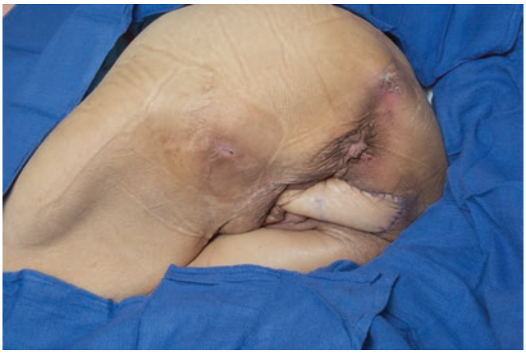
Case 13.3

(**a**) An intraoperative view of a patient in lithotomy position with a significant perineal volume defect and skin deficit. Two gracilis flaps were harvested. One myocutaneous flap from the right thigh was used to provide empty space obliteration and soft tissue coverage and a left thigh-based muscle-only flap was harvested for increased empty space obliteration. Part of the skin paddle from the right gracilis flap was trimmed and inset close the perineal defect. (**b**) The donor site of the right thigh is shown where the gracilis myocutaneous flap was harvested. (**c**) The perineal defect and the transferred, muscle-only gracilis flap are demonstrated here. (**d**) Imaged here is the inset of the myocutaneous flap of the repaired perineal defect, demonstrating good vascularity and minimal tension.



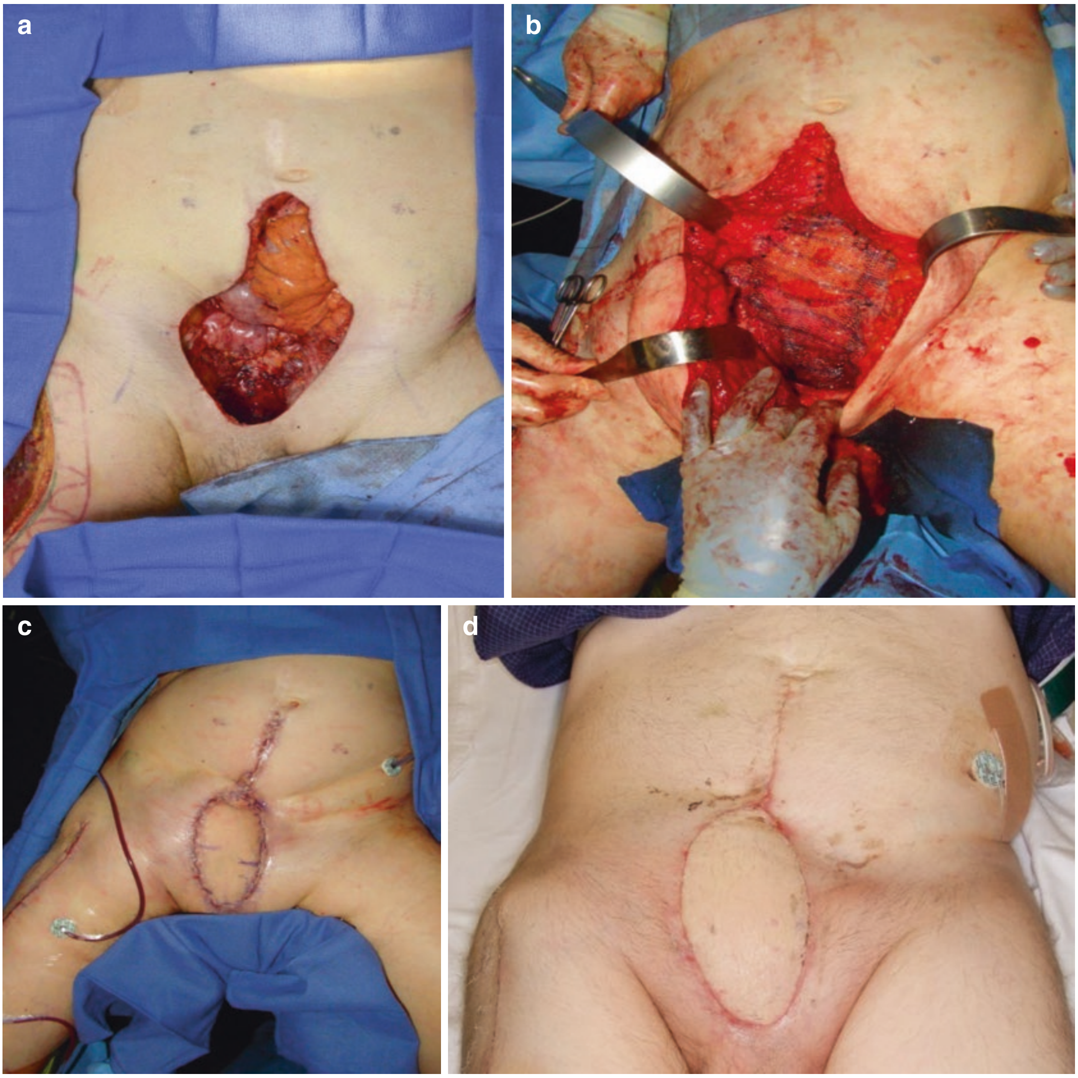
Case 13.4

Intraoperative view of perineal defect after final flap inset. Reconstruction of the perineal defect was accomplished with bilateral gracilis muscle flaps for empty space obliteration of the pelvic floor followed by soft tissue coverage and additional empty space ablation with a pedicled left anterolateral thigh (ALT) flap.

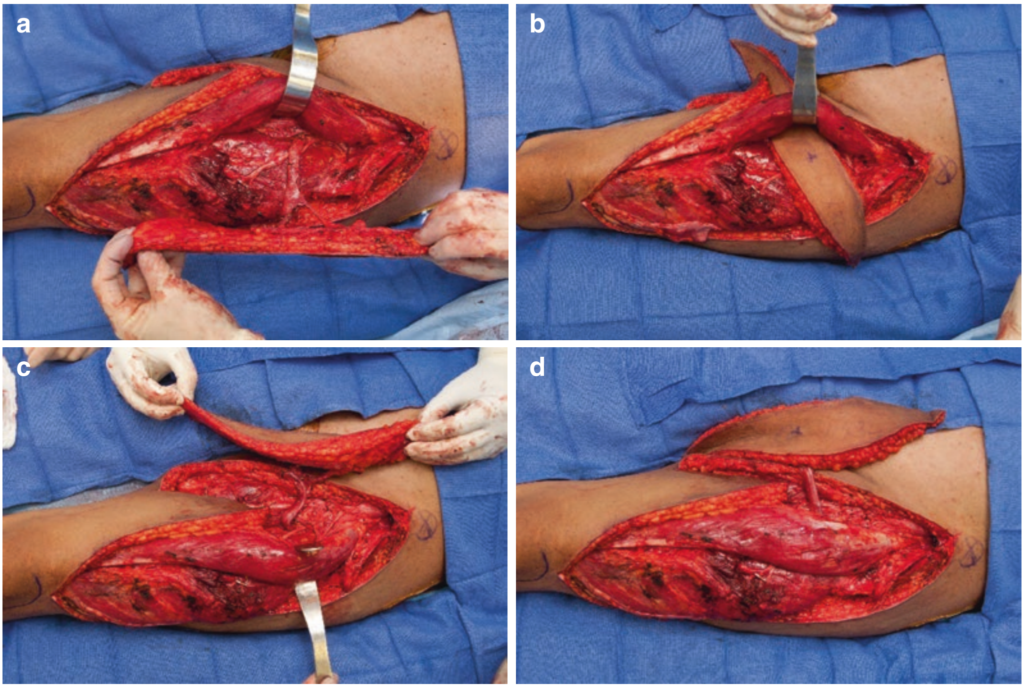


Case 13.5

This is the case of a 56-year-old patient with a history of tumor resection and neoadjuvant radiation for bladder cancer. The pelvic floor and abdominal wall were reconstructed with a pedicled anterolateral thigh (ALT) flap along with the tensor fascia lata (TFL) muscle. (**a**) Intraoperative anterior view of the lower abdominal defect after omentum has been placed to protect the bowels. (**b**) A mesh has been placed as an on-lay to strengthen the repair and minimize the potential for the development of abdominal hernia. (**c**) The flap is inset into the defect under minimal tension with good perfusion. (**d**) Anterior view of the pelvis and lower abdomen at 9 weeks postoperatively.

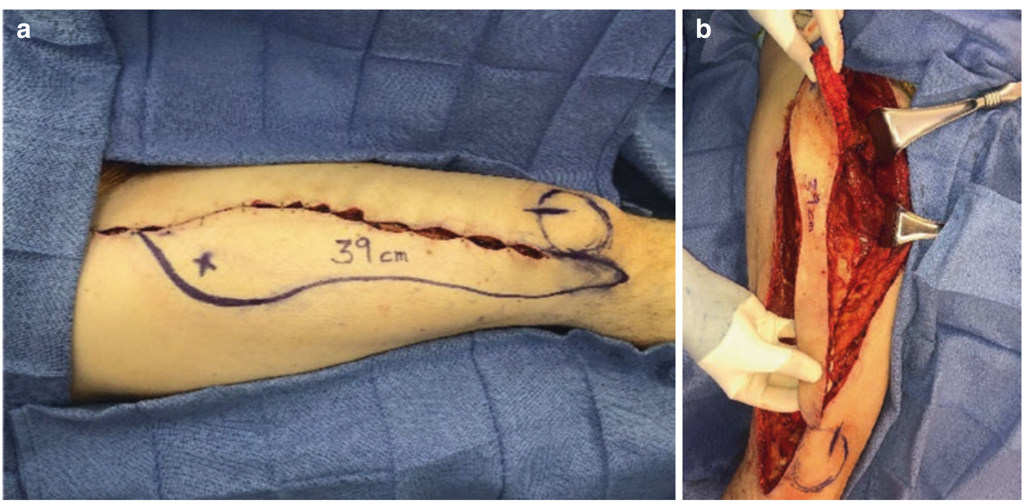


Case 13.6
(**a**) Intraoperative view of a complete pedicled anterolateral thigh flap, with dissection of the pedicle all the way up to the origin, corresponding to the lateral circumflex femoral artery and vein. A Deavar retractor is shown in the top of the image retracting the rectus femoris (RF) muscle medially. Care is taken to preserve the blood supply to the RF by maintaining the dominant proximal vessels and perforators, whenever possible. (**b**) A small window is created under the RF in order to tunnel the ALT flap to improve arc of rotation and flap reach to the perineal defect. (**c**) The ALT flap is transposed under the RF with minimal tension, careful to avoid any shearing forces over the pedicle. (**d**) The transposed flap is shown at the limit of the pedicle, demonstrating the improved reach that can be utilized to cover a myriad of defects involving the groin and the perineum.

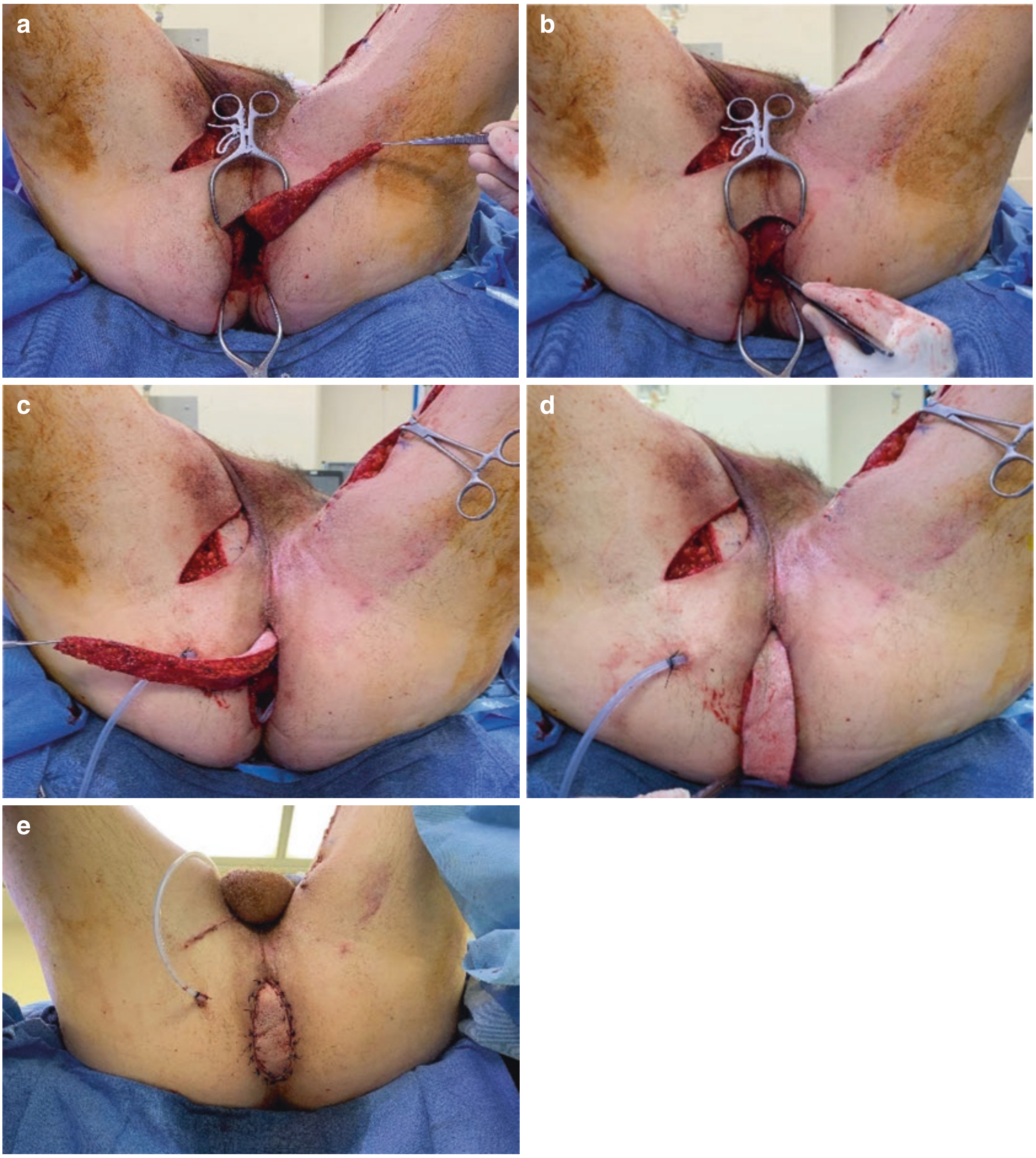


Case 13.7

This is a 57-year-old male patient with anal adenocarcinoma treated with chemotherapy and radiation who subsequently underwent abdominoperineal resection for surgical extirpation. The patient's height was 5 ft 9 in. and his body-mass index was approximately 32. The patient's comorbid conditions are notable for hypertension and obesity. At the completion of the ablative portion of the operation, the resultant defect included pelvic empty space and a skin defect at the perineum. Reconstruction of the pelvic empty space was achieved by utilization of a pedicled left gracilis muscle flap. (**a**, **b**) Reconstruction of the skin defect was performed utilizing a right-pedicled anterolateral thigh fasciocutaneous flap based on a single dominant perforator from the oblique branch of the profunda femoris system.

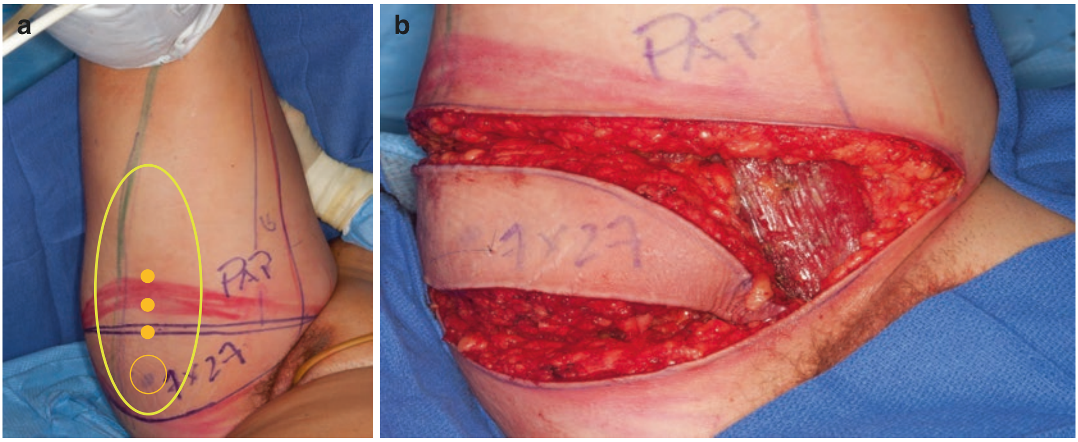


(**a**) The left gracilis muscle flap was tunneled to the defect via the access incision utilized for flap dissection and the right ALT flap was tunneled via a counter incision made at the right groin crease. (**b**) The gracilis flap was inset first to ablate the pelvic space followed by inset of the fasciocutaneous ALT flap for reconstruction of the external skin defect. (**c–e**) The intervening portion of the ALT flap skin paddle that was tunneled was de-epithelialized prior to final tunneling and inset.



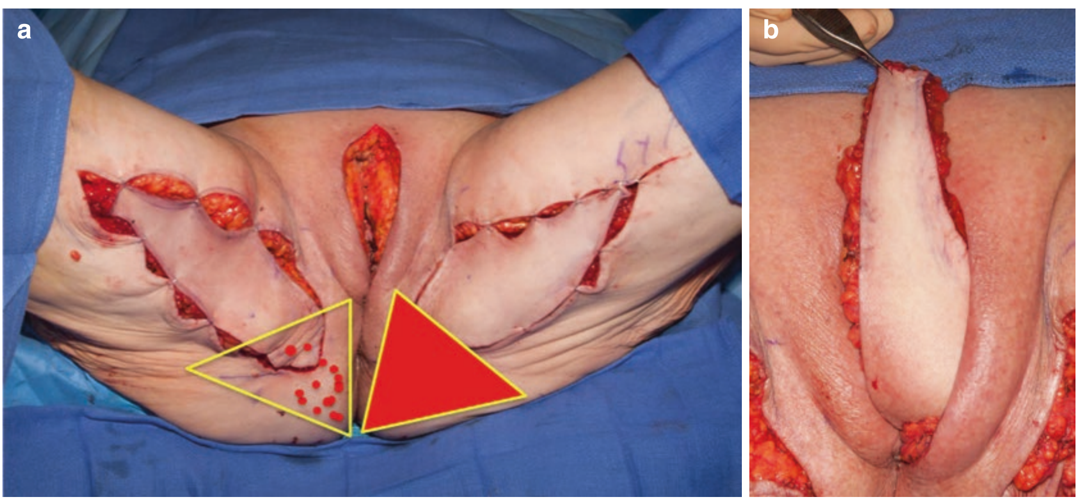
Case 13.8

Intraoperative view of an alternative profunda artery perforator (PAP) flap. (**a**) Multiple perforators (orange dots) allow for versatility of flap design. (**b**) The PAP has a robust blood supply and recruits a large amount of skin, while obviating the concern for abdominal wall hernias associated with abdominally-based flaps.



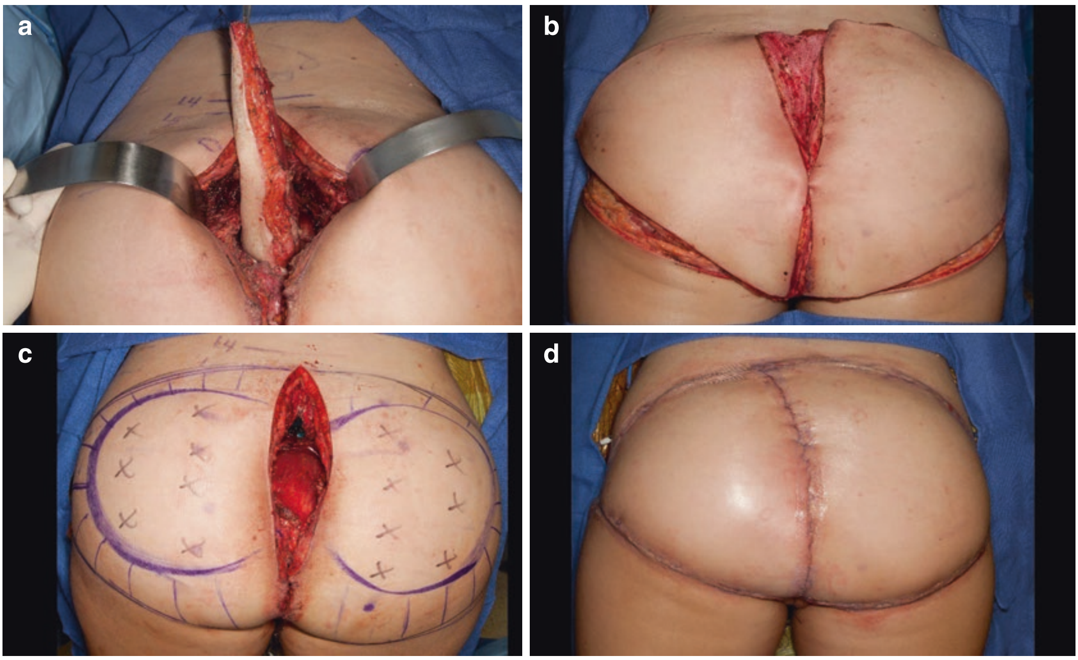
Case 13.9

The image demonstrates the harvest of bilateral internal pudendal artery perforator (IPAP) flaps can be raised to fill pelvic defects after tumor excision. (**a**) With the patient in lithotomy position, bilateral IPAP flaps have been dissected. Note the high density of perforators from the pudendal artery (red dots) within the pudendal triangle (yellow), which create a rich source of potential pedicled perforator flaps for perineal and vulvar defect reconstruction. (**b**) Inset of one of the IPAP flaps provides soft tissue coverage, while internal inset of a de-epithelialized flap is utilized for empty space obliteration.



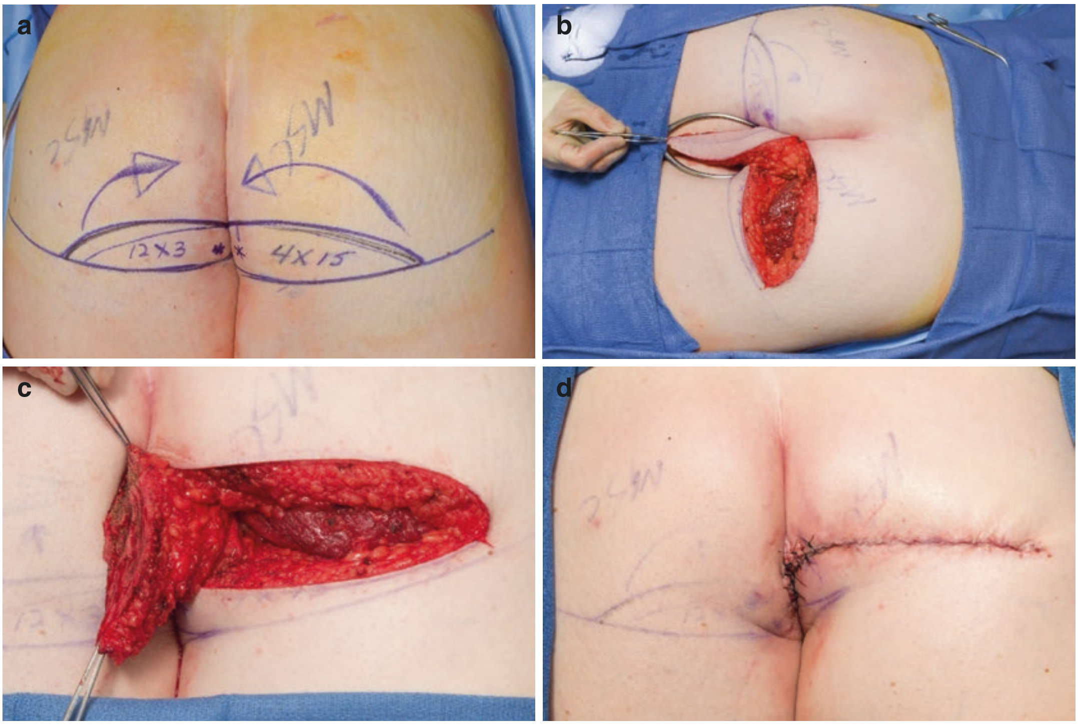
Case 13.10

(**a**) Intraoperative view of a two-staged reconstruction following a sacrectomy with residual pelvic floor volume deficiency. We can see a previously harvested pedicled vertical rectus abdominus myocutaneous (VRAM) flap, which has been passed through the abdomen into the pelvic defect. (**b**) The wide bilateral gluteal V–Y advancement flaps were de-epithelialized centrally for additional empty space obliteration. (**c**) The markings demonstrate the preharvest perforator location of both gluteal advancement flaps. (**d**) Final closure of the bilateral V–Y advancement flaps was obtained with minimal tension.



Case 13.11

Intraoperative view of vaginal reconstruction with a gluteal fold flap incorporating the skin along the gluteal fold. (**a**) The donor site and alternate site are marked prior to reconstruction. (**b**) The flap is raised and rotated into position, demonstrating adequate reach. (**c**) The gluteus muscle remains intact. (**d**) Intraoperative view of closed donor site demonstrates concealment within the gluteal fold.



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14 Omental Flap

Buddhika Thilakarathna, Annamaria Minicozzi, and C. R. Selvasekar

14.1 Introduction

Reconstruction of pelvic and perineal defects is one of the main challenges oncological surgeons face after a major pelvic surgery. It can be either colorectal, urological, or gynecological malignancies where patients end up with not only a large skin defect but also a large soft tissue dead space in the pelvic cavity. Even though perineal and pelvic defects are commonly encountered in an oncological setting, they may also present following trauma and infection (e.g., Fournier's gangrene).

Extensive pelvic exenterative procedures produce a large fixed dead space within the pelvic cavity which leads to accumulation of fluid and blood clots. These accumulations in turn lead to pelvic and perineal problems such as abscess formation, wound dehiscence, and ultimately delayed wound healing leading to increased morbidity and mortality. Furthermore, this dead space might lead to hernias, bowel obstruction, fistulas, and chronic draining sinuses or nonhealing wounds. Studies have shown that the perineal wound dehiscence following standard Abdominoperineal excision of rectum and anus (APER) occurs in 35–65% of patients and rates of delayed healing at 6 months range from 17 to 26% [1]. A recent systemic review demonstrated a rate of perineal wound complication of 31.8% after ELAPE and flap reconstruction [2].

Several techniques are described to mitigate the risk by filling the pelvic defects using biological mesh, V to Y fasciocutaneous flaps, myocutaneous flaps such as the VRAM and gracilis flaps, and pedicled and/or free omental flaps [3]. Almost all techniques, apart from pedicled omental flap, are complicated, resource-intensive, and time-consuming [4].

It is an utmost necessity to consider both functional and aesthetic aspects during these pelvic reconstructions. General prerequisites of adequate reconstruction of pelvic defects include provision of skin cover, well-vascularized tissue to fill the dead space (reducing fluid collection and infection), vulvovaginal reconstruction, and no fecal or urinary contamination. In pelvic cancer management, the use of multimodality treatment ensures cancer is successfully eradicated, but quality of life can be compromised with surgery and radiotherapy certainly exacerbating the pelvic and perineal complications.

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14.2 Role of Omentum After Major Pelvic Surgery

Intrinsic features of omentum make it an ideal tissue which can be used to fill the dead space after a major pelvic surgery. It is easy to harvest and it has a robust blood supply with minimal chances to undergo ischemic necrosis. Once created, the length of the flap is adequate most of the time. Its angiogenic and immunogenic properties help in early healing of perineal wounds. It brings non-irradiated well-vascularized tissue into the pelvic "dead space", preventing formation of seromas and abscess. It also functions as a barrier between the abdominal viscera and pelvic floor, preventing formation of adhesions.

Many studies have shown that most complications due to fixed "dead space" after major pelvic surgery can be avoided by using omentum as a filler in the pelvic space.

Sometimes omental flap alone may not be enough to fill the large dead space in the pelvis, and in those circumstances, combination of omental and myocutaneous or fasciocutaneous flap can be considered.

Omentum can be used as either a pedicled flap or free flap for the purpose of pelvic reconstruction. Pedicled flap is more popular among most surgeons as it does not need fine microvascular surgical technique, and it is very easy to harvest, not time-consuming, and hardly ever suffers an ischemic necrosis.

The length of the pedicle varies with the volume needed to fill the dead space. A pedicled flap based on subsidiary arterial branches can be used for shorter and smaller flaps. Pedicled flaps based on one of three main branches of major gastroepiploic arcades are required for larger and longer flap reconstructions, depending on defect-requirements.

14.3 Preoperative Evaluation and Patient Selection

It is an essential surgical knowledge that thorough preoperative evaluation and appropriate patient selection will lead to a better postoperative outcome. If patient is undergoing a major pelvic surgery and expecting a pelvic reconstructive procedure, it is advisable to undergo preoperative reconstructive evaluation. Patients' questions and expectations need to be addressed during preoperative clinic visits to aid in psychological preparation for this extensive surgery. Each patient should be offered a tailored reconstructive procedure according to the particular defect requirements. Here is some of the important information that can be gathered from such a pre-op evaluation meetings.

- Patient comorbidities
  - Diabetes
  - History of cardiovascular disease
  - Malnutrition
  - History of connective tissue disorders
- Prior surgeries which may interfere with expected reconstructive procedure
  - Previous abdominal or pelvic surgeries—adhesions, omental excision
  - Perineal surgeries
- Adverse social habits such as smoking
- Adverse effects of neoadjuvant treatment including chemotherapy and radiation
- Local area assessment in regards to swelling and lymphoedema, wound tension, and poor perfusion of tissues

After a proper and thorough evaluation of the patient, reconstruction can be planned considering both patient and surgical need. Common factors to be considered in planning are as follows:

- Size, volume, and location of defect
- Patient's ability or inability to heal
- Availability of potential donor sites
- Donor-site evaluation
  - Volume adequacy
  - Flap pedicle viability
  - Possibility of donor site closure (skin, fascial levels)
  - Location of perforators to skin (for flap design)

There is no place for routine preoperative imaging to assess omentum and its blood supply before surgery. Computed tomography has a limited sensitivity in assessing the omental volume.

Sometimes, properly timed contrast studies may give some idea about the celiac axis branches and gastroepiploic arteries. Magnetic resonance imaging has a better sensitivity in assessing the omental volume if required. Abdominal and pelvic cross-sectional imaging which is available as a primary disease workup, may give useful information on dimensions of the pelvic inlet, outlet, and depth of the pre sacrococcygeal space.

The full details of surgery need to be explained to the patient, and a written consent should be obtained for both resectional and reconstructive procedures. Consent should be broad to include various anatomical areas such as thigh, gluteal, and abdominal wall donor-site alternatives, as the omentum alone may not be enough for the intended reconstructive procedure, which may become evident following resection.

14.4 Omental Anatomy

The greater omentum is a derivative of dorsal mesentery, which folds over on itself, forming a blind-ended four-layered pouch and hangs down from the greater curvature of the stomach.

The part that extends from the stomach to the transverse colon is called the gastrocolic omentum, and the apron that extends from transverse colon down is the greater omentum proper. The size of the omentum varies from 300 to 2000 g with a surface area of 300 to 1500 cm^2.

The greater omentum is supplied by the right and left gastroepiploic arteries, which create an arterial arcade along the greater curvature of the stomach. The right gastroepiploic artery is a branch of gastroduodenal artery (branch of common hepatic artery), and the left gastroepiploic artery is a branch of splenic artery and both are branches of the coeliac trunk. The right and left gastroepiploic arteries anastomose within the two layers of the anterior greater omentum along the greater curvature of the stomach and give off three dominant vessels descending from the main arterial arcade. These right, middle, and left omental branches with smaller intervening branches make the greater omentum a highly vascularized tissue. Venous drainage follows the arterial system and drains to the portal venous system. Microscopically, it contains characteristic capillary convolutions (omental glomeruli), which lie directly under the mesothelium.

The greater omentum has an abundant lymphatic network. It plays a major role in containment of intraperitoneal infections and inflammation, hence given the name "abdominal policeman." The leukocytes aggregate in the perivascular area is supported by delicate network of reticular fibers.

One of the well-known capabilities of the omentum is its angiogenic activity adjacent to the structures to which it is applied. This process of neovascularization allows the omentum to provide vascular support to adjacent tissues and assist in healing in ischemic or inflamed tissue-environments.

These features of anatomical location, mobility, greater volume, high vascularity, and its ability to withstand infections and inflammation make the greater omentum an ideal tissue for the obliteration of pelvic dead space after a major pelvic surgery.

14.5 Surgical Procedure

Initially, the omentum is separated from the transverse colon without damaging the transverse mesocolon (Fig. 14.1). Separation of omentum from the transverse colon allows entering into the lesser sac (Fig. 14.2).

Then, the greater omentum is detached from the greater curvature of stomach. The gastroepi-

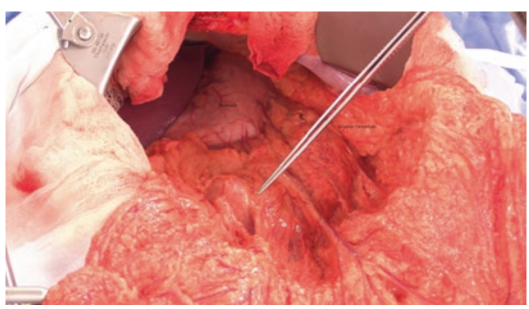

Fig. 14.1 Photograph showing the omentum attached to the stomach and the transverse colon

Fig. 14.2 Omentum released from the transverse colon

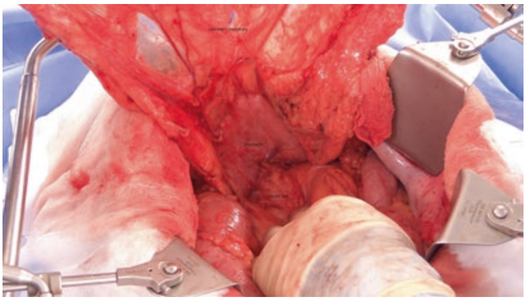

Fig. 14.3 Entering the lesser sac following the complete release of the transverse colon

ploic arterial arch is retained in most of the omental pedicle flap; however, when ischemic omentum is thought be an issue, close gastric dissection is performed allowing for the gastroepiploic arcade to enhance the blood supply of the omentum. The vessels supplying the stomach from the gastroepiploic arch are individually ligated and carefully divided (Figs. 14.3 and 14.4). Strict hemostasis needs to be maintained throughout. The omental pedicle must not be subjected to tension and must be kept moist during the procedure.

Once the omentum is fully mobilized, one of the gastroepiploic arteries needs to be divided to harvest the omental pedicle. Usually, by this point, the length of the omental pedicle is enough to reach the pelvic cavity. Omentum can be lengthened by dividing it according to the anatomical pattern of the vessels if needed, but in general, right gastroepiploic vessels are divided and the omental pedicle is based on the left gastroepiploic vessels. The created flap is then tunneled laterally along the left or right colic gutter to the pelvic floor, where it is attached.

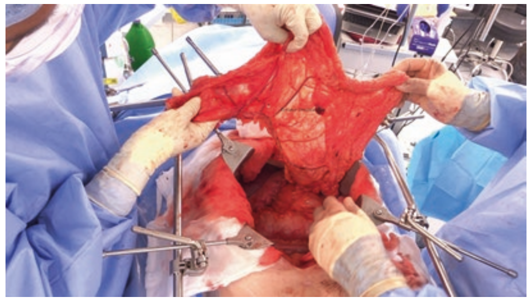

Fig. 14.4 Complete omental flap following division of the right gastroepiploic vessels and close gastric dissection

The presence of adhesions, prior surgical resection, malignancies with peritoneal or omental metastases, and other concomitant abdominal diseases, makes the creation of omental flap difficult and sometimes contraindicated. The volume of the omentum also depends on various factors. With a recent history of weight loss or in extremely thin patients, the omental volume may be insufficient for flap-based reconstruction.

14.6 Postoperative Complications After Pedicled Omental Flap

Pedicled omental flap is generally a robust flap with few possible complications. The recognized complications include ileus, infection, abscess, adhesions, intestinal obstruction, and total necrosis of the omental flap [5].

Interestingly, there are some recent studies reporting the results of omental flap reconstruction giving rise to more complications rather than benefits. One study revealed no beneficial effect of omentoplasty on presacral abscess formation and perineal wound healing after APER, while it increases the likelihood of developing a perineal hernia. These findings do not support the routine use of omentoplasty in abdominoperineal excision for cancer [6, 7]. However, more prospective studies are needed to identify the true value of omental flap in major pelvic surgeries.

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Infantile Hemangiomas of the Perineal Area

15

Holly Boyd and Lea Solman

Key Points

- Infantile hemangiomas (IHs) are the most common vascular tumors of infancy.
- IHs are characterized by an early proliferative phase followed by a plateau and gradual involution.
- The diagnosis of IH is usually made clinically, but radiological imaging and biopsy can aid diagnosis.
- Perineal hemangiomas represent 1% of IH and are more prone to ulceration and thus require early recognition and timely therapy.
- Segmental lumbosacral or perianal IH should prompt early investigation for associated LUMBAR syndrome.
- Treatment with oral or topical beta blockers is the first-line therapy for complicated IH.
- Surgery is now rarely required if treatment to reduce the bulk and/or complications such as ulceration is initiated early.

Infantile hemangiomas (IHs) affect up to 4% of infants and are considered the most common vascular childhood tumors [1]. In the widely accepted International Society for the Study of Vascular Anomalies (ISSVA) classification system, IHs are considered benign vascular tumors [2–4]. IHs proliferate in infancy and eventually involute spontaneously in childhood. They are more common in premature or low birth weight infants, multiple pregnancies (e.g., twins, triplets), white infants, and females [5–7], and placental anomalies are an important risk factor [1].

The pathogenesis of IHs has yet to be fully defined. Dysregulation in both vasculogenesis and angiogenesis has been proposed as mechanisms contributing to neovascularization in IH [8–10]. Intrinsic defects in vascular stem cell regulation involving endothelial progenitor cells or hemangioblasts or extrinsic factors such as hypoxia, developmental field defects, embolization of placental origins due to GLUT-1 protein expression, and the presence of CD133 primitive marker from the fetal cardinal vein speculating fetal vascular origins have been hypothesized [9, 11–15]. On histology, GLUT-1 is consistently expressed on the endothelium of proliferating and involuting lesions confirming the diagnosis and providing a definitive immunohistochemical test for distinguishing IH from other types of vascular tumors and vascular malformations [13].

IHs are typically described by their depth, distribution, and phase of growth. IH can be superficial, deep, or mixed (Fig. 15.1). Superficial hemangiomas are the most common subtype, attributing to approximately 50–60% of cases; deep hemangiomas constitute approximately

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Fig. 15.1 (**a**) Superficial infantile hemangioma, (**b**) mixed infantile hemangioma, (**c**) deep infantile hemangioma

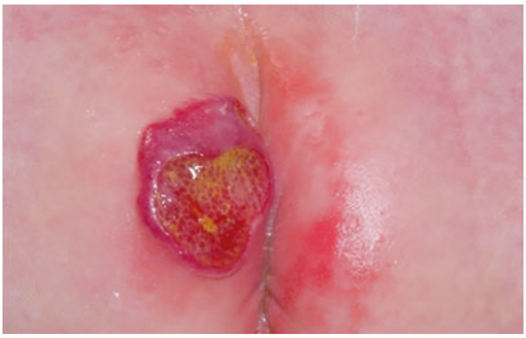

Fig. 15.2 Ulcerated infantile hemangioma

15% of cases and mixed superficial and deep hemangiomas 25–35%. Superficial hemangiomas (previously called strawberry or capillary hemangiomas) appear as bright red papules or plaques and an absence or minimal presence of a subcutaneous component. Deep IHs (previously called cavernous hemangiomas) are identified by skin-colored or a bluish-purple surface due to the deep location or extension. Mixed IHs combine the features of both superficial and deep IHs. Hemangiomas can be confined to a small area and termed focal or localized IH or appear plaque-like and encompass a larger area or region of the body which are classified as segmental IH. Segmental hemangiomas can be associated with underlying malformations which require investigation especially when located on the face, sacrum, or pelvis.

IH can affect any part of the body but have a propensity for the head and neck and typically appear in the first few weeks of life. The natural course of IH is well understood. They are characterized by an early proliferative phase, whereby they grow rapidly in size in the first few months of life with 80% of proliferation being completed by 5 months of age [16, 17]. Slower proliferation can continue up to 12 months or occasionally years. The rapid growth phase is followed by a plateau and gradual involution until the age of 5–10 years [18].

Hemangiomas located in the anogenital area represent about 1% of all IHs but are more prone to ulceration due to irritation from urine, stool, and friction [19]. Ulcerated hemangiomas are painful, may become infected, and tend to heal slowly with topical treatment (Fig. 15.2). Prevention of ulcerating should be the most important aim in these cases. Ulcerated hemangiomas in the anogenital area are treated like other chronic wounds with dressings at every nappy change (nonadherent silicone dressing, covered by alginate and padded by gauze), pain relief, topical or systemic antibiotics, and barrier creams or ointments to prevent contact with urine and stool. Medical and specialist nursing input to support parents in the prevention and correct management of ulceration care as well as psychosocial support is recommended. Treatment with oral propranolol has been shown to be effective for bulky ulcerated hemangiomas; however, care is needed in plaque IH as occasionally the ulceration can be worsened with the use of propranolol. Flat scarring of the skin with hypopigmentation develops following healing of ulcerated hemangiomas. The differential diagnosis of ulcers in the anogenital area includes bacterial or herpetic ulcerations [20].

In rare instances, large lower limb, lumbosacral, and perianal segmental hemangiomas can be associated with anorectal, urinary tract, spine, and external genitalia malformations (Fig. 15.3).

Fig. 15.3 Infantile hemangioma on the sacral area, associated with LUMBAR syndrome

Acronyms of LUMBAR syndrome (lumbosacral/lower body infantile hemangiomas, urogenital anomalies/ulceration, myelopathy, bony deformities, anorectal/arterial anomalies, and renal anomalies) are described to define this association [21]. PELVIS (perineal hemangiomas, external genitalia malformations, lipomyelomeningocele, vesicorenal abnormalities, imperforate anus, and skin tag) [22], and SACRAL syndrome (spinal dysraphism, anogenital, cutaneous anomalies, renal and urologic anomalies, angioma of the lumbosacral region) [23] have also been used and most likely represent a spectrum of the same entity. The most common of these anomalies is a tethered spinal cord, often accompanied by an occult lipomyelomeningocele. Detailed physical examination of the abdomen, pelvis, genitalia, and lower limbs is recommended and MRI spine and pelvis with contrast to evaluate for possible spinal dysraphism or tethered spinal cord [21–24] with other investigations considered based on clinical findings, such as imaging of the renal and urinary tract.

Hemangiomas are usually a clinical diagnosis, and investigations are not routinely indicated. Cytology or histopathology and/or radiological imaging can be helpful in confirming the diagnosis and to define the extent of disease or associated structural anomalies such as renal abnormalities. Ultrasound imaging can help to differentiate hemangiomas from malformations or other tumors making it a good, inexpensive, and minimally invasive screening procedure. Magnetic resonance imaging (MRI) can better delineate the extent of the lesion or of suspected anatomical associations such as PHACES, LUMBAR, and PELVIS syndrome and MRI with gadolinium enhancement is regarded as the best single technique to evaluate vascular anomalies [25–28].

Owing to the spontaneous resolution, the majority of IHs do not need treatment; however, approximately 15% require treatment as a result of complications. Large lesions, segmental morphology, and facial and perineal locations are associated with an increased likelihood of complications [29, 30]. Recently, published consensus guidelines for the treatment of proliferating IH include those associated with breathing or feeding difficulties, visual and auditory obstruction, anatomical distortion or disfigurement, spinal cord compression, and ulceration with subsequent scarring [31]. Due to the rapid growth in the first few months of life, timely and early intervention during the proliferative phase is necessary for optimal outcome.

Since Léauté-Labrèze et al. reported the antiproliferative effect of propranolol on IH in June 2008 [32], this nonselective β-blocker has been the first-line treatment for complex IH, replacing oral corticosteroids, with an aim to induce regression in the proliferative phase. Topical β-blockers such as timolol (0.5% gel-forming solution eye drops) can be used to successfully treat smaller IHs that are not ulcerated [33, 34]. Historically, treatment with corticosteroids, laser, or surgery was often used but now rarely indicated due to the safe and effective treatment with oral or topical β-blockers for most patients [35–37].

In the anogenital area, treatment with timolol is often initiated to help with accelerating the involution of small IH. Ulcerated IH may require treatment with oral propranolol if topical treatment has not been effective, or if it is not appropriate, for example, large lesions that cannot be treated by topical timolol, or rarely, in those associated with spinal cord compression or spinal dysraphism. Due to the rare association of arterial anomalies with anogenital lesions, and the challenges of performing MR angiography in young infants, oral propranolol should be used under close supervision in this group.

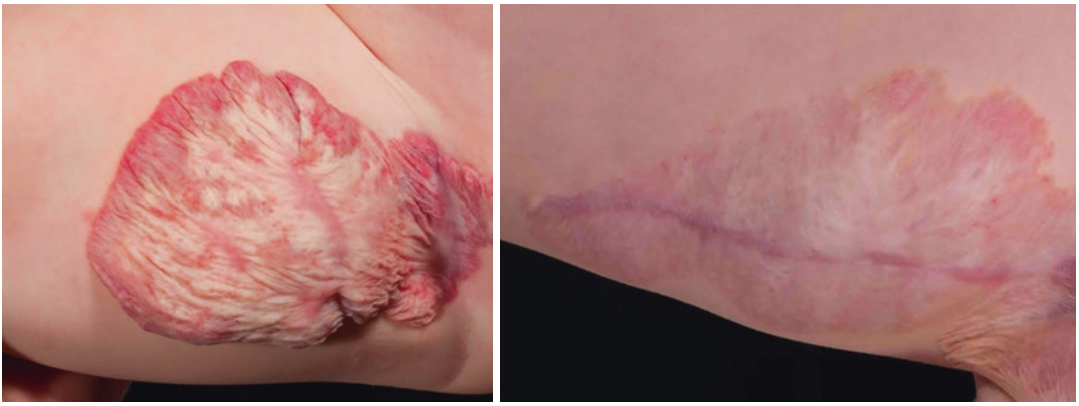

Fig. 15.4 Residual fibrofatty tissue after the involution of the IH on the left and after surgical removal of the bulk on the right

In early childhood, surgical excision of IH is rarely indicated and limited to localized or pedunculated lesions which fail medical therapy and in a location amenable to resection which are likely to resolve with permanent skin changes [38–42]. Following reduction of the size and, or bulk of IH, laser treatment or reconstructive surgery may be considered. Surgery may be useful for removal of residual fibrofatty tissue following involution and reconstruction of damaged structures (Fig. 15.4). Timing is based on the age of the patient, the location and the degree of deformity, and whether the IH is still in the regression phase. Laser therapy most often pulse dye laser (PDL) plays a limited role in treatment but can be successfully used for treatment of hemangioma ulceration; however, data are limited to small case series and case reports [37, 38]. PDL can be used for the treatment of residual erythema and cutaneous telangiectasias which persist following involution [40] but often requires several treatments to achieve optimal results.

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16 Use of Lasers in Perineal Area

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16.1 Introduction

The term LASER stands for light amplification by the stimulated emission of radiation. This concept was first conceived by Albert Einstein and his quantum mechanics theory in 1917; however, medical application of this technology did not develop till 1960s when the invention of the ruby laser won the Nobel Prize for medicine and physiology. With the increasing technological prowess internationally, today there are a myriad of applications for LASER in the various subspecialities of medicine [1]. In this chapter, we will provide a basic introduction to laser technology and explore its use in perineal area.

16.2 Laser Physics

Light energy travels in the form of waves and can be described as a series of particles (photons). This electromagnetic spectrum can be visible or invisible to the naked human eye, depending on its wavelength. Conventional light energy produces photons of different wavelengths, frequency, direction, and amplitude (Fig. 16.1). In contrast, laser light is *monochromatic* (i.e., single wavelength), *collimated* (single direction), and *coherent* (single frequency), giving it its unique properties [2].

An atom at rest has a central nucleus surrounded by orbiting electrons. Excitation of the atom makes the electrons circulate at a higher orbit. This, however, is an unstable state, and in seeking to return to its stable ground state, the atom will emit a photon. The wavelength, frequency, and direction of the photon released can be manipulated by striking an incident photon on an atom already in the excited state. This *stimulated emission of radiation* (i.e., photons) is what forms the basis of laser technology.

The construction of a laser requires three important parts as follows:

1. A source of energy.
2. A lasing medium—solid, liquid, or gas—which defines the wavelength and frequency of photons emitted.
3. A laser tube with mirrors at each end—to reflect the photons of desired wavelength back into the lasing medium, to *amplify* the intensity of light released.

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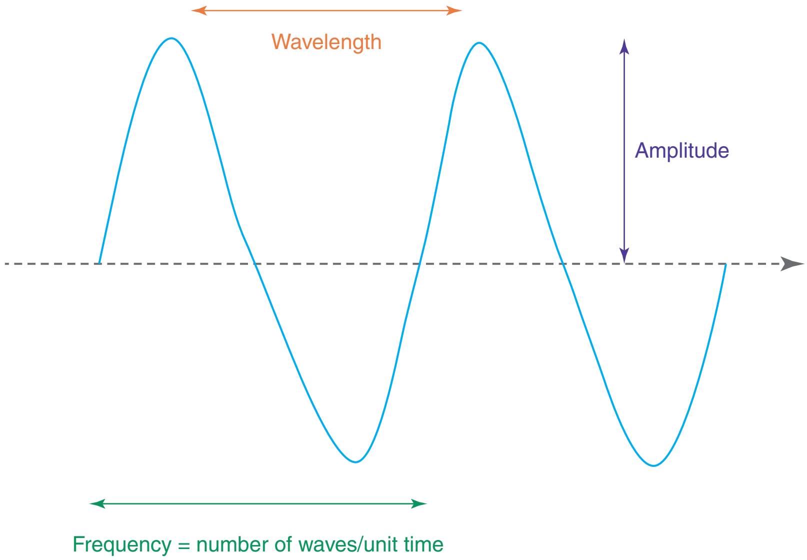

Fig. 16.1 Wave characteristics, showing wavelength, amplitude, and frequency

16.3 Types of Lasers

Lasers can be classified by their wavelength on the electromagnetic spectrum, which in turn depends on the laser medium, as follows:

1. Solid—ruby, neodymium YAG, KTP, erbium YAG, diode, alexandrite.
2. Liquid—yellow dye, green dye.
3. Gas—argon, helium:neon, carbon dioxide, excimer.

Each of these has a specific target chromophore, which determines its medical application (Table 16.1) [3].

Lasers can also be categorized based on their tissue interactions. When a beam strikes any object, it is either reflected, scattered, absorbed, or transmitted. Most of this energy is converted into thermal energy, which is responsible for the desired effects and also the complications of lasers. Depending on how quickly tissues heat up, the surgical effects of lasers can vary between coagulation, denaturation of protein, desiccation, welding, and vaporization.

Lasers can also be generalized (i.e., target all living tissues) or selective (i.e., target specific pigments or chromophores like melanin, oxyhemoglobin, and tattoos). Some lasers can target blood vessels specifically without damage to the surrounding skin, which is referred to as selective photothermolysis. Ablative lasers are of the former generalized category. Of these, we will explore the role of carbon dioxide (CO_2) lasers in detail, in reference to management of perineal pathology.

Table 16.1 Laser classification based on medium

Medium	Laser type	Wavelength	Electromagnetic spectrum	Application
Solid	Ruby	694 nm	Deep red (visible)	Tattoo, hair removal
	Nd:YAG	1064 nm	Near-infrared	Dermatology, ophthalmology, urology, dentistry, gynecology
	KTP	532 nm	Green (visible)	Vascular pigmented lesion, hair removal
	Erbium:YAG	2940 nm	Infrared	Dentistry, benign lesion excisions
	Diode	800–1550 nm	Infrared	PDT, aesthetic applications, surgery, hair removal, physiotherapy
	Alexandrite	755 nm	Near-infrared	Tattoo, hair removal
Liquid	Dye lasers	Dye-dependent, 585/595 nm	Yellow/green (visible)	Vascular lesions, hair removal
Gas	Argon	488/514 nm	Blue/green (visible)	Ophthalmology (glaucoma), dermatology—benign lesions
	CO_2	10,600 nm	Infrared	Ablative surgeries
	Excimer	193–351 nm	Ultraviolet	Ophthalmology, cardiology, dermatology

16.4 Carbon Dioxide (CO_2) Laser

The carbon dioxide laser, first developed in the early 1960s, is an ablative laser that nonspecifically destroys the tissue it is used on. It emits laser light at 10,600 nm wavelength in the infrared spectrum and targets intracellular water (Fig. 16.2). Thermal energy converts this water into steam, thus vaporizing, cutting, or coagulating tissues. If cells are heated above boiling point, it results in explosion of the cellular membrane. Tissue adjacent to the target area can be affected by thermal transmission.

16.4.1 Clinical Indications

The CO_2 laser has widespread applications in colorectal, urogenital, and gynecological pathologies with differing operating modalities of continuous, pulsed, and super-pulsed modes. Typically, these indications include multifocal pathologies of the cervix, vaginal, vulva, and perianal areas [4–10]. Examples include the following:

1. Intraepithelial neoplasias of the lower genital tract (commonly manifestations of human papilloma virus—HPV).
2. Bartholin gland cysts and abscesses.

Fig. 16.2 CO_2 laser machine

3. Condylomata in pregnant women.
4. Excision of vaginal polyps.
5. Chronic anal fissures.
6. Treatment of anal dysplasia.
7. Treatment of refractory anogenital lichen sclerosis.

8. Intra-abdominal use in endometriosis resection.
9. Laparoscopic resection of myomas/adenomyomas.
10. Vulvovaginal rejuvenation and treatment of vaginal atrophy (not FDA approved).

The carbon dioxide laser is preferred over other excisional procedures when precision is required and in cases with large surface areas where pathology requires precision over depth of penetration.

16.4.2 Advantages of CO_2 Laser

The CO_2 laser can also be used in combination with a laparoscope or colposcope, which provides it with increased precision. It is also hemostatic compared to other excisional/ablative modalities. When settings are properly utilized, it results in minimal thermal necrosis. This laser can be frequently used in an outpatient setting, requiring only a local anesthetic. For smaller areas of treatment, the procedure time is very short, facilitating a favorable patient experience. In the intra-abdominal setting with the laparoscope, CO_2 lasers are rapid and precise, which make them safe and predictable.

16.4.3 Contraindications

As for any laser modality, inability to completely visualize target area is a prime contraindication for use of CO_2 laser in the treatment of perineal pathology. These may be due to anatomic considerations (e.g., prolapsing vagina/rectum) or patient factors. Any preoperative histology that indicates infiltrative malignancy does not warrant the use of CO_2 laser for its treatment. Also, sufficient training and experience are required for safe use of the laser delivery system. These contraindications can also be extrapolated to the laparoscopic use of CO_2 lasers; i.e., inability to visualize the site wholly may lead to adjacent organ damage, anatomic findings consistent with neoplasms cannot be treated with this ablative modality, and inadequate training or experience is also a contraindication to its use.

16.4.4 Practical Considerations of Use in Perineal Pathology

Given the unique forte of CO_2 laser use in perineal pathology, below are some practical considerations and tips of performing this procedure, following the patient journey before, during, and after surgery.

16.4.4.1 Preoperative Considerations

Anesthesia for CO_2 laser treatment for the perineal areas can be either local injections or general anesthesia. The anesthetist must always be trained in laser safety protocols and have working core knowledge of the laser system, along with the surgeon and the CO_2 laser operator.

The theater room is set up with clear visible signage. The layout should allow for adequate entry and exit points approved by the trust/hospital—LASER advisor.

Personal protection equipment as per standards is a must—using correct protective eye wear and double filter mask (to avoid inhalation of the laser plume) is mandatory for all staff and for the patient in theater.

The next step is a safety test of machine. The trained laser operator performs a test patch on a wooden stick to ensure the machine is working adequately and there are no faults.

It is advised to have a minimal cohort of people in theater, i.e., the laser operator (who operates the machine and manually overrides the surgeon in case of any emergency), the surgeon (who is trained in use of the laser machine), and an assistant surgeon (who helps in evacuation of the laser plume using a smoke evacuator). Unnecessary movement of staff into and out of theater is strongly discouraged during the procedure.

The desired power density range for adequate ablation or excision of perineal lesions with minimal thermal damage to adjacent areas is 750–2000 W/cm^2 (generally, 10–30 W at a continuous

Fig. 16.3 Laser settings

Fig. 16.4 Operation theater layout with laser operator, surgeon, and assistant. Smoke evacuator and laser machines seen. Patient in lithotomy position with moist drapes surrounding operative site

setting), with an effective beam diameter of 1–2 mm to maximize ablation and haemostasis while minimizing lateral thermal damage (Fig. 16.3). Super-pulse settings also help with reducing risk of thermal injury.

The patient is placed in the lithotomy position, and the surrounding area is draped in damp towels to absorb any misdirected laser beams. A smoke evacuator system is used to remove the vapor plume. This is accomplished most efficiently with a suction catheter (Fig. 16.4).

16.4.4.2 Intraoperative Considerations

Once the safety checks are complete and settings defined, the first step is to perform a punch biopsy of the most suspicious-looking area. This is sent for histopathological testing to reconfirm the absence of an invasive element of neoplasia.

The lesion is then marked to redefine its extent, and care is taken not to stray away from these margins (Fig. 16.5a).

The continuous laser setting, with depth variation, is used for perineal lesion ablation. The start is with a wider beam (superficial depth), and increasingly, the probe is brought closer to the patient to address the thicker/deeper areas of disease.

In order to prevent overheating of a single area, the probe should be moved in a systematic fashion, e.g., slow circles, allowing time for the treated areas to cool. The depth of the laser burn caused on the pathology is continuously assessed, to determine the amount and depth of any further pulses required during the session. At the end of the procedure, the wound is assessed for signs of healthy dermis, which will help in healing (Fig. 16.5b). Haemostasis is achieved once healthy tissue is reached. The local anesthetic may be topped up at this stage for patient comfort postoperatively. The area is then covered with hydrocolloid dressing with or without the use of a topical antibiotic.

16.4.4.3 Postoperative Course and Follow-Up

Management of postoperative pain following ablative laser therapy to external genitalia usually consists of anti-inflammatory agents and rarely narcotics. Some units have considered the use of pregabalin to act as a neuropathic agent. We have not found any benefit in our experience of the latter. Pain of the vulva and perineal area can also be alleviated with use of topical local anesthetic agents.

Perineal hygiene is of utmost importance to facilitate wound healing. Sitz baths, with or without the use of Epsom salts, can help bring relief to patients. They also require at least twice weekly dressing changes to reduce the risk of infection.

Along with general postoperative instructions advising pelvic rest (i.e., no use of tampons/intercourse) and no strenuous activities for 3–5 days, patients should also be given information about “red flag signs” to promptly identify bleeding or infection in the postoperative period.

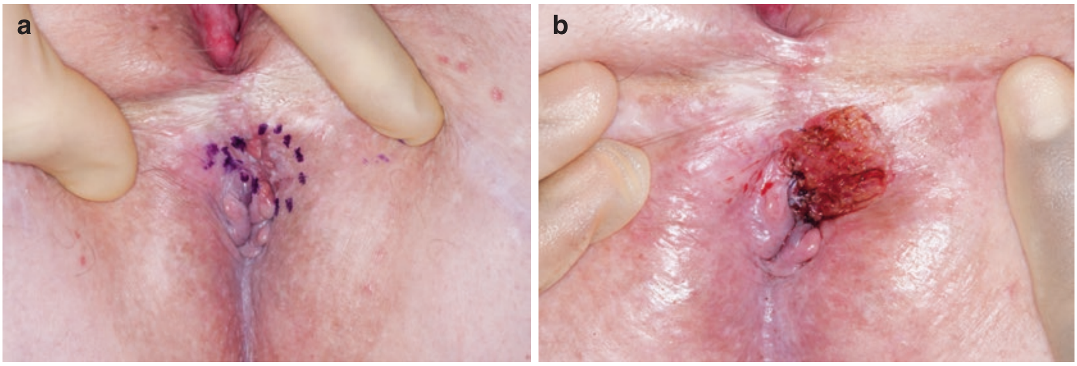

Fig. 16.5 (**a**) Preoperative photograph, showing marking of anal intraepithelial neoplasia (AIN). (**b**) Intraoperative photograph, showing healthy dermal bed postlaser treatment

Follow-up from a surgical perspective with respect to laser therapy is usually in 6–8 weeks, at which time wound healing is assessed, and a plan is formulated for any further treatment sessions if required. Multiple laser therapy sessions are necessary in cases with large areas of pathology or inadequate response to initial treatment, and these are spaced 3–6 months apart (Fig. 16.6a–c).

16.4.5 Outcomes

The use of CO_2 laser in perineal pathology does compare favorably to other excisional techniques in terms of eradication of pathology and recurrence rates. Our experience over the last 5 years in treating intraepithelial neoplasms of the vagina and anus has shown promising results. A majority of patients required only one session of laser treatment. Pain, as we found, was a common complaint postoperatively; however, we have adopted the use of simple analgesia like paracetamol, codeine, and ibuprofen, which has worked well for most patients.

16.4.6 Complications

Ablative CO_2 laser complications include the following

1. Bleeding—immediate or late.
2. Infection.
3. Scarring, including hyperpigmentation.
4. Anesthetic complications—tinnitus, dizziness, rarely seizures, and cardiac arrest.
5. Burns.

Procedures performed on the cervix may result in cervical scarring/stenosis and cervical insufficiency, leading to premature labor or pregnancy loss in the future. It may also be difficult to distinguish infectious discharge from expected postoperative healing in cases of procedures on the cervix, vagina, or vulva. True signs of infection may present as pelvic pain, fever, dyspareunia, prolonged bleeding, or delayed healing. Laser therapy to perianal areas may cause increased scarring, pain on defecation, and adhesions.

It is generally safer to use the pulsed laser light on skin as compared to a continuous beam,

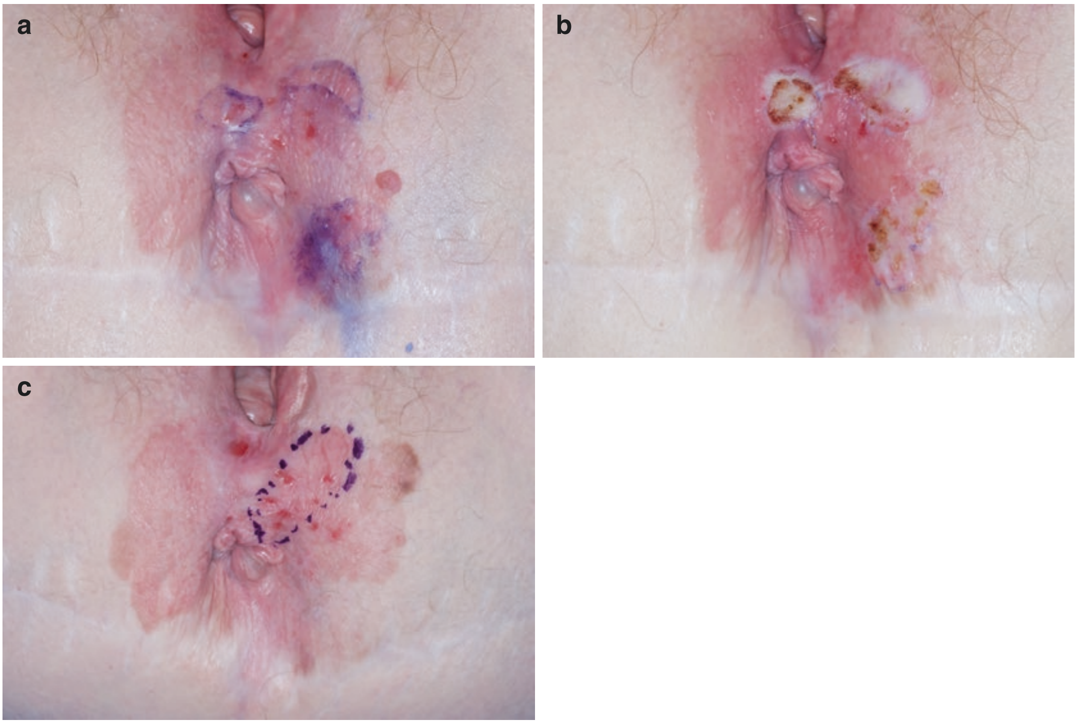

Fig. 16.6 (**a**) Preoperative photograph, showing marking of AIN lesion at first laser session. This patient was planned for multiple laser sessions. (**b**) Intraoperative photograph, showing areas treated with CO_2 laser in the first session. (**c**) Subsequent laser session marking, showing healing and resolution of previously treated AIN areas. The marked areas were treated in the second session

to allow the tissues to cool and minimize transmission of thermal energy to surrounding dermis. Inadvertent injury to the patient or staff in the operating theater may result from unsafe use of the laser delivery system, causing accidental burns. Fires are also a serious risk, especially when used around flammable materials like alcohol skin preps, oxygen cylinders, curtains, and drapes. Laser safety is therefore an absolute requirement for deployment of laser therapy.

16.5 Conclusion

In a rapidly evolving era of technology and innovation, lasers are an important modality to learn and master as a minimally invasive solution to a myriad of pathologies. Although its use is widespread, there are very specific indications for the use of laser in the perineal area. With emerging evidence in areas of HPV-related disease and long-term effects of vaccination, the niche role of the ablative CO_2 laser in the management of these diseases may evolve. It is imperative for the laser operator/surgeon to have thorough knowledge and training of laser delivery, equipment handling, settings, and safety protocols for optimum results and successful outcomes.

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Complications Following Perineal Surgery and Perineal Reconstruction

17

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17.1 Introduction

The role of plastic and reconstructive surgery in the management of challenging perineal defects is crucial [1]. Regardless of the etiology of defects, several requirements have to be met, including the need for cutaneous coverage, internal lining, obliteration of often irradiated dead space, prevention of herniation, preservation of sphincters, and overall satisfactory aesthetic and functional outcome. All the above criteria can be met with facilitation of well-vascularized tissue transfers, as discussed thoroughly in previous chapters.

In the present chapter, we will focus on complications associated with these challenging operations. We will mainly focus on the perineum-specific complications, as flap-specific donor-site complications have been thoroughly discussed in previous chapters. Furthermore, intra-abdominal complications associated with pelvic and perineal surgery for colorectal disease, such as postoperative ileus, bowel obstruction, stoma complications, enteroperineal fistula, and perineal hernia are discussed later in this chapter.

Extensive perineal resections account for creation of large dead space that can accumulate fluid with high bacterial load, predisposing to wound infections. Moreover, due to the anatomical location of the perineum, direct pressure on the wound increases the chances for ischemia and necrosis of already poorly vascularized tissue [2]. Previous irradiation, malnutrition, sepsis, cancer, and comorbidities pose an even higher risk in the postoperative period for patients undergoing perineal reconstructions [3]. All abbreviations used in the following paragraphs can be synopsized in Table 17.1.

Table 17.1 Abbreviations

ALT	Anterolateral thigh (flap)
APR	Abdominoperineal resection (of rectum)
ASA	American Society of Anesthesiologists (grade)
BMI	Body mass index
COPD	Chronic obstructive pulmonary disease
CT	Computerized tomography
ELAPE	Extralevator abdominoperineal excision
IGAP	Inferior gluteal artery perforator (flap)
SSI	Surgical site infection
TPE	Total pelvic exenteration
VAC	Vacuum-assisted closure
VRAM	Vertical rectus abdominis musculocutaneous (flap)

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17.2 Types of Complications

As in all reconstructive cases, complications can occur at the donor and recipient sites. Flap complications include venous congestion or vascular compromise, partial or total failure [4]. A series of different perineal-specific complications are reported in the international literature. These are commonly classified as minor and major. Minor complications would include superficial skin infections, simple wound breakdowns, seroma, cellulitis, and suture abscesses (Fig. 17.1). Major complications include deeper abscesses, sepsis, partial or complete dehiscence, hematomas, pelvic herniation, and chronic fistulas—sinuses [5] (Fig. 17.2).

Fig. 17.1 Superficial wound breakdown after bilateral V–Y fasciocutaneous flaps

Fig. 17.2 Complete dehiscence following vulvar reconstruction with pedicled ALT flap

In addition, intra-abdominal complications can occur after Abdomino-Perineal Resection (Traditional APR or ELAPE) or exenterative surgery, which are major colorectal resections required to treat rectal and anal cancers or IBD cases. The more common surgical complications associated with pelvic and perineal surgery are postoperative ileus, bowel obstruction, stoma complications, enteroperineal fistula, and perineal hernia.

17.3 Predictors and Risk Factors for Complications

With an analysis of 8999 patients undergoing APR of the rectum, Althumairi et al. [6] identified the main risk factors for developing complications. African American race, ASA score ≥4, BMI ≥35, and weight loss were found to be the most significant factors for developing a deep SSI. ASA ≥4, history of COPD, smoking, and BMI ≥35 were seen to be the main risk factors for developing a wound dehiscence. In other similar studies, poor nutritional status in the form of hypoalbuminemia, smoking, neo-adjuvant chemotherapy, and diabetes was found to be predictors of delayed healing and wound complications [6, 7]. The effect on neo-adjuvant radiotherapy has been repeatedly highlighted in the literature and it has been suggested that not only can increase wound complication rates by 25–60% [8–11], but also the chances for perineal hernias [11, 12]. Finally, the operative technique and the indication for surgery alone (rectal or anal cancer vs. ulcerative colitis) are strong risk factors for perineal wound complications [13]. Indeed, our own clinical experience suggests that such risk factors play a major role in predicting higher complication rates in sub-groups of patients with above mentioned comorbidities, particularly previous irradiation and higher BMI (Table 17.2).

Table 17.2 Risk factors

General	Neo-adjuvant treatments, low albumin, diabetes, pathology, cancer stage ≥III
Deep SSI	Race, ASA ≥4, BMI ≥35, weight loss
Dehiscence	ASA ≥4, BMI ≥35, COPD, smoking

Patients who have been diagnosed with aggressive disease and local invasion require extensive perineal surgery. It has been shown that these patients are statistically associated with higher comorbidity and increased chances for wound complications [7]. However, flap reconstruction does not seem to statistically increase overall complication rates, total and effective cost compared to nonflap patients [7]. Another contributing factor to higher complication rates, often overlooked, is secondary reconstruction in patients who developed local recurrence after they already had perineal reconstruction +/− radiotherapy years ago. These cases are particularly challenging as previous scars limit the blood supply to already radiotherapy-damaged local tissues. Under these circumstances, correct choice of flap is crucial for reconstructive outcome.

17.4 Musculocutaneous Flap Reconstruction

The systematic review and meta-analysis of Devulapalli et al. [14] (2015) suggested that perineal reconstruction with muscle flaps following APR and/or TPE is associated with statistically less total perineal complications compared with primary closure (16.7–64.7% vs. 29–72.2% and mean 34.5% vs. 51.9%). For the muscle group, major complications ranged from 0 to 16.7% (mean 8.4%) versus the primary closure group with ranges of 15.3–60% (mean 25.3%). Minor and abdominal wall complications, as well reoperation rates were not found to be statistically significant. Davidge et al. reported minor complications in 23%, major in 17%, abdominal wound complications in 10%, 5% reoperation rate, and 10% readmission rate in their series of 52 flaps following APR and/or TPE [3].

Muscle flap reconstruction specifically after an APR is combined with overall perineal wound complications ranging from 13 to 50%, flap necrosis from 0 to 13%, and donor-site complications from 8 to 29% [15]. In the series of Choudry et al. [16] (20 flaps after an APR), the overall reported major complications were 30%, and 20% incidence of wound dehiscence (Fig. 17.3a, b).

A systematic review on the perineal reconstruction for an ELAPE (2013) with musculocutaneous flaps (VRAM, gracilis, and gluteal muscle flaps) reported minor complications in 29.4%, major complications in 19.4%, and perineal hernias in 0%. The primary closure groups were associated with 17.1, 6.4, and 1.2% of these complications, respectively. The same review suggested that the VRAM flap is associated with higher risk for abdominal wall hernia and therefore mesh repair might be required [5].

Looking deeper into the VRAM flap complications, in a series of 100 perineal reconstructions following TPE, the major donor-site complications were found in 6% and the major perineal complications in 11%, mainly in the form of partial dehiscence, while in 2% there was a total flap necrosis in the series of Horch et al. [17]. The authors highlighted that cancer-stage above III and irradiation increased the presence of perineal complications. Sagebiel

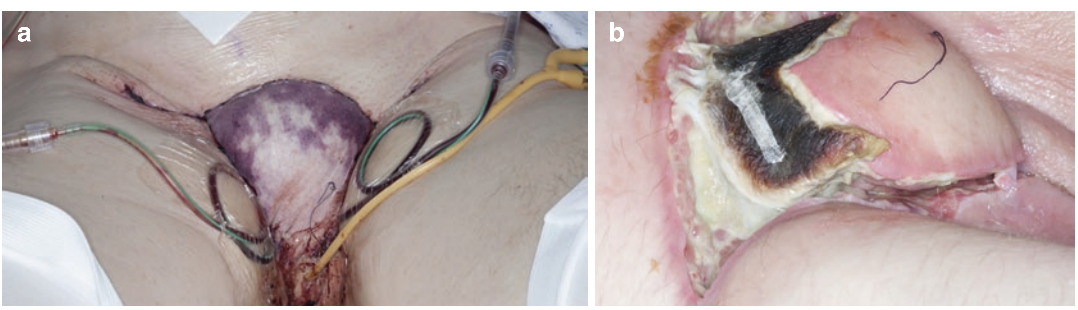

Fig. 17.3 (**a**) Partial flap necrosis following reconstruction with musculocutaneous VRAM flap. (**b**) The same flap few weeks later presenting with complete dehiscence, requiring debridement and V.A.C. application

et al. [4] reported perineal dehiscence 9% in their VRAM series. Nisar et al. [18] reported a 5% chance for developing abdominal wound dehiscence and 5.5% for herniation. Finally, Butler et al. [19] showed that the use of VRAM flap for perineal reconstruction of patients who had initially radiotherapy treatment, followed by an APR, reduced perineal abscesses to 9%, and major perineal dehiscence to 9% (while in the primary closure group, the chances were 37% and 30% respectively). From the practical point of view, abdominal-based flaps have a major advantage in partially obliterating pelvic opening, unlike gluteal or thigh flaps, which cannot reach that far once raised from their respective donor-sites. However, in patients with long and narrow pelvis and relatively short inferior epigastric pedicle, there may be additional stretch on the vascular pedicle and thrombosis as a result. In these patients, larger skin island (usually oblique) may be necessary, to circumvent the above issue, as flap-reach may be limited otherwise.

17.5 Fasciocutaneous and Perforator Flaps

The advances of laparoscopic surgery in combination with the reported perineal and donor-site complications, as mentioned above, reduced gradually the popularity of the use of the VRAM flap while increasing the use of fasciocutaneous gluteal-based flaps [20]. Hainsworth et al. (40 IGAP flaps for APR and/or TPE) reported 10% minor and 10% major complications, 0% flap necrosis, and 5% perineal hernias. Hellinga et al. [21] reported experience around the use of lotus petal flap using the Clavien–Dindo classification (137 flaps). About 30.1% of the patients had no complications and 51.7% of the subjects developed grade I–II complications and required no or minimal intervention. About 18.3% developed a grade IIIb, requiring debridement in theater. Donor-site complications occurred in 14% of the patients.

Hong et al. [22] presented their experience on perineal reconstruction with the use of perforator flaps (37 flaps based on the internal pudendal, medial circumflex, superficial external pudendal, and superficial inferior epigastric artery perforators). They reported 2.7% minor wound complications, no donor site complications, and 100% flap survival.

Winterton et al. [23] published a large series of 127 gluteal fold flaps for the reconstruction of the perineum, following advanced cancer resection (77 patients). Minor wound complications were found in 29.8% and required management with simple dressings. About 11.6% of patients developed an infection requiring intravenous antibiotics while 9% required initiation of VAC for management of deeper wound dehiscence. Flap success rate was reported at 97.6%, while partial loss and complete flap loss were 1.6% and 0.8%, respectively. A major issue with these flaps is the position of suture line between bilateral flaps in the midline, where most of the pressure is while sitting. As patients would normally loose the protective sensation following a pelvic clearance, central dehiscences are relatively commonly observed, if patient is not fully compliant with the postoperative regime of avoidance to sit directly on the reconstructed area.

17.6 VRAM Versus Thigh Flaps

Nelson et al. [24] in a multivariate analysis in 2009, compared the complication rates in 133 patients undergoing perineal reconstruction with thigh-based flaps and VRAM flaps. The thigh-flap group (ALT, gracilis) presented higher complication rates, with major complications in 42% (vs. 15% of the VRAM group), donor-site cellulitis 26% (vs. 6%), flap cellulitis 21% (vs. 4%), pelvic abscess 32% (vs. 6%), and wound dehiscence in 21% (vs. 5%). The authors favored the immediate use of VRAM flaps due to overall less complications and despite increased abdominal wall morbidity. However, this was contradicted in the literature 5 years later, as the study of Pang et al. [25] did not show statistically significant differences in the rates of the complications reported by the use of the ALT and VRAM flaps for perineal reconstructions. A common chal-

Fig. 17.4 Wound breakdown following ALT flap reconstruction of a vulvar defect

lenge of the ALT-vastus pedicled flap in perineal reconstruction, which can certainly lead to complications, is its limited reach in larger defects in patients with very short thighs. In addition, wider defects would necessitate skin grafting of wider thigh-surface area, which is often associated with prolonged wound healing and unfavorable aesthetic outcomes (Fig. 17.4).

17.7 Omentoplasty

Omental flaps are commonly used by abdominal-colorectal surgeons for closure of the superior pelvic opening, to prevent bowel herniation into pelvis, postpelvic clearance.

Pedicled flaps can be shifted into the presacral area in order to enhance the perineal closure, with very low omental complication rates (such as bleeding, necrosis, and internal herniation) [26]. Combination of muscle flaps with omentoplasty has been associated with decreased dehiscence, flap necrosis, hematoma, perineal abscess, and hernia rates when compared to muscle flaps alone [5].

17.8 Management of Perineal Complications

It becomes apparent that perineal complications following reconstruction of extremely challenging defects are unavoidable. Therefore, prevention is of paramount importance and this would include: meticulous surgical technique, thorough hemostasis, maximum obliteration of dead spaces, usage of suction drainage systems, optimization of diabetic and nutritional status. In that respect high-protein diet is important peri- and postoperatively to facilitate primary wound healing.

Careful management of patients during the first postoperative hours and days is imperative. Following reconstruction of the perineum, supine position and direct pressure on the flap should be avoided for a minimum of 24 h with alternating rotation to sides every 2 h. After that, mobilization (standing or walking) should be allowed, patients' condition permitted, but not sitting directly on the chair for the first—4–5 days [20]. Furthermore, Calotta et al. [27] suggested that with the implementation of enhanced recovery programs, early ambulation can be associated with decreased rate of minor complications and wound dehiscence. Postoperative regime however, varies greatly between different surgeons and different units. In our experience, best results and low dehiscence rates are achieved if patients avoid full pressure on the wound for 6 weeks postoperatively.

Superficial wound breakdown is quite common and requires routine wound care. Similarly, superficial infections can be easily managed with oral antibiotics as per local policies (Fig. 17.5). Over-granulations of the tissue can be managed simply with application of silver nitrate.

Major complications can present in the form of pelvic abscess or deep wound dehiscence.

Fig. 17.5 Superficial infection following V–Y flap reconstruction, requiring management with antibiotics

Patients presenting with fever, signs of sepsis, and pelvic pain will require CT investigation to exclude collection and deep-seated pelvic abscess. CT scan can be diagnostic, but also therapeutic, by inserting drain into the pelvic cavity for drainage. Admission of these patients for the management of sepsis with intravenous antibiotics is required. Chronic fistulas and sinuses will similarly require CT evaluation and often additional reconstructive procedure. Surgeons need to keep an open mind regarding nonhealing and chronic perineal wounds, as this can be associated with tumor recurrences and therefore tissue biopsies might be considered.

Deep wound dehiscence can be managed with combinations of debridement of devitalized tissues with absorbent dressings and packing. This process is well established in the management of chronic perineal wounds. Clinicians need to make sure that their patients are fully aware of the fact that it might take several months of dressing changes before the whole area is completely healed (Fig. 17.6). Common adjuncts used in the management of wound dehiscence are the use of V.A.C., hydrotherapy, enzymatic debridement, and growth factors [13]. It is quite important to highlight the contribution of the tissue viability nursing team during the hospital setting but also the support of the district nursing team in the community in the management of problematic wounds (Fig. 17.7).

The role of V.A.C. in the management of perineal defects has been well proven [28]. It removes excess fluid and products of metabolism, which include bacteria and inflammatory mediators. In this way, it increases the granulation rate, reduces the wound size, and promotes quicker healing. It does not only offer comfort to the patients but also is overall cost-effective.

Fig. 17.6 Bilateral wound breakdowns following V–Y flap reconstruction, requiring long-term management with special dressings

Fig. 17.7 Deep wound dehiscence, requiring debridement and V.A.C application

17.9 Intra-Abdominal Complications

17.9.1 Postoperative Ileus (POI)

Postoperative ileus (POI) is a temporary inhibition of gastrointestinal motility after surgical intervention due to non-mechanical causes and it is a common complication following colon and rectal surgery. Its definition is not standardized and for this reason, there is a large variation in reported incidence of POI.

A systematic review and meta-analysis and RCT and non-RCT studies revealed an incidence of 10% [29, 30], other studies have reported its occurrence in 10–30% of patients following abdominal surgery [31]. Risk factors for development of POI in patients who undergo colorectal surgery have been investigated. The more common risk factors identified including age, ASA 3–4, open surgery, complex surgery, duration of surgical procedure more than 3 h, low hemoglobin and transfusion, administration of high dose of opioids in the postoperative period, and delayed mobilization. POI treatment is conservative and intravenous fluids and NG tube are recommended. Several strategies have been considered to mitigate development of POI or shorten its duration including minimally invasive surgery and multimodal pain management [31, 32].

17.9.2 Small-Bowel Obstruction

Small-bowel obstruction remains one of the most frequent complications after APR, ELAPE, and exenterative surgery. Of particular concern is small-bowel adhesion to the pelvic dead space that causes obstruction, sometimes necessitating laparotomy. The more common procedure to prevent small-bowel obstruction is an omental pedicle flap to fill the pelvic dead space [33]. Ports site, incisional, parastomal or internal hernias are other causes of small-bowel obstruction that can require urgent laparotomy.

17.9.3 Stoma Complications

Permanent colostomy is performed after APR, ELAPE, and posterior exenteration. Permanent colostomy and ileal conduit are fashioned when total pelvic exenteration is required for oncological reason. Stoma complications have a negative impact on patients' quality of life and cause prolonged medical care and occasionally re-operations resulting in increased health care costs.

The more common stoma complications are: retracted stoma, stenosis, prolapse, parastomal hernia (PH), leakage due to poor fitting appliance [macerated skin; skin conditions, i.e., psoriasis, eczema, allergy; ulceration, i.e., pyoderma gangrenosum (Fig. 17.8); bleeding, i.e., granulomas], peristomal skin soreness due to broken skin, dry skin irritation, and chronic papillomatous dermatitis. High output stoma (>1500 mL/24 h) is frequent in patients with ileostomy and less common if colostomy is performed.

PH is the most frequent stoma-related complication (Fig. 17.9). The first colostomy was performed more than 200 years ago [34] and despite the stoma formation being one of the most common operations to treat intestinal conditions, PH is a complication that still reaches unacceptable levels.

Fig. 17.8 Stoma ulceration

Fig. 17.9 Parastomal hernia

Approximately 20,000 and 100,000 new stomas are fashioned annually in the United Kingdom and in the United States, respectively [35, 36].

The rate of PH is more than 50% [37] and is lower after end ileostomy compared with the end colostomy (1.8–28% vs. 10–56%) [38].

The real incidence of PH is probably much higher than published reports due to the short follow-up [39]. Indeed, the diagnostic accuracy for asymptomatic, small or reducible PHs is low [40] when radiological confirmation is not performed [41].

Surgical repair of PH has had unsatisfactory results, whatever technique is used.

The surgery-related causes of PH include size of trephine and weakness of abdominal wall. The ideal diameter of trephine to allow permanent adhesion of the intestine with reduced risk of herniation has never been studied in prospective trials or using homogeneous groups of patients.

There is a variety of ways of creating the trephine: some surgeons would have accurately measured it with a ruler, some would do a crude measurement with fingers, staple devices, and some perform trephine in relation to diameter of bowel [36].

For these reasons, the comparison between the various procedures is difficult.

The functional and anatomical damage of the rectus abdominis muscle in relation to the site of the stoma and to the midline laparotomy is an important surgical risk factor for the occurrence of PH.

Patients who underwent midline laparotomy and simultaneous stoma develop both incisional (IH) and PH hernias with an incidence between 30 and 41% [42, 43].

The risk of PH in patients with history of multiple abdominal surgeries is not known. Multiple laparotomies decreased blood flow to the abdominal wall resulting in fascial ischemia and a higher likelihood of fascial dehiscence and neuropathic pain [44, 45].

A recent retrospective study showed that the rate of PH with a laparoscopic approach is higher than with an open one (40% vs. 12.7%, $P < 0.001$) [46], but the etiology and the pathophysiological mechanisms remain unclear.

The precise position of a transrectal stoma through the rectus muscle, either in a craniocaudal or lateral-medial sense, is a surgical risk factor of PH that is not well documented.

Al-Momani et al. suggested placing the transrectal stoma in more cephalic position, above the arcuate line, where there is the posterior sheath of rectus muscle in order to reduce the incidence of PH [47].

Stephenson et al. describe a novel approach to stoma formation, the lateral rectus abdominis positioned stoma (LRAPS) [48]. The new technique implies that the stoma is made a little more cephalad than usual, the anterior and posterior rectus sheets are only divided horizontally (not vertically) and the rectus muscle is not incised but separated from its sheet by a sharp and blunt dissection and is then retracted medially. With this technique, the rectus muscle is not sacrificed and the risk of injury to the main inferior epigastric vessels is reduced and also the damage to the branches of the thoracic nerves is minimized by the horizontal incision of the rectus sheath. All these details of surgical technique reduce the loss of mechanical strength and paradoxical movement of the abdominal wall and thus reduce the risk of occurrence of PH.

A recent Cochrane review that compares the transrectal stoma with the lateral pararectal stoma did not show a significant difference in terms of the risk of PH [risk ratio (RR) 1.29; 95% confidence interval (CI) 0.79–2.1] [49].

Alongside surgical risk factors for PH, there are those associated with the patient: advanced age, gender, sedentary lifestyles, malnutrition, severe systemic and respiratory diseases, constant increase of intraabdominal pressure associated with obesity, prostatic hypertrophy, and ascites [38], genetic disorders characterized by alterations of collagen (osteogenesis imperfecta, Marfan and Ehlers–Danlos syndrome, congenital dislocation of hip of childhood and polycystic kidney disease) [50], and prolonged and debilitating therapies (chemotherapy, radiotherapy). The changes of the transversalis fascia and of the rectus sheet documented in literature have allowed to explain the etiopathogenesis of inguinal hernia and likewise could contribute to the occurrence of PH [51].

17.9.4 Perineal Hernias

Perineal hernias after APR, ELAPE or exenterative surgery are rarely reported in the literature because of the short follow-up periods of most studies [52]. Perineal hernias usually appear between 6 months and 5 years after surgery and are associated with risk factors such as smoking, chemotherapy, radiotherapy, long mesentery, excision of levator ani, and coccygectomy [53, 54]. These hernias are typically managed conser-

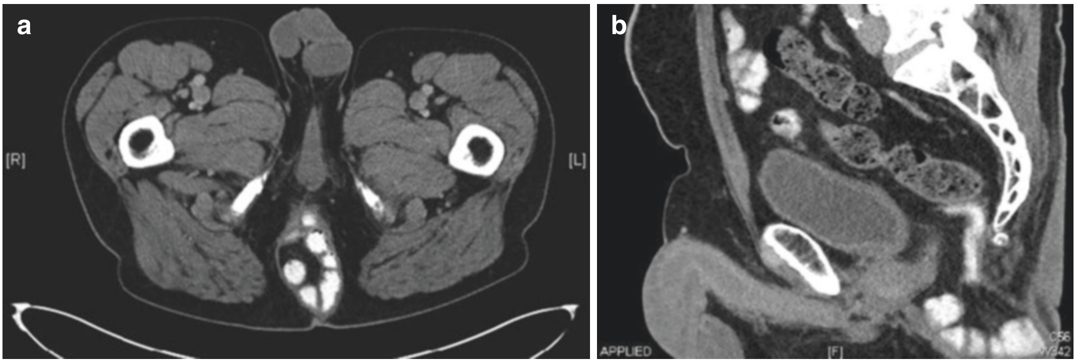

Fig. 17.10 (**a**) Perineal hernia. (**b**) Perineal hernia—APR resection

vatively but should be repaired if there is a significant perineal bowel exposure or obstruction. Our incidence of perineal hernia after exenterative surgery is low and occurred in only four patients with no postoperative perineal complications. The timing of onset of the perineal hernia was 4, 5, 12, and 48 months after surgery. Three of these patients had a primary closure of perineum and only one patient had a perineal reconstruction with gracilis flap and omentoplasty. Figure 17.10a, b shows a perineal hernia diagnosed 1 year after APR resection.

However, these perineal hernias had no impact on the patients' quality of life and no surgical treatment was necessary.

17.9.5 Enteroperineal Fistula

The morbidity associated with the development of enteroperineal fistula is also a major concern. To avoid the occurrence of this complication, it is important to prevent the herniation of small bowel into pelvis using an omental pedicle graft.

17.10 Conclusion

Flap reconstruction of the perineum is challenging and is definitely associated with minor, major, and donor site-related complications. There is a wide range of reported complication rates in the literature, according to the flap selection, the pathology, and the type of perineal surgery performed. Certain risk factors can increase chances for postoperative morbidity as discussed before. While, wound dehiscence and delayed wound healing still remain problematic for both oncological and reconstructive surgeons, there is an absolute agreement around prevention of complications, optimization of patients, careful flap selection, and increased level of perioperative patient care.

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18 Surgical Management of Lower Limb Lymphedema After Pelvic/Perineal Resections

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18.1 Introduction

Damir Kosutic

Lower extremity lymphedema following perineal resections and particularly pelvic clearance and/or inguinal lymphadenectomies is a debilitating complication of cancer treatment.

Condition develops as a result of either surgical or radiotherapy-related damage to lymphatic system, including removal of inguinal and pelvic lymph nodes through groin dissection, ilioinguinal dissection, pelvic clearance or radiotherapy to any of the above mentioned anatomical areas. Patients with lower limb lymphedema often present at advanced stage as a result of lack of knowledge and understanding by various surgical and nonsurgical specialists involved in their initial cancer treatment as well as frequently inadequate access to or lack of organized lymphedema services locally or nationally. They are at significant higher risk for developing cellulitis and sepsis. They often struggle with mobility due to heavy lower limbs, choice of shoes and clothing. Many patients with advanced lower limb lymphedema would also suffer serious psychosocial consequences, social stigma, shame, depression or even being suicidal as their quality of life is significantly and permanently impaired. Up until recently, only conservative treatment measures were available. These include life-long use of compressive garments and MLD (manual lymphatic drainage). Recent years have seen great developments in the field of lymphatic surgery and microsurgery. This has been driven by advances in new technologies and instrumentation required to adequately work-up patients with lymphedema as well as to perform surgical procedures on lymphatic system. Better understand-

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ing of lymphatic system, its anatomy and physiology founded on basic and clinical research coupled with growing experience in surgical treatments for this condition have greatly increased chances of lymphedema patients to deal with their condition and gave a tool to clinicians to offer them treatments not available previously. Over the years, three principal surgical techniques have emerged for treatment of lymphedema patients: (1) Lymphaticovenous anastomosis (LVA), (2) Microvascular free lymph-node transfer, and (3) Liposuction (with or without excisional procedures). It is important to understand that none of these techniques can completely cure lymphedema, however with appropriate patient selection, preoperative planning including advanced lymphatic and microvascular imaging and use of one or combination of these techniques, most patients can benefit from improved quality of life as a result of decrease in volume to their swollen limbs, reduced number of episodes of cellulitis, and or being partially or completely free of compressive garments.

18.2 Lymphaticovenous Anastomosis Technique

Jaume Masia, Gemma Pons, and Cristhian Pomata

The lymphaticovenous anastomosis (LVA) technique for treatment of lower limb lymphedema (LLL) consists of the microsurgical connection between subcutaneous lymphatic vessels and veins to redirect the lymphatic drainage of the limb. Experimental microsurgical LVA was first reported by Jacobson and Suarez [1] and Laine and Howard [2] in the early 1960s. Not long after this, Yamada performed similar experiments in canine models and presented, in 1967, the first clinical application of microsurgical LVA for treatment of LLL [3]. In the 1970s, O'Brien used the same concept and later published his clinical experience in the treatment of secondary obstructive lymphedema of limbs [4]. During the same period, Degni [5] described his method of lymphaticovenous communications for obstructive lymphedema of the lower limbs by performing end-to-side anastomoses into the saphenous vein in the groin.

The work of these pioneers laid the foundation for the development of lymphedema surgery. Later technological innovations gave rise to advances in surgical instruments and intraoperative surgical microscope, which in turn allowed the refinement of microsurgical techniques. As a result of these developments, in the late 1990s, Koshima introduced the concept of super-microsurgery [6, 7], which consists of working with even smaller vascular structures, ranging from 0.3 to 0.8 mm in diameter [8]. This novel discipline marked the beginning of a new era in the field of surgical treatment of lymphedema.

18.2.1 Pathophysiology

LLL secondary to pelvic/perineal resection is a consequence of the interruption of lymphatic drainage, often bilateral and proximal, due to para-aortic, bilateral pelvic or inguinal lymph nodes dissection or irradiation. The main clinical manifestation is distal swelling of the limb due to accumulation of interstitial fluid. Over time, this swelling will affect proximal part of the limb as well. However, degeneration of the lymphatic system will occur from proximal to distal [9]. This concept is of crucial importance for optimal surgical management of secondary LLL.

18.2.2 Indication and Treatment Strategy

The LVA technique is indicated for patients with functional lymphatic channels in the affected lower limb. In subclinical and early stages of LLL, the integrity of the lymphatic system probably remains preserved up to the inguinal region. Therefore, the best approach will be to perform LVA proximal to the interruption to recanalize

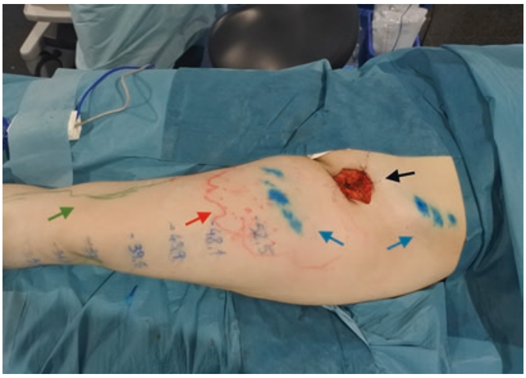


Fig. 18.1 Inguinal approach to perform ELVA technique (black arrow). The green line corresponds to the trajectory of a superficial lymphatic channel detected by preoperative ICG-L (green arrow). The red marking corresponds to the zone of dermal backflow (red arrow). Blue dye injection sites (blue arrow)

lymphatic drainage of the limb. In cases when the interruption of the lymphatic drainage is produced above the inguinal lymph nodes, it is recommended to perform the derivation at the level of the efferent lymphatic vessels. By performing efferent lymphaticovenous anastomosis (ELVA), the intranodal–extranodal mechanism of the inguinal lymph nodes can be preserved (Fig. 18.1) [10].

In advanced stages of LLL, proximal degeneration of the lymphatic system is imminent. As the lymphatic degeneration progresses, the remaining functioning channels will be found increasingly distal to the initial damage. In this context, LVAs should be performed distally, near the area where functioning lymphatic channels are found (Fig. 18.2). It is even advisable to perform a combined approach, consisting of distal LVAs together with proximal functional vascularized lymph tissue transfer.

18.2.3 Diagnostic Imaging Technique

Imaging techniques play an essential role when assessing the lymphatic system structure and functionality in order to determine the most appropriate therapeutic strategy. Indocyanine green lymphography (ICG-L) is the first imaging technique to be performed and the most decisive. It will help to determine the presence or absence of functioning lymphatic channels and whether or not the patient is a candidate for LVA [11].

Fig. 18.2 Distal LVA approach (black arrow). The green line corresponds to the trajectory of superficial lymphatic channels detected by preoperative ICG-L (green arrow). The markings in red correspond to the locations of the most suitable lymphatic channels (red arrows)

Lymphoscintigraphy is the second imaging technique to carry out. It will confirm the diagnosis of LLL and help identify the presence or absence of the major lymphatic collectors, the direction and flow of the lymphatic drainage, and the number of lymph node stations visualized [12].

Once it is decided to proceed with LVA surgery, magnetic resonance lymphangiography (MRL) is performed for preoperative planning [13]. MRL provides a three-dimensional reconstruction of the whole limb, showing both the superficial and the deep lymphatic system. This detailed information will help to preoperatively select the most suitable lymphatic channels for LVA, allowing LVA surgery to be planned more efficiently and precisely [14].

18.2.4 Preoperative Preparation and Surgical Planning

From the third day before LVA surgery, it is essential to prepare the affected limb through complex decongestive therapy. Reducing swelling as much as possible before surgery will allow better preoperative planning and enable LVA surgery to be performed in suitable conditions. To reach this ideal preoperative condition, Godoy's lymph drainage therapy is highly recommended [15].

On the day of surgery, ICG-L is repeated to map and mark the superficial lymphatic system. Simultaneously, the information provided by MRL is transferred to the skin using a tape measure according to previously determined *x*–*y* coordinates (Fig. 18.2). The ideal location to perform the LVA is the most proximal area where the ICG-L and MRL information meet. Second best location for LVA to be performed is the most proximal area of ICG-L markings, followed by the most proximal area of MRL coordinates [14].

18.2.5 Surgical Technique

LVA is generally performed under general anesthesia to avoid patient discomfort in view of the lengthy surgical procedure. The surgery starts by performing the LVA at the points of double coincidence of the ICG-L and MRL assessments. At the selected cutaneous point, a small quantity of local anesthetic with epinephrine is injected to reduce bleeding.

About 2 cm distally to the planned incision, 0.1–0.2 mL of blue patent V dye is injected to allow easier identification and dissection of the lymphatic channels. A 2–3 cm skin incision is performed at the selected points marked in preoperative planning. Under a high magnification microscope, subcutaneous dissection is carried out until a lymphatic vessels and a nearby vein of similar caliber are identified.

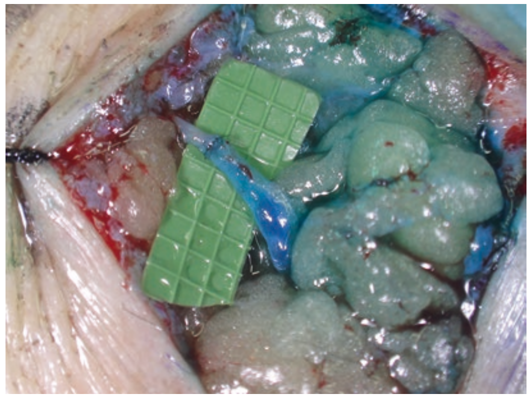


Fig. 18.3 End-to-end LVA

LVA can be performed end-to-end or end-to-side using 11–0 or 12–0 sutures (Fig. 18.3). Veins with intact valves and low back flow are the most suitable ones for LVA. The small diameter of these veins allows caliber-matching with lymphatic vessels [16]. The number of anastomoses needed to provide satisfactory volume reduction is a matter of debate. However, 2–4 LVAs per limb are recommended [17]. The incisions are closed with 4–0 nylon sutures.

18.2.6 Postoperative Care

The affected extremity should be elevated, and the amount of activity should be limited. In the immediate postoperative period, lymphatic drainage should be started. Mechanical lymphatic drainage using the RA Godoy device is highly recommended [18]. Alternatively, gentle massage can be performed every 2 h in the distal area where LVAs were performed to stimulate drainage. Compression tights are used from postoperative day 1.

Patients are generally discharged on postoperative day 4. On day 15, the patient may start swimming or attend a water rehabilitation program three times a week for 1 year. Manual lymphatic drainage is indicated for 1 year, twice a week during the first 6 months, and once a week during the second 6 months.

18.2.7 Outcomes

Most studies report the efficacy of LVAs for LLL treatment, demonstrating positive outcomes based on limb circumference, volume changes, and subjective clinical improvement in long-term follow-up. The reduction rate after LVA surgery for LLL ranges between 51.1 and 63.8%, with better results in mild to moderate LLL. An important decrease in episodes of infection is also reported [19]. However, in advanced stages of LLL, the reduction in limb size reduction after LVA surgery is variable. Since fat hypertrophy will already be present, a combined two-stage approach should be considered. This should consist first of LVA surgery, followed by a liposuction procedure in a second intervention.

18.3 Vascularized Lymph Node Transfer Technique

Marco Pappalardo and Ming-Huei Cheng

As lymphatic microsurgery has become more common, vascularized lymph node (VLN) transfer has recently become a mainstay surgical procedure in the treatment of lymphedema, with many authors demonstrating promising results [20–22]. In this physiologic surgical treatment, a group of healthy functional lymph nodes and perinodal tissue are transferred as a free flap from a donor site to the affected limb either to a proximal anatomical (orthotopic) site or into a distal nonanatomic (heterotopic) location to restore lymphatic drainage function [22, 23].

VLN transfer was first described in a rat animal model by Shesol in 1979 [24] and clinically by Clodius in 1982 [25]. O'Brien and Chen [26] in 1990 described the free VLN transfer for the treatment of lymphedema in a canine model. Hence, Tobbia et al. [27] in their animal study showed that the restoration of lymphatic function in VLN transfer was significantly better than in the transferred avascular lymph nodes. Becker et al. [28] reported a series of vascularized groin lymph node (VGLN) flap transfers to axilla or elbow for postmastectomy lymphedema with promising outcomes in 2006. Cheng's group reported anatomic and clinical application of the groin and submental lymph node flap for upper and lower extremity lymphedema transferred into the distal limb since 2009 [23, 29, 30]. Following these initial reports, increasing popularity of this innovative technique has led many international groups to use VLN transfer to treat extremity lymphedema. Despite the accepted benefits reported with VLN flaps, few reports of iatrogenic donor-site lymphedema have been documented [31–33]. Several donor sites of VLN flaps including supraclavicular [34–36], lateral thoracic, submental [30], omental [37], and jejunal/mesenteric [38] have been described in an attempt to avoid the potential risk of donor-site lymphedema with promising results reported. Systematic reviews have demonstrated the efficacy of VLN transfer for secondary extremity lymphedema [39–42]. Carl et al. in their systematic review of ten studies including 185 patients treated with VLN transfer, 111 for upper extremity, and 74 for lower extremity lymphedema showed an average of 39.5% limb circumference reduction and 26.4% volume reduction [41]. With increasing reports of successful outcomes with VLN transfer, some aspects of this lymphatic microsurgery became more understood. Several controversies remain regarding the functional mechanism of VLN transfer, its surgical indication and timing of surgery, VLN flaps donor site, recipient sites (i.e., orthotopic or heterotopic), and postoperative evaluation [20, 43]. This chapter was to report the mechanism, indications, donor-site selection, and outcomes of VLN flap transfer for treating lower extremity lymphedema postpelvic lymph nodes dissection.

18.3.1 Mechanism of Action of VLN Transfer

The mechanism of action by which VLN transfer improves lymphedema had been investigated and proved as the mainly lymphatic pump mechanism with the assistance of lymphangiogenesis [24, 44]. VLN transfer promotes the clearance of static lymphatic fluid from an area without functioning lymph nodes and lymphatics. Functioning VLN transfer depends on an intact perfusion to drive the adequate extracellular fluid filtration and the regenerative capability.

The lymphangiogenesis is the formation of new lymphatic collateral pathways between the transferred lymph nodes and the recipient site to restore outflow. This mechanism occurs via lymphatic growth factor secretion, in particular vascular endothelial growth factor C (VEGF-C), produced by the transplanted lymph nodes [45]. Authors supporting this theory emphasized the crucial role of scar tissue release, opening the obstructed lymphatic channels and replacing it with well-vascularized lymph node flap in an anatomically proximal location. Experimental studies showed that lymphatic vessels have an important capacity to regenerate following the tissue transfer by neolymphatic regeneration and lymphovenous shunting at the flap level [46, 47]. However, this theory does not consider the progressive changes observed in lymphedematous limbs [48]. A previous experimental study demonstrated that the progression of the disease produced a less effective outcomes for the anatomic–orthotopic location of the transferred VLN flap [24]. The scarring and stenosis of the local lymphatics and the insufficient distal lymphatic pump did not allow the progression of lymph from distal to proximal site resulting in increased swelling of the distal limb.

The proposed theory for VLN transfer is that the lymph node flap functions as a "vacuum-like" or "pump," shunting the lymph from the local environment into the lymph nodes and directing it into the venous system through the natural formation of new intrinsic lymphovenous connections [23, 29, 30, 44]. The distal placement of the flap in non-anatomic-heterotopic locations of lymphedematous limbs allows for optimal clearance of the lymphedema fluid into the venous system ("catchment effect") as most of the lymph is accumulated in the distal extremity due to the "gravity effect". This mechanism has been confirmed in both animal and human studies following the injection of ICG in the peripheral dermis or directly into the transferred lymph node by direct visualization of the fluorescence in the recipient vein after completion of pedicle anastomosis [44]. A study investigating the long-term follow-up of VLN flap transferred to the distal limb, showed the migration of ICG, previously injected into the flap edge, from proximal to distal and the visualization of the fluorescence within the flap showing the integration and function of the lymph nodes in the long-term [49].

Despite the current limitations in understanding of the mechanism of action, VLN transfer is likely a combination of the proposals above theories as well as factors that have not been described yet.

18.3.2 Surgical Indications and Preoperative Planning for VLN Transfer

Patient selection and preoperative work-up play a key role for success in lymphedema microsurgery. Surgical treatment should be tailored based on the lymphedema severity and patient-specific characteristics [43, 50]. All patient considered for VLN transfer should receive standardized preoperative evaluations including lymphoscintigraphy, indocyanine green (ICG) lymphography, computed tomography scan, Doppler ultrasound, and magnetic resonance imaging (MRI).

There are different opinions among the experts regarding the indications for VLN transfer. Based on the Cheng's Lymphedema Grading (CLG) system, a 5-grade system that integrates symptoms, quantitative limb measurements, and imaging findings, VLN transfer is particularly indicated for cases with advanced stages (CLG II–IV) with total obstruction pattern at the Taiwan Lymphoscintigraphy Staging system [51, 52]. This selected group of patients present a limb circumferential difference greater than 20%, history of recurrent infections, and showed total obstruction pattern of the lymphatic drainage (stages T-4, T-5, and T-6) in the Taiwan Lymphoscintigraphy Staging with absent visualization of ilioinguinal lymph nodes [12, 52]. ICG lymphography typically shows no functional lymphatic ducts and diffuses dermal backflow.

Examination of the donor site is an important preoperative consideration as inclusion of as many functional lymph nodes as possible into the flap is desired. Preoperative duplex ultrasound and/or MRI are useful imaging tools for the selection of the VLN flap donor sites identifying specific donor-site characteristics of the number of lymph nodes and their blood supply. Preoperative evaluation of the recipient sites with duplex Doppler scanning is equally important for surgical planning to confirm the patency, flow, and size of the recipient's vessels and to rule out vascular anomalies including superficial or deep venous incompetence. Patients presenting with proximal vein obstruction or insufficiency with limited venous return should be considered for vascular-surgery intervention to solve the venous problem first, before the VLN flap transfer.

18.3.3 VLN Flap Donor-Site Selection

Although the VGLN flap is still considered the most popular donor site due to its reliability and proven clinical outcomes in the setting of upper extremity lymphedema [23, 28, 29], alternative VLN flaps are suggested to avoid the possible risk of iatrogenic lower extremity lymphedema [32]. Several flaps have been described including submental flap [30] supraclavicular flap [34, 36], lateral thoracic flap [53], omental flap [37], and jejunal mesenteric lymph node flap [38]. With increasing options related to lymph node donor sites, decision making regarding flap choice may influence outcomes. Each of the above-mentioned VLNs donor site has advantages and disadvantages regarding pedicle length, vessel size, number of lymph nodes, skin paddle design, donor-site morbidity, and cosmesis. In this regard, surgeon's familiarity of the anatomic basis of variable donor sites of VLN flaps and surgical technique refinement are essential to ensuring successful and reproducible outcomes.

The *vascularized submental lymph node (VSLN) flap* has been used successfully in the treatment of upper and lower limb lymphedema. First described by the Cheng's group in 2012 for the treatment of lower extremity lymphedema [30], the VSLN flap is nourished by the submental artery and carries submental (level 1A) and submandibular (level 1B) lymph nodes [30]. An average of 3.0–3.3 lymph nodes have been identified in the flap [54, 55]. Both submental areas are preoperatively investigated with duplex ultrasonography or MRI, and the side with larger lymph nodes (greater than 5 mm in diameter) is generally selected for the flap harvest. Numerous refinements have been described by Cheng's et al. to achieve the optimal VLN flap. The incision is made along the upper border of a 6 × 2.5 cm elliptical skin paddle designed with its upper margin along the inferior border of the mandible over the submental artery. After preserving the medial platysma with 5 cm in width, care should be taken to preserve branches of the marginal mandibular nerve under the microscope [56]. Then the distal facial artery and vein are identified and divided. Following incision of the posterior skin, the skin paddle with perforators of the submental artery is retrogradely dissected along its axis. However, anatomical variations regarding the location of the facial artery and vein between the mandible and the submandibular gland have been described [57]. The soft tissue around the facial artery and vein is included to maximize the number of lymph nodes included. The donor site is primarily closed with a suction drain. The VSLN flap offers several advantages including consistent anatomy, adequate size of the submental and facial artery, adequate number and size of lymph nodes, easier flap inset due to its less bulkiness, and minimal donor-site morbidity [30, 54, 55, 58]. Due to its advantage of minimal chance of iatrogenic lymphedema, this donor site is particularly useful for the treatment of lower extremity lymphedema and is also suitable for distal extremity placement with its low flap volume. Its scar in the submental area is inconspicuous. The potential risk of marginal mandibular nerve palsy or pseudoparalysis can be avoided by the delicate dissection under microscope [56]. Several studies in the literature have reported reduction in limb circumference and improvement in quality-of-life using VSLN transfer for the treatment of extremity lymphedema [21, 30, 49, 51]. Cheng et al. described the first clinical study of VSLN transfer to the ankle in seven lower extremity lymphedemas. A mean circumferential reduction of 64 ± 11.5% above the knee, 63.7 ± 34.3% below the knee, and 67.3 ± 19.2% above the ankle was reported [30]. In a recent study, 35 patients who had received VSLN transfer to the ankle for lower limb lymphedema following gynecologic cancer treatment showed a mean above-knee and below-knee improvement of circumferential difference of 19.8 ± 9.2% at 12-month follow-up [21]. Indeed, this study highlighted that the number of lymph nodes included in the flap is important in volume reduction of lymphedematous lower limbs [21]. Bilateral VSLN flaps transferred simultaneously to the ankle and thigh have also been described for treating severe lower extremity lymphedema following the Charles procedure with subjective symptomatic and objective improvement (Fig. 18.4) [59].

The *vascularized supraclavicular lymph node (VScLN)* flap is based on transverse cervical vessels and includes cervical level Vb lymph nodes [60]. The advantages of the VScLN flap include its thinness, particularly suitable for distal extremity transfer and the inconspicuous scar donor site. Patel et al. in their study showed a lower number and size of lymph nodes in the VScLN flap compared to the groin and submental flap with variations between the right and left side [55, 60]. The disadvantages of this flap include the potential risk to damage the supraclavicular nerve resulting in paresthesia of the lateral upper anterior chest. In case the left side is chosen, care must be taken when harvesting the flap to avoid damaging the thoracic duct. Akita et al. in a study comparing VScLN transfer with lymphovenous anastomosis (LVA) for severe lower extremity lymphedema found a greater improvement in lymphatic function in the VScLN transfer group than LVA group [61]. In a prospective study of 100 consecutive VScLN transfers for upper and lower extremity lymphedema with a mean follow-up of 11 months, no cases of iatrogenic lymphedema have been reported and three patients presented chyle leakage at the donor site. Majority of patients showed satisfaction regarding the cosmesis of the donor site [62].

The vascularized thoracic lymph node (VTLN) flap is based on level I axillary lymph nodes. The VTLN flap is typically perfused by the lateral thoracic vessels. However in 12.5% cases in which the artery is absent, the thoracodorsal vessels are the main vascular supply to the flap [63]. Advantages of the VTLN flap include the abundance of soft tissue that can be included together with the lymph nodes, size and length of the vessels sufficient for anastomosis, and adequate number of lymph nodes within the flap [53, 64]. The main limitation of this VLN transfer is the inherent risk of causing iatrogenic lymphedema to the upper extremity. In this regard, reverse lymphatic mapping should be always used to identify the correct lymph nodes to harvest and to leave those important for the limb drainage intact [65]. Other disadvantages include an unreliable vascular supply, variable presence of the perforators supplying the overlying skin paddle, and the risk of sacrificing the thoracodorsal nerve. Limited outcome data have been published using this VTLN donor site [66]. Further clinical studies are needed to determine the safety and efficacy of the VTLN flap.

The *Greater Omental lymph node flap (GOLF)* is based on the gastroepiploic vessels. This VLN flap is generally harvested laparoscopically and involves only the area adjacent to the gastroepiploic vascular arcade, with the lymph nodes located around them. The main advantage of the intra-abdominal donor site is to eliminate the risk of iatrogenic lymphedema. The GOLF offers the potential advantage for a large number of small lymph nodes to be included, allowing for bilateral or dual-level transfer on the right and left side of the pedicle [67–69]. On the other hand, GOLF lacks a cutaneous component for coverage and the flap monitoring and carries a potential risk of abdominal complications due to the need to enter into the peritoneal cavity during the harvest. Reported abdominal complications include hernia, small-bowel obstruction, and one case of peritonitis [68–71].

The outcomes using the GOLF in extremity lymphedema have been addressed recently [72, 73]. Ciudad et al. [68] reported outcomes of a 10-patients' series of extremity lymphedema treated with GOLF, which resulted in an average limb reduction rate of 39.5% at a mean follow-up

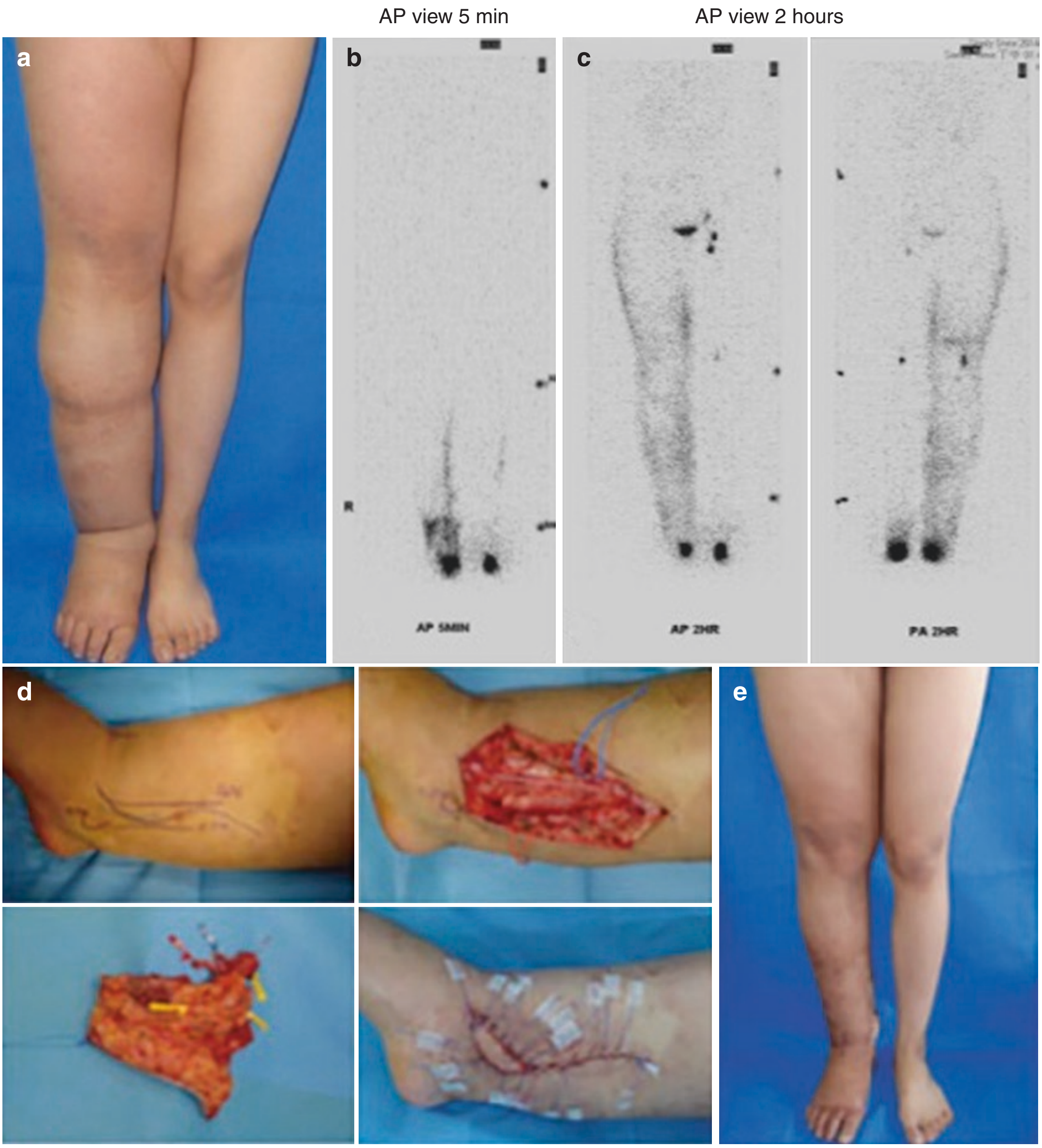


Fig. 18.4 A 19-year-old female with right lower extremity lymphedema since birth and a history of Klippel–Trenaunay Syndrome. Her preoperative circumferential difference was 48.8% above-knee and 42.9% below-knee (**a**). Lymphoscintigraphy showed partial obstruction pattern, Taiwan lymphoscintigraphy stage P-3 with absent ilioinguinal lymph nodes, uptake of popliteal lymph nodes, and entire dermal backflow in the right lower limb (**b**, **c**). She underwent vascularized submental lymph node flap transferred to the right ankle (**d**). Anatomical landmarks for recipient site preparation (upper left **d**). Posterior tibial artery and great saphenous vein marked with vessel loops (upper right **d**). VSLN flap with artery, vein, and lymph nodes marked (lower left **d**). Delayed primary retention sutures technique for flap inset (lower right **d**). At 12-month follow-up, she showed circumferential reduction rate of 47.7% and 42.3% above-knee and below-knee, respectively (**e**). (From Sachanandani NS, Chu SY, Ho OA, Cheong CF, Lin MC, Cheng MH. Lymphedema and concomitant venous comorbidity in the extremity: Comprehensive evaluation, management strategy, and outcomes. J Surg Oncol. 2018;118(6):941–952)

of 14.7 months. A statistically significant improvement in quality-of-life scores was reported together with satisfaction with the cosmetic result [68]. Another study investigating the effectiveness of the double gastroepiploic VLN transfers to middle and distal limb showed that this approach was safe with a mean circumferential reduction rate of the lymph-edematous limb of 43.7% at a mean follow-up of 10 months [69]. Further innovations including the robotic harvesting of the GOLF could further improve the safety and outcomes of this procedure in the future [74].

The *vascularized jejunal mesenteric lymph node (VJMLN) flap* is another valuable VLN donor site that avoids any risk of donor-site iatrogenic lymphedema. This flap is generally harvested by mini-laparotomy or abdominoplasty approach from the periphery of the mesentery or from closer to the root of the mesentery [38, 75]. The advantages of the VJMLN flap include a reliable but short vascular pedicle, adequate number of lymph nodes, the flap is thin and particularly suitable for distal extremity placement. Disadvantages include the risk of intra-abdominal complications including hernia, adhesions, visceral injury, and bowel ischemia. Preliminary clinical outcomes using the VJMLN flap have been promising. Coriddi et al. in their clinical study using the VJMLN flap in 15 patients with extremity lymphedema found a flap success rate of 93% and an objective improvement in lymphedema in 7/10 patients compared to preoperative measurements [75].

18.3.4 Recipient Location for VLN Transfer

The ideal recipient location for VLN transfer is still controversial in both proximal-anatomical and distal-non-anatomical placement.

In the *proximal anatomical* placement such as axilla in upper extremity lymphedema and groin in lower extremity lymphedema, following an extensive scar release, the VLN flap is transferred to the site of the lymph node dissection to promote lymphangiogenesis, creating a bridge across the site of initial damage [46]. An advantage of this recipient site includes well-hidden scars and a good cosmetic result. The main disadvantage of the placement of VLN transfer in severe lymphedema stages is that damaged lymphatic ducts may not be able to transport the lymph from the distal limb to the proximal site where the VLN has been transferred. The lack of skin paddle of VLN flap transfer to proximal recipient site makes the postoperative flap monitoring challenging with little chance to evaluate venous compromise. To the best of our knowledge, there is no report of VLN flap transfer to groin for lower extremity lymphedema so far.

In secondary lower extremity lymphedema due to pelvic lymph node dissection, distal-non-anatomical placement is currently the preferred method. In the d*istal non-anatomical* transfer, the VLN flap is placed in the distal limb-ankle, acting as a "pump" with a catchment effect draining lymph fluid into the venous system [23, 30]. For patients with lower extremity lymphedema, the ankle region is the most commonly preferred recipient site because of its distal location and easier recipient vessels exposure. Limited skin laxity around the ankle requires the use of a skin paddle that is important for early detection of subtle changes to the venous flow and also to achieve tension-free wound closure of the fibrotic skin pocket [76]. Some aesthetic concerns due to a temporary unsightly skin paddle could be improved by excising it 1 year postoperatively (Fig. 18.5).

Another non-anatomic recipient site is the medial calf, that allows the transfer of the VLNs below the knee, usually the popliteal area, without the use of a skin paddle or skin graft [53]. A reduced gravity effect in the popliteal fossa, compared to the ankle is present to facilitate the drainage of the lymph into the venous system. The medial calf is an interesting option for patients who are more concerned about the donor-site cosmesis.

Dual-level transfer has been described for cases in which the entire extremity was affected to provide more than one shunting for the lymph [77]. Splitting the GOLF into two flaps and transferred to the knee and ankle [69] or groin and

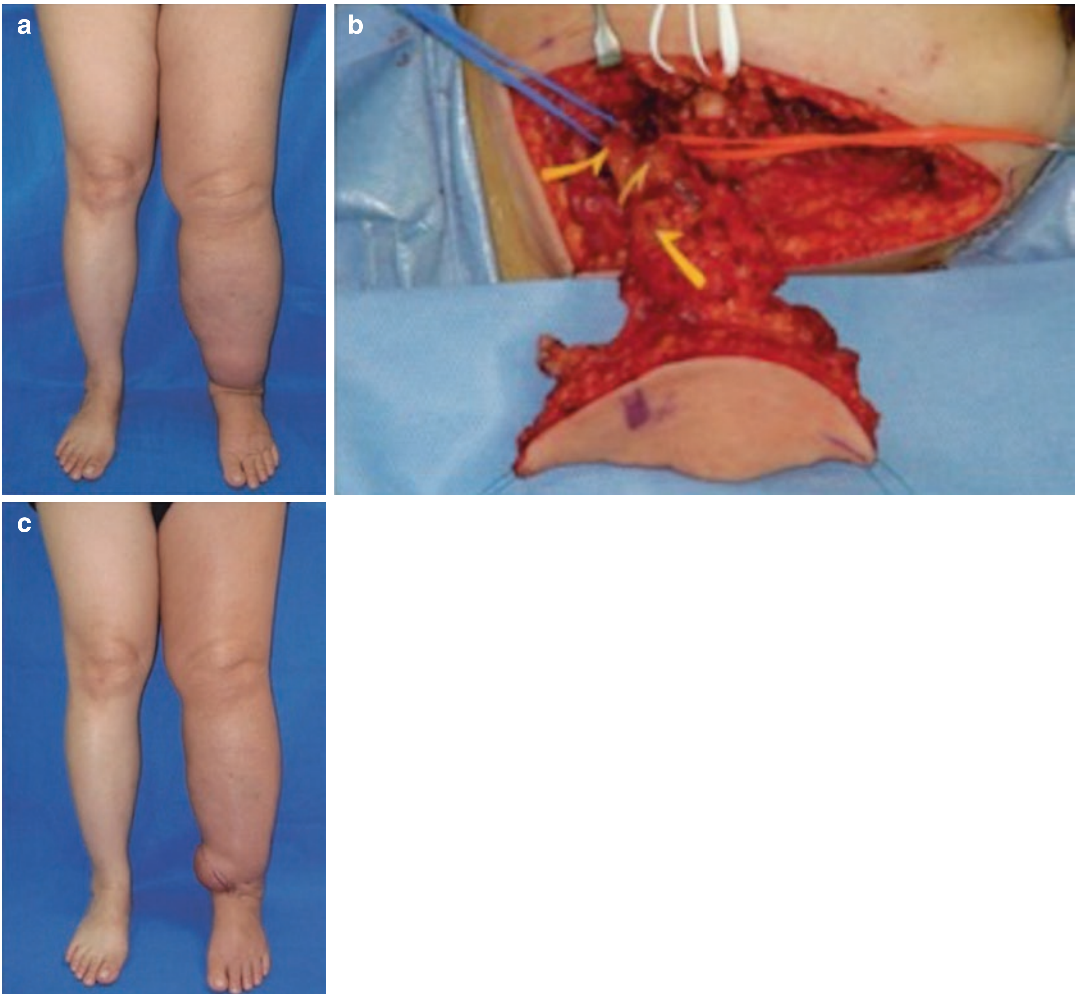


Fig. 18.5 (**a**) A 43-year-old female suffered left lower extremity lymphedema following a radical hysterectomy, pelvic lymph node dissection, and radiation. Preoperative circumferential difference was 45% above the knee and 55% below the knee. (**b**) A vascularized submental lymph node flap measuring 9 × 3 cm was designed on the right neck. Facial artery (red loop) and facial vein (blue loop) and 3 sizable lymph nodes (yellow arrows) are shown. (**c**) At 8-month follow-up, the circumferential difference was decreased to 30% above the knee and 15% below the knee, and the circumferential reduction rate was 22% above the knee and 55% below the knee. (From Cheng M-H, Chang D, Patel KM. Principles and practice of lymphedema surgery. United States. Elsevier. 2016)

knee [71] showed promising results in early reports.

18.3.5 Postoperative Care for VLN Transfer

Careful postoperative considerations are mandatory for the success of VLN transfer. In the setting of VLN flap transferred to the distal limb, significant swelling commonly occurs in this area together combined with flap swelling due to absorption of lymph fluid. These findings could make the VLN transfer at higher risk to develop early vascular complications. The distal extremity in lymphedema patients is often severely affected by fibrosis involving the vessels adventitia. Care should be taken to create an adequate recipient site pocket with removal of part of the deep fibrotic subcutaneous tissue for flap inset. Removal of adventitia around the recipient veins and meticulous recipient site hemostasis are highly recommended. Removal or loosening of sutures at the flap edge is suggested in the early postoperative period to allow for flap swelling. The delayed primary retention suture for inset of VLN transfer allows to control the tightness of the wound in the early postoperative period by releasing the sutures when the flap became swollen, and gradually tightening the stitches at the bedside once the swelling is settled [76]. However, even with using these strategies, the vessels in these areas could be compromised due to the build-up of pressure resulting in vascular complications [78]. In a recent study investigating the long-term outcomes and venous complications of VSLN transfer to lower extremity lymphedema, the authors found 6/75 (8%) flaps having venous complication [78]. Interestingly, types, numbers of veins, and venous anastomoses techniques did not influence the venous complication rates. Of note, the functional outcome of the VSLN transfer was maintained if the venous complications were salvaged rapidly [78].

Following the immediate postoperative care, regular outpatient follow-up is recommended assessing limb circumference and any cellulitis episode. Imaging modality including CT, lymphoscintigraphy, and ICG lymphography could be useful to better define surgical success comparing preoperative and postoperative imaging. No compression garments were required following the VLN transfer to distal ankle, which is one of the main goals of the procedure for extremity lymphedema.

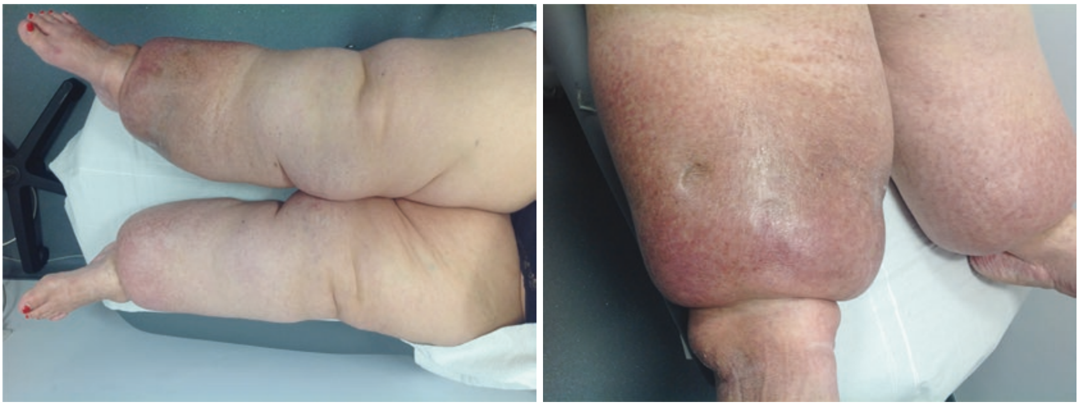
In conclusions, the VSLN flap transfer to the ankle is the preferred lymph nodes basin for the lower extremity lymphedema with ultimate functional outcome. The pump mechanism, catchment effect, and gravity effect of the VLN flap transfer provide the greater drainage function of the VLN flap without the requirement of compression garments after surgery.

18.4 Liposuction

Damir Kosutic

Natural progression of lymphedema invariably shows a change over time from predominantly excess fluid to predominantly excess fatty deposits in subcutaneous tissues of affected extremity/ies. Exact mechanism for this is unknown and several theories were proposed [79], mainly linking adipogenesis to stasis of lymphatic fluid [80]. Indeed, in most patients over time, fluid is replaced by fat though mixed clinical picture is also frequently found, even within the same lymphedema-affected extremity. Conversion from excess fluid to predominantly excess fat is usually seen in advanced stages of chronic lymphedema in patients who present with a longer history of this condition. However, author has seen this conversion sometimes to occur in patients even after only 6 months following the first clinical occurrence of swelling to patients' extremity. Most patients clinically present with a swollen upper or lower limb with a usually negative "pitting test" and failure of compressive garments and other conservative measures (MLD for example) as fat cannot be compressed and redistributed, as opposed to fluid. Some patients underwent microsurgical reconstruction in the past, which worked only temporarily or was unsuccessful and despite combination of these efforts and conservative treatment, still progressed toward increased fatty-tissue deposits. Those that, in addition, experienced number of episodes of cellulitis, would also develop significant fibrosis and in late stages and in neglected patients, one can also see chronic skin changes related to lymphatic stasis and inflammation/infection. These unfavorable conditions coupled with excess fat make any microsurgical/supermicrosurgical attempt impossible (Figs. 18.6 and 18.7).

Liposuction has long been in use for removal of excess fat as a body contouring aesthetic surgery procedure [81]. It allows removal of large volumes of fat through minimal access and is considered a low-risk procedure, if properly executed. Systematic use of this technique with certain modifications in lymphedema patients was popularized by Brorson [82], who demonstrated its efficacy and stable long-term results in compliant patients for both upper and lower limb lymphedemas [83–84]. Apart from obvious



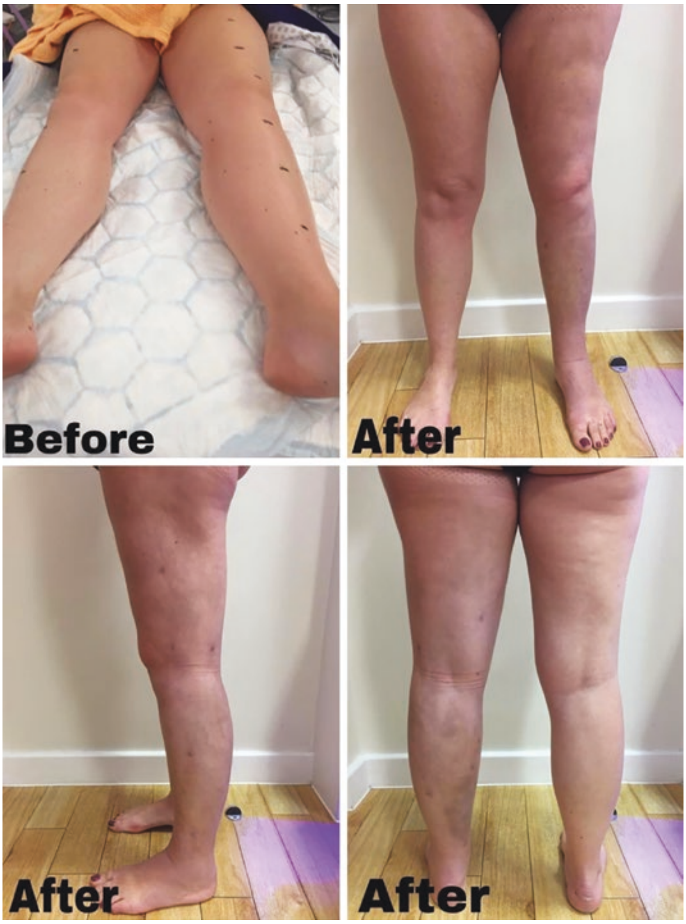
Figs. 18.6 and 18.7 Advanced stage lymphedema with conversion to predominantly fatty deposits but still present degree of pitting. Visible chronic skin changes as a result of prolonged stasis and multiple episodes of infection

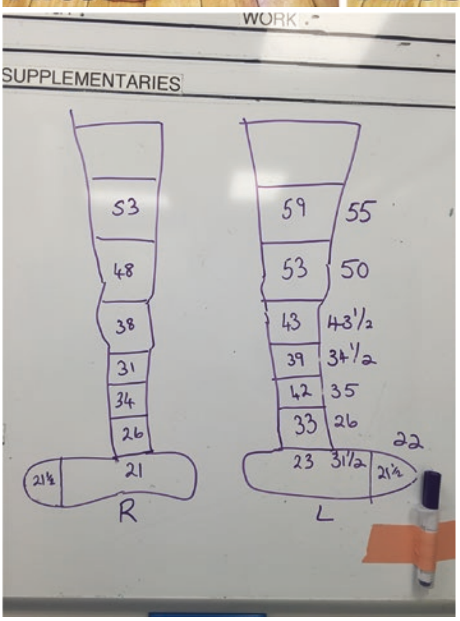
reduction in volume, overall quality of life can be improved with this technique long-term, as demonstrated by extensive literature and in authors own experience.

18.4.1 Preoperative Management

As in all patients with lymphedema, viability of existing lymphatics (if any) needs to be investigated with ICG and/or lymphoscintigraphy. In majority of late-stage lymphedema patients, dermal backflow and nonvisualization (or poor visualization) of lymph nodes in the groin/axilla are found. Some patients, however, still do have partially viable lymphatics, particularly if LVA or lymph-node transfer was performed initially. In these situations, care must be taken to avoid damaging existing viable lymphatics (Fig. 18.8) with careful planning and precise preoperative markings (Figs. 18.9, 18.10, and 18.11). Clinical examination consists of inspection and palpation of lymphedema-affected extremity, with special attention to surgical scars (if any present), areas that received previous radiotherapy (RT), sequential measurements comparing both limbs, inspection and palpation of skin quality, turgor, capillary refill, popliteal, groin, and axillary lymph-node bearing areas as well as abdomen to exclude potential masses. In that respect, particularly in postsurgical/RT-related lymphedema in cancer patients, one should exclude cancer recurrence with follow-up scans prior to offering lymphedema surgery. Contrast MRI scan of abdomen and pelvis can be helpful to exclude pressure on viable lymphatics via tumor mass. It can also be very useful in objectifying results of clinical examination by determining the volume of excess fat in lymphedema-affected extremity, which can

Fig. 18.8 Preoperative markings of lower limb lymphedema patients—care is taken to avoid sites of previous LVA surgeries





Figs. 18.9–18.11 Preoperative measurements in lower limb lymphedema patient should use the nonaffected limb as a guide in terms of volume that needs to be removed surgically. Measurements of both limbs' circumferences at corresponding points distances prior to surgery and after are important to achieve good symmetry

be used as a guidance at the time of liposuction procedure. It is also very important to preorder made to measure compressive garments of the smaller size than current patients' measurements so these can be applied either immediately postoperatively or several days after, depending on the extent of postsurgical swelling. In unilateral limb lymphedema, a healthy limb is used as the best template; however, if lymphedema is bilateral it is best to reduce the current measurements size by several centimeters, depending on the planned volume removed.

18.4.2 Surgical Technique

In unilateral lower limb lymphedema, preoperative measurements are best taken in operating theater to guide the volume that needs to be removed from the lymphedema-affected extremity (Figs. 18.10 and 18.11). Once patient is under general anesthetic, both limbs are prepped and draped sterile and sterile tourniquet is fixed onto lymphedema-affected limb (thigh), as high as possible and inflated to 250–280 mmHg pressure or higher, depending on the limb circumference. Infiltration of limb follows, with 1–2 L of tumescent solution made by mixing normal saline, local anesthetic, 1 mL of adrenaline (1:1000), and 1500 IU of hyalase. Tumescent solution is infiltrated through multiple small incisions (11-size blade), which are then used as liposuction ports. Number and location of ports vary depending on particular anatomy of the operated limb and volume that needs to be removed. It is useful to try to reduce the number of liposuction ports as each wound carries additional risk of infection to lymphedema-affected extremity. Despite their relatively small size, in larger limbs with significant volume reduction required, larger-size liposuction cannulas are used and these can leave somewhat wider scars. However, most patients are very much focused on reduction in volume achieved and are happy to accept liposuction-ports scars, which in most fade away over time. It is important though to place incisions along relaxed-skin tension lines for best aesthetic outcome. Liposuction for lymphedema is technically executed in the same manner as aesthetic liposuction, radiating movements of the cannula in subcutaneous plain which should be evenly reduced circumferentially as much as possible. In authors' practice, avoidance of long saphenous vein and immediate area around it has proved beneficial in reducing postoperative bleeding/bruising. The volume of fat that can be "safely" removed in single surgery remains controversial topic. Some studies suggest that liposuction volumes in excess of 100 mL per unit of body mass index can be an independent predictor of complications [85]. In authors' experience, removal of over 5 L of fat from each limb (Figs. 18.12 and 18.13) in one setting could, in patients with higher BMI, be associated with postoperative anemia due to blood loss, whilst reduced oxygenation of skin detached by liposuction from its under surface could cause patchy skin necrosis, especially in lower leg. Most patients achieve significant reduction in volume after only 2–4 L are removed though, hence the above complications are extremely rare. Perioperative bleeding is usually much reduced with the use of tourniquet. However, tourniquet prevents addressing the top part of the upper thigh in a well-controlled manner. Therefore, it is best to complete liposuction of all other areas apart from upper thigh where tourniquet still is, perform measurements to correlate reduction with either desired one or opposite, non-lymphedematous extremity, then close liposuction ports, and wrap the extremity with cotton-wool and bandage (or premade compressive garment) up to the level of tourniquet band, while tourniquet cuff still inflated. At that point, tourniquet can be deflated and upper part of thigh addressed with liposuction, followed by suturing of ports (vicryl 4-0 and vicryl rapide 4-0 in two layers, skin glue, steri-strips, and water-proof dressing).

18.4.3 Postoperative Care

Patients are best kept on prophylactic antibiotics for 6 weeks as well as low-molecular weight heparin. Procedure is in most instances performed as a day-case or overnight stay. Whilst some sur-

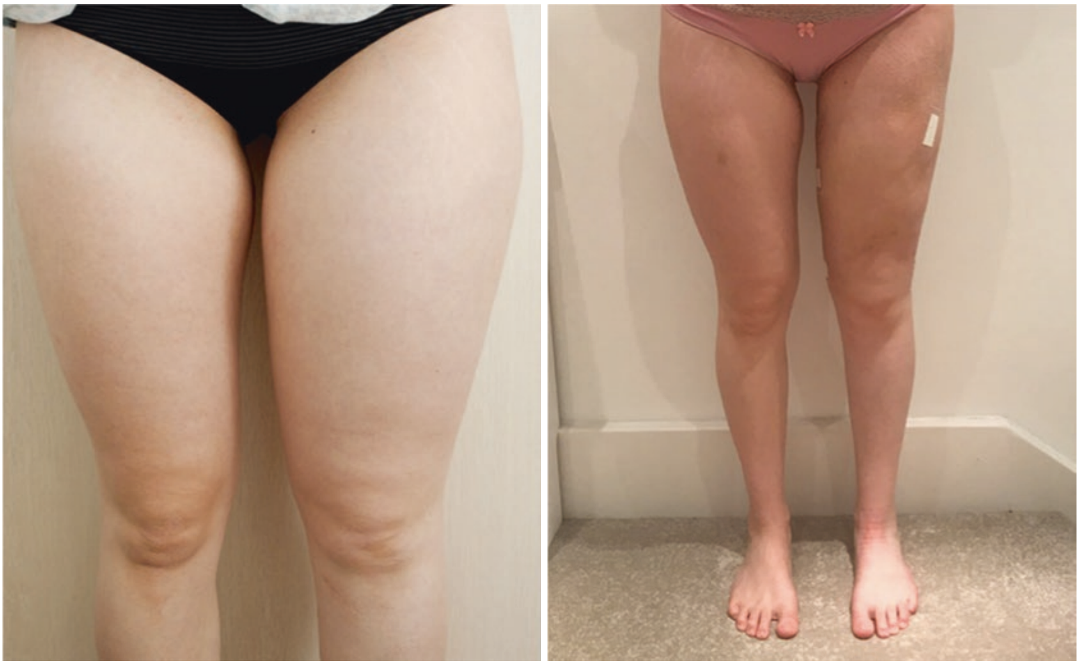
Figs. 18.12 and 18.13 Large volume liposuction (5 L or more removed in one session) can be associated with higher complication rates including anemia, seroma, and skin breakdowns, requiring delayed healing

geons apply compressive garment already in operating theater, author prefers to keep patient in elastic bandages with a cotton-wool layer underneath until initial postsurgical swelling subsides. Bandages are then swapped for made-to-measure compressive garments between day 5 and day 7 at the time of the first wound check. Although mobilized immediately after surgery, patient is advised to mainly rest with leg elevated for the first several weeks. It is expected to see skin bruising in most patients initially. Those with the higher BMI are sometimes prone to seroma development, especially if large volume liposuction is performed. This can be aspirated in outpatient setting. After 2 weeks, an intense MLD (manual lymphatic drainage) is commenced and continued for a minimum of 6 months to achieve stable results. Skin care and good hygiene are of utmost importance during that time to prevent unnecessary episodes of cellulitis, which would jeopardise postoperative outcome (Figs. 18.14 and 18.15).

18.4.4 Outcomes

Outcomes are assessed on month 3, 6, 9, 12, and 18 postoperatively. Use of compression garments in combination with MLD and other conservative measures is crucial for success. Significant permanent reduction in limb volume with much improved esthetics can be achieved and results kept stable/permanent for as long as patient is compliant with conservative measures. In some patients once results are stable for over 6 months, the number of hours per day spent in compression can be gradually reduced without significant recurrence of lymphedema. This can only be done successfully with regular follow-ups under surgeon's supervision (Figs. 18.16, 18.17 and 18.18).

Disclosures The content is solely the responsibility of the authors. Ming-Huei Cheng received textbook royalties from Elsevier, Inc.



Figs. 18.14 and 18.15 Thigh liposuction for lymphedema following LVA to lower leg before and 2 weeks after surgery with very good symmetry obtained. Patient subsequently maintained stable result with garments worn 6 h a day only now 4 years since her surgery

Fig. 18.16 Entire lower limb liposuction for advanced lower limb lymphedema before and 2 years after surgery

Figs. 18.17 and 18.18 Before and 6 months after targeted liposuction followed by intense conservative treatment

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19 New Frontiers in Perineal Reconstruction

Jeffrey C. Y. Chan, Miriam Byrne, and Hung-Chi Chen

19.1 Introduction

Central perineal defects arise from resection for oncological clearance of anorectal, colorectal, vulvar, vaginal or penile cancers. Adjacent peripheral defects could arise following resection of extensive fungating tumor metastases to the regional inguinal lymph nodes from these cancers or from the lower limb. Potentially extensive but less uniform defects are commonly the result of necrotizing fasciitis of the perineum (Fournier's gangrene) but could also be due to injury from thermal, radiation, and combat-related trauma. Furthermore, congenital abnormalities are usually tissue-deficient conundrums while gender reassignment surgeries involve creative use of adjacent or transferred tissues, and both of these challenges present themselves with both functional and aesthetic concerns.

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Reconstruction of the perineal area is complex as the colorectal, vaginal, and bladder tissues are in close proximity to each other. Frequently, oncological surgery of one organ may involve partial or total resection of the adjacent organ. Even if the resection is limited to one organ, the imbalance or loss of structural integrity of the perineal diaphragm and its interdependent ligamentous support could result in prolapse, herniation or dysfunction of the remaining tissues. Local flap works well for partial defects with minimal volume loss as skin or internal lining replacement. Larger pedicled flaps from the abdominal wall, thigh or gluteal regions are the workhorse strategies for more extensive defects that require both skin/internal lining replacement and for obliteration of dead space. The preceding chapters have concentrated on these reconstruction options. This chapter will focus on supporting reconstruction strategies including those for secondary surgery and salvage cases.

19.2 Vaginal Reconstruction

Local flaps based on the internal pudendal vessels such as Wee's Singapore flap and Niranjan's lotus petal flap work well for vulvar and vaginal defects [1, 2]. However, bilateral flaps are commonly required for larger defects.

Regional flaps such as the gracilis myocutaneous flap, profunda artery perforator flap, anterolateral thigh flap, and inferior gluteal fold

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flap provide more bulk and a larger skin paddle for both internal lining and perineal skin replacement. A posterior vaginal wall defect is most common after tumor resection and pedicled flaps are ideal for both skin replacement and obliterating dead space. Reconstruction with vascularized healthy tissue accelerates healing and prevents wound dehiscence and fistulas in an irradiated field.

In circumferential vaginal defects, a large skin paddle can be tubed or coned to create a neovagina in situations where the vagina is resected. When performed unilaterally however, the inset and subsequent scarring could distort the vaginal orifice or vulva due to attempts to maximize reach of the flap used. Hence, the vertical or oblique rectus abdominis muscle flap is a good alternative if the oncological clearance involves a laparotomy [3–5]. The pedicle of the RAM is more centrally located and facilitates an aesthetic inset. However, this may not be a sensible option if laparotomy is not planned as a part of cancer resection.

A neovagina with adequate width, length, and intrinsic lubrication is critical for a normal sexual performance in patients who had vaginal reconstruction. Hence, creating a neovagina as close as possible to normal functioning tissue can influence positively woman's self-esteem, confidence, and sense of femininity. Previously, techniques such as the Frank procedure (serial mechanical dilatation), the Abbé–McIndoe procedure (perineal cleavage and skin graft over a conformer), amnion graft, bladder mucosa graft, and various local, pedicled or free flaps had been used to achieve this [6, 7]. The Vecchietti procedure involves stretching the urogenital sinus using an olive attached to a traction system that passes through the pelvis and attached to a traction device on the abdominal wall [8, 9]. In transgender patients, penoscrotal skin grafts and flaps are commonly used to line an artificial vaginal passage [10]. These simplistic methods attempt to create a graft-lined canal or skin tube passage for sexual intercourse, which becomes unstable and shrink with repeated frictional forces.

The disadvantages of using skin grafts or skin flaps as vaginal wall lining or for creation of a neovagina include neovaginal dryness, skin graft/flap contracture or shrinkage, hair growth in the passage, inadequate caliber, vaginal malodor, and dyspareunia. Use of pedicled flaps to create neovagina causes anatomical distortion as described above and also risks distal necrosis of the deepest part of the tube or cone. It is difficult to reach or treat surgically when this occurs.

19.2.1 Intestinal Flaps

Increasing demand and higher expectation for a functional neovagina in gender reassignment surgery and vaginal agenesis have inspired the use of intestinal flaps to create a neovagina with mucosal lining. Intestinal flaps with its inherent mucosa are closer to the vaginal mucosal, more durable to trauma, resistant to stricture formation, and even provide its own lubrication. This eliminates the need for repeated dilatation and the use of obturators to maintain a graft-lined tunnel or prevent shrinkage of a skin tube. Rectovaginal fistula and squamous cell carcinoma have been reported due to chronic inflammatory response in the graft-lined passage.

A segment of intestine can be used to construct a neovagina. Sneguireff first described turning the rectum into a vaginal passage in 1892, and his operation was subsequently modified by Popow (1910) and Schubert (1911) [11]. These early methods essentially involved mobilizing a segment of lower rectum anteriorly to form a neovaginal passage and joining the upper rectum to the anal sphincter. Baldwin first discussed the use of a sigmoid colon loop to create the neovagina in 1904 but his patient declined this idea. It was not until 1907 that Baldwin had the opportunity again to reconstruct a neovagina but he used a loop of ileum instead in another patient [12]. Around the same time, Mori of Japan (1910) described using ileum but unlike Baldwin's procedure, it was not a loop but a single lumen of ileum [11]. Schubert in 1911 described using a pedicled rectum while Wallace used a sigmoid colon to create a neovagina as suggested by Baldwin [13]. While the English literature was dominated in the 1950s and 1960s with the

Abbe–McIndoe technique of skin grafting, the rest of the world (main European and Russian surgeons) of the same era reported hundreds of cases of vaginal reconstruction with bowel flaps. Wagner reported on a successful pregnancy delivery through a neovagina created using Schubert's method using sigmoid colon to connect the cervix to the lower vagina for a patient with vaginal atresia [13]. Alexandrow from Russia reported successful pregnancy of a patient in 1942 delivered by Caesarean section following sigmoid loop vaginoplasty. He reported a mortality rate of 2.9% in 67 cases. Further to that, in his report of 175 cases, he reported a mortality rate of 1.7% in 1955. Gigovskij reported only one mortality from a total of 110 cases of sigmoid vaginoplasty in 1956 [11, 13, 14].

In previous decades, there have been limited interests to use intestinal flaps to reconstruct the vagina although this has started to change. Most experiences in recent literature were reported from the Middle East and Asia. In order to create a neovagina, a segment of jejunum is pedicled on its jejunal vessels. Similarly, a segment of colon such as the sigmoid colon can be pedicled on its sigmoid vessels. The length of the vascular pedicle is extended by preservation of its marginal branches in its mesentery to reach the perineum if required.

19.2.2 Large Intestine

Djordjevic et al. published their large series of 86 cases of rectosigmoid vaginoplasty in 2011 based on the sigmoidal and/or superior hemorrhoidal vessels for 54 cases of vaginal agenesis and 27 male-to-female transgender cases [15]. They reported good aesthetic result in 77 cases, but seven neovagina prolapses and nine cases of introitus deformity requiring minor revision surgery. Excess mucus secretion resolved after 3–6 months. Their reported mean FSFI score (Female Sexual Function Index) was 28.9 with satisfactory sexual function in >80% of patients. About 37% of patients reported mild bleeding with dyspareunia in the early postoperative period which disappeared after 6 months. Khen-Dunlop also published their experience with sigmoid vaginoplasty in 23 patients with Mayer–Rokitansky–Kuster–Hauser (MRKH) syndrome and reported 26% introitus stenosis requiring Hegar dilators, 9% mucosal prolapse, and one unfortunate case of bilateral lower limb compartment syndrome [16].

In 2018, Ozkan and colleagues described their technique of pedicled rectosigmoid colon for vaginal reconstruction in a cohort of 43 patients for Mullerian agenesis and male-to-female gender reassignment. The pedicled flap was kept in an ischemic state for 1–2 h with clamps to reduce the goblet cells to reduce the incidence of hypersecretion and the nerves within the pedicle were resected to eliminate tenesmus and contraction during sexual intercourse [17]. Although the authors did not report reduction in hypersecretion or tenesmus in their results, 14 patients scored 26.6 in their Female Sexual Function Index (FSFI) assessment indicating no sexual dysfunction.

Laparoscopic harvest of colon segment has become popular recently as it avoids a laparotomy scar. Ikuma from Japan and Delga from France both described their first laparoscopic sigmoid vaginoplasty in 1996 and 1997, respectively [18, 19]. This was followed by Ota in 2000 [20]. Urbanowicz from Poland reported five cases of laparoscopic sigmoid vaginoplasty in teenagers with MRKH syndrome and vaginal agenesis [21]. Shen and co-authors published a small series of 11 patients who underwent laparoscopic sigmoid vaginoplasty in patients with MRKH syndrome in 2009 [22]. They reported an average hospital stay of 9 days with excellent cosmetic result with no introitus stenosis and neovagina length of between 11 and 14 cm. The benefit of laparoscopic surgery includes absence of laparotomy incision, simultaneous diagnostic laparoscopy for MRKH syndrome, confirmation of feasibility by visualization of the sigmoid colon length/mobility on its mesentery, and precision with camera magnification.

In our unit, we have performed vaginoplasty for male-to-female transgender patients with pedicled transverse colon harvested laparoscopically. The cohort of patients included patients with penoscrotal hypoplasia following suppress-

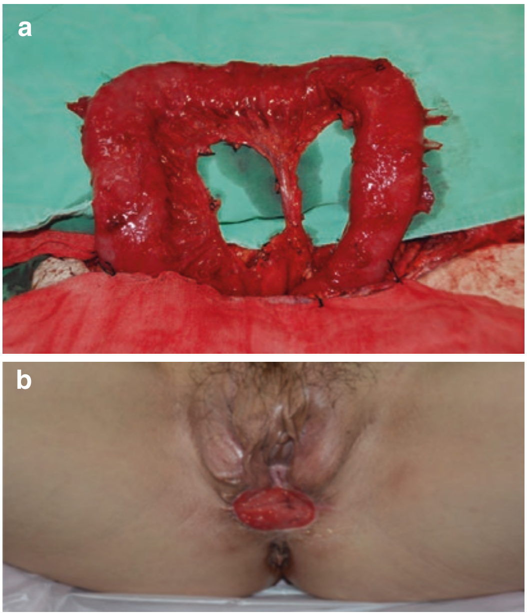

Fig. 19.1 (**a**) Dissection of transverse colon segment. (**b**) Transposition of the transverse colon segment for vaginal reconstruction

ing hormonal therapy and those who had vaginoplasty with the penoscrotal flaps method but were unsatisfied with the length of their penoscrotal vaginoplasty [23]. The transverse colon of 15 cm in length is pedicled equidistant on the middle colic artery (Fig. 19.1a). In our cohort of 15 patients with 12-year follow-up, there was one introitus narrowing and only one case of hypersecretion which subsided 3 months postoperatively. Regular secretions were of small amount, but the patient still needs to use pad in her daily life. All patients have normal sexual function and their mean FSFI score was 28.6 (Fig. 19.1b).

The disadvantages of colon vaginoplasty include a less clean surgical field and more extensive dissection to free the intestinal segment. Diversion colitis has been a problem and some authors believe the mucus secreted from a sigmoid vaginoplasty is due to colitis. Ulcerative colitis from a sigmoid vaginoplasty could occur. Stenosis, perforation, and peritonitis from diversion colitis have also been suggested. The sensation of tenesmus and stimulation of defecation have discouraged some surgeons from this technique [17, 24, 25]. Furthermore, adenocarcinoma from the transferred sigmoid colon has been observed many years later and hence there is an issue of long-term surveillance [26].

19.2.3 Small Intestine

Emiroglu and colleagues reported free jejunal flap vaginoplasty in 1996 for a female with Mayer–Rokitansky–Küster–Hauser (MRKH) syndrome [27]. The inferior epigastric vessels were used as the recipient vessels. They reported that the patient achieved successful sexual intercourse at 6 weeks and a period of mucus hypersecretion that reduced at 3 months. We typically use a jejunal flap pedicled on the fourth jejunal vessels, a branch of the superior mesenteric vessels. The case presented is a patient who had undergone a radical hysterectomy and radiotherapy resulting in a short and atrophied vaginal stump that is inadequate for sexual intercourse [28]. Following surgery, the patient regained the ability for sexual intercourse with no dyspareunia or hypersecretion. The hypersecretion disappeared at 4 months.

Ozkan and colleagues reported using free jejunal flap from the first jejunal artery in 22 patients for vaginal reconstruction [29]. The neovagina diameter was increased by folding one segment over another segment, and joining them at the antimesenteric border, if needed. Microanastomosis with the deep inferior epigastric vessels was performed to re-establish perfusion with no failure but three cases returned to theater for venous compromise. Hypersecretion from the transferred jejunum segment settled after 3 months (>80%) and patients reported successful intercourse.

The benefits of using a jejunum flap include most of the advantages of a sigmoid colon vaginoplasty. There is less extensive intra-abdominal dissection making the abdominal part of the procedure easier and faster, the jejunum is cleaner and is more reliable as a free flap [28, 29]. Additionally, the vascular pedicle is larger in caliber and this makes microsurgical anastomosis less challenging. Furthermore, there is no sensation of anal intercourse, feeling of tenesmus or stimulation of defecation during sexual intercourse as reported with sigmoid vaginoplasty [28, 29]. In our experience, the jejunum free flap is less tolerant to ischemia because its metabolic rate is higher than a free colon flap. Colon flap has more bacteria but a lower metabolic rate.

One disadvantage of jejunal vaginoplasty is that the lumen diameter may be inadequate and therefore an additional loop of jejunum may be combined to widen the diameter of the reconstructed neovagina. The greatest disadvantage is arguably the requirement of a laparotomy incision, which is an aesthetic concern, especially for a young female patient, but this also delays their postoperative rehabilitation. However, in patients with previous abdominal or gynecological surgery, it is safer to perform a laparotomy. Liguori reported the use of ileal flap for vaginoplasty in five cases of male-to-female transgender patients [30]. Similarly, laparoscopic harvest of jejunal flap has recently been described by Ozkan [31]. The jejunal flap was a pedicled flap with turbocharging of a second set of vascular pedicle to improve perfusion. Both authors required a small abdominal incision to deliver the flap for reshaping the neovagina and for re-establishing intestinal continuity.

19.2.4 Colon–Cecum–Appendix Flap

In addition to using small or large intestines, the cecum with the ascending colon is rarely used as a pedicled flap for vaginoplasty. Filipas et al. demonstrated the value to this technique in 17 patients with the majority being salvage cases or previous unsuccessful vaginoplasty [32]. A 12–15 cm of cecum and the ascending colon are preserved on the ileocolic artery. The distal portion is rotated so that the ascending colon forms anastomosis with the vulva or remaining vagina.

In our unit, we have found a modified method useful for recreation of the vaginal passage between a blind vaginal pouch, an atretic cervix, and didelphic (double-genital tract) uterus [33]. A pedicled colon–cecum–appendix flap based on the ileocolic artery was harvested with the colon segment measuring 8 cm and an appendix measuring 10 cm. The distal appendix was bivalved and inserted into the didelphic uterine tissue and endometrium so that the uterine cavity communicates with the appendix lumen. This effectively recreates the uterine cervix region and allows menstrual blood flow. This delicate appendix-uterine tissue construct was held open with a T-tube to prevent stricture and menstrual flow obstruction during the healing period. The cecum was anastomosed to the atretic cervical tissue and the ascending colon was connected to the proximal end of the short vaginal pouch to create the vaginal passage. The cervical gland was preserved in this method of inset. Cervical gland is important to prevent infection during pregnancy [33, 34].

19.3 Penile Reconstruction

Phalloplasty is performed for three main indications namely, postoncologic resection, congenital deformities, and gender reassignment. Penile reconstruction for gender reassignment cases usually involves creation of the entire phallus. In contrast, reconstruction after cancer resection or congenital condition may involve subtotal phalloplasty that preserves residual structures or total phalloplasty.

Total phalloplasty remains a surgical challenge today, as four main objectives must be addressed. First, a reconstructed phallus must have as normal an appearance as possible with the appropriate length and girth to influence the patient's self-esteem and sense of masculinity positively. It must also have a neourethra for passage of urine and semen, and allow urination with a straight stream while standing. Thirdly, it should be appropriately rigid to allow sexual intercourse. Finally, the skin flap must regain sensation to be both protective and erogenous.

A myriad of techniques have been described but none of these is yet ideal. The formation of the shaft usually involves the use of a skin flap, which is tubed to form the desired length and width. The urethra can be created with the use of skin graft within the skin flap. Alternatively, part of the skin flap can be tubed internally and the adjoining skin de-epithelialized to create an independent skin tunnel for the urethra. This tunnel is then wrapped around with the remaining skin flap to form a “tube within a tube” construct. The glans is created by suturing a semicircular or triangular skin design at the distal end of the flap. The corona can be simulated with the use of skin graft or suturing techniques. Cutaneous nerve of the flap is coapted to the dorsal nerves of the penis or clitoris for sensation. Additional nerve coaptation could be anastomosed to iliohypogastric or ilioinguinal nerves.

Bogoras first reconstructed the penis with the use of a tubed abdominal flap with rib cartilage in 1946 [35]. This was followed by Gilles on the use of tube within a tube concept in 1948 on his use of tubed pedicle flaps with embedded cartilage graft and neourethra to reconstruct the penis [36]. Modern total phalloplasty has not evolved far from this concept. Chang and Hwang were the first to report on the use of the “Chinese flap” (radial forearm free flap-RFFF) for reconstruction of the penis post-trauma utilizing this concept [37]. The neourethra is typically formed with the less hair bearing skin from the ulnar side of the forearm.

The cosmetic appearance of the phallus derived from the RFFF is very acceptable. However, this technique sacrifices almost two-thirds of the forearm circumference. The skin-grafted forearm leaves an unsightly donor site that can be very visible without long sleeve clothing particularly in warm countries and can be a stigma in patients reconstructed for gender reassignment purpose. Furthermore, sexual intercourse is virtually impossible with RFFF phalloplasty unless a stiffener is incorporated (either in the form of an autologous graft or prosthesis). The insertion of a prosthesis for erection ideally should be done after re-innervation of the RFFF phallus, to reduce incidence of explantation or revisional surgery, which can be as high as 41% [38–40]. The indication for revision includes prosthesis extrusion, erosion, infection or device malfunction. To avoid the use of prosthetic material, other authors had described the osteocutaneous RFFF [41, 42].

Although the RFFF remains the most common “workhorse” flap for penile reconstruction because of its cosmetic advantage, its inadequacy led to many other methods being used. Apart from the inability for penetrative intercourse, prosthesis, and donor-site complications, the incidence of neourethra complications such as fistula and stricture formation requiring surgical correction is up to 17% [38]. Additionally, the fasciocutaneous construct tends to atrophy and loses its shape and girth over time with scar maturation and effect of gravity. Other methods for phalloplasty include the free extended lateral arm flap [43, 44], free deltoid flap [45], pedicled iliac flap [46], free scapular flap [47], pedicled island tensor fascia lata flap [48], free and pedicled anterolateral thigh flap, pedicled groin flap [49], and free osteocutaneous fibular flap [50]. Although the ALT flap is gaining popularity more recently, it has not been proven to be exceptionally different except that it can be used as a pedicled flap and the donor site is more easily hidden [51, 52]. Various methods reported to reconstruct the neourethra within the ALT flap suggest that an optimal method has not been determined [53].

We prefer the free fibula osteocutaneous flap, inspired by the canine os penis bone as first described by Sadove in 1992 [50]. Similar to the radial forearm flap, the fasciocutaneous tissue from the calf is thin and sufficient to cover the circumference of the fibula. The fibula provides a natural stiffener for penetrative intercourse, avoiding the use of an artificial prosthesis and its associated complications. The donor site is skin grafted and more conveniently concealed. Since the calf has circumferential hair-bearing skin, the tube within a tube method is not suitable for neourethra formation. This is a disadvantage of the free fibula flap phalloplasty. Even if the calf is not hair bearing, such as for a female to male gender reassignment, using a tube within a tube method will sacrifice the skin width required for the phalloplasty. Therefore, the neourethra is prefabricated using a controlled fistula method with split skin graft 3–6 months prior to flap harvest to ensure graft maturation [54].

Following free fibula flap harvest and shaping, the fibula is anchored with nonresorbable suture to the pubic bone periosteum to ensure adequate support for sexual intercourse. Microvascular anastomosis is reliable as the peroneal artery and vein are frequently large. Sensory reinnervation is accomplished by including the sural nerve in the flap and coapting to the dorsal nerve of the penis or clitoris. If a patient desires an extended phallus, we recommend performing osteotomies along the fibula (pseudojoint) and fascia interposition to enable flexibility of the phallus and therefore, less painful penetration for the partner, as the vaginal passage is curved [55]. The versatility of free fibula flap for penile reconstruction has encouraged others to use it for salvage cases where another method has been unsuccessful or unsatisfactory [56].

Finally, penile transplantations have been performed successfully in China, South Africa, and the United States [57–60]. The first transplant was removed due to severe psychological problem experienced by the patient and his wife [57]. The case from South Africa reported good functional recovery such as ability to void in a standing position, maintain erection, and impregnate his wife. Despite demonstrating technical feasibility and early functional results, questions regarding bioethics, immune-modulation therapy, and psychological benefits are not yet resolved.

19.4 Urethral Reconstruction

Urethra is frequently reconstructed with a local flap or mucosal graft such as in hypospadias—patients, to recreate a mucosa-lined urethra and allow mucosa-to-mucosa healing [61]. Buccal mucosa is frequently chosen as it could tolerate constant moisture, there are no hair-bearing skin issues and it is easy to harvest. However, its survival depends on a healthy wound bed for a graft take. This is not always possible when multiple operations had been performed previously due to local tissue shortage, scarring, inadequate tissue flexibility for release, and poor tissue vascularity [62]. Skin tube made from the RFFF is frequently used to reconstruct the male urethra. Recently, some authors have started to use mucosal grafts to line a prefabricated urethra for phalloplasty [63, 64].

Healing at the skin-to-mucosa anastomosis site is problematic and because of this, there is a risk of obstruction, stricture, stone formation, fistula or diverticulum formation. The keratinized squamous epithelium of skin graft or flap does not tolerate harsh irritative environment of the urinary tract, that is more tolerated by the mucosal surface. In chronic cases where the urethra had been reconstructed repetitively or there is inadequate support for mucosal graft such as in cases of penile trauma, we have used the appendix-free flap with success [34]. The appendix with its mucosal lining supports mucosa-to-mucosa healing even when transferred from the intestinal tract to the urinary tract. It can be harvested on the appendiceal vessels or the ileocolic vessels. The cecum or ileum can be included for longer urethra to reach the native urethral stump, while the appendix tip is placed at the tip of the penis [34, 65]. In the case shown here, the patient had previous urethral reconstruction using scrotal skin flap 20 years ago. Repetitive infection and stone formation resulted in chronic inflammation and urethral stricture (Fig. 19.2a, b). A free segment of ileum based on its mesenteric vessels was used to reconstruct the urethra following excision of the extensive stricture (Fig. 19.2c–e).

Fig. 19.2 (**a**) A patient with hypospadias who had reconstruction with scrotal skin flap 20 years ago. Repetitive occurrence of stone formation and infection resulted in contracture of the urethra. (**b**) Excision of the urethral segment with stricture. (**c**) The previous anterior urethra made of scrotal skin was totally excised because of chronic inflammation. The urethral defect was reconstructed with a segment of free ileum. The recipient vessels were the right inferior epigastric artery and vein. (**d**) Post-operative appearance the penis after reconstruction of the urethra with a segment of free ileum. (**e**) Smooth standing passage of urine after reconstruction

19.5 Perineal Reconstruction

Various workhorse flaps have been described for tissue coverage and dead space obliteration such as the vertical rectus abdominis muscle (VRAM) and gluteal artery perforator flaps. The smaller gracilis muscle or myocutaneous flap is also commonly used for smaller defects or in situations involving rectourethral or rectovaginal fistulas [66, 67]. The anterolateral thigh (ALT) flap could also be an option (Fig. 19.3). In these examples, a slit or aperture was made in the skin paddle to accommodate the penis or the anus in the middle of the flap (Fig. 19.4a–d). We have

Fig. 19.3 ALT flap reconstruction with a keyhole aperture for skin coverage around the anus following wide excision of squamous cell carcinoma. Cotton bud stick showing the keyhole/anal opening

also described the dual-pedicle combined transverse upper gracilis (TUG) and profunda artery perforator (PAP) flap in our unit as an alternative method for both breast and perineal reconstructions [68, 69]. This robust flap is perfused by the profunda artery perforator and the medial circumflex femoral artery (Fig. 19.5a). The TUG–PAP flap can reach the perineum easily since both pedicles originate from the profunda femoral artery, which gives flexibility for optimizing flap reach (Fig. 19.5b, c). This is an excellent reconstructive solution for cases where an abdominal laparotomy is not required or when the VRAM is not available.

Fig. 19.4 (**a**) Paget's disease at the scrotum. (**b**) Skin marking showing the area of scrotum to be excised. (**c**) An anterolateral thigh flap was designed over the right thigh for coverage. (**d**) After wide excision of the scrotum, the anterolateral thigh flap was elevated and was fashioned into a key-hole flap to cover the defect with the penis in the middle of the flap like a key-hole

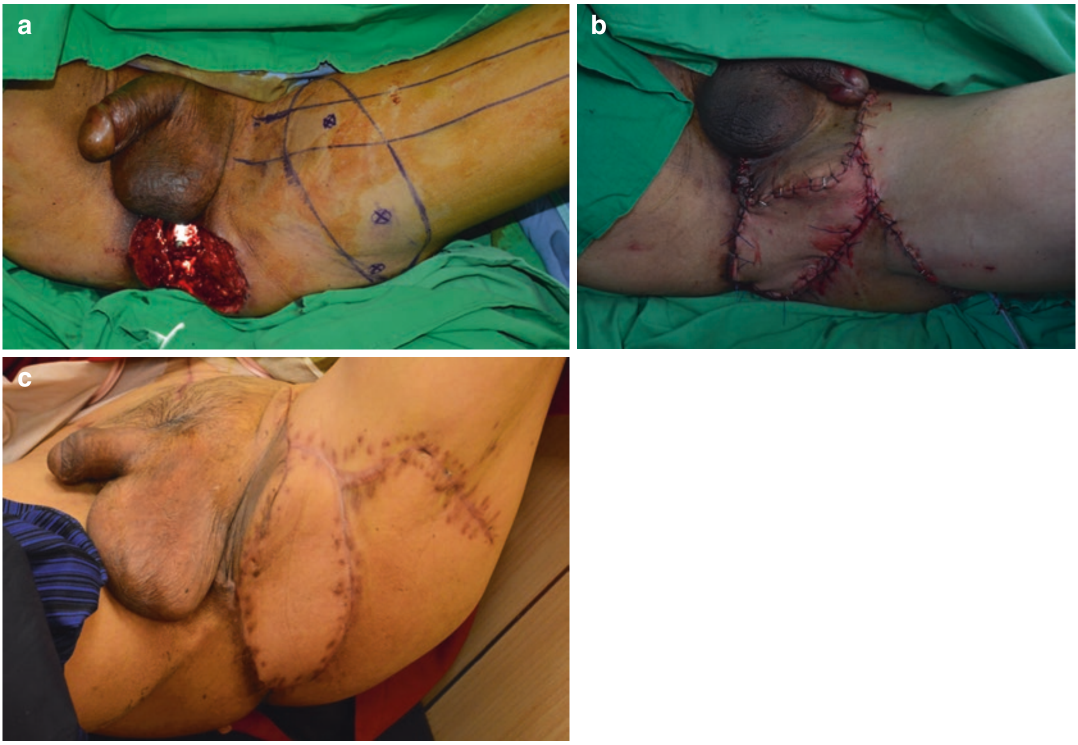

Fig. 19.5 (**a**) A large defect of the perineum after wide excision of squamous cell carcinoma. A combined PAP-TUG flap was raised as a pedicled flap for reconstruction of the perineal defect. (**b**) Early postoperative result showing both the donor and recipient site were adequately covered after mobilization of the surrounding tissue. (**c**) Good healing of the donor site and recipient site

19.6 Anal Sphincter Reconstruction

Fecal incontinence is a disabling condition with no widely accepted reconstructive surgery solution. Patients with partial or limited anal sphincter weakness are commonly managed conservatively, or with nonreconstructive methods such as with sacral nerve stimulation, biofeedback therapy or sphincter muscle repair (e.g., overlapping sphincteroplasty). However, in patients with complete sphincter deficiency or absence, permanent stoma formation, artificial sphincter device or muscle transposition are the main modalities of treatment. Although permanent stoma is commonly offered to patients, it has direct negative impact to their quality of life and satisfaction [70–72]. Artificial sphincter consists of a balloon cuff around the anal canal to maintain continence with an implanted pump to control inflation and deflation. They allow almost immediate restoration of continence but common problems associated with these devices include high explantation rate, erosion, device extrusion, infection, and obstruction [73, 74].

The earliest description of reconstruction of the anal sphincter was reported by Chetwood using gluteus maximus muscle transposition [44]. Transpositions of thigh adductor muscles were attempted by various authors. Gracilis muscle transfer was reported in 1952 by Pickrell for children with anal incontinence [75]. Fedorov described using the adductor longus muscle while Hakelius attempted free muscle flap transfers using either the palmaris longus or the sartorius muscle to regain anal continence [76, 77]. These skeletal muscle transfers have difficulties maintaining prolonged tonic muscle contraction to preserve continence [78]. With the exception of gluteus muscle and gracilis muscle transfers, none of the other muscle transfers have stood the test of time. However, dynamic transfer of gluteus or gracilis muscle assisted by low frequency electrical stimulation to modify their muscle properties has been attempted to overcome muscle fatigue [79, 80]. Morbidity of these procedures remained high, which includes necrosis of muscle or neo-anus, stimulation problem, wound complication, tendon detachment, constipation, obstruction, chronic pain, anal stricture, incontinence, and device problem [81, 82]. More recently, anorectal transplantation has been suggested as a possible treatment approach with promising preliminary results in animal models [83, 84].

19.7 Conclusion

Perineal reconstruction techniques have evolved from being merely a method for wound closure to become a functional replacement of the resected structures or organs. These techniques will continue to improve as patients' expectations continue to grow and surgeons strive to achieve a truly functional reconstruction.

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