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Reconstruction of the Intra-Abdominal Pelvis and the Perineum

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Introduction

Reconstruction following excision of cancers involving the pelvis, perineum, or vagina is complex for many reasons. First, the perineum is the exit site for three separate epithelialized structures—the rectum and gastrointestinal tract, the urethra and urologic tract, and in women, the vagina and gynecologic tract. Second, the deep location of the pelvis is difficult to access, and the perineum and vaginal areas are relatively remote from common flap donor sites. Third, the unyielding nature of the bony pelvis acts to block wound contracture as a means of wound healing. And fourth, the pelvis, perineum, and vagina are associated with multiple sexual, reproductive, and body image issues of variable importance to each patient. This chapter will elucidate some of the reconstructive options unique to the intra-abdominal pelvis, the perineum, the vagina, and the buttocks.

Reconstruction of the Intra-Abdominal Pelvis

The intra-abdominal pelvis is defined as the space below the pelvic inlet, and above the peritoneal reflections between the bladder, uterus, and rectum. Abdominoperineal resections (APR) of the distal colon/rectum/anus and anterior pelvic exenterations of the bladder and uterus/vagina for bladder and uterine cancer, posterior exenterations of the uterus/vagina and rectum for locally invasive rectal cancer, and total pelvic extenterations for a variety of locally advanced tumors all create soft-tissue defects within the intra-abdominal pelvis. Left untreated, the pelvis can become filled with fluid, and cause problems including drainage, infection (abscess), and perineal wound breakdown. This space may also be filled by the small intestine, resulting occasionally in bowel obstructions and/or herniation through the perineal wound. Therefore, reconstruction of the intra-abdominal pelvis is performed in order to fill the

space created by tumor excision, as well as in certain instances to reconstruct the vagina.

Rectal Cancer

The rectum is a tubular structure of the alimentary tract, located within a bony cavity. The bony cavity of the pelvis renders the rectum difficult to reach for the cancer surgeon. Resection of the rectum results in a contaminated surgical field, increasing the risk of early infections and wound breakdowns. Reconstructive flaps are often able to help prevent and or treat wound-healing problems associated with rectal cancer surgery, particularly APRs.

The closer the lesion is to the anus, the less likely the surgeon can remove the tumor and anastomose the proximal transected bowel segment to the distal segment deep in the pelvis near the anal sphincter. This procedure, called a low anterior resection (LAR), is the most common surgery for cancer of the rectum for tumors more than 7 cm from the anus. When the tumor is less than 5 cm from the anus, it is frequently impossible for the surgeon to remove the tumor and preserve a functional sphincter mechanism. Patients with cancer of the rectum located near the anus usually undergo the APR procedure, which includes removal of the rectum and anus and placement of a permanent colostomy through the abdominal wall. The APR is problematic for several reasons. The contaminated nature of the procedure (owing to the transection of the colon) and the removal of the tumor from within the confines of the bony pelvis have already been mentioned. An added difficulty is the dead space caused by removal of the rectum and the inability of local soft tissues to collapse the space in the bony pelvis. With LAR, the space previously occupied by the rectum is replaced by a segment of left colon (similar in diameter and bulk) mobilized and brought inferiorly to anastomose to the rectal remnant. APR, in contrast, does not replace the rectal space with a similarly sized segment of colon. Rather, the distal colon is brought out through the abdominal wall as a permanent colostomy. Thus, the pelvic space formerly occupied by the rectum is empty, and if it is left unmanaged fills with fluid or small bowel. The fluid can become infected, and small bowel adherent within the pelvis can become obstructed. The possibility of these complications may be reduced if a flap is placed into the pelvic defect.

When APR was devised almost 100 years ago, surgeons would close the peritoneum to hold the intestines within the abdominal cavity and leave the pelvic space packed open with dressings to help prevent infection *(1)*. Management of the deep pelvic space in this manner was difficult, because open dressings of the perineum would require months for the soft tissues to contract and allow for secondary intention wound closure. The bony confines of the pelvic ring act to slow the wound contracture process dramatically. A completely different treatment of the pelvic dead space was adopted in the 1970s, when Silen and Glotzer reported on a technique that allowed the space to be filled by the intestines *(2)*. Filling the pelvis with vascularized tissue (the intestines) decreased fluid collection and subsequent abscess formation within the pelvis, and consequently, there was a decrease in wound breakdown rates. Unfortunately, the tight

confines of the pelvis occasionally caused obstructions of the small bowel, and could result in difficult reoperative situations.

Healing of the intra-abdominal pelvis and APR defects is further rendered more difficult by the radiation therapy (RT) used to further treat low rectal cancers. RT is used to treat patients either before or after the APR procedure. Given pre-operatively before the APR procedure, radiation has been shown to decrease local cancer recurrence rates significantly. It may also reduce the magnitude of the resection required so that LAR becomes an option. However, pre-operative RT increases the local wound complication rate from 1–10% (without radiation) to 10–20% *(3)*. The means by which RT inhibits wound healing is by decreasing the tissue's ability to produce a normal wound-healing response of inflammation, angiogenesis, and deposition of collagen for wound healing. At the time of surgery, the tissues mechanically become stiff and difficult for the surgeon to manipulate, in part also contributing to local wound complications.

In contradistinction to pre-operative RT, post-operative RT has also been used for patients thought to be at high risk for cancer recurrence (e.g., those with positive lymph nodes or extensive invasion of surrounding tissues) and is also associated with reduced rates of local recurrence *(4)*. Post-operative RT is generally not started until the surgical field is healed, and therefore, it generally does not affect immediate post-operative wound healing. However, the small bowel that occupies the pelvic space after APR would be simultaneously radiated at the time of the tumor bed treatment. The bowel, adherent and unmoving in the pelvis because of surgical adhesions, is relatively sensitive to RT, increasing the likelihood of small-bowel radiation enteritis, stricture, and fistula formation. Radiation injury to the small bowel is reduced by limiting the total post-operative dose that is delivered—but this also tends to prevent an optimal treatment of the cancer bed *(5)*.

Placement of vascularized flaps into the perineum at the time of APR directly addresses many of the issues of wound healing and tumor treatment with radiation delineated in this chapter *(6)*. The vascularized tissue of a flap can fill the pelvic dead space created after APR with pliable, non-irradiated soft tissue whose blood vessels can carry in healing wound factors and antibiotics. The flap can also serves to block the small bowel from becoming located within the pelvis. This has the dual purpose of preventing a bowel obstruction and keeping the small bowel out of potential post-operative RT fields.

Historically, the most common flap used to fill the pelvis has been the pedicled greater omentum flap. The greater omentum can be dissected off of the transverse mesocolon and the stomach, elongated by dividing some of the vascular arcades, and passed to the right or the left of the midline to place it into the pelvic dead space. The flap is based on either the left or right gastroepiploic vessels. Unfortunately, the omentum may not be available or usable for reconstruction because of previous surgical adhesions in the upper abdomen, previous surgical removal, or insufficient size.

Myocutaneous flaps taken from the abdominal wall are an ideal alternative to the omentum for pelvic and perineal reconstruction. In essence,

a trade-off of extra surgery and potential consequences with the abdominal wall is made for a decrease in wound-healing problems in the intra-abdominal pelvis. Considering the difficulty of treating pelvic abscesses, wounds, adhesions, and fistulae, use of the abdominal wall as a donor site for flaps seems justified. These flaps are typically based on the right deep inferior epigastric artery system. The left-sided vessels nourish the left rectus abdominis muscle, which is typically reserved for placement of the end colostomy required for completion of APR. There are three main types of flap "designs" based on the right rectus abdominis muscle and/or overlying skin. A right rectus abdominis muscle flap includes the muscle from above the costal margin to the vascular pedicle near the symphysis pubis. The anterior (above the arcuate line) and posterior rectus fasciae are still present for closing the abdominal wall. The muscle-only flap can improve initial pelvic/perineal wound healing, can be harvested through the same midline incision used for the laparotomy, and preserves the anterior abdominal wall fascia for closure of the abdominal wall. The problem with this flap is its relatively low volume. The muscle flap alone has limited bulk to obliterate pelvic dead space. Also, the muscle atrophies over time owing to division of the intercostal nerves necessary to transfer the flap into the pelvis, and this atrophy allows the small bowel to slowly descend into the pelvis.

As opposed to muscle-only flaps, myocutaneous flaps carry skin, subcutaneous tissue, and muscle based on the right rectus muscle and the right deep inferior epigastric vessels. Most of the flap volume with these myocutaneous flaps is composed of fat, which unlike muscle does not atrophy over time. Therefore, the small bowel is unlikely to slowly descend into the pelvis over time. When the skin is oriented vertically along the length of the rectus muscle, the flap is termed a vertical rectus abdominis myocutaneous flap (VRAM), whereas an oblique skin paddle based on peri-umbilical perforators is called an oblique rectus abdominis myocutaneous (ORAM) flap. The decision of whether to employ a rectus muscle flap, a VRAM, or an ORAM flap depends on pre-existing abdominal incisions, individualized requirements for soft tissue in the pelvis, and surgeon preference *(7)*. The two myocutaneous flap designs each have the potential to transfer skin into the pelvis, to help recreate the lining of the vagina, or to provide external skin at the level of the anus.

The benefits of filling the pelvic dead space with vascularized tissue must be compared to the risks of the procedure. In general, myocutaneous abdominal flaps are dependable, and partial or total flap loss owing to vascular insufficiency is not common. The reconstructive surgeon may attempt to take overlying skin and fat with less muscle in a desire to reduce morbidity of early wound-healing problems and late hernia formation of the abdominal wall. The VRAM flap generally includes the full width of the rectus muscle from the costal margin to the symphisis pubis. This creates the most vascularized flap, but the abdominal closure requires a moderate amount of medial advancement of fascia and skin. The ORAM flap bases the skin blood flow on perforators found near the umbilicus. Only a strip of muscle containing the right deep inferior epigastric vessel is harvested with an ORAM, leaving more muscle and fascia present for closing of the abdominal wall. However, muscle-sparing

flaps may have more unpredictable blood flow and thus an increased risk of partial or even total flap loss.

Collections of fluid can accumulate at the donor sites from which the flap soft tissues were removed. These fluid collections (seromas) may be prevented with drains placed at the time of surgery. Although drains are usually effective, these seromas can cause small wound separations that become apparent 1–2 weeks after surgery. The trade-off of a small wound problem on the anterior surface of the abdomen is generally accepted to decrease the chances of a deep pelvic abscess or wound-healing complication. Another complication with these flaps is late abdominal hernia formation from the harvest of a portion of the rectus abdominis muscle. Because of the contaminated nature of the bowel resection, the use of permanent synthetic meshes are best avoided at the time of surgery to reinforce an area of the abdominal wall weakened by flap harvest. An example of an ORAM flap placed into the abdomen is represented in Figure 13.1.

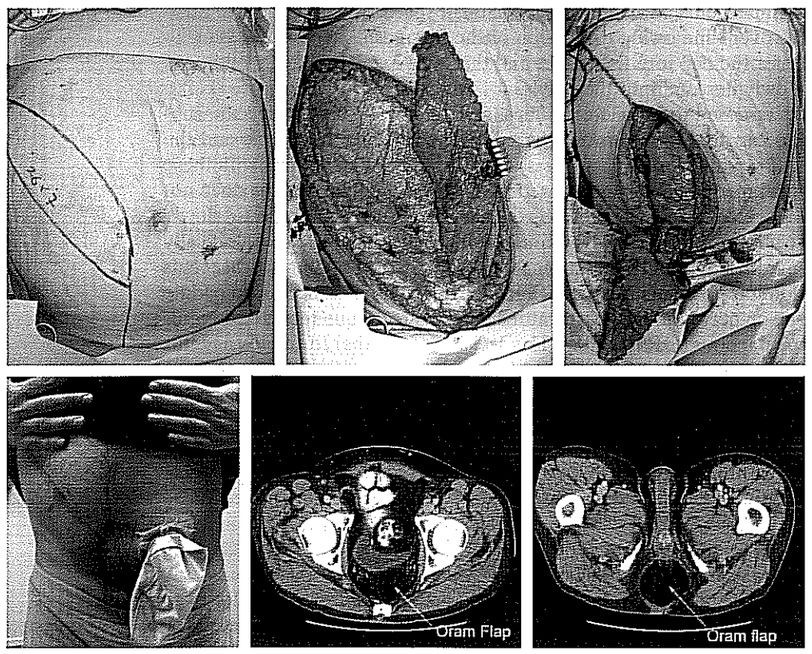

Figure 13.1. An ORAM flap was used to fill an intra-abdominal pelvis defect created after APR. Pre-operative RT had been given to the patient. **(A)** Drawing of the flap design and the pre-operative marking for stoma placement. **(B)** The flap is being elevated. **(C)** Rectus muscle dissection. The lateral border of the rectus muscle is still intact on the abdomen. The upper aspect of the incision is closed. **(D)** Post-operative photograph demonstrating the relationship of the incision to the stoma appliance. **(E)** The CT scan at 2-years follow-up with view of the upper aspect of pelvis showing the flap and bladder. **(F)** The CT scan at 2-years follow-up with view of the lower aspect of intra-abdominal pelvis showing the ORAM flap in place and the small bowel has been excluded from the area.

As described in this chapter, flaps have been used prophylactically in order to prevent a problem of the intra-abdominal pelvis. Flaps can also be useful in the treatment of wounds that develop after pelvic surgery. Pelvic wounds that occur after APR and without a previous flap can be difficult to treat. The wounds are typically in the lower aspect of the bony pelvis, radiated, chronically contaminated with bacteria, and can be painful. The bowel is located just superior to the wound, making debridement of the wound difficult and at risk for the creation for an enterocutaneous fistula. In order to avoid another laparotomy, gracilis flaps can be harvested from the inner thigh and tunneled into the wound. The muscle or myocutaneous gracilis flaps have been used successfully to treat non-healing wounds and sinus tracts of the perineum after APR. The abdominal flaps are generally performed at the time of ablative surgery, to help fill dead space and to help prevent perineal wound complications. The gracilis flap is generally smaller and can often fill only the lowest aspect of the rectal defect. It is less effective for filling the pelvis and preventing the small bowel from descending into the pelvic space. Therefore, the gracilis flap is often reserved for established wounds of the perineum after APR, rather than for their prevention.

Perineal Reconstruction

Vaginal Reconstruction

The vagina can be reconstructed by several methods, and the optimal technique depends on the reason for the vaginal absence. In vaginal atresia, the soft tissues of the perineum are intact, and often a tubed skin graft placed inside-out into a space created between the bladder and rectum can be used to construct a vaginal wall. However, vaginas constructed from skin grafts tend to contract over time, and dilators are generally required to maintain the size of the neovagina.

Tumor resections for cancers of the introitus, vagina, and cervix remove enough tissue that skin grafts generally cannot be reliably used for reconstruction. For low and small defects, local perineal skin flaps can be transposed to reach the remnant of the vaginal cuff. Adducting the patient's legs usually allows the donor site to be closed primarily *(8)*.

The optimal means of reconstruction for larger defects depends on the method of tumor extirpation. Vaginal tumors are often removed without a laparotomy. Reconstruction of the resulting defects is often performed using bilateral gracilis myocutaneous flaps. The skin paddles are sutured together to create a vascularized tube, which is inset into the perineum. The flap requires bilateral inner-thigh donor-site incisions that are usually cosmetically acceptable. One shortcoming of this reconstructive method is that occasionally the skin overlying the gracilis muscle does not remain viable during the flap transfer. The flaps can also be also difficult to sew into place with just a perineal (without a laparotomy) approach. The vascularized tissue is anchored deeply within the bony pelvis, and these stitches are much easier for the surgeon to place when the abdomen is

entered at the time of tumor extirpation. These flaps are also more easily inset when there is a larger tissue defect, such as occurs with an APR or pelvic exenteration.

An alternative to bilateral thigh flaps for vaginal defects is a myocutaneous flap taken from the abdomen. When a vaginal tumor is removed during a laparotomy, then the rectus abdominis muscle with overlying skin can be tubed and transferred into the perineum. The skin used for the vaginal reconstruction will come mostly from above the umbilicus, resulting in a visible scar on the patient's upper abdomen. Despite that drawback, this method of reconstruction may be more reliable than bilateral tubed gracilis flaps. An example of reconstruction of the posterior aspect of the vagina, removed with the APR for locally advanced rectal cancer, is shown in Figure 13.2.

Other methods of vaginal reconstruction are less frequently used. Tubed fasciocutaneous flaps can be harvested from various remote locations and transferred into the pelvis using microsurgery. These are technically difficult operations, requiring several hours of surgery for the microvascular reconstruction, and with a chance of failure if the vascular anastomoses were to thrombose. Another alternative for vaginal reconstruction is transfer of a vascularized, defunctionalized segment of bowel into the pelvis, with the superior end sutured closed and the inferior end sutured to the perineal defect. This provides a tubed epithelial structure with its own mucous production for lubrication. Many surgeons avoid this means of vaginal reconstruction, however, because of its technical difficulty, need for bowel anastomoses, and the constant production of mucous, which often requires the patient to always wear a sanitary pad for hygiene.

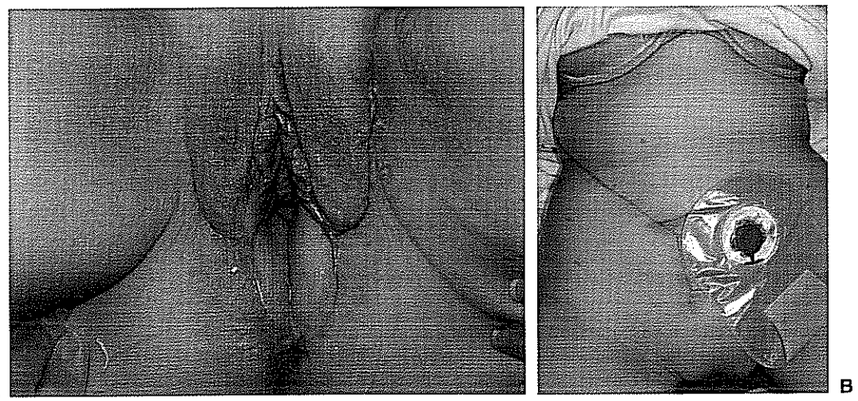

Figure 13.2. (A) Post-operative photograph of an ORAM reconstruction of the perineum after APR and partial (posterior) vaginectomy. The posterior vaginal wall and perineal skin were reconstructed with the ORAM flap harvested from right side of abdomen. **(B)** The APR was performed and the same incision used to harvest the right ORAM flap. An end colostomy was created through the left rectus abdominis muscle.

Perineal Skin Reconstruction

Although reconstruction of both the intra-abdominal pelvis and the vagina requires a "three-dimensional" reconstruction of the pelvic cavity and/or creating an internal lining of skin, reconstruction of the perineum typically requires only a two-dimensional reconstruction of the missing perineal skin. However, this skin replacement is often complicated by the need to preserve the exit sites for the vagina and urethra.

Perineal reconstruction may be required after removal of large primary tumors and smaller recurrent tumors of the labia, vagina, cervix, urethra, bladder, and penis. When the tumor involves the superior aspect of the vagina, the anus, and/or the rectum, perineal reconstruction may be required in conjunction with reconstruction of the pelvis and vagina.

Squamous cell cancer of the vulva is one of the most common tumors of the perineum, and the treatment of vulvar cancer is primarily surgical. The primary tumor is excised, and dissection of the inguinal lymph nodes may be performed at the same time, if indicated. Wound closure after resection of a small to moderately sized primary vulvar cancer is typically possible by adducting the patient's legs, flexing the patient at the waist, and advancing the thigh skin medially and the lower abdominal skin inferiorly. Larger primary tumors can be excised and the defect skin grafted if the area has not already received RT.

When vulvar cancers recur, secondary surgery is difficult because the tissues may be tight owing to prior removal of the primary tumor and/or RT. Tumor re-excisions result in large defects of the perineal skin. Thin skin flaps from the thighs or abdominal wall are the optimal coverage of these defects. Skin grafts alone may be insufficient as these areas are typically irradiated, contaminated with bowel flora, and under the stress of chronic movement. Skin flaps used in this area should be thin because even the thinnest skin flap may be more bulky than native tissue and be redundant and bothersome during ambulation. A representative case of a perineal defect repaired with an ORAM flap is demonstrated in Figure 13.3; the urethra and the vagina were inset into an opening created in the center of the skin flap. The underlying fat of skin flaps may be thinned at a delayed setting using liposuction once several months have elapsed since the surgery.

Obese patients have thick skin flaps, rendering the use of an abdominal flap difficult because of the marked difference between the thick layer of fat beneath the thin perineal skin. An alternative to the use of a skin flap for obese patients is a skin-grafted muscle flap. Both the gracilis muscle and the rectus abdominis muscle will reach the perineum, and can provide excellent interfaces between the irradiated bed and the skin graft to improve the "take" of the graft and to achieve wound healing. However, it is more difficult for the surgeon to create "exit sites" for the urethra, vagina, and anus when using a skin-grafted muscle flap in comparison to a skin flap, and consequently skin-grafted muscle flaps are not generally the first choice of reconstructive surgeons for perineal defects.

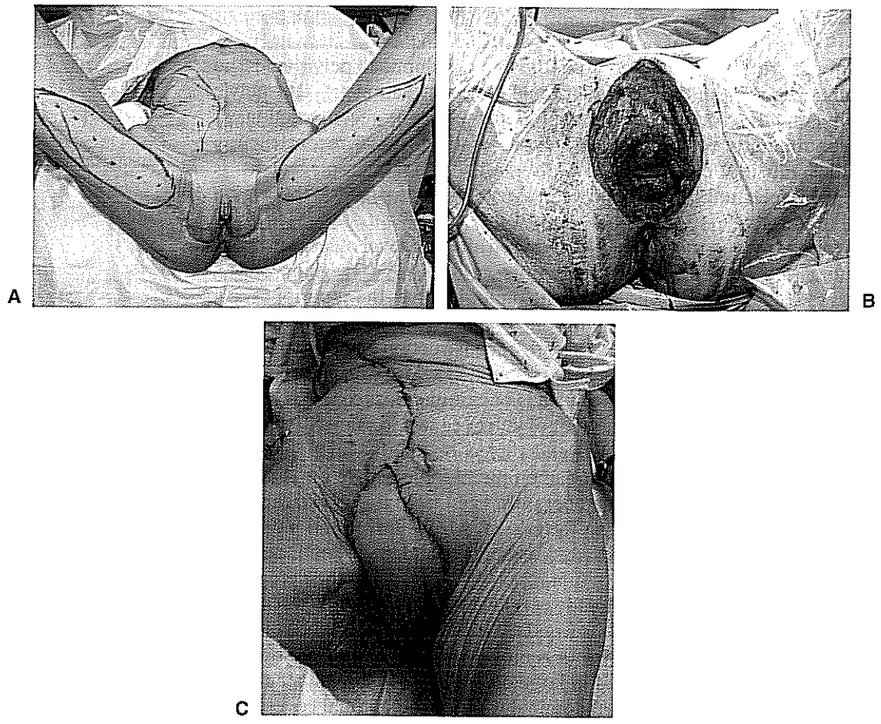

Figure 13.3. A 75-year-old woman with recurrent squamous cell carcinoma of the vaginal introitus was treated initially with RT and surgery. **(A)** The design of bilateral gracilis flaps (not used for the reconstruction) and an ORAM flap are marked on the patient. **(B)** Surgical resection with grossly negative margins. **(C)** Photograph at 3 weeks after a pedicled ORAM flap. An opening in the center of the flap was created for the exit of the vagina and urethra.

Anal/Buttock Skin Reconstruction

Squamous cell cancers of the anus, very low rectal cancers, and other tumors of the buttock skin, including melanoma, can involve the skin of the anus and buttocks. Anal cancer is different from other cancers described in this chapter, in that non-surgical treatment involving chemotherapy and RT alone is effective in preserving the anus in up to 85% of patients *(9)*. Failures of treatment can still be salvaged with an APR, though the radiation used for initial treatment becomes problematic in achieving wound healing. An ORAM or VRAM flap can be transferred to reach the anus and to facilitate incisional healing. Such a flap is performed at the time of APR, when the abdomen is completely open. The

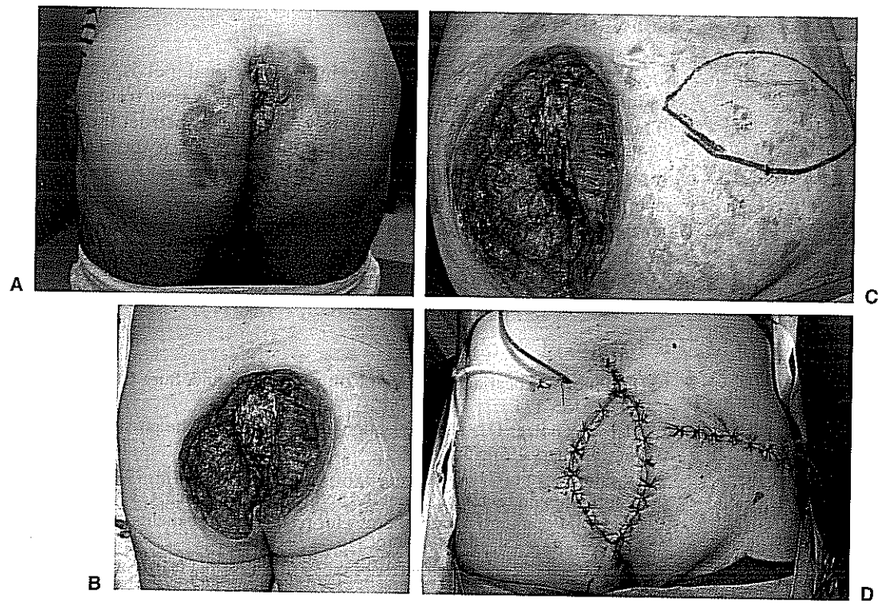

Figure 13.4. (A) A 64-year-old man with squamous cell carcinoma (Marjolin's ulcer) arising from a chronic pilonidal cyst. **(B)** Surgical resection with grossly negative margins. **(C)** The design of a superior gluteal artery perforator flap is marked on the right buttock. **(D)** Photograph of the reconstruction with donor and recipient sites closed.

flap is tunneled through the intra-abdominal pelvis to reach the buttock skin for wound closure.

Squamous cell carcinoma (Marjolin's ulcer) can develop in chronic perineal wounds present for prolonged periods of time. Figure 13.4 represents an unusual case of a large squamous cell carcinoma arising out of a chronic pilonidal cyst that had been present for 30 years. An important surgical consideration is that attention must be paid to diminishing the potential injury of the donor site for an ambulatory patient, particularly gluteal muscle function. Rather than creating a myocutaneous buttock flap for wound closure, a large gluteal perforator flap was harvested, leaving the entire gluteus maximus muscle in place while transposing the buttock skin to achieve wound closure. Another important consideration is the prevention of pressure on the incision during the early post-operative period. Pressure relief sand mattresses are employed for 7–10 days so that the patient can lie directly on the flap to decrease the chances of breakdown at the incision line and to prevent pressure on the vascular pedicle.

Conclusion

Successful tumor excisions of the intra-abdominal pelvis, perineum, vagina, and buttocks require not only a plan of how best to remove the tumor, but also a detailed plan as to how best to reconstruct the patient. Well-vascularized flaps are employed to fill dead spaces, prevent migration of the bowel into tight pelvic recesses, provide epithelized tissue for reconstruction of the vagina, and to achieve wound closures of the perineum and buttocks. The role of the reconstructive surgeon is to use the most reliable flap with the smallest long-term side-effects to the patient to achieve the desired goals.

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