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Review Article

Penile reconstruction post-oncologic surgery: comprehensive approaches

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ABSTRACT

Post-oncologic penile reconstruction aims to restore penile form and function following surgical resection due to penile cancer. This reconstructive surgery is essential as treatments like partial or total penectomy can severely impact a patient's quality of life. The primary goals include maintaining urinary and sexual function while achieving a cosmetically acceptable result. Techniques range from simple resurfacing of the glans to complex procedures like phalloplasty, while penile-sparing therapies, including topical treatments and laser ablation, are also used to minimize disfigurement. Penile cancer, predominantly squamous cell carcinoma, is rare but more prevalent in developing countries, with risk factors such as human papillomavirus (HPV) infection and poor hygiene. The preoperative evaluation involves assessing comorbidities, psychological state, and functional capacity to ensure optimal outcomes. Criteria for reconstruction include the extent of the defect, oncological status, and desired outcomes. Techniques employed in reconstruction include local, inguinal, anterolateral thigh, and myocutaneous flaps, as well as grafts and alloplastic materials. Innovations in surgical methodologies and multidisciplinary strategies have significantly improved outcomes. However, complications, including high perioperative morbidity, underscore the need for careful patient selection and management. Psychosocial support is crucial for optimal recovery and quality of life, emphasizing the importance of a comprehensive, patient-centered approach in post-oncologic penile reconstruction. This holistic approach ensures that patients not only achieve cancer survival but also maintain a high quality of life following their treatment.

Keywords: Penile reconstruction, Penile cancer, Surgical techniques, Post-oncologic care, Quality of life

INTRODUCTION

Definition and relevance of post-oncologic penile reconstruction

Post-oncologic penile reconstruction refers to the surgical procedures undertaken to restore the form and function of the penis following oncologic resection due to penile cancer. This type of reconstruction is crucial as penile cancer treatments, such as partial or total penectomy, can be significantly mutilating and adversely affect the patient's quality of life. The primary goals of post-oncologic penile reconstruction are to maintain or restore urinary and sexual function while achieving a cosmetically acceptable result. Techniques vary depending on the extent of the defect created by the tumor excision and can range from simple resurfacing of the glans to more complex procedures like phalloplasty.[1] Penile-sparing therapies, which include topical treatments, laser ablation, and partial glansectomy, are also employed to minimize disfigurement while maintaining oncologic control, especially in early-stage disease.[2] Additionally, penile

rehabilitation, although more commonly associated with post-prostatectomy care, underscores the importance of preserving erectile function and expediting recovery, which is also a consideration in penile reconstruction post-cancer treatment.[3] Overall, the evolution of surgical methodologies and the implementation of a multidisciplinary strategy have greatly enhanced the results of penile reconstruction. This progress has ensured that patients not only achieve cancer survival but also maintain a high quality of life following their treatment.

Cancers involving the penis

Penile cancer, though rare, presents a significant health concern, particularly in developing countries. The most common type of penile cancer is squamous cell carcinoma, which accounts for approximately 95% of cases and typically arises from the mucosal surfaces of the foreskin, glans, and coronal sulcus.[4,5] Other types of penile cancers include non-squamous variants such as Kaposi sarcoma, melanoma, basal cell carcinoma, and extramammary Paget disease, which collectively make up about 5% of penile malignancies.[6] The incidence of penile cancer varies globally, with higher rates observed in developing regions. For instance, the state of Maranhão in Brazil has the highest recorded global incidence, attributed largely to human papillomavirus (HPV) infection, which is present in up to 80.5% of cases.[7] In Europe, the incidence is about 1 per 100,000 males per year, with Spain reporting a slightly higher rate of 2.55 per 100,000 males in 2015.[5] Risk factors for penile cancer include human papillomavirus (HPV) infection, poor hygiene, phimosis, chronic inflammatory conditions like lichen sclerosus, smoking, and multiple sexual partners.[4] The incidence and mortality rates of penile cancer are rising in many countries, with 36,068 new cases and 13,211 deaths reported globally in 2020.[8] Imaging modalities such as magnetic resonance imaging (MRI), computed tomography (CT), PET/CT, and ultrasound play crucial roles in the diagnosis, staging, and treatment planning of penile malignancies.[4] Treatment strategies often involve multimodal approaches, especially for advanced cases with regional lymph node involvement, which is a key prognostic factor. Neoadjuvant and adjuvant therapies, including chemotherapy and radiation, are essential for improving outcomes in patients with nodal disease.[9] Despite advancements in treatment, the prognosis for penile cancer continues to be poor, especially in low-income areas where healthcare access is restricted. Emphasizing the necessity for standardized diagnostic protocols and the establishment of referral centers is crucial to optimize management and enhance survival rates. Additionally, the rising incidence in high-income regions underscores the importance of preventive measures such as HPV vaccination and improved penile hygiene to mitigate the disease burden.[8] While penile cancer remains a rare malignancy, its impact is significant, necessitating continued research and improved clinical practices to address this public health issue effectively.

Preoperative evaluation of the patient

Preoperative patient evaluation for post-oncologic penile reconstruction requires careful consideration of various factors to optimize outcomes. First, it is essential to assess preoperative comorbidities such as diabetes, heart disease, hypertension, obesity, as well as chemotherapy and radiation, as these conditions can profoundly affect surgical outcomes and should be proactively addressed to improve patient readiness for surgery. Additionally, frailty assessment is essential, particularly in older adults, as frailty is associated with adverse postoperative outcomes, including complications and prolonged hospital stays. Tools that measure physical and cognitive function, comorbidities, and self-reported health can help identify at-risk patients and guide tailored operative plans.[10] Psychological and psychosocial evaluations are also important, as surgical interventions can lead to significant anxiety and fear related to anesthesia, potential loss of sexual function, and overall control over one's body. Addressing these concerns preoperatively can help reduce anxiety and improve patient cooperation and satisfaction.[11] In summary, a comprehensive preoperative evaluation that includes medical, psychological, and functional assessments, along with early therapeutic interventions, can significantly enhance the success of post-oncologic penile reconstruction.

Criteria for post-oncologic penile reconstruction

The primary criteria include the extent of the defect created by the oncologic resection, the patient's oncological status, and the desired functional and aesthetic outcomes. The extent of the defect is crucial as it dictates the type of reconstructive technique to be employed. For instance, smaller defects may be managed with simpler techniques such as glans resurfacing or partial penectomy, while larger defects may necessitate more complex procedures like phalloplasty or the use of free flaps.[1] The patient's oncological status at the time of surgery is another critical factor. Immediate reconstruction is often preferred to minimize the psychological impact and improve the quality of life, as seen in studies where penile reconstruction was performed simultaneously with partial penectomy, resulting in high patient satisfaction and low complication rates.[12] However, in cases of locoregionally advanced penile squamous cell carcinoma, the high risk of recurrence and complications may necessitate a more cautious approach, with some studies reporting a 67% mortality rate and a high incidence of wound complications following extensive surgery and reconstruction.[13] Functional outcomes, including the ability to urinate while standing and the potential for sexual activity, are also paramount. Techniques such as penile-sparing therapies and the use of sensate free flaps have been shown to offer good cosmetic results and reasonable phallic length without compromising oncologic control.[2] In cases where there is a high risk of infection or other complications, delayed reconstruction may be more appropriate. The choice of reconstructive technique also

depends on the availability of suitable flaps and the patient's overall health. Techniques such as the use of vertical rectus abdominis myocutaneous flaps, anterolateral thigh flaps, and other pedicled or free flaps are commonly employed, each with its own set of indications and potential complications.[14] Moreover, the patient's age, sexual activity, and personal preferences should be considered, as younger, sexually active patients may benefit more from total phallic reconstruction compared to older, sexually inactive patients who may be content with simpler procedures.[15] Finally, the psychological impact of penile cancer and its treatment cannot be overlooked. Studies have shown that satisfactory reconstruction significantly improves health-related quality of life, self-esteem, and sexual function, making it a critical component of the overall treatment plan.[16] In general, the criteria for post-oncologic penile reconstruction are multifactorial, involving the extent of the defect, oncological status, functional and aesthetic goals, timing of reconstruction, availability of suitable flaps, and the patient's overall health and preferences.

SURGICAL TECHNIQUES

Oncological surgery techniques

For penile cancer, surgical options include partial and total penectomy, which involve the removal of part or all of the penis, respectively, with a standard resection margin of 5mm to ensure complete excision of the tumor. These procedures are crucial for early-stage penile cancer, while penile-preserving techniques like circumcision, laser ablation, and Mohs micrographic surgery are considered for lower-grade tumors with favorable histology and location.[17] Inguinal lymphadenectomy, involving the removal of lymph nodes in the groin, is a crucial procedure for penile cancer, aiding in both staging and managing locally advanced disease.

Cancer surgeries can be classified into diagnostic, curative, and palliative types. Diagnostic surgeries, such as biopsies, are performed to confirm cancer by analyzing tissue samples, whereas curative surgeries aim to excise all cancerous cells, typically in early-stage cancers. Palliative surgeries are designed to alleviate symptoms and enhance the quality of life for patients with advanced cancer.

Penile reconstruction techniques

Reconstruction with local flaps

Local rotation flaps have been effectively utilized for reconstructing defects after the excision of divided nevi of the penis, demonstrating a high rate of patient satisfaction and minimal complications. In a study involving eight young male patients, the use of local rotation flaps resulted in no postoperative infections and preserved sexual function, as confirmed by the brief male sexual function inventory (BMSFI) and international index of erectile function-5 (IIEF-5) scales, while also improving psychological outcomes such as reduced depression, anxiety, and stress.[18] In the broader context of oncologic surgeries, local flaps have also been successfully employed in oral cavity reconstructions, with the facial artery myo-mucosal flap and nasolabial flap being the most commonly used. These flaps have shown reliable outcomes with no complete flap loss and minimal complications.[19] Collectively, these studies underscore the versatility and efficacy of local flaps in reconstructive surgeries following oncologic resections, highlighting their role in achieving satisfactory functional and cosmetic outcomes while minimizing postoperative complications.

Inguinal flaps

For more extensive reconstructions, especially after lymphadenectomy in metastatic penile cancer, fasciocutaneous and myocutaneous flaps from the abdomen and thigh are commonly employed. These flaps facilitate tensionless closure and faster postoperative recovery, enabling patients to commence adjuvant treatments sooner.[20] In cases where conventional reconstructive techniques are contraindicated due to factors like compromised deep femoral artery networks or lower limb lymphedema, abdominal adipocutaneous advancement flaps have proven to be an effective alternative, offering reproducible outcomes and minimal complications.[21] For patients with locally advanced penile cancer presenting with ulcerated or fixed bulky inguinal masses, primary radical inguinal surgical debulking combined with myocutaneous pediculate flap reconstruction using tensor fascia lata or gracilis flaps can provide temporary local control of the disease, although it is associated with a high incidence of complications. Adjuvant chemotherapy in these cases has been linked to improved overall survival.[22] Furthermore, for isolated penile skin sheath reconstruction, the superficial circumflex iliac perforator pedicled flap offers a viable alternative to traditional skin grafts, reducing the risk of contracture and donor-site morbidity.[23]

Anterolateral thigh flap

Post-oncological penile reconstruction using the anterolateral thigh flap is a complex but effective approach, particularly when addressing extensive defects following oncological resection. The anterolateral thigh flap is favored due to its reliable soft tissue coverage and low donor site morbidity compared to other options like the vertical rectus abdominis flap.[24] A novel approach combining a pedicled anterolateral thigh flap for penile shaft reconstruction with a radial forearm free flap for neourethra and glans reconstruction has demonstrated successful outcomes without neourethral strictures or fistulas, highlighting the potential of double flap techniques in cases requiring extensive urethral length reconstruction.[25] The versatility of the anterolateral thigh flap is further supported by its use in other reconstructive scenarios, such as thigh reconstruction post-oncological resection, where it has shown high patient satisfaction and

low complication rates.[26] The anterolateral thigh flap, whether used alone or in combination with other flaps, offers a robust solution for post-oncological penile reconstruction, balancing functional and aesthetic outcomes while minimizing donor site morbidity.

Myocutaneous flap

The use of myocutaneous flaps, such as the rectus abdominis myocutaneous flap, is particularly advantageous due to their independent and constant blood supply, ease of harvest, and substantial skin coverage, which are crucial for covering large defects and ensuring robust vascularization in the reconstructed area.[13] The tensor fascia lata flap and gracilis flap are also commonly employed, with the tensor fascia lata flap being the standard of care for many patients, providing a reliable option for tensionless closure and faster postoperative recovery.[22] However, these procedures are not without complications; a significant proportion of patients experience wound complications, including high-grade Clavien-Dindo complications, which can impact the overall success and recovery.[13] Despite these challenges, the use of myocutaneous flaps in inguinal reconstruction after lymphadenectomy for metastatic penile cancer has shown to reduce patient morbidity and enable quicker initiation of adjuvant treatments, which is critical for improving overall survival rates.[20]

Reconstruction with grafts

For localized penile cancer, organ-sparing surgeries such as glans resurfacing using split-thickness skin grafts, dorsal or ventral V-Y skin advancement, and urethral centralization are preferred due to their ability to achieve good cosmetic and functional outcomes while maintaining oncological safety.[27] Meticulous patient selection, thorough preoperative counseling, and vigilant postoperative monitoring are critical elements for successful post-oncological penile reconstruction.

Use of alloplastic materials and prosthesis

Alloplastic materials have played a significant role in penile reconstruction post-oncology, particularly in restoring erectile function and structural integrity following cancer treatment. Historically, alloplastic devices, such as single acrylic rigid rods, were among the first prosthetic devices used to re-establish erectile function in impotent males, initially implanted subcutaneously and later into the cavernous tissue for better stabilization.[28] However, the use of alloplastic materials has not without challenges. For instance, complications associated with surgical mesh in pelvic floor reconstructions, such as erosion, infection, and pain, highlight the potential risks of using synthetic materials in reconstructive surgeries. Thus, while alloplastic materials offer significant benefits in penile reconstruction post-oncology, careful consideration of their potential complications and ongoing advancements in biocompatibility are essential for optimizing patient outcomes.

Innovations and advances in penile reconstruction

Penile reconstruction post-oncologic surgery has seen significant advancements, focusing on preserving function and aesthetics while minimizing complications. Innovations in surgical techniques and materials have greatly improved outcomes for patients. Reconstructive surgery of the penis, particularly after trauma or cancer, now often employs full-thickness skin grafts and pedicled scrotal flaps for penile shaft skin defects, while the radial artery-based forearm free flap remains the gold standard for neophallus creation due to its superior function, sensation, and cosmesis, despite its complexity and the disfiguring scar it leaves.[29] Organ-sparing approaches, such as glans resurfacing for carcinoma in situ, have shown low local recurrence rates and high patient satisfaction, while more extensive reconstructions, including flap techniques for total penectomy, are also being refined. Furthermore, the integration of tissue engineering and transplantation innovations is on the horizon, promising even more advanced reconstructive options.[30] Vascularized composite allotransplantation has emerged as an alternative reconstruction technique for patients with severe penile loss, with successful cases demonstrating the potential for natural urinary and erectile functions, although challenges such as immunosuppressive therapy complications and psychological impacts remain.[31] These advancements collectively represent a significant leap forward in penile reconstructive surgery, offering improved oncologic, functional, and cosmetic outcomes for patients undergoing these complex procedures.

OUTCOMES AND COMPLICATIONS

Functional and esthetic results

Post-oncological penile reconstruction aims to restore both functional and aesthetic aspects of the penis, significantly impacting patients' health-related quality of life, self-esteem, and sexual function. Various techniques have been developed to achieve these goals. For instance, partial penectomy with inverted urethral flap reconstruction has shown promising results, with a 6-year overall survival of 86.5% and a mean global health score of 84.6%.[16] Organ-sparing surgery has also gained traction, offering good cosmetic and functional outcomes without compromising oncological safety. Techniques such as glans resurfacing and urethral centralization are particularly effective in preserving penile aesthetics and function.[27] The importance of aesthetic outcomes in genitourinary malformations, including penile cancer, has been emphasized since the latter half of the 20th century, highlighting the need for a normal-looking penis with functional capabilities.[32] Overall, while the techniques and outcomes vary, the overarching goal remains the same: to

create a functional and aesthetically pleasing phallus that significantly enhances the patient's quality of life.

Complications

Penile reconstruction post-oncologic surgery, particularly following treatments for penile cancer, is fraught with complications that can significantly impact patient outcomes. The transition to minimally invasive techniques, such as robotic-assisted surgery, has helped mitigate some limitations of traditional methods, yet complications remain inevitable and often carry significant morbidity.[33] For instance, reconstructive surgery after penile cancer treatment must address defects from tumor excision, with advancements in techniques like resurfacing of the glans and complex phalloplasty improving outcomes by minimizing complications such as urethral stricture formation and flap/graft loss.[1] However, the treatment of locoregionally advanced penile squamous cell carcinoma often involves extensive surgery, leading to large defects that necessitate reconstructive procedures like rectus abdominis myocutaneous flaps. Despite their benefits, these procedures are associated with high rates of perioperative complications, including severe Clavien-Dindo grade III complications, and a significant recurrence rate of the disease, highlighting the need for careful consideration and alternative treatments.[13] Additionally, sarcopenia, a marker for malnutrition and frailty, has been linked to higher complication rates and prolonged hospital stays in oncologic surgeries, suggesting that muscle quality, rather than quantity, is a critical predictor of adverse outcomes.[34] Complications during and after penile prosthesis surgery are also not uncommon, but prompt management according to established principles can minimize morbidity.[35]

Psychosocial aspects and quality of life

Psychosocial factors significantly impact post-oncological penile reconstruction outcomes, influencing both recovery and quality of life. The incorporation of psychosocial oncology services into urological practice can alleviate the distress linked to cancer diagnosis and treatment, enhancing patients' overall well-being and quality of life throughout the course of their disease. Studies have shown that psychosocial variables such as depression, social support, and attitudinal factors are predictive of surgical outcomes, including postoperative pain and functional recovery, even when accounting for clinical variables like presurgical health status.[36] The psychosocial consequences of invasive procedures, such as those involved in pelvic exenterative surgery, include high incidences of anxiety, depression, self-image issues, and sexual dysfunction, which can be managed through preoperative preparation and postoperative psychiatric care.[37] Addressing these complex barriers through multidisciplinary care, including couple psychosexual counseling and peer support, is crucial for facilitating successful sexual recovery and improving the overall quality of life for patients undergoing penile reconstruction after oncological treatments. Thus, a comprehensive approach that includes psychosocial support is essential for optimizing post-oncological penile reconstruction outcomes.

CONCLUSION

Penile reconstruction after oncological resection is a complex but evolving field that offers patients the possibility of restored function and improved quality of life. Careful preoperative assessment, consideration of oncological status and patient preferences, and judicious selection of surgical techniques are crucial for successful outcomes. Advancements in surgical techniques, tissue engineering, and prosthetic materials hold promise for even better results in the future. However, challenges such as complications, psychological impact, and the need for multidisciplinary care remain.

Furthermore, cost-effectiveness and access to specialized care are critical considerations, particularly in low- and middle-income countries where the burden of penile cancer can be significant. Future research should focus on optimizing existing techniques, developing minimally invasive approaches to reduce complications, and exploring cost-effective solutions to make this life-changing surgery more widely accessible.

Overall, post-oncological penile reconstruction represents a significant step forward in providing patients with a chance to regain normalcy after cancer treatment. By addressing the remaining challenges and fostering continued innovation, this field can ensure even more patients benefit from these reconstructive procedures.

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