

Fournier's gangrene: a review of reconstructive options

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Introduction Fournier's gangrene is a rapidly progressive necrotizing fasciitis of the genital and perineal tissues with a high mortality rate. Early diagnosis and treatment with fluid resuscitation, surgical debridement and wide-spectrum antibiotics are essential in the management of Fournier's gangrene. After primary treatment, reconstructive surgery is often necessary for coverage of soft-tissue defects. This review article aims to provide an overview of the main reconstructive procedures used in Fournier's gangrene.

Material and methods A literature search was performed on the subject of reconstructive surgery in Fournier's gangrene.

Results Techniques of reconstructive surgery for soft-tissue defects following Fournier's gangrene include skin grafts, local advancement flaps, scrotal flaps, multiple fasciocutaneous and myocutaneous flaps, and testicular transposition. The surgical goal is to achieve the best functional and cosmetic result possible with minimal morbidity. Advantages and disadvantages of each technique and potential indications are discussed.

Conclusions Characteristics of the defect, patient preference and surgeon experience should guide the choice of reconstructive procedure. Further comparative studies are needed to optimize results.

Key Words: Fournier's gangrene ↔ necrotizing fasciitis ↔ reconstructive surgery

INTRODUCTION

Fournier's gangrene is a rare and rapidly progressive necrotizing fasciitis of the genital and perineal tissues that typically affects males over the age of 50 years old, although females and patients of any age may be affected [1, 2]. It is thought to be caused by a polymicrobial infection that progresses to obliterative endarteritis with microthromboses of cutaneous and subcutaneous arterioles and perifascial spread of bacteria, causing gangrene of overlying tissues [1, 2, 3]. Although initially described as an idiopathic disease, studies can now identify a cause of infection in the majority of cases, most often dermatological, colorectal or urological [1, 2, 4]. Comorbid conditions such as diabetes mellitus, alcoholism, obesity and any condition resulting in immunosuppression are common and may be considered risk factors [2, 5].

The diagnosis of Fournier's gangrene is essentially clinical. Clinical features include sudden onset of genital or perineal pain and swelling, fever and prostration with progression to tissue necrosis with purulent discharge, crepitus or fluctuation and septic shock [2, 5]. Imaging studies such as plain abdominal x-ray, ultrasonography, computed tomography (CT) or magnetic resonance imaging (MRI) may be helpful in early diagnosis or atypical presentations and in evaluating the extent of the disease by revealing thickening of the scrotal wall and presence of gas in subcutaneous tissue [1, 3, 5]. CT is the most specific imaging study for diagnosis and can also aid in preoperative planning and investigation of the underlying causes [1, 3]. Bacterial culture often isolates multiple organisms, including anaerobes and aerobes [1, 2, 3]. Early diagnosis and treatment are essential in the management of Fournier's gangrene, with intensive

fluid resuscitation, surgical debridement and wide-spectrum antibiotics covering gram-positive cocci, gram-negative bacilli and anaerobes. Early surgical exploration with aggressive debridement of devitalized tissue is mandatory and multiple procedures may be needed. Orchiectomy is rarely required because of the independent blood supply to the testes, although it has been reported in cases of severe peritesticular infection [1, 2, 3]. Some authors recommend routine urinary diversion with Foley catheter or suprapubic cystostomy in all patients, while others believe that it should be reserved for cases of extensive penile or urethral involvement [1, 3]. A diverting colostomy may be beneficial in cases of rectal or colic perforation, anal sphincter involvement, fecal incontinence and risk of fecal contamination of the wound [1, 3]. After debridement, wound care with wet-gauze dressing and frequent dressing changes is recommended.

Even with appropriate treatment, reported mortality remains high, ranging from 3 to 67 percent [3]. Causes of death include sepsis, coagulopathy, acute renal failure, diabetic ketoacidosis and multiple organ failure [2]. Patients with an anorectal source of infection seem to have the highest mortality rate [2, 4]. Other factors associated with higher mortality include delayed diagnosis and treatment, older age, immunosuppression, diabetes mellitus, alcoholism, hepatic dysfunction and renal failure [1–4, 6]. The Fournier's Gangrene Severity Index (FGSI) has been proposed by Laor et al. and has been shown to stratify the risk and predict the prognosis of these patients, using a number of clinical and analytical parameters [7].

After primary treatment of the disease, patients may need secondary reconstruction of skin and soft-tissue defects. We aim to review the main reconstructive procedures used in Fournier's gangrene to provide skin coverage with the best functional and cosmetic results and minimal morbidity.

Reconstructive surgery in Fournier's gangrene

Once the infection has been appropriately treated, the goal is shifted to coverage of surgical wounds with the best functional and cosmetic results possible and minimal morbidity and mortality. Options include healing by secondary intention, primary closure or reconstructive procedures with skin grafts or flaps. Considering that these are often high-risk patients with significant comorbidities, reconstruction with technically simple and single stage procedures is typically preferred [8]. Primary closure may achieve the best result, but it is only possible for very small defects when there is no tension on closure [8].

Healing by secondary intention is an option for relatively small defects, as well as for patients with high anesthetic risk, although wounds may take longer to heal and there is risk of contraction and deformity [8]. A study of 60 patients by Silva et al. revealed that 67 percent of patients with Fournier's gangrene were submitted to some type of reconstructive procedure [9]. There is no consensus on the best method of reconstruction for patients with Fournier's gangrene. Several reconstructive techniques can achieve coverage of soft-tissue defects, including split- or full-thickness skin grafts, local advancement flaps, scrotal flaps, fasciocutaneous flaps, muscle or myocutaneous flaps, perforator flaps and testicular transposition.

Skin grafting

Skin grafting is a popular option in the reconstruction of defects following Fournier's gangrene. It has multiple advantages: it is a simple one-stage procedure with short operative time, has low donor-site morbidity, can cover large areas and may have reasonable functional and cosmetic results [1, 8, 10]. There is possibility of graft contraction, which can be problematic and may limit reconstruction of larger defects. There is also risk of graft loss due to hematoma, shearing or infection.

In scrotal reconstruction, split-thickness skin grafts can resemble normal scrotal skin color, shape and thickness [1, 10]. There is controversy about whether scrotal skin grafts will take if the scrotum is stripped off its tunica vaginalis; some authors support this statement [11], while others do not confirm it [8]. Regardless, this technique should only be attempted in cases of a healthy scrotal granulating wound bed. There are also concerns about vulnerability to trauma and scrotal pain or discomfort [10].

Perineal and perianal areas often present reconstructive challenges due to the risk of fecal and urine contamination, tissue maceration and trauma. For this reason, reconstruction with split-thickness skin grafts is frequently impaired, making them useful options only for small defects [12].

Penile reconstruction has been performed with skin grafting with satisfactory results; thick skin grafts are recommended for their minimal contraction compared to thin skin grafts [12]. Penile skin grafting does not appear to interfere with sexual and erectile function in these patients [13].

Flap reconstruction

Flap reconstruction has several reported benefits compared to skin grafting. It has been described

as an option best suitable for defects larger than half the area of the scrotum or extending beyond the scrotum [8]. Some authors believe that early single stage sensate flap reconstruction that provides adequate testicular protection is the ideal option for scrotal coverage [14]. Flaps provides a more robust and durable protection to the testes, have a lower incidence of contraction, provide immediate coverage without relying on granulation tissue formation, and are considered cosmetically superior by some. However, these procedures are more complex, have a longer surgery duration, are associated with higher morbidity and donor sites are limited [8, 12, 13, 15]. There is also concern about higher testicular temperature and impaired testicular function [8]. Regarding cosmesis, some argue that flap reconstruction is inferior to skin grafting due to flap bulkiness. Multiple flaps are used for reconstruction of the defects caused by Fournier's gangrene, including local advancement flaps, scrotal flaps and multiple myocutaneous and fasciocutaneous flaps.

Scrotal and prepuccial flaps

Scrotal flaps are a good reconstructive option for small to medium scrotal defects, providing durable good quality skin and good aesthetic results with a simple technique and low donor-site morbidity [12, 15]. This procedure is done by undermining the remaining scrotal skin in all directions, taking advantage of the extensibility of the scrotum. While dissection may be performed in the subcutaneous plane, some authors incorporate the dartos muscle in the elevation of the flaps, which may improve elasticity and durability of the skin [12]. Scrotal flaps are recommended for defects confined to half the surface area of the scrotum that cannot be closed primarily without tension [8]. For larger defects, they should be applied cautiously because high-tension closure increases the risk of flap loss or wound-edge necrosis. Scrotal flaps can also be used for penile or perineal reconstruction [12]. The prepuccial skin flap is another option for small to medium scrotal defects, providing good quality and durable skin coverage [16].

Fasciocutaneous thigh flaps

Numerous fasciocutaneous flaps have been described for scrotal and perineal reconstruction in Fournier's gangrene, providing good coverage without the sacrifice of functioning muscles, often with superior durability and cosmetic results than split-thickness skin grafts. The medial thigh is common source of flaps. One of these is the superomedial thigh fasciocutaneous flap, first described by Hirshowitz et al. in 1980, sup-

plied by a combination of the deep external pudendal artery, the anterior branch of the obturator artery and the medial femoral circumflex artery [17]. It is also a sensate flap innervated by the genital branch of the genitofemoral nerve and the ilioinguinal nerve. It provides robust scrotal coverage with aesthetically acceptable results and easy primary closure of the donor site in most cases [12, 18]. The main limitation of this flap is its transverse length, which may dictate the need for bilateral flaps.

The medial thigh fasciocutaneous flap, first described by Wang et al. in 1987, was later described for scrotal reconstruction after Fournier's gangrene by Hallock et al. in 1990 [14, 19]. Its vascularization is based on the communicating suprafascial vascular plexus of the medial thigh, with reliable elevation of flaps with dimensions up to 9 × 20 cm. The donor site usually allows direct closure.

Reconstruction with the pudendal thigh flap, supplied by branches of the internal pudendal artery, is another alternative. Designed laterally to the crural-inguinal fold, primary donor site closure is possible and aesthetic results are satisfactory. It is also a sensate flap, including the superficial perineal nerve. Its use has been described in various forms, including as a transposition flap, an island flap or a V-Y advancement flap [15, 20, 21].

Muscular or myocutaneous flaps

Muscular or myocutaneous flaps are useful options for contaminated environments, as is often the case in perineal and perianal areas, and may be used to cover large and deep wounds. The gracilis myocutaneous flap, often considered the workhorse flap for perineal reconstruction, is a good reconstructive choice in these situations [12, 15, 22]. It is an easily harvested and reliable flap based mainly on the ascending branch of the femoral medial circumflex artery.

The use of the pedicled rectus abdominis myocutaneous flap, supplied by the deep inferior epigastric artery, has also been described in Fournier's gangrene, providing good coverage but failing to mimic the normal appearance of the scrotum [8]. It can be useful in cases of extensive and deep defects that require reliable bulky coverage. Vertical designs are usually used for this purpose, although transverse and oblique designs have also been described [23, 24]. Concerns about the use of myocutaneous flaps include donor-site complications and the sacrifice of functioning muscles.

Perforator flaps

The popularization of perforator-based flaps has broadened the range of reconstructive options.

The perineum and upper thigh are anatomical areas rich on perforator vessels, and multiple designs have been described using the existing vascular axis in the region, such as the internal pudendal artery, the external pudendal artery, the medial circumflex femoral artery or the profunda femoris artery [25–28]. Free-style flap designs can be used. Although dissection is often technically demanding, they provide thin and pliable tissue with direct closure of the donor site and minimal morbidity.

The anterolateral thigh (ALT) flap, based on the descending branch of the lateral femoral circumflex artery, is another option for the reconstruction of scrotal and perineal defects. It can be harvested as a sensate flap by including the lateral femoral cutaneous nerve and may include the vastus lateralis muscle or the fascia lata, if necessary. It is a highly versatile flap with a large and reliable skin paddle that enables reconstruction of defects of the perineum, scrotum, groin or mons, making it a good option for large defects extending beyond the scrotum, often with minimal donor-site morbidity and aesthetically satisfactory results [15, 29]. A keyhole design for the ALT flap has been described by Sirimahachaiyakul and colleagues, allowing reconstruction of defects around structures such as the penis or anus with the use of a single flap [30].

The pedicled deep inferior epigastric perforator (DIEP) flap offers a large amount of tissue without the donor-site abdominal weakness caused by the harvest of the rectus abdominis muscle. While it has been employed in perineal and genital reconstruction, its role in male genital reconstruction seems to be limited, mainly because of its bulkiness and the existence of numerous alternatives, often technically less demanding [31]. Nonetheless, it remains a reliable option in the reconstructive surgeon's armamentarium, especially when dealing with extensive defects.

Testicular transposition

The transposition of testes and spermatic cords to a subcutaneous pouch created in the upper thigh may be employed in cases of scrotal defects, either permanently or as temporary testicular coverage until final reconstruction at a later stage. Despite being a simple technique with fewer postoperative wound complications, it creates a highly unnatural look with poor cosmetic results and low patient satisfaction [8, 10]. There are also concerns about testicular function and temperature regulation, as well as reports of testicular atrophy and pain [8, 11].

Urethral reconstruction

Urethral reconstruction may be necessary in selected cases of mucosal defects or urethral strictures. Urethroplasty has been performed using full-thickness skin grafts from penile skin donor sites with good results [12]. Buccal mucosa has also been successfully used [32]. Complex urethral defects may also be reconstructed with a number of flaps, including the anterolateral thigh flap, the gracilis flap and the radial artery forearm free flap [5].

Adjuvant therapies

Adjuvant therapies such as negative pressure therapy (NPT), hyperbaric oxygen therapy, tissue adhesives and local application of honey or bactericidal agents have been described in the treatment of Fournier's gangrene, although no evidence-based recommendations have been made for their use. NPT has the potential of accelerating wound closure and reducing bacterial counts by improving perfusion and cell proliferation. Studies comparing NPT to conventional dressings in Fournier's gangrene have reported fewer dressing changes, less pain, greater mobility and larger reduction in wound surface areas with the use of NPT [33, 34]. NPT has also been described following skin grafting of genital defects after Fournier's gangrene to secure and improve skin graft take, with no graft loss reported in 13 patients [35]. The use hyperbaric oxygen has been shown to enhance tissue oxygenation and improve wound healing and has been used as an adjuvant treatment in Fournier's gangrene with satisfactory results, although its overall benefit and cost-effectiveness remain controversial [3, 5, 6]. Side effects include central nervous system toxicity and barotrauma injury to the middle ear [3]. The use of tissue adhesives like fibrin or cyanoacrylate glue may be helpful in securing skin grafts or flaps, grafting over complex contours and decreasing the incidence of complications such as a seroma and hematoma. Their use in Fournier's gangrene has been described in combination with skin grafts with good results [8], although no studies exist at this point that allow the recommendation of their use in this setting. Honey is known to inhibit bacterial growth and its use as an adjuvant therapy in Fournier's gangrene for enhancing wound healing has been reported [36], although randomized studies are still lacking. Irrigation of wounds with sodium hypochlorite or hydrogen peroxide solutions also aids in the cleaning of wounds and promotes destruction of anaerobic bacteria [3, 5, 37]. Enzymatic debridement of wounds with lyophilized colla-

genase, an enzyme that digests necrotic tissues, has also been described with satisfactory results [38].

Choice of reconstructive procedure

Opinions on the best method for reconstruction in patients with Fournier's gangrene are conflicting and the choice of reconstructive procedure should be based on individual characteristics of the defect, patient preference and surgeon experience. While skin grafting is a technically simple procedure with lower donor-site morbidity compared to flap reconstruction, graft contraction and susceptibility to trauma are a concern. On the other hand, flap coverage probably provides better testicular protection with lower incidence of contraction, although it requires more complex and longer procedures, is associated with higher donor-site morbidity and may be excessively bulky. Opinions on cosmetic results are conflicting among authors. Objective data on patient satisfaction, function and cosmesis is still lacking.

In a 2015 systematic review by Karian et al. including a total of 425 patients with soft-tissue defects following Fournier's gangrene, 5.9% of the defects healed by secondary intention, 10.4% were treated with delayed primary closure, 1.4% with loose wound approximation, 8.5% with testicular implantation in a medial thigh pocket, 22.6% with skin grafts, 16.0% with scrotal advancement flaps, 30.1% with flaps and 5.2% with the combination of grafts or flaps with tissue adhesives [8]. The author concludes that reliable coverage and protection of testicular function with acceptable cosmetic results were seen in most reconstructive methods. Based on the collected data, the author has proposed an algorithm for reconstruction, recommending the use of local scrotal advancement flaps (with or without incorporation of the dartos muscle) or healing by secondary intention for defects con-

finied to less than half the scrotal area if the defect cannot be closed primarily without tension, or the use of split-thickness skin grafting or flap reconstruction for defects larger than half the scrotal area or extending beyond the scrotum.

Also under debate is the effect of scrotal reconstruction on long-term testicular function and spermatogenesis. Although some authors demonstrated superior spermatogenesis in rat models with scrotal flap reconstruction as opposed to scrotal skin graft reconstruction [39], others have demonstrated the disruption of scrotal thermoregulation with thick flap reconstruction or thigh testicular transposition in small case series [40]. While the ideal method for maintaining spermatogenesis is still controversial, the surgeon performing scrotal reconstruction in a patient wishing to remain fertile should take these concerns into consideration.

CONCLUSIONS

Fournier's gangrene is a rapidly progressive and potentially fatal necrotizing infection of genital and perineal tissues. Treatment includes wide-spectrum antibiotics and timely aggressive surgical debridement. Early coverage of soft-tissue defects is an important part of treatment. Several reconstructive options are available and can be performed to achieve coverage with good functional and cosmetic results. Good results are achieved in most reconstructive methods. There is no consensus on the best method of reconstruction and the choice of reconstructive procedure should be based on individual characteristics of the defect, patient preference and surgeon experience. Further comparative studies are needed to optimize reconstructive results.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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