Fournier's Gangrene

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Introduction

Fournier's gangrene is a serious, progressive necrotizing infection of the skin, subcutaneous fat, and superficial fascia of the external genitalia and/or perineum. In 1883 Jean Alfred Fournier described the gangrene as idiopathic, of sudden presentation and rapidly developing in previously healthy young males [1]. This definition has changed substantially. Today, an underlying etiology can almost always be identified [2, 3], the disease may follow a more indolent course in certain cases, and the at-risk population is not limited to young people or to males [4–13]. Fournier's gangrene is rare, representing less than 0.02 % of hospital admissions with an overall incidence of 1.6 cases per 100,000 males [14]. Fournier's gangrene is rare in pediatric patients but the incidence increases with increasing age until it peaks and then remain steady after age 50 at 3.3 cases per 100,000 males [14]. Fournier's gangrene remains a life-threatening disease that requires early recognition with aggressive surgical debridement, resuscitation, and broad-spectrum antibiotics as the cornerstones of therapy [2–4, 15].

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Etiology and Pathogenesis

Fournier's gangrene is a synergistic infection with multiple aerobic and anaerobic bacteria [3, 4]. These include *Escherichia coli*, *Bacteroides species*, *staphylococci*, *Proteus*, *streptococci*, *Pseudomonas*, *enterococci*, and *Clostridium perfringens* [2, 3, 8, 9, 11].

Multiple comorbid conditions have been associated with Fournier's gangrene. Between 32 and 77 % of patients have diabetes mellitus [5–9, 12, 16–18]. An increase in the prevalence of diabetes has also been shown to be associated with an increase in the incidence but not mortality from Fournier's gangrene [14]. Alcoholism, immunosuppression (including acquired immunodeficiency syndrome [AIDS]) [19], malignancy, obesity, malnutrition, and intravenous drug use predispose to necrotizing genital infections [5–7, 9, 12, 16, 20]. Local trauma and surgery to the external genitalia are further risk factors [4, 12, 20].

The source of infection is identifiable in more than 75 % of cases [2, 3, 8, 9, 11]. Perirectal and perianal abscesses are both the most common and most moribund causes [4, 7–11, 18, 21]. Periurethral infection resulting from stricture disease or instrumentation with urinary extravasation

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is identified in approximately 20–30 % of cases [4, 10, 20, 21]. A scrotal abscess, epididymitis, or skin lesions, such as suprainfected sebaceous cysts, can also progress to Fournier's gangrene [4, 10].

The route of rapid spread of necrotizing infection is determined by the contiguous fascial anatomy of the external genitalia, perineum, and abdomen. Bacterial infection can spread along the dartos fascia of the scrotum and penis, Colles' fascia of the perineum, the fascia lata onto the thigh, and Scarpa's fascia of the anterior abdominal wall up as high as the axillae. Histological characterization shows dermal and subcutaneous necrosis covered by intact epidermis [22]. The primary pathophysiological mechanism of the superficial necrosis is via thrombosis of small subcutaneous arterioles in their investing fascia, which leads to ischemia, allowing polymicrobial bacterial growth and contributing to rapid extension of infection [9, 23, 24].

Presentation and Diagnosis

The findings on examination of a patient with Fournier's gangrene are characteristic; the history and secondary signs and symptoms will give clues on the source of the infection. The infection commonly starts as cellulitis adjacent to the portal of entry. Genital pain, swelling, and erythema are the most prominent symptoms [6]. Fournier's gangrene can be distinguished from acute cellulitis by the concomitant signs of systemic toxicity, including fever, mental status changes, tachypnea, and tachycardia [25–27]. On the other hand, physical findings may underrepresent the true extent of the disease. Marked progression may occur within hours, leading to crepitus and dark purple discoloration of the tissue (Fig. 11.1), followed later by sloughing, drainage, and demarcation of dead tissue.

A history of local trauma, obstructive voiding symptoms, recent instrumentation, or urethral stricture will direct further evaluation. Perirectal pain, rectal bleeding, and a history of anal fissures are suggestive of perianal or rectal sources. If the infection originates in the scrotal skin, the palpation of the scrotal contents should be normal; secondary involvement of the scrotal skin caused by an intrascrotal process should reveal abnormal intrascrotal findings on physical exam.

Laboratory analysis will often show leukocytosis and anemia as well as an elevated serum creatinine, hyponatremia, hypocalcemia, and hypoalbuminemia [24, 26, 27].

Radiographic studies can be useful when the physical exam does not allow definitive diagnosis of Fournier's gangrene, but should not delay prompt debridement in unequivocal cases. Scrotal ultrasonography is useful to delineate an intrascrotal process if physical exam is indeterminate. Scrotal and perineal ultrasound as well as plain radiographs may reveal the presence of gas in the soft tissue, a hallmark of gangrene [28–30]. Computed tomography provides a higher specificity for the diagnosis of Fournier's gangrene, as well as early and superior evaluation of disease extent by allowing assessment of the retroperitoneum for disease spread [29]. Subcutaneous or deep tissue gas is the hallmark of Fournier's gangrene and should prompt immediate surgical exploration (Fig. 11.2), though this may not be seen in all cases. Some abscesses will produce gas in the absence of necrotizing fasciitis, but these patients will still require drainage of the collection. It is likely that, left untreated, such collections could progress to Fournier's gangrene.

Retrograde urethrography is indicated when a urethral injury or urinary extravasation is suspected. This may assist in deciding whether to place a suprapubic cystostomy tube [25].

Management

Emergent Management

The treatment of Fournier's gangrene depends on rapid recognition, radical debridement of necrotic tissue, and broad-spectrum antibiotics. Intravenous hydration is initiated immediately, and a combination of intravenous antibiotics are started, including penicillin for Gram-positive organisms, a third-generation cephalosporin or aminoglycoside for Gram-negative organisms,

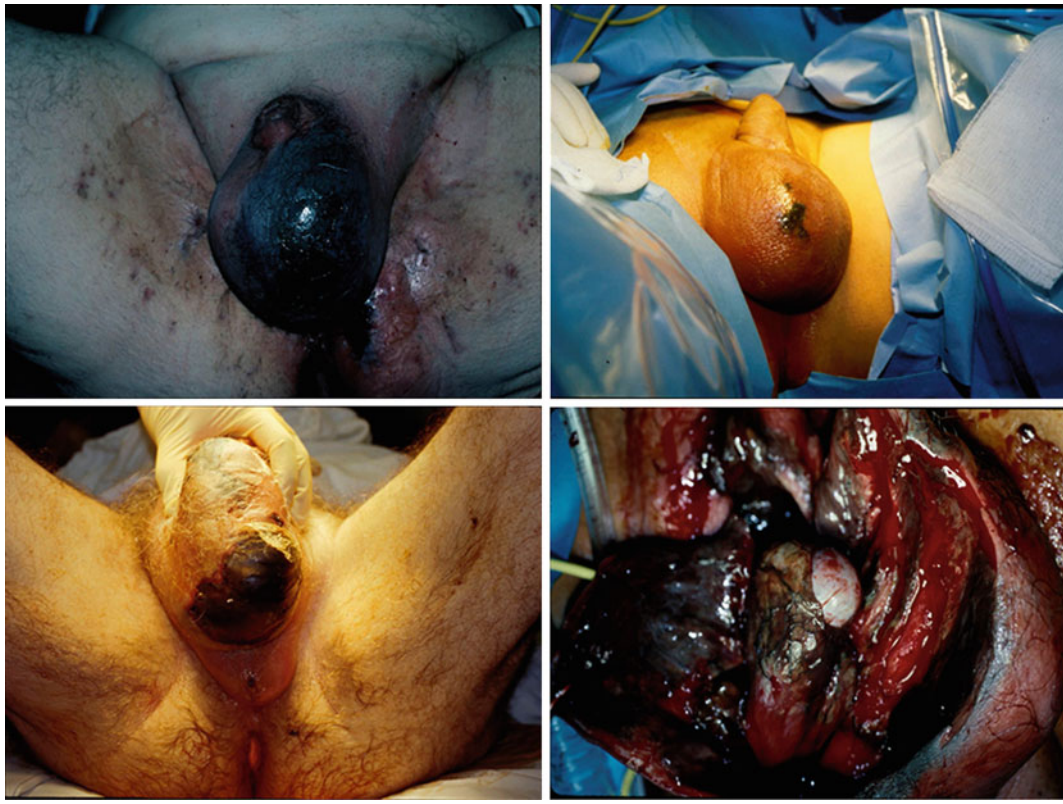

Fig. 11.1 Fournier's gangrene of the scrotum and perineum

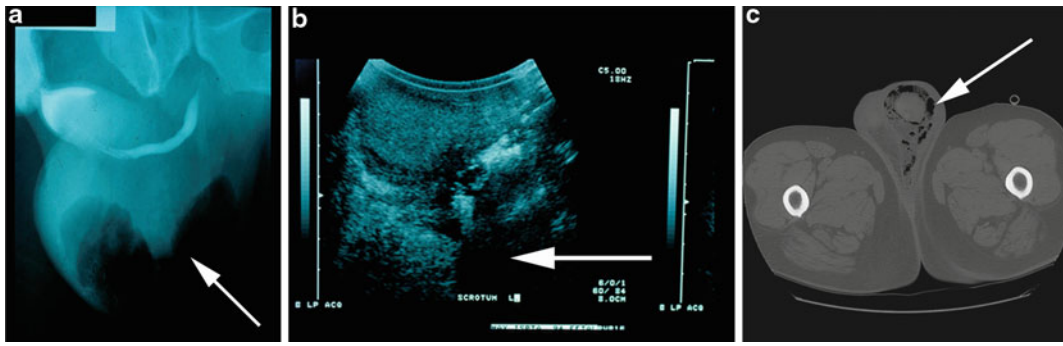

Fig. 11.2 Radiographic appearance of subcutaneous or deep gas in the soft tissues. This should prompt immediate surgical debridement. (**a**) Retrograde urethrogram plain radiograph demonstrating gas within the scrotum (*arrow*). (**b**) Subcutaneous gas on ultrasound appears as an area with high echogenicity (*arrow*). (**c**) Computed tomography demonstrating a gas-filled abscess (*arrow*)

and metronidazole or clindamycin for anaerobic organisms [3, 5]. Clindamycin may have antitoxin effects and should be used in cases where *Clostridial* infection is suspected. The critically ill patient may need correction of electrolytes, ventilatory support, and vasopressors. Purulent discharge is sent for culture from the emergency room or at the time of incision in the operating room.

Fournier's gangrene remains a surgical emergency. Aggressive, sharp excision of all devitalized skin, subcutaneous tissue, and fascia

is performed expeditiously. Debridement is extended into vital tissue at all margins. The glans penis, corpus spongiosum, corpora cavernosa, and testes are almost always preserved because of their deep blood supply, which is independent of the compromised fascial and subcutaneous circulation. The perineal artery, a branch of the internal pudendal artery, supplies the skin and superficial fascial planes of the perineum and posterior scrotum. The blood supply to the skin and dartos fascia of the anterior scrotum and penis is derived from the external pudendal branches of the femoral artery.

Buck's fascia on the penile shaft and the corpora are uninvolved by the necrotizing process because they receive blood from the dorsal, cavernosal, and bulbar arteries, which are further branches of the internal pudendal artery. The spermatic fascia, tunica vaginalis, and testes are supplied by the cremasteric, vasal, and testicular arteries, respectively, and are generally spared from necrotizing gangrene. These structures rarely require debridement and should be preserved. Once the tunica vaginalis has been violated, suprainfection of the testis is more likely and may necessitate secondary orchiectomy. Primary orchiectomy should be performed at the time of debridement if the etiology of the necrotizing infection is epididymo-orchitis or scrotal abscess [20].

We perform debridement with scalpel, scissors, and 0 chromic suture ligatures rather than electrocautery, which is more time consuming. Significant hemorrhage may occur and necessitates careful hemostasis. Intraoperative proctoscopy and cystoscopy are performed when indicated for suspected rectal or urethral sources of infection [25].

Large complex wounds with massive contamination and simultaneous colorectal or urinary tract disease may necessitate fecal or urinary diversion. Fecal diversion is achieved with end colostomy, and suprapubic cystostomy is preferred for urinary diversion [10, 12, 18, 31]. Our experience has been that few patients require colostomy, and Foley catheter drainage is sufficient in the absence of urethral stricture of fistula.

Repeat inspection and debridement should be scheduled within 24 h; two to four surgeries are commonly required for each patient [5, 7, 10, 12, 17, 20, 32, 33]. It remains controversial whether the denuded testes should be placed in thigh pouches (Fig. 11.3) or kept free and wrapped in moist gauze dressings. Until the wound bed is free of gross contamination, the testes should be kept in standard dressings. Once the wound becomes clean, the thigh pouch offers the advantage of easier dressing changes and less patient discomfort. In cases of isolated scrotal gangrene, placement of the testes in thigh pouches may allow primary closure of the perineum and more rapid discharge of the patient. Scrotal reconstruction can then be planned electively. It is important to place the testes anteriorly to avoid compression and pain with adduction. The rare patient may prefer to leave the testes in thigh pouches.

The majority of patients will have additional areas of skin loss of the penis, perineum, thighs, or lower abdominal wall. In such cases, we leave the testes exposed: Delayed scrotal reconstruction with skin grafts at the time of coverage of other reconstruction makes sense (*see* "Coverage" section).

Postoperative Management

Debrided wounds are left open, and aggressive wound care is initiated postoperatively with saline gauze dressings, whirlpool or waterpick therapy, and repeat debridement. This prepares the wounds for secondary coverage. Intravenous antibiotics are stopped when the wound is clean. Quantitative cultures may be used to estimate suitability of the wound for reconstruction. Important postoperative concerns include the careful control of diabetes and sufficient caloric and protein intake to allow adequate wound healing. Attention to supportive care is also important as up to 10 % of cases may require mechanical ventilation, and almost 2 % may require dialysis [14].

Hyperbaric oxygen therapy may be used as an adjunct after rapid debridement [4, 16, 20, 25]. High oxygen tension is thought to improve wound healing and mitigate ongoing necrosis in the hypoxic tissues at the margins of the debrided field. Mechanisms may include stimulation of leukocyte function, enhanced neovascularization,

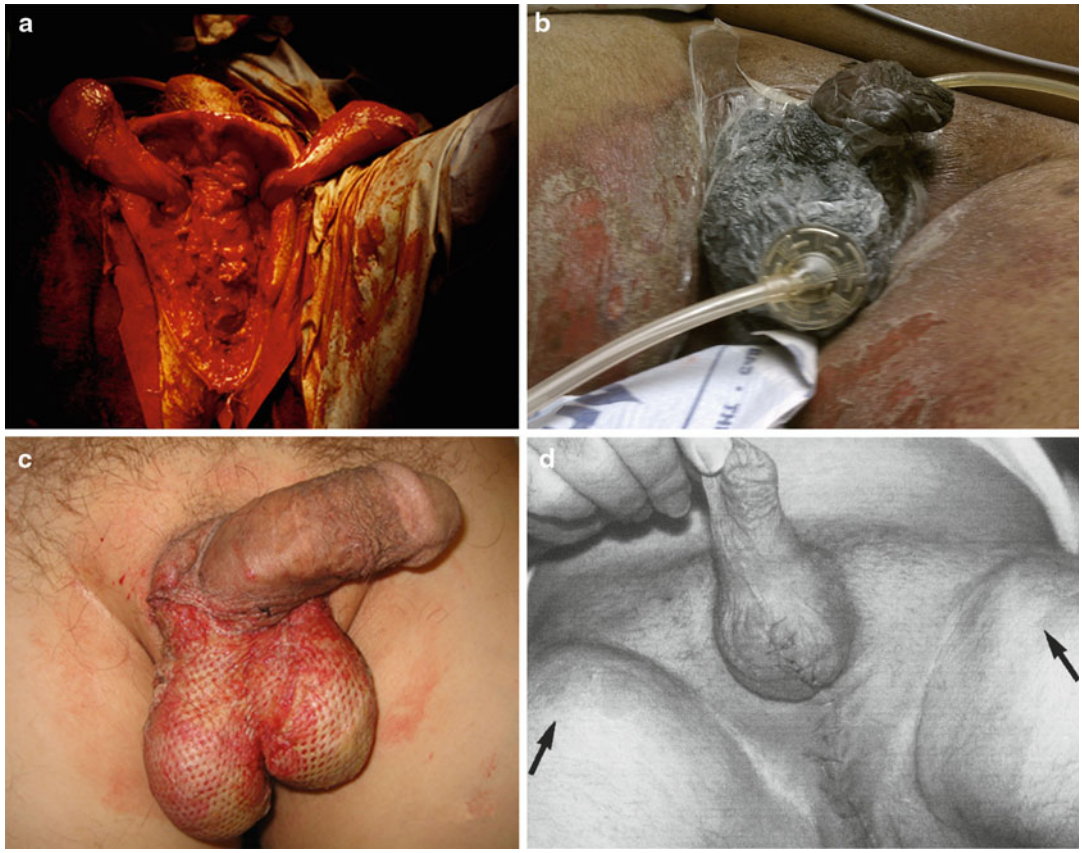

Fig. 11.3 Scrotal defect and options for closure. (**a**) Primary defect. (**b**) Vacuum-assisted closure (VAC) device applied to the scrotum. (courtesy of Thomas G. Smith, MD, Baylor College of Medicine). (**c**) Scrotal wound coverage with cadaveric allograft. (**d**) Testicles placed into thigh pouches (*arrows*) and primary closure of the wound

and inhibited toxin formation by anaerobic bacteria [14, 20, 34]. Therapy is typically initiated as soon as possible after debridement with as many as three dives within the first 24 h, with decreasing dive frequency until 5 days after surgical wound closure [20]. Patients must be medically stable and able to tolerate relative isolation from medical care for 1–2 h. Hyperbaric oxygen appears to work best if initiated early in the treatment of a necrotizing soft tissue infection, and this is the time when patients are the least stable. If infection is controlled rapidly and completely with conventional treatment, hyperbaric oxygen may be unnecessary [34, 35]. Hyperbaric oxygen treatment may decrease mortality, but the current evidence consists primarily from case-series and thus there is divergence in the literature as to its benefits [20, 36].

The topical application of honey is an adjunctive treatment that has been advocated when hyperbaric oxygen is not accessible [12, 37, 38]. Unprocessed honey has a pH of 3.6 and is thought to contain enzymes that promote digestion of necrotic tissue. It also has topical antibacterial activity and increases local oxygenation [12].

Coverage

Once the wound bed is clean and clear of infection, reconstruction is based on the size of the defect, the presence or absence of the testes, sexual function, remaining transferable genital skin, and overall patient status [39]. Reconstruction is typically planned once wounds are clean and granulating,

usually 7–21 days after initial debridement. Patients may be able to perform dressing changes at home or in a skilled facility while waiting elective reconstruction, especially if their wounds are small.

Recently, vacuum-assisted closure (VAC) devices have been used once the wounds are stable and no longer require daily evaluation (Fig. 11.3). These negative pressure devices are believed to improve wound healing by encouraging perfusion, fibroblast migration, and cell proliferation. They also remove excess exudates, reduce edema, and draw the wound edges together. Prospective randomized control trials have demonstrated improved wound healing and decrease in wound surface area in patients treated with VAC devices compared to conventional gauze therapy alone [40]. These devices also decrease patient discomfort with dressing changes, improve patient mobility, and decrease hospital length of stay by speeding wound closure [40–43]. It may decrease the need or extent of wound coverage and allow earlier reconstruction, though they can sometimes be challenging to place [44].

We have used human cadaveric skin allografts as temporary biological dressings to reduce the frequency of dressing changes and to prepare the wound for skin autografting. The allograft is typically placed for 5–7 days to promote neovascularization and re-epithelialization of the wound, and is then removed at the time of skin grafting (Fig. 11.3).

Split-thickness skin grafting (STSG) remains the preferred method of penile skin replacement due to its versatility, relative ease of use, and consistent take [45, 46]. Meshing of the STSG allows the wound to drain and may have better take in debilitated patients or those with contaminated wounds. Meshed STSG has been used in impotent men where wound contraction is not a concern [46]. Unmeshed STSG is typically used in potent men, although we have used unexpanded (e.g., 1:1) meshed STSG in men with various etiologies of penile skin loss, and have demonstrated excellent graft take with no function impairment regardless of sexual function (Figs. 11.4 and 11.5) [47]. Others have reported wound coverage with remnant foreskin [48] and scrotal skin [49], but full-thickness skin grafting is typically avoided in Fournier's gangrene [50].

Scrotal reconstruction is more challenging. When defects are large and primary wound coverage is impossible, flaps or meshed STSG

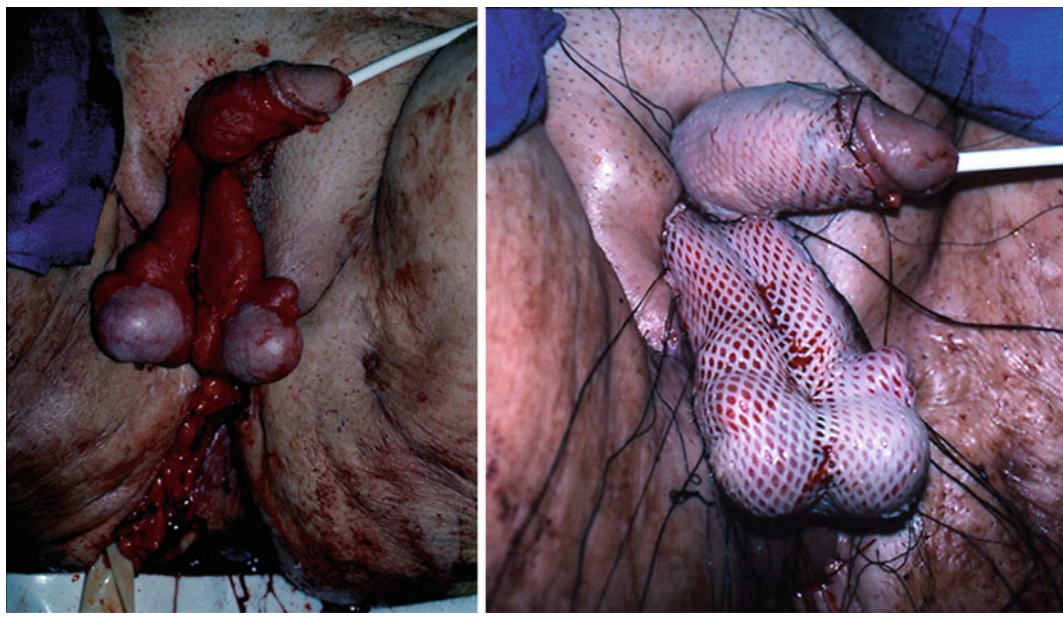

Fig. 11.4 Split-thickness skin graft to the penis and scrotum with primary closure of the perineum

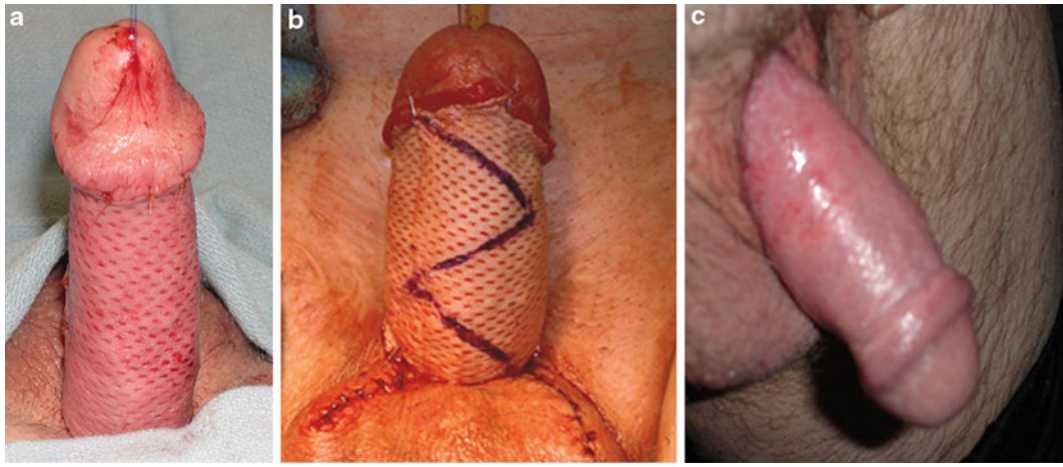

Fig. 11.5 Details of unexpanded 1:1 meshed split-thickness skin graft to the penis. (**a**) Dorsal view. (**b**) Ventral view demonstrating z-plasty of the graft to allow for slight contraction. (**c**) Follow-up picture after recovery with near 100 % graft take

may be used though this may require a staged closure with rotational or advancement flaps [51–53]. Flaps are preferred by some for purported improvement in functional outcome, with a resultant sensate and hair-bearing scrotum [54]. Tissue expanders have been used to reconstruct a two-compartment scrotum when there is at least a small remnant of scrotal skin [55]. If a STSG is already planned to cover a penile or abdominal wound, a meshed STSG should be used for scrotal reconstruction. We prefer meshed STSG due to its availability and excellent take. Perineal defects provide a suboptimal graft bed, and residual defects in adjacent areas typically heal well by secondary intention. When possible, remnant scrotal or medial thigh skin can be reapproximated to reduce the size of the perineal defect.

Prognosis

Despite maximal medical and surgical treatment, Fournier's gangrene remains a potentially lethal disease. Most studies report mortality rates of 20–40 % with some studies reporting fatality rates as high as 88 % [56]. These data tend to come from small series at tertiary referral centers. With each passing decade, the mortality rate has decreased but morbidity remains high [14].

Several factors appear to be associated with mortality. Advanced age may be the most important independent predictor of mortality, increasing the risk of death 4–15-fold [9, 11, 24, 32, 57]. More extensive disease may predict a poor outcome [11, 16, 57] and a colorectal or perianal source also appears to confer a worse prognosis [4], which may be related to delay in diagnosis and more extensive disease. Deaths tend to occur late during hospitalization. Although Fournier's gangrene is less common in women, they may have a higher mortality rate [7, 58].

Hospital experience with Fournier's gangrene also appears to be related to mortality. Most hospitals (up to 66 %) care for no patients with Fournier's gangrene, and less than 1 % of hospitals care for five or more cases in a given year [14]. Hospitals that treat more Fournier's gangrene patients have lower mortality rates; [32] they likely care for the most severely ill patients but are more likely to offer the substantial resources required for the treatment of these patients. Further regionalization of care for patients with Fournier's gangrene may help to improve access to an experienced multidisciplinary team, including urologic surgeons, general surgeons, intensivists, and plastic surgeons, which is important for these severely ill patients.

There have been previous attempts to predict mortality in patients with Fournier's gangrene with the Fournier's Gangrene Severity Index using patient vital signs and laboratory tests to calculate a score that may potentially be used to monitor therapy and predict patient mortality [57]. This index is based on the Acute Physiology and Chronic Health Evaluation II classification system and consists of admission vital signs (temperature, heart rate, respiratory rate) and laboratory values (hematocrit, white blood count, serum sodium, potassium, creatinine, and bicarbonate). However, the Fournier's Gangrene Severity Index was developed using retrospective data gathered from 30 patients over a 15-year period and thus has had variable accuracy in predicting mortality [59–67]. Others have tried to improve the prediction of the index by including the extent of skin involvement [68]. Furthermore, Fournier's gangrene may take a fulminant course in the immunocompromised patient [16], although some reports indicated no worse prognosis in human immunodeficiency virus (HIV)/AIDS [2, 9, 11]. Diabetes has not been predictive of a poor outcome because of its high prevalence in this patient population.

Morbidity from Fournier's gangrene remains high. Cases often require multiple operations, orchiectomy, cystostomy, and/or colostomy [7, 12, 20, 33]. In patients that do not undergo surgical wound closure, the burden of wound care after discharge from the acute hospitalization can be tremendous. As many as 30 % of survivors may require ongoing care after discharge in the form of home health care or a skilled nursing facility stay [32].

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