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REVIEW ARTICLE

Reconstructive

Practical Review of the Current Management of Fournier's Gangrene

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Background: Fournier's gangrene is a fulminant disease. If diagnosed and treated early, mortality can be minimized, but morbidity can still be important with extensive soft tissue defects affecting form and function. We aimed to perform a comprehensive review and provide the current evidenced-based management to treat this condition.
Methods: A review was conducted to identify relevant published articles involving Fournier's gangrene in PubMed on September 8, 2021. Search keywords included "{[(Fournier's gangrene) AND (reconstruction)] OR [Fournier's gangrene]} AND [(repair) OR (management)]."
Results: A total of 108 articles met the inclusion criteria. The comorbidities most frequently associated included diabetes, hypertension, and obesity. Pillars of treatment involve urgent debridement, fluid resuscitation, IV antibiotics, and reconstruction. Several variables must be considered, including time to debridement, duration of antibiotics, debridement, and an individualized approach to choose a reconstructive option. Skin grafts and multiple types of flaps are commonly used for reconstruction.
Conclusions: Treatment of Fournier's gangrene should be initiated as early as possible. Surgeons' expertise, patient preference, and resources available are essential factors that should direct the election of reconstruction. *(Plast Reconstr Surg Glob Open 2022;10:e4191; doi: 10.1097/GOX.0000000000004191; Published online 14 March 2022.)*

INTRODUCTION

Fournier's gangrene (FG) is a rare necrotizing fasciitis of the scrotum and perineum. FG was first described by Jean-Alfred Fournier in 1883.[1] FG predominantly affects men, with an incidence of 1.6 per 100,000 in the United States.[2] Risk factors associated with FG include diabetes, chronic alcoholism, immunodeficiency, chronic steroid abuse, oncologic conditions, cytotoxic drugs, malnutrition, and low socioeconomic status.[3,4]

Treatment of FG entails rapid diagnosis, antibiotic therapy, and debridement. Once the patient is stabilized, reconstructive options to restore the remaining defects are then prioritized. It is estimated that up to 67% of patients will need some degree of reconstruction afterward.[5]

Existing literature on FG is available; however, few studies evaluated the disease process and spectrum of patient care from presentation to reconstruction. We aimed to offer a comprehensive review on practical clinical management and reconstructive options used for these patients.

METHODS

The PubMed database was queried on September 8, 2021 by using the following key search: {[(Fournier's gangrene) AND (reconstruction)] OR [Fournier's gangrene]} AND [(repair) OR (management)]. Inclusion criteria consisted of English language literature, which described management, reconstructive methods, complications, and/or outcomes of five or more FG patients. Unavailable studies, nonEnglish studies, and studies with less than five patients were not included in this review. After all inclusion and exclusion criteria were applied, 103 studies remained, and five studies were added from other sources. A total of 108 studies published between 1984 and 2021 were included in our review (Fig. 1). Level of evidence was assigned based on the methodological quality of the studies' design.

RESULTS

Our review includes a total patient pool of 11,069 (Table 1). Most of the studies (n = 104) were retrospective

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with level III (n = 22) and IV (n = 83) evidence. Only four studies were prospective, corresponding to level II evidence.

Comorbidities and Origin

Based on our review, the most frequent comorbidities related to FG are diabetes mellitus (31.7%), hypertension (26.1%), and obesity (12.1%) (Table 2). The role of comorbid conditions in the prognosis of FG is conflicting. Chalya et al[50] found significant higher mortality in patients with diabetes (P = 0.001), whereas Ioannidis et al[44] found no statistical significance. Interestingly, several studies have found that renal failure is associated with higher mortality.[54,57] Chronic renal failure was present in 0.9% of patients included in this review.

Sources of infection include cutaneous, genitourinary, gastrointestinal, traumatic, and other causes. Skin sources were responsible for FG in 24.3% of cases, urologic in 16.8%, gastrointestinal in 11.9%, trauma in 5.1%, mixed anorectal and urogenital sources in 1.7%, unknown in 32.4%, and other sources of infection in 3.6% of cases (Table 3).

Takeaways

Question: Which is the current evidenced-based management for Fournier's gangrene?

Findings: In the acute phase, aggressive fluid resuscitation, broad-spectrum antibiotics, and immediate radical surgical debridement are required. Secondarily, patients will need definitive reconstruction. Skin grafts and flaps are recommended for reconstruction depending on the situation.

Meaning: Fournier's gangrene requires rapid diagnosis and individualized management strategies for reconstruction.

Pathophysiology

FG is often caused by a polymicrobial infection that progresses to obliterative endarteritis with microthromboses along fascial planes. It begins in the genitalia or perineum and further spreads along Buck's fascia, Colle's fascia, and, in some cases, Scarpa's fascia.[23] The edema and compromised blood supply result in progressive exponential

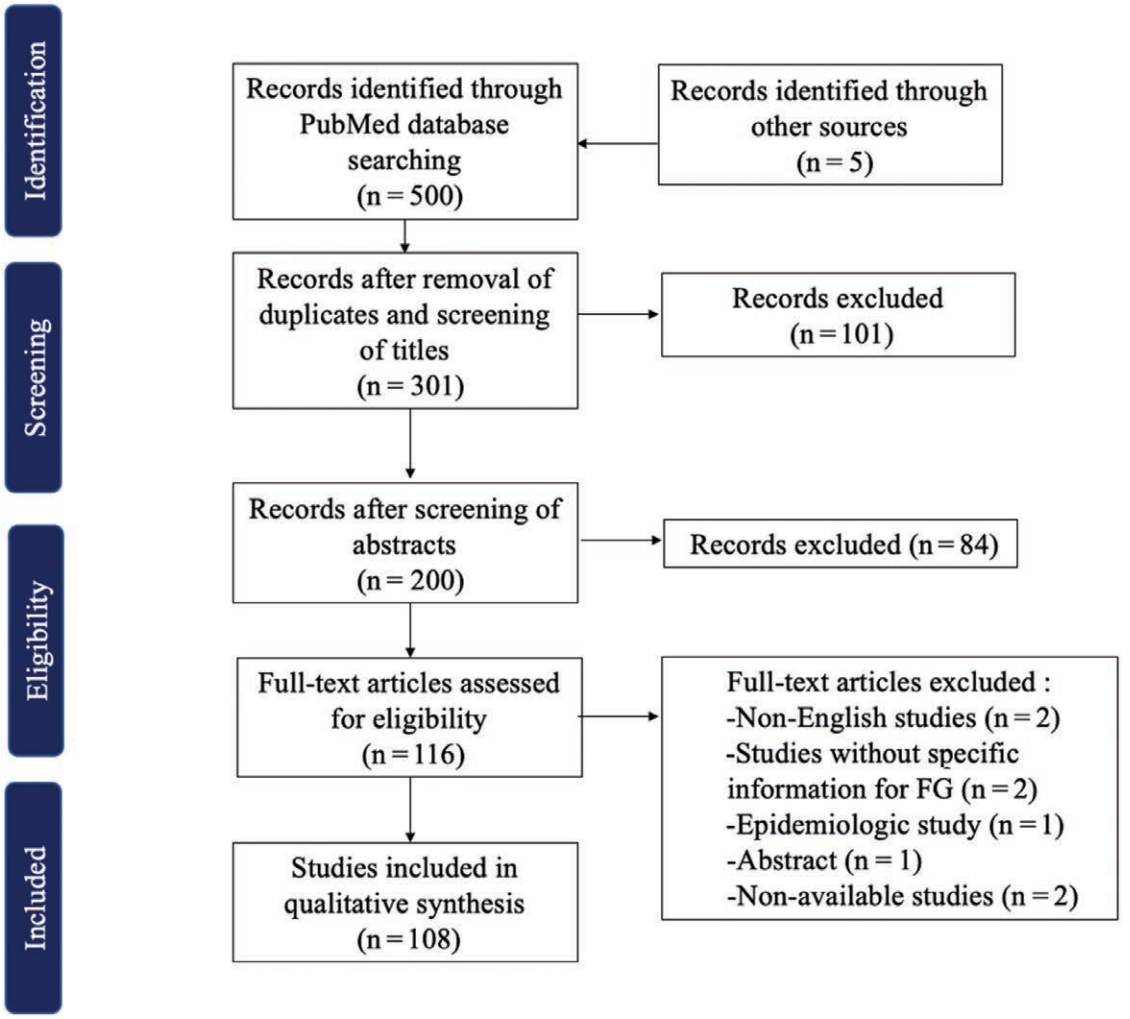

Fig. 1. PRISMA flow diagram.

Table 1. Included Studies

Author	No. Cases	Study Type	Level of Evidence	Reconstruction (No. Cases)	Reconstruction of Complications (No. Cases)
Parkash et al[6]	43	Retrospective	IV	Scrotal advancement flap = 40; skin graft = 3	Minor scrotal wound dehiscence = 4
Morris et al[7]	18	Retrospective	IV	Skin graft = 6; skin flap = 12; tissue adhesive = 18	Flap wound breakdown = 1
Ferreira et al[8]	43	Retrospective	IV	Skin graft = 22; scrotal musculotaneous flap = 17; local advancement flap = 9; superomedial thigh flap = 28	Superomedial thigh flap partial suture dehiscence = 1
Hsu et al[9]	8	Retrospective	IV	Gracilis myofasciocutaneous advancement flap = 8	Hematoma = 1; donor site abscess = 1
Carvalho et al[10]	67	Retrospective	IV	Healing by secondary intention = 11; scrotal advancement flap = 16; skin graft = 20, skin flap = 21	Skin graft infection = 5; flap infection = 2; flap loss = 2
Bhatnagar et al[11]	110	Retrospective	IV	Skin graft = 20; thigh pouch = 26; fasciocutaneous thigh flap = 12; orchiectomy = 4	N/A
Chen et al[12]	31	Retrospective	IV	Scrotal advancement flap = 11; skin graft = 9; pudendal thigh fasciocutaneous flap = 5; pedicled anterolateral thigh flap = 3; gracilis flap = 3	Scrotal advancement flap partial loss = 1; scrotal advancement flap wound necrosis = 2; pedicled anterolateral thigh flap hematoma = 1; skin graft partial loss = 1
Tan et al[13]	27	Retrospective	IV	Skin graft = 24; thigh pouch = 1; VRAM flap = 1; medial thigh flap = 1	Skin graft infection = 1; skin graft scarring = 1; skin graft adhesions = 5; skin graft bilobed appearance = 1; medial thigh flap shallow scrotal sac = 1; thigh pouch scrotal sac absent = 1
Coskunfirat et al[14]	7	Retrospective	IV	Medial circumflex femoral artery perforator flap = 7	Flap suture dehiscence = 2
Lee et al[15]	7	Retrospective	IV	Skin graft = 4; gracilis muscle flap = 7; internal pudendal artery perforator flap = 7	Flap wound dehiscence = 1; partial flap necrosis = 1
Sivrioğlu et al[16]	15	Retrospective	IV	Skin graft = 15	None
Akilov et al[17]	28	Retrospective	IV	Skin graft = 8; loose wound approximation = 6; secondary intention = 14	Orchiectomy due to late epididymo-orchitis = 3; orchiectomy due to chronic scrotal pain after STSG = 1
Ünverdi and Kemaloğlu[18]	13	Retrospective	IV	Internal pudendal artery perforator flap = 13	Flap hematoma = 1; flap marginal necrosis = 1
Eswara and McDougal[19]	32	Retrospective	IV	Skin graft = 17; Flap = 2; healing by secondary intention = 5; primary closure = 2	None
Wolach et al[20]	10	Retrospective	IV	Thigh pouches = 6; skin graft = 4; bilateral orchiectomy = 1	None
El-Khatib[21]	13	Retrospective	IV	Pudendal thigh flap = 8; skin graft = 3	None
Hejase et al[22]	38	Retrospective	IV	Skin graft = 6; delayed primary closure = 31; orchiectomy = 8	None
Louro et al[23]	15	Retrospective	IV	Skin graft = 6; internal pudendal pedicled flap = 2; contralateral rotational flap = 1; internal thigh bilateral fasciocutaneous transposition flap = 1; McGregor propellor flap = 1; local sliding flap = 1; medial femoral circumflex fasciocutaneous flap = 1; internal thigh flaps = 2	Partial skin graft loss = 3; skin flap partial dehiscence = 2; skin flap partial necrosis = 1
Chen et al[24]	41	Retrospective	IV	Skin graft = 6; scrotal advancement flap = 9; gracilis muscle flap = 1; pudendal thigh fasciocutaneous flap = 4	Skin graft partial loss = 1; scrotal advancement flap partial loss = 1
Zhang et al[25]	12	Retrospective	IV	Skin graft = 6; advancement flap = 1; pudendal thigh flap = 1	None
Koukouras et al[26]	45	Retrospective	IV	NA	NA
Perry et al[27]	17	Retrospective	IV	NA	NA
Saffle et al[28]	30	Retrospective	IV	NA	NA
Gürdal et al[29]	28	Retrospective	IV	Skin graft = 14	NA
Wang et al[30]	24	Retrospective	IV	Skin graft = 15	None
Omisanjo et al[31]	11	Retrospective	IV	NA	NA
Khanal et al[32]	14	Retrospective	IV	Bilateral pudendal flaps = 14	Flap necrosis = 1
Dadaci et al[33]	29	Retrospective	IV	Limberg thigh flaps = 29	Dehiscence and seroma = 4
Boughanmi et al[34]	18	Retrospective	IV	N/A	N/A
Agwu et al[35]	47	Retrospective	IV	Scrotal advancement flap = 2; secondary intention =10; primary closure 16	N/A
Garg et al[36]	72	Retrospective	IV	Skin graft = 16	N/A
Lin et al[37]	60	Retrospective	IV	Skin graft = 45; primary closure = 15	N/A
Sockkalingam et al[38]	34	Prospective	II	Skin graft = 2; prepucial skin flap = 2; primary closure = 15	N/A
Lin et al[39]	103	Retrospective	IV	N/A	N/A
Arora et al[40]	50	Prospective	II	N/A	N/A
Hahn et al[41]	41	Retrospective	IV	Skin graft = 8; skin flap = 5; primary closure = 10; orchiectomy 4;	N/A
Kranz et al[42]	154	Retrospective	IV	Orchiectomy = 22	N/A
Kuzaka et al[43]	13	Retrospective	IV	Thigh pouch = 1; orchiectomy = 2	N/A

(*Continued*)

Table 1. (*Continued*)

Author	No. Cases	Study Type	Level of Evidence	Reconstruction (No. Cases)	Reconstruction of Complications (No. Cases)
Ioannidis et al[44]	24	Retrospective	IV	Secondary intention = 14; skin graft = 5	N/A
Lauerman et al[45]	168	Retrospective	IV	Secondary intention = 101; primary closure = 67	N/A
Morais et et al[46]	19	Retrospective	IV	N/A	N/A
Osbun et al[47]	165	Retrospective	IV	Skin graft = 34; orchiectomy = 12;	N/A
El-Shazly et al[48]	28	Prospective	II	Skin graft = 12	N/A
Tarchouli et al[49]	72	Retrospective	IV	N/A	N/A
Chalya et al[50]	84	Retrospective	IV	Skin graft = 14; skin flap = 5; secondary closure = 65; orchiectomy = 3	N/A
Oguz et al[51]	43	Retrospective	IV	N/A	N/A
Aliyu et al[52]	38	Retrospective	IV	Skin graft = 4; skin flap = 20; secondary intention = 14	N/A
Avakoudjo et al[53]	72	Retrospective	IV	Orchiectomy = 5	N/A
Benjelloun et al[54]	50	Retrospective	IV	Orchiectomy = 1	N/A
Katib et al[55]	20	Retrospective	IV	Orchiectomy = 6; penile amputation = 3	N/A
Aridogan et al[56]	71	Retrospective	IV	Secondary intention = 7; orchiectomy = 11	N/A
Altarac et al[57]	41	Retrospective	IV	N/A	N/A
Djedovic et al[58]	10	Retrospective	IV	Skin graft = 2; medial thigh lift flap = 10	Wound infection = 2; hematoma and partial flap necrosis = 1; hematoma and wound dehiscence = 1
Chia and Crum-Cianflone[59]	59	Retrospective	IV	N/A	N/A
Yanar et al[60]	35	Retrospective	IV	Orchiectomy = 6	N/A
Iacovelli et al[4]	92	Retrospective	III	Orchiectomy = 26	N/A
Feres et al[61]	197	Retrospective	III	N/A	N/A
Beecroft et al[62]	143	Retrospective	IV	Primary local flaps and split thickness skin graft = 6; gracilis myocutaneous flaps, fasciocutaneous flaps, local flaps, xenografts and split thickness skin grafts = 25	N/A
Oyelowo et al[63]	31	Retrospective	III	Secondary wound closure = 21, skin grafting = 10	N/A
Michalczyk et al [64]	35	Retrospective	III	N/A	N/A
Cipriani et al[65]	81	Retrospective	III	N/A	N/A
Lauerman et al[66]	168	Retrospective	IV	Complete primary wound closure = 67; secondary intention = 101; orchiectomy = 9	From the secondary intention, 1 patient underwent flap coverage of urinary fistula
Chang et al[67]	13	Retrospective	IV	Local flap = 6, direct suture = 7	N/A
Yucel et al[68]	25	Retrospective	IV	Primary closure or skin graft	N/A
Hong et al[69]	20	Retrospective	III	Skin flap = 4	N/A
Furr et al[70]	9249	Retrospective	III	Complex wound closure = 816, orchiectomy = 153	N/A
Yanaral et al[71]	54	Retrospective	III	Terciary closure = 30, skin flap or graft = 20	N/A
Ozkan et al[72]	12	Retrospective	IV	N/A	N/A
Rosen et al[73]	35	Retrospective	III	Skin graft or myocutaneous flap coverage = 22	N/A
Zhang et al[74]	36	Retrospective	III	Skin grafting = 36	N/A
Eray et al[75]	48	Retrospective	III	Skin grafting or primary wound closure	N/A
Milanese et al[76]	6	Retrospective	IV	Two fasciocutaneous flaps = 1	N/A
Li et al[77]	28	Retrospective	III	Scrotal skin grafting = 13	N/A
Li et al[78]	51	Retrospective	III	Skin grafting = 16	N/A
Haidari et al[79]	17	Cross sectional	III	Testicular thigh pouches; orchiectomy = 2	N/A
Ugwumba et al[80]	28	Retrospective	IV	Scrotal skin apposition = 22; scrotal skin apposition and split-skin grafting = 8	N/A
Altunoluk et al[81]	14	Retrospective	III	Scrotal reconstruction = 14	N/A
Ozturk et al[82]	44	Retrospective	III	Skin grafting = 11	N/A
Malik et al[83]	73	Prospective	II	Skin grafting = 7	N/A
Mehl et al[84]	40	Retrospective	IV	Skin grafting = 10	N/A
Czymek et al[85]	35	Retrospective	III	Meshed grafts or flaps	N/A
Ozturk et al[86]	10	Retrospective	III	Tertiary closure = 6; split thickness skin grafting = 4	N/A
Al-Meshaan et al[87]	11	Retrospective	III	N/A	N/A
Karaçal et al[88]	8	Retrospective	IV	Neurovascular pedicled pudendal thigh flaps = 5	N/A
Tahmaz et al[89]	33	Retrospective	III	Secondary closure = 8; delayed closure = 13; skin grafting = 6	N/A
Singh et al[90]	9	Retrospective	IV	Split skin grafting = 2; secondary suturing = 2; delayed closure = 5	N/A
Tayib et al[91]	9	Retrospective	IV	Skin grafting = 6; orchiectomy = 1	N/A
Xeropotamos et al[92]	11	Retrospective	IV	Secondary closure = 8, healing by second intention = 3	N/A
Norton et al[93]	33	Retrospective	IV	N/A	N/A
Villanueva-Sáenz et al[94]	28	Retrospective	IV	Reconstruction of scrotum = 2	N/A
Fillo et al[95]	8	Retrospective	IV	Reconstruction = 2; orchiectomy = 1	N/A
Corman et al[96]	23	Retrospective	IV	N/A	N/A
Frezza and Atlas[97]	9	Retrospective	IV	Skin muscle flaps = 2	N/A
Aşci et al[98]	34	Retrospective	IV	Split-thickness skin graft = 19; delayed closure = 12; subcutaneous thigh pouches = 11; skin flaps = 5; orchiectomy = 11	N/A

(*Continued*)

Table 1. (*Continued*)

Author	No. Cases	Study Type	Level of Evidence	Reconstruction (No. Cases)	Reconstruction of Complications (No. Cases)
Korhonen et al[99]	33	Retrospective	IV	Skin grafts, secondary closure, implantation of testicles	N/A
Hollabaugh et al[100]	26	Retrospective	IV	Testicular thigh pouches = 11; split-thickness skin grafts = 11; local advancement flap = 2; combination of skin graft with local advancement flap = 2	N/A
Ayumba and Magoha[101]	46	Retrospective	IV	Skin grafting = 5; secondary wound closure = 15; primary closure = 1; orchiectomy = 1	N/A
Pizzorno et al[102]	11	Retrospective	IV	Urethroplasty with onlay flap = 1; Sachse's internal urethrotomy = 1; split-thickness skin graft =1	N/A
Ong and Ho[103]	12	Retrospective	IV	Thigh pouches = 2; orchiectomy = 1	N/A
Benizri et al[104]	24	Retrospective	IV	Skin grafting = 1; orchiectomy = 1	N/A
Efem et al[105]	41	Retrospective	III	Secondary suturing = 19; scrotal reconstruction with medial thigh fasciocutaneous flap = 2	N/A
Salvinho et al[106]	10	Retrospective	IV	Split-thickness skin graft = 5; testicular thigh pouches = 2	N/A
Attah et al[107]	13	Retrospective	IV	N/A	N/A
Thambi Dorai and Kandasami[108]	12	Retrospective	IV	Secondary suturing = 3; secondary intention = 2; split thickness skin grafts = 6	N/A
Hirn and Niinikoski[109]	11	Retrospective	IV	Orchiectomy = 2	N/A
Scott et al[110]	5	Retrospective	IV	Secondary intention = 4	N/A
Barkel and Villalba[111]	8	Retrospective	IV	N/A	N/A
Badejo[112]	16	Retrospective	IV	Subcutaneous thigh pouch, and shift peduncle graft (N/A); orchiectomy = 2	N/A

perifascial dissection with overlying skin and subcutaneous tissue necrosis,[113] which occurs at rates of 2–3 cm per hour, necessitating rapid diagnosis and treatment.[114]

Microbiology of FG

From 1227 patients with polymicrobial or monomicrobial infections reported in culture, polymicrobial infections accounted to 58.4% of the cases, whereas monomicrobial infections accounted for 30.1% of the cases (Table 4). A total of 2521 bacterial isolates were identified. Due to small vessel thrombosis and subsequent hypoxia, facultative and obligatory anaerobic bacteria prevail.[115,116] We found that *Escherichia coli* (26.6%), *Staphylococcus* sp. (13.8%), *Streptococcus* sp. (11.3%), and *Pseudomonas* sp. (8.6%) were the most common causative organisms. Interestingly, sterile cultures were reported in 18.7% of cases. Culture status was unknown in 3.7% of cases (Table 4).

It is important to recognize that drug resistance has been observed in patients with FG. For instance, Chia and Crum-Cianflone[59] identified 12 cases of FG being caused by multi-drug resistant organisms (MDROs). The majority is caused by Methicillin-resistant *Staphylococcus aureus*. They found MDROs were responsible for 67% of FG cases in their cohort over the final 3 years of the 10-year study. MDROs were more strongly associated in patients with immunosuppression and chronic wounds, indicating that these patients might benefit from empiric antibiotic therapy.[59]

Clinical Presentation and Diagnosis

Diagnosis of FG can be difficult due to nonspecific presenting symptoms. Scrotal swelling, fever, pain, necrosis, and erythema and edema changes were the most common presenting symptoms (Table 5). Fatigue is a rare symptom that has been reported in severe cases.[117,118] Early diagnosis and treatment are critical to decreasing mortality. Ultrasound and CT scan imaging can help exclude other diagnoses such as epididymo-orchitis or testicular torsion.[27,119] However, imaging should not delay operative intervention.

MANAGEMENT

Fluid Resuscitation and Glucose Management

Fluid resuscitation should be initiated immediately. Patients often present with electrolyte imbalances and elevated blood glucose levels. In fact, the majority of FG patients with uncontrolled diabetes present with diabetic ketoacidosis.[11] As poor diabetes control correlates with more aggressive FG disease progression,[44] glucose levels should be immediately corrected.[11] Managing blood glucose in patients with FG can be challenging when blood glucose levels reach up to 1020 g per dL.[19] In these cases, insulin pumps seemed to be more suitable to subcutaneous insulin[25,120]; however, there was no evidence to support this recommendation.

Antibiotic Therapy

Broad spectrum antibiotics covering gram positive (including methicillin-resistant *Staphylococcus aureus*), gram negative, and anaerobic organisms are essential in FG due to the increasing prevalence of MDROs and polymicrobial infections.[45] Aerobic, anaerobic, and fungal blood and urine cultures should be collected, and antibiotic therapy should be initiated immediately after this. Vancomycin or daptomycin can be initiated,[121] plus a carbapenem (imipenem, meropenem, or ertapenem) or piperacillin-tazobactam.[122] Clindamycin can be added to this regimen if suspicious of toxin production.[45,122] Local antibiograms should be reviewed to allow customization of proper coverage depending on local drug resistance at

Table 2. FG Comorbid Conditions

Comorbid Condition* (N = 20,259)	n	%
Diabetes	6264	31.7
Hypertension	5163	26.1
Obesity	2395	12.1
Anemia	1961	9.9
Heart failure/CAD/CHF/PVD	1156	5.8
Alcoholism/liver disease/cirrhosis	1043	5.3
Coagulopathy	666	3.4
Smoking	187	0.9
CRF/ESRD	179	0.9
HLD	126	0.6
COPD	117	0.6
HIV/AIDS	109	0.6
Immunosuppression	53	0.3
Malignancy	78	0.4
Colorectal disease	38	0.2
Bedridden	37	0.2
IV drug use	16	0.1
Urologic disease	29	0.1
Neurological deficit (paraplegia, hemiplegia, quadriplegia)	19	0.1
Immunonutrition/malnutrition	16	0.1
Pelvic radiotherapy	13	0.1
Chemotherapy	13	0.1
Filariasis	12	0.1
Steroid use	11	0.1
Uremia	9	0.05
Malaria	8	0.04
Chronic wound	7	0.04
Stroke	7	0.04
Psychiatric disease	6	0.03
Hormonotherapy	6	0.03
Hypoproteinemia	6	0.03
Tuberculosis	3	0.02
Neurogenic bladder	3	0.02
Hidradenitis	3	0.02
Extramammary Paget's disease	2	0.01
GERD	2	0.01
Adrenal insufficiency	2	0.01
SLE	2	0.01
Chicken pox	1	0.01
Dermatitis	1	0.01
Gout	1	0.01
MGUS	1	0.01
Omphalitis	1	0.01
Pemphigus vulgaris	1	0.01
Sickle cell disease	1	0.01
Spondylarthrosis	1	0.01
Ulcerative colitis	1	0.01
Psoriasis	1	0.01
Dementia	1	0.01
Wegener's granulomatosis	1	0.01

CAD, coronary artery disease; CHF, congestive heart failure; PVD, peripheral vascular disease; CRF, chronic renal failure; ESRD, end-stage renal disease; HLD, hyperlipidemia; COPD, chronic obstructive pulmonary disease; HIV/AIDS, Virus Human Immunodeficiency/Autoimmune Deficiency Syndrome; GERD, gastroesophageal reflux disease; SLE, systemic lupus erythematous; MGUS, monoclonal gammopathy of undetermined significance.

*A total of 92/111 Studies (N = 20; 259 cases)[4,6–9,11–34,36–38,40–45,49–52,54–62,64,66–72,74,76–85,87,89,91–104,106–111]

Table 3. Sources of Infection Leading to FG

Cause* (N = 1638)	n	%
Skin	398	24.3
Perianal abscess/infection	166	10.1
Perineal abscess	53	3.2
Ischiorectal	32	2.0
Perirectal abscess	27	1.6
Scrotal abscess/infection	18	1.1
Fistula	15	0.9
Pressure ulcer	9	0.5
Chronic perineal itching	8	0.5
Penile abscess	4	0.2
Bartholin gland cyst	4	0.2
Scrotal furuncle	3	0.2
Fissure	1	0.06
Perianal wound	1	0.06
Thigh abscess	1	0.06
Inguinal abscess	1	0.06
Infected sebaceous cyst	1	0.06
Burns	1	0.06
Folliculitis	1	0.06
Dermatologic unspecified	52	3.2
Urologic sources	343	16.8
Urogenital	96	5.9
Urethral stricture	50	3.1
UTI	46	2.8
Urethral rupture	29	1.8
Urethral catheterization	22	1.3
Acute epididymo-orchitis	20	1.2
Urethral fistula	4	0.2
Urinary extravasation	3	0.2
Prostatic abscess	2	0.1
Penile pain at coitus	1	0.06
Erosion of catheter	1	0.06
Blocked catheter	1	0.06
Acute prostatitis	1	0.06
Genitourinary unspecified	67	4.1
Gastrointestinal sources	195	11.9
Rectal cancer	15	0.9
Hemorrhoidectomy	9	0.5
Inguinal hernia	9	0.5
Thrombosed hemorrhoid	8	0.5
Intestinal obstruction/perforation	3	0.2
Anal fistula	3	0.2
Diverticulitis	1	0.06
Anal cancer	1	0.06
Anorectal/colorectal unspecified	146	8.9
Mixed anorectal and urogenital	28	1.7
Trauma	84	5.1
Other sources	59	3.6
Recent surgery	37	2.3
Instrumentation	7	0.4
Paraplegia	3	0.2
Injection	3	0.2
Filariasis	2	0.1
Radiotherapy	2	0.1
Steroid enema treatment for ulcerative colitis	1	0.06
Lumbar puncture	1	0.06
Nursery manipulation	1	0.06
Carcinoma of bladder	2	0.1
Unknown	531	32.4

*A total of 57/108 studies (N = 1638 cases)[4,6,8,9,11,13–15,20,22,23,25,26,29–31,34,37,38,40,41,44,46,49,50,52,54–56,60,68,69,71,72,77,81–84,87,89,90,93,94,96,98,100–110]

that hospital/community. Once culture results are available, antibiotics can be refocused based on sensitivity.[45] Antibiotic treatment duration does not seem to influence mortality, primary closure, surgical site infection, nor rates of *C. difficile* colitis.[45] Antibiotics may be stopped after a set course of 14 days or before when surgical control was achieved depending on the case.[45]

Surgical Debridement

Extensive surgical debridement prevents progression of FG while also decreasing mortality (Fig. 2). The timing of debridement is paramount to clinical outcomes. Lin et al[39] developed the simplified Fournier Gangrene Severity Index (sFGSI), a three variable scoring system that can predict mortality and categorize patients as high-risk or low-risk. In sFGSI high-risk patients, timing of intervention dramatically decreased mortality from 68.8% in those with late intervention to 23.8% in those with early intervention. The optimal window for surgery from time of presentation to the emergency department has been determined to be within the first 14.35 hours.[39] El-Shazly et al[48] found higher rates of patients requiring more aggressive surgical debridement due to disease progression in

Table 4. Organisms that Cause FG

Microbiology*	n	%
Polymicrobial versus monomicrobial infections (N = 1227)		
Monomicrobial infections	369	30.1
Polymicrobial infections	717	58.4
Unknown if polymicrobial or monomicrobial	45	3.7
No growth from culture	230	18.7
Isolated organisms (N = 2521)		
E. coli	671	26.6
Staphylococcus sp.	365	13.8
Streptococcus sp.	285	11.3
Pseudomonas sp.	216	8.6
Bacteroides sp.	208	8.3
Enterococcus sp.	175	6.9
Klebsiella sp.	153	6.1
Proteus sp.	143	5.7
Clostridium sp.	43	1.7
Acinetobacter sp.	56	2.2
Peptostreptococcus sp.	45	1.8
Candida sp.	40	1.6
Enterobacter sp.	29	1.2
Prevotella sp.	26	1.0
Corynebacteria sp.	12	0.5
Diphtheroides	8	0.3
Fuscobacterium sp.	7	0.3
Citrobacter sp.	5	0.2
Morganella sp.	5	0.2
Providencia sp.	5	0.2
Aerococcus sp.	3	0.1
Serratia sp.	3	0.1
Salmonella	2	0.1
Actinomyces sp.	2	0.1
Peptoniphilus sp.	2	0.1
Propionibacterium	2	0.1
Flavobacterium	1	0.04
Moraxella	1	0.04
Neisseiria sp.	1	0.04
Parabacteriodes	1	0.04
Porphyromonas	1	0.04
Gram negative not specified	5	0.2

*An estimated 61 of 108 studies quantify patients who underwent culture.[4,8,11,12,17,18,20,21,23–25,30,31,34,36–38,41–46,49,50,52,56,57,59,60,63,69,72,76,77,80,82,84–87,89–91,93–96,98–109,111]

Table 5. Presenting Symptoms in FG

Initial Presenting Symptoms* (N = 2573 patients)	n	%
Scrotal swelling	430	16.7
Fever	335	13.0
Scrotal pain	266	10.3
Skin necrosis	263	10.2
Erythema and edema changes	171	6.6
Purulent/foul-smelling discharge	169	6.6
Perineal pain	182	7.1
Scrotal discoloration	123	4.8
Perianal swelling/discomfort	85	3.3
Local swelling	132	5.1
Crepitus	100	3.9
LUTS	37	1.4
Local pain	56	2.2
Severe sepsis/septic shock	49	1.9
Genital abscess	30	1.2
SIRS	18	0.7
Hyperemia/erythema	63	2.4
Altered consciousness	10	0.4
Perineal swelling	18	0.7
Penile swelling	6	0.2
Vomiting	5	0.2
Dysuria	4	0.2
Urine retention	4	0.2
Hematuria	3	0.1
Perianal pruritis	1	0.0
Ulcer	11	0.4
Blisters	2	0.1

*A total of 28/108 papers (N = 2573 patients).[8,11,12,20,22,24,30,36,37,40,41,44,49,52–54,59,72,87,90–92,97,98,101–103,107]

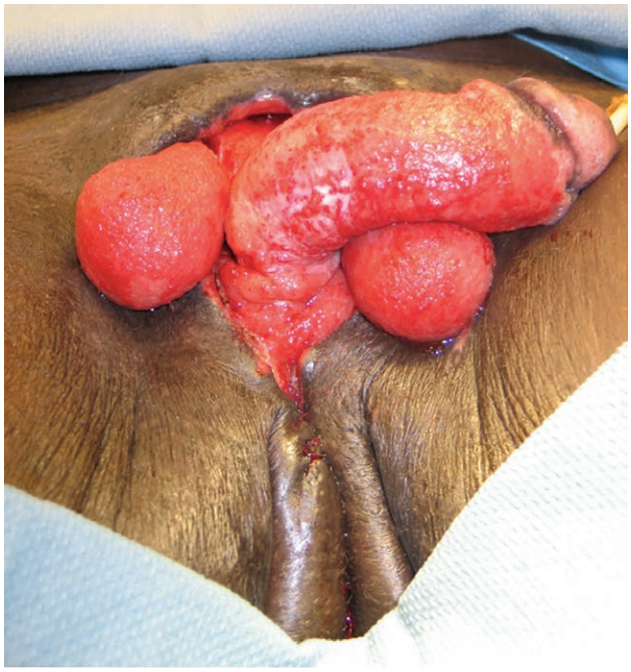

Fig. 2. Extensive surgical debridement prevents progression of FG. The figure shows patient A with FG who underwent aggressive debridement and local dressing changes until granulation was noticed.

those who had longer delays in getting to the operating room (76.5% versus 27.2%, respectively). The authors also reported that patients with conservative management had significantly greater body surface area affected, required more serial debridement, and longer hospital stays than their counterparts who underwent urgent exploration.[48] Zhang et al[25] reported that debridement should continue until reaching normal-appearing fascia. Surgeons should have a low threshold to return to the operating room and perform further debridement if there is evidence of continued progression. Attempting to salvage tissue with the incentive of making later reconstruction easier should be avoided, as this increases the risk of fulminant disease.

Interestingly, Osbun et al[47] compared management of FG at high-volume and low-volume FG health centers. They found that low-volume centers had higher rates of orchiectomy when compared with high-volume centers. On the contrary, high-volume centers had higher rates of reconstruction in FG patients. There was no difference in mortality between these groups; however, delayed transfer from a low-volume to a high-volume center was associated with mortality in four patients.[47] Although referrals should be a thoughtful clinical decision based on the capabilities to stabilize and treat these patients, it is preferable for FG patients to be transferred to high volume centers, when possible.

Orchiectomy

The consensus is that orchiectomy should be avoided whenever possible and should never be done prophylactically. Testicular involvement in FG is rare—credited to the separate blood supply of the testicles by the gonadal

arteries.[123] Although incidence is not widely reported, we found that 290 (2.6%) of 11,069 patients underwent orchiectomy.[4,11,17,20,22,23,26–28,41–43,47,50,53–56,60,66,70,79,91,95,98,101,103,104,109,112] Yanar et al[60] found that when orchiectomy was performed, using surgeon judgment, 100% of final histologic analysis showed normal testicular tissue with no signs of FG—supporting the principle that orchiectomy is often not necessary. There are no guidelines about the best timing to perform orchiectomy when needed.

OTHER MEDICAL TREATMENT

Hyperbaric Oxygen

Adjunctive hyperbaric oxygen therapy (HBOT) increases tissue oxygen levels, enhancing collagen synthesis, angiogenesis, epithelialization, and resistance to bacteria that may be beneficial for FG cases.[84] HBOT has been reported to reduce morbidity and mortality for patients with FG.[61,64,77,99,100,102,109] Feres et al[61] studied 79 patients who underwent adjunctive HBOT for FG and compared their mortality rates with a control group of 118 patients who underwent traditional treatment, including debridement, antibiotic therapy, and intensive care. They found a significantly lower mortality rate in patients who were treated with HBOT (3.7%) compared with the control group (28.8%, $P < 0.001$).[61] Similarly, Li et al[77] evaluated 28 cases with FG retrospectively, and found a statistically significant lower mortality and lower number of surgical debridements, indwelling drainage tube time, and curative time for patients who had HBOT ($P < 0.05$). However, they did not find any difference in the length of stay (LOS) between groups.[77] An absolute contraindication for HBOT is the untreated pneumothorax. Relative contraindications include upper respiratory infections, low threshold for seizures, emphysema with CO_2 retention, high fever, and congenital spherocytosis.[84] Disadvantages to this treatment include barotrauma, claustrophobia, and availability of hyperbaric chambers.[61]

Dressings or Ointments

Conventional wet-to-dry dressings are commonly used once the debridement is accomplished, but frequent changes to keep the wound clean are needed.[72] Conventional dressings that contain multiple active agents such as saline, povidone-iodine, potassium permanganate, Dakin's solution, enzymatic agents, or polyhexanide have been used to promote wound healing after surgical debridement in FG cases.[71] Only a few studies evaluated the use of dressings to promote wound healing in these patients. Altunoluk et al[81] compared the use of daily antiseptic dressings with povidone-iodine (n = 6) and dressings with Dakin's solution (sodium hypochloride 0.025%) (n = 8). They found a statistically significant shorter length of hospital stay in those receiving dressings with Dakin's solution.[81] Plates and strips of calcium alginate followed by hydrogel and polyurethane dressings have also shown promising outcomes in a few cases.[76] Still, the hyperbaric oxygen sessions that these patients also received might have influenced these outcomes. Dermal matrix has also been beneficial for patients with FG.[74] Zhang et al[74] evaluated the use of porcine acellular dermal matrix for wound healing in patients with FG. They found statistically significant shorter preparation wound time (until granulation tissue was suitable for skin grafting or wound was repaired) and hospitalization period in patients who had porcine acellular dermal matrix compared with those whose wounds were cleaned with hydrogen peroxide and sodium hypochlorite solution. In addition, moist exposed burn ointment, an herbal formulation containing β-sitosterol, baicalin, and berberine, has been reported to be beneficial by inducing keratinocyte migration and interaction with growth factors.[87] Finally, the use of enzymatic debridements with topical lyophilized collagenase applied twice a day in 11 patients whose active infection was arrested, demonstrated to reduce the number of surgical debridements and duration of hospitalization compared with 23 patients who did not have it as part of their treatment.[98] In general, further studies with higher sample size are needed to determine the type of dressing that produces the best wound healing. However, this is hard to assess given the differences in the extent of the disease and each patient's individual treatment.

Negative Pressure Wound Therapy

Vacuum-assisted closure therapy (VAC) has been implemented in the treatment of FG by some institutions with positive results.[4,66,67,69,71,85,86] A lower pressure between 50 and 125 mm Hg, with 5 minutes of suction followed by 2 minutes of rest, is recommended.[72,86] VAC can only be applicable after proper debridement of FG. Before debridement, this therapy is contraindicated because it can hide the disease's progression. VAC dressing changes should be done every 48–72 hours, and in case of progressive necrosis, surgical debridement needs to be repeated.[71,86] Iacovelli et al[4] performed a multi-institutional cohort study evaluating the use of VAC therapy for patients with FG. They observed higher rates of survival at 90 days and higher rates of wound closure at 10 weeks after surgery in patients with disseminated FG compared with those who were not treated with VAC.[4] Yanaral et al[71] compared the use of conventional antiseptic dressings with VAC after debridement of FG in 54 patients, retrospectively. They found that VAC statistically significantly decreased pain, number of daily dressing changes, number of daily analgesics and narcotics, and increased mobilization per day compared with conventional dressings. Similarly, Ozturk et al[86] compared five patients who received conventional wet-to-dry dressings with saline and five patients who underwent VAC therapy. The authors observed less pain and use of analgesics in those patients treated with VAC therapy.[86] These two prior studies reported a similar LOS for both groups.[71]

Michalczyk et al[64] performed a retrospective study evaluating the use of HBOT in combination with VAC for wound healing after debridement in patients with FG. The authors did not find any statistical difference in hospitalization time compared with patients who had an open standard wound care, but showed a correlation with the extent of resection. These findings suggest that the use of

combined therapy might be beneficial for patients with large wound defects.[64]

The current evidence on VAC therapy for FG consists only of retrospective and observational studies with a low number of subjects. Further studies are needed to determine its real benefit and potential treatment algorithm.

Honey

The use of topical unprocessed honey to promote granulation after wound debridement in FG cases has been investigated. Even though some studies suggested that honey accelerated wound healing[89,105] and showed less hospitalization time[79] in patients with FG, there is still not enough evidence that honey can be directly associated with improved wound healing. Further studies are needed with control of confounding factors and greater sample size.

Fecal Management System

Urinary or fecal diversion is required in those patients with necrosis involving the periurethral and perianal area to protect the wound from urinary and fecal discharge. Fecal management systems appeared as an alternative to colostomy. Flexi-Seal Fecal Management System is a short-term fecal diversion consisting of a rectal tube that allows diversion of feces from the rectum to a collector bag.[72] It has been suggested to be a promising method in the treatment of FG when used along with VAC.[72] However, studies are needed to determine its efficacy and specific indications.

RECONSTRUCTION

No studies, with high-level evidence, were identified to discuss superiority of reconstructive options or approaches. The majority of studies discussing reconstruction methods were level of evidence IV.

Healing by Secondary Intention

Eighteen studies included 179 patients who underwent healing by secondary intention/secondary closure.[10,17,19,20,25,31,35,41,45,50,52,56,60,63,66,92,108,110] Zhang et al[25] left healing by secondary intention for defects occupying less than 50% of the scrotum. This was feasible due to increased elasticity of the scrotum, and adequate cosmetic results were achieved. Similarly, Eswara et al[19] found healing by secondary intention ideal for small or dehisced wounds, especially those located near the anus or inguinal folds. It has been reported that 18% of FG wounds that underwent attempted healing by secondary intention remained open at 6 months.[27] Even though no correlation was identified between surface area and time to closure,[66] when leaving defects to close by secondary intention, it should be expected to observe prolonged time of healing, contractures, and as a consequence, poorer patient satisfaction.

Skin Grafts

Skin grafts were used in 521 patients. Although minimally complex, they can be used to successfully reconstruct scrotal skin, which has unique properties (Fig. 3). Graft take occurred in most of the cases; a single patient's graft became infected, resulting in scarring, and five patients developed scarring with adhesions. It has been reported that neoscrotal contraction can occur in 3–6 months following skin grafting.[13] However, with daily massaging using emollients, contraction can be reduced to minimum.[13] Neoscrotal rugosity and cremasteric activity may also be observed after 6 months of reconstruction.[13] Ferreira et al[8] also found utility

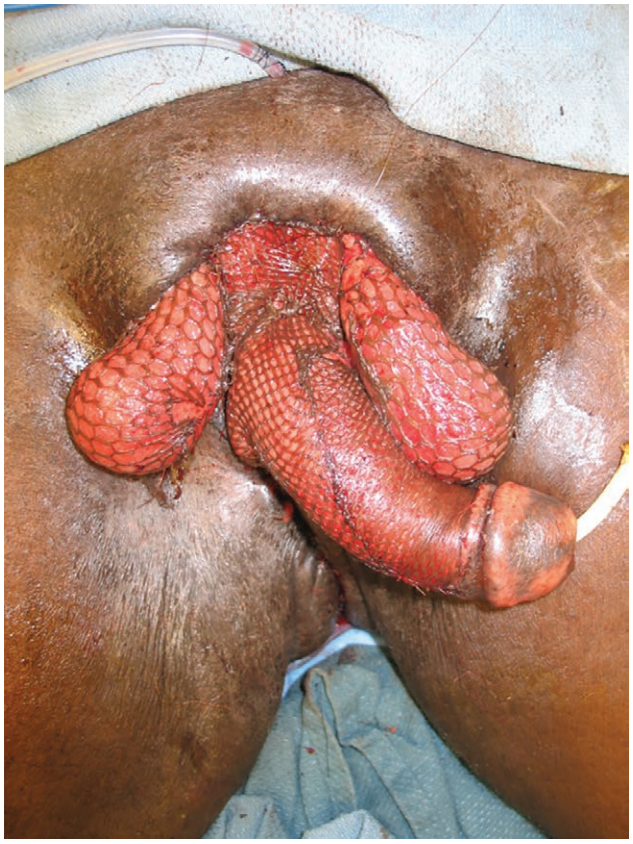

Fig. 3. Meshed split-thickness skin grafting following FG debridement in patient A.

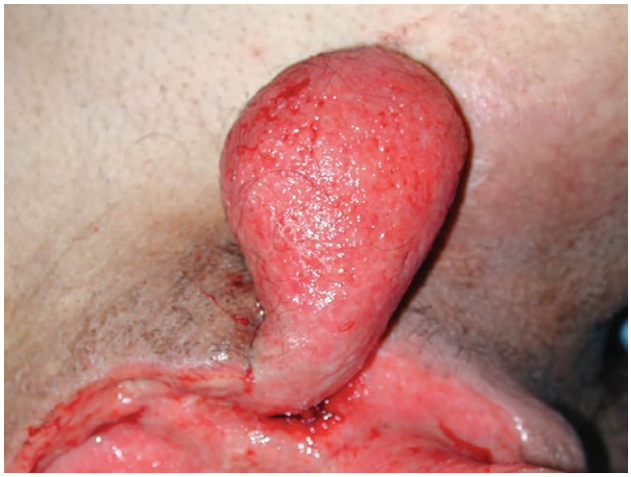

Fig. 4. Preservation of the tunica vaginalis is critical to ensure success of STSG.

in using skin grafts in patients with penile involvement. Thick split-thickness skin grafts were preferred to minimize contractures.[8] Full-thickness skin grafts were used in four patients for tubed urethroplasty.[8] Importantly, when skin grafting is needed to cover defects in the testicles, the tunica vaginalis needs to be intact; in its absence, skin grafting will not be successful[13] (Fig. 4). This procedure is considered a good option to keep morbidity low when specialized care is not available. Downsides to split-thickness skin graft include high rates of skin contracture, poor take in areas with abnormal contours such as the perineum, and less protection for future injury.[24] In addition, cosmesis and patient satisfaction have been reported to be poor.[11] In summary, skin grafting is a good option for reconstruction, especially in areas with poor resources where a plastic surgeon may not be available.

Subcutaneous Thigh Pouches

Twelve studies (63 patients) underwent reconstruction with subcutaneous thigh pouches.[11,13,17,20,22,38,43,98,100,103,106] Subcutaneous thigh pouches offer low surgical complexity but should be avoided due to poor aesthetics, poor patient satisfaction, chronic testicular pain, and disruption of spermatogenesis caused by elevated testicular temperatures.[8]

Loose Wound Approximation

Akilov et al[17] recommended loose wound approximation for FG defects that affect less than 50% of the scrotum. Their study compared loose wound approximation using a U-stitch (six patients) to healing via secondary intention (14 patients), finding a shorter LOS in the U-stitch group. The benefits include loose wound approximation immediately after debridement, testicular coverage, the ability to place a drain that theoretically will allow drainage of residual infection and reduction of contracture, technical ease, and shorter LOS.[17] Further studies with a larger sample size are necessary to determine the efficacy of this method.

Tissue Adhesive

Morris et al[7] found that diluted fibrin sealant resulted to be successful when flaps and grafts were used for reconstruction. All patients who required split-thickness skin graft (n = 6) had 100% graft take, and 11 of 12 patients who required flap reconstruction had excellent flap adherence. Almost all patients had no complications and satisfactory results. A single patient developed flap breakdown in the setting of reconstruction immediately following a large debridement.[7] Sivrioğlu et al[16] used 2-octyl-cyanoacrylate glue in FG patients needing skin grafts and found 100% success in all patients with a mean length of hospital stay of 9 days (range: 7–12). Its application allowed meticulous graft positioning and decreased the need for quilting sutures, showing possible antimicrobial properties.[16] Although requiring further investigation, tissue adhesive appears to be beneficial at fixing the abnormal contours of the perineum.[7,16]

Flap Reconstruction

Flap reconstruction is helpful in some defects (Figs. 5 and 6). A total of 33 articles reported on the use of some sort of flap with a total pool of 373 (31.7%) patients[6–15,18,19,21,23–25,28,32,33,35,38,41,50,52,58,66,67,76,88,97,98,100,105] (Table 6).

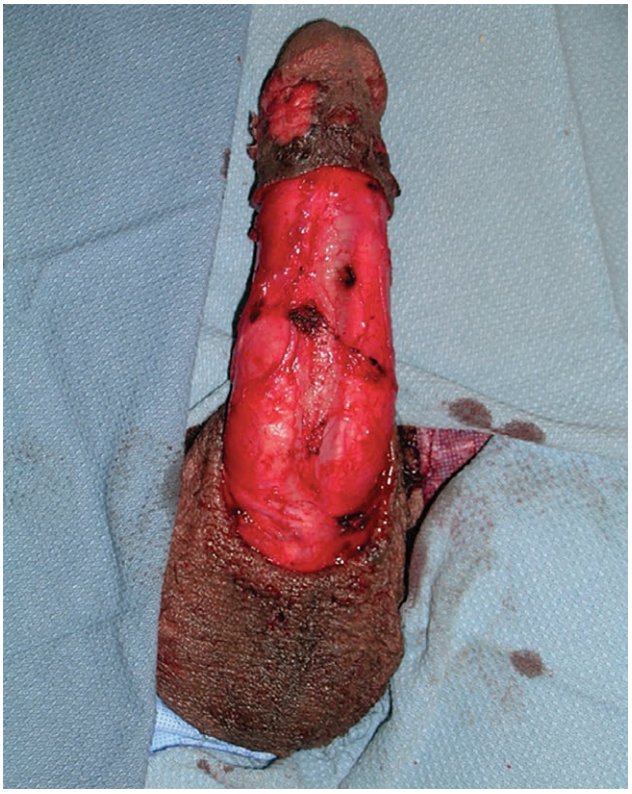

Fig. 5. Postsurgical debridement of nonviable tissue in patient B with FG.

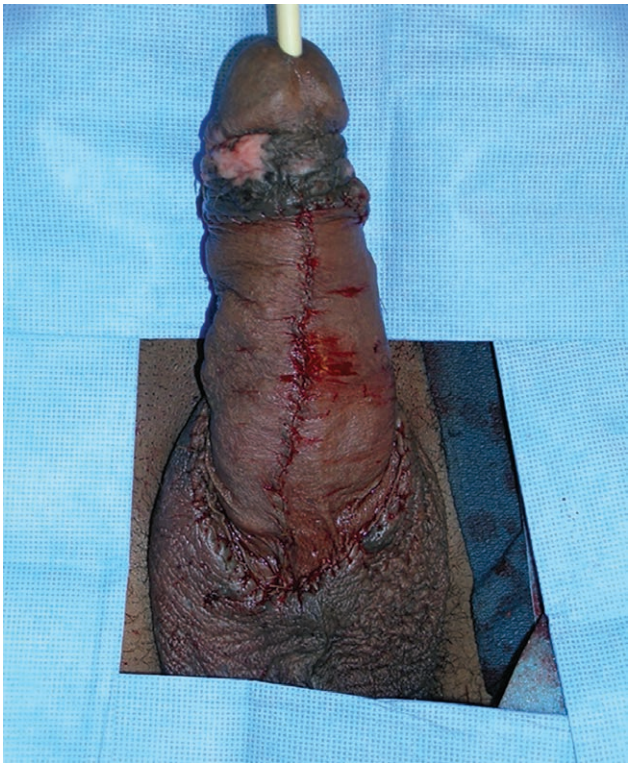

Fig. 6. Perforated split-thickness skin grafting in patient B following initial debridement.

Table 6. Reconstructive Methods in FG

Reconstruction Type* (N = 1175)	n	%
Healing by secondary intention[10,17,19,20,25,31,35,41,45,50,52,56,60,63,66,92,108,110]	179	15.2
Skin grafts[6–8,10,11,13,15–17,21,23–25,29,30,36–38,41,44,47,48,50,52,58,63,66,77,78,80,82–84,86,89–91,98,100,102,104,106,108]	521	44.3
Subcutaneous thigh pouches[11,13,17,20,22,38,43,98,100,103,106]	63	5.4
Loose wound approximation[17]	6	0.5
Tissue adhesive[7,16]	33	2.8
Flaps (total)[6–15,18,19,21,23–25,28,32,33,35,38,41,50,52,58,66,67,76,88,97,98,100,105]	373	31.7
Scrotal advancement flap[6,10,12,24,35]	86	7.3
Gracilis muscle flaps[8,9,12,15,24]	24	2.0
Gracilis muscle flap	14	1.2
Gracilis myofasciocutaneous advancement flap	8	0.7
Gracilis myocutaneous flap	2	0.2
Pudendal thigh flaps[12,15,18,21,23–25,32,88]	63	5.4
Pudendal thigh flap	18	1.5
Pudendal thigh fasciocutaneous flap	23	2.0
Internal pudendal artery perforator flap	20	1.7
Internal pudendal pedicle flap	2	0.2
Medial or lateral thigh fasciocutaneous flaps[8,11,13,19,23,24,32,105]	59	5.0
Superomedial thigh flap	28	2.4
Medial thigh lift	10	0.9
Fasciocutaneous thigh flap	12	1.0
Pedicled anterolateral thigh flap	3	0.3
Medial thigh flap	3	0.3
Internal thigh bilateral fasciocutaneous transposition flaps	1	0.1
Internal thigh rotational flap	1	0.1
Rotational thigh flap	1	0.1
Medial circumflex femoral flaps[14,23]	8	0.7
Medial circumflex femoral artery perforator flap	7	0.6
Medial femoral circumflex artery perforator fasciocutaneous flap	1	0.1
Unspecified flap[7,10,41,52,66,76,97,98]	73	6.2
Limberg thigh flap[33]	29	2.5
Scrotal musculocutaneous flap[8]	7	0.6
Local advancement flap[8,67,100]	17	1.4
Prepucial skin flap[33]	2	0.2
VRAM flaps[13]	1	0.1
Latissimus flap[19]	1	0.1
Contralateral rotational flap[23]	1	0.1
McGregor rotational flap[23]	1	0.1
Local sliding flap[23]	1	0.1

*A total of 67/108 studies (N = 1175 patients).

Scrotal Advancement Flaps

A total of 88 patients (5.6%) underwent scrotal advancement flaps. Scrotal advancement flaps offer a good aesthetic result and fulfill the "replace like by like" principle.[24] This flap is recommended for small-to-medium defects of the scrotum, smaller than 50% of the total scrotal surface area.[12,24,35] The largest reported defect repaired with this flap was 96 cm.[2,24] In addition, they can be used when neither secondary intention nor primary closure have resulted in wound closure.[35] It is not recommended for larger defects, as they require a tension-free closure, without which flap loss and wound edge necrosis are more likely.[24] Benefits of this method include durable and good skin quality, elasticity (presence of dartos muscle), and robust blood supply that allows adequate healing.[24]

Gracilis Flaps

Five studies used variations of gracilis muscle flaps.[8,9,12,15,24] Chen et al[12,24] reported using gracilis muscle to fill deep perineal defects when harvested as a muscle or myocutaneous flap. The advantages of using this flap include the proximity to the affected area, the single-stage procedure, the ability to fill larger/deeper defects, and the robust vascular supply that allows better penetration of antibiotics to the affected tissue.[8,24] The gracilis flap has a long pedicle that allows a good arc of rotation and great blood supply, in addition to the well-nourished sensitive skin.[124]

Complications related to gracilis flap included hematoma,[9] donor site abscess,[9] wound dehiscence,[15] and partial flap necrosis.[15] Disadvantages include the time-consuming dissection, its relative bulk when compared with native tissue, the risk of split-thickness skin graft contracture, and the need for patient compliance with multiple dressing changes per day to avoid humidity and infections.[12,14,15,125]

Pudendal Thigh Flaps

Nine studies used pudendal thigh flaps in 63 patients.[12,15,18,21,23–25,32,88] Chen et al[12,24] reported using a pudendal thigh fasciocutaneous flap for a scrotal defect affecting less than 50% of total surface area, or in combined defects involving the scrotum and perineum, reporting no complications. The benefits of a pudendal thigh flap are numerous and include the preservation of sensation in the flap, the presence of a reliable blood supply, less bulk than other options, minimal donor site morbidity, and the avoidance of using a functional muscle.[24] Interestingly, several patients expressed concern regarding fertility. However, semen analyses were performed 3 months postoperatively, showing normal results in these patients.[32]

Medial or Lateral Thigh Fasciocutaneous Flaps

Eight studies used a variation of a medial thigh fasciocutaneous flap in 59 patients.[8,11,13,19,23,24,32,105] Ferreira et al[8] used superomedial thigh flaps in 26 patients. In patients with large defects, bilateral flaps were needed to increase the transverse dimension and cover the defect. Bhatnagar et al[11] used fasciocutaneous medial thigh flaps in 12 patients, reporting an 83.3% success rate. Chen et al[24] performed pedicled anterolateral thigh flaps in patients who had defects involving more than 50% of the scrotum and combined defects involving the scrotum. Benefits include being a single-stage procedure that provides sensate coverage with adequate cosmesis and patient satisfaction; however, specialized surgical skills are often required.[11] Reported complications consisted of dehiscence,[8] hematoma,[24] shallow scrotal sac,[13] higher morbidity,[11] and longer hospital stay.[11]

Medial Circumflex Femoral

Two studies used the medial circumflex femoral artery perforator flaps in eight patients with good results.[14,23] Coskunfirat et al[14] used these flaps in seven patients. Five patients had a propeller flap variation to cover both testes, whereas two patients had a VY advancement flap when only one testicle needed to be covered. All patients were immobilized for 3–5 days, and only two minor dehiscences were reported, with one repaired by secondary suture and the other by secondary intention.[14]

Other Types of Flaps

Dadaci et al[33] reported using Limberg thigh flaps for reconstruction in 29 patients with defects occupying 50% or more of the scrotum. Benefits included no need for specialized microsurgical skills, the ability to close the primary donor site, adequate cosmesis, and easy harvesting while

providing a tension-free repair. Tan et al[13] used a vertical rectus abdominis myocutaneous (VRAM) flap in a single patient, which offered good coverage but had an unsatisfactory aesthetic result with an abnormal appearing scrotum. VRAM flaps, like gracilis flaps, are useful especially for testicles where tunica vaginalis is no longer present.[33] The benefit of using a VRAM flap relies upon a constant blood supply that makes it ideal in conditions of a contaminated recipient bed such as the perineum, and the wide flat shape that makes it easy to inset.[126] Other possible flaps included scrotal musculocutaneous flaps,[8] local advancement or sliding flaps (not necessarily scrotal),[8,23,67,100] latissimus free flap,[23] contralateral rotational flap,[23] and McGregor propeller flap.[23] Ferreira et al[8] reported using scrotal musculocutaneous flaps in 10 patients with small- and medium-sized defects.

DISCUSSION

Management of FG relies on four pillars: fluid resuscitation, broad-spectrum antibiotics, rapid/aggressive debridement, and reconstruction, if indicated (Fig. 7). Early management of FG should be warranted. Many options to reconstruct FG defects with flaps exist; however, deciding which type of flap depends on the size of the defect, location, surgeon skill, patient age, and desires. Surgeons should be aware of the potential complications of using flaps for FG reconstruction, including the possibility of total flap loss. Scrotal advancement flaps or secondary intention closure are used for defects of less than 50% of the scrotum that cannot close by primary intention.[127] In contrast, skin grafts or flaps ± skin grafts are better suited for defects of greater than 50% of the scrotum or extending beyond the scrotum.[127]

LIMITATIONS

Our study is not without limitations. No randomized control trials or level I evidence was identified or included in this study. Furthermore the majority of studies in this review fall below level II evidence.

CONCLUSIONS

FG is a life-threatening condition. The most frequent comorbidities associated with FG included diabetes, alcoholism/liver cirrhosis, and hypertension. A polymicrobial infection often causes FG, but *E. coli* was the most

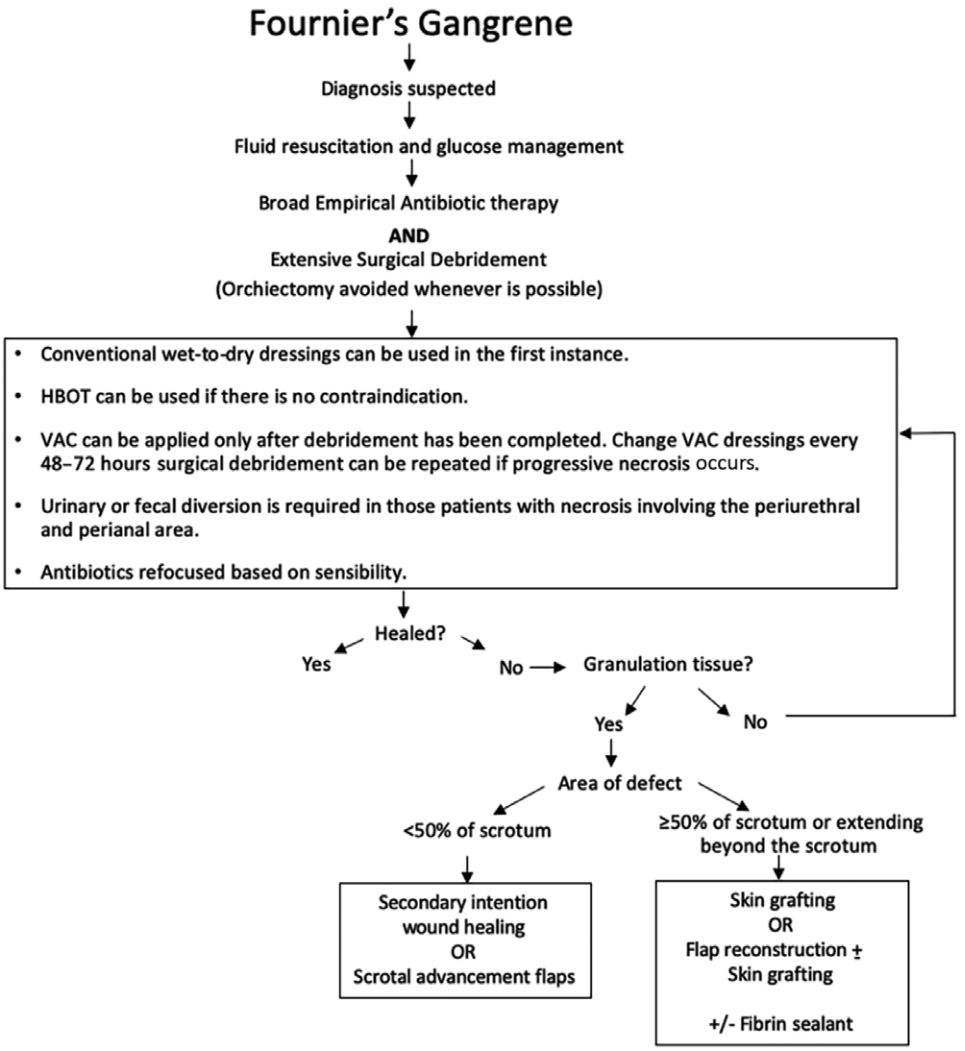

Fig. 7. Evidence-based FG treatment flowchart.

common causative organism involved. Treatment should be initiated as soon as possible with fluid resuscitation, broad-spectrum antibiotics, aggressive surgical debridement, and reconstruction. Skin grafts and a variety of flaps are commonly used for reconstruction. The best option for reconstruction should rely on the surgeon's expertise, patient preference, and available resources.

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