Journal on Surgery

www.journalonsurgery.org

Research Article

Open Access, Volume 2

New Strategy in Fournier's Gangrene Treatment: 10-Year Experience of a Tertiary Hospital

Hanghui Cen[1]*; Jun Yin[1]; Caiyun Xu[2]

[1]Department of Burns and Wound Repair Surgery, The Second Affiliated Hospital, Zhejiang University, Hangzhou, Zhejiang Province, P.R.China.

[2]Specialist Department, The Second Affiliated Hospital, Zhejiang University, Hangzhou, Zhejiang Province, P.R.China.

Abstract

Introduction: To analyze the diagnosis and treatment of Fournier's Gangrene (FG) for the first diagnosis and referral at a tertiary hospital retrospectively.

Methods: This retrospective study included all patients diagnosed with FG at the authors' tertiary medical institution. Patient characteristics, treatment features, and clinical results were extracted from the medical charts.

Results: The average age of patient was 56.7 (range, 23-81) years. In addition to the systemic application of antibiotics, extensive debridement and open drainage were performed in all patients. Seventeen patients underwent surgical treatment, and finally, the wound surface was repaired. Eight cases were treated with negative pressure wound therapy (NPWT) after debridement, and 14 patients were subject to dressing change many times a day and wet compress with povidone-iodine gauze. The average hospitalization time was 22 (range, 3-128) days. Eight patients were admitted to the ICU. Nineteen patients survived, and three died, for a mortality rate of 13.6%.

Gram-positive bacteria accounted for 36%, Gram-negative bacteria accounted for 48%, and fungi accounted for 16%.

Conclusion: Early accurate diagnosis of FG and early debridement surgery are necessary to reduce hospitalization time, course of disease, complications, and mortality. NPWT is an active way to help wound repair.

Keywords: Fasciitis; Necrotizing; Perineum; Negative Pressure Wound Therapy (NPWT); Management; Prognosis.

Manuscript Information: *Received: Nov 09, 2022; Accepted: Dec 07, 2022; Published: Dec 14, 2022*

Correspondance: *Hanghui Cen, Department of Burns and Wound Repair Surgery, The Second Affiliated Hospital, Zhejiang University, Hangzhou, Zhejiang Province, P.R.China. Tel: +86-13757119579; Email: 2196028@zju.edu.cn*

Citation: *Cen H, Yin J, Xu C. New Strategy in Fournier's Gangrene Treatment: 10-Year Experience of a Tertiary Hospital. J Surgery. 2022; 2(2): 1068.*

Copyright: © Cen H 2022. *Content published in the journal follows creative common attribution license.*

Introduction

Necrotizing fasciitis is a life-threatening infection that spreads along fascial planes [1-3]. Necrotizing fasciitis, irrespective of its location, is a surgical emergency and prompt diagnosis and management are imperative [2,4,5]. Fournier's gangrene (FG) refers to necrotizing fasciitis in the perineal area, including the perineal skin, subcutaneous tissue, and superficial and deep fascia caused by the invasion of one or more pathogenic microorganisms [1-3]. The incidence rate of FG is 0.4/100,000 Sabzi Sarvestani, 2013 #30}6-10. It is often associated with rectal colon diseases, genitourinary system diseases, skin infections, or local tumors [6-11]. The fatality rate of this condition is high, at 16.9%-76% [11-16]. Patients with comorbidities such as cancer, immune system diseases, and alcohol and drug abuse often have a poor prognosis [12,14,17].

Early correct diagnosis, active surgical expansion, the correct treatment of inducing factors and comorbidities, combined application of broad-spectrum antibiotics, and comprehensive treatment of severe sepsis are the keys to reducing mortality [2,4,5,18]. FG is often misdiagnosed and mistreated because it is not recognized early [11-16]. If the diagnosis is made early (less than 3 days), the mortality rate of patients undergoing regular comprehensive treatment is only 8.7%, and the mortality rate of patients who do not undergo regular comprehensive treatment due to delay of the optimal opportunity for treatment is as high as 42.4% [11-16].

Postoperative wound management is crucial to patients' outcomes [19]. Negative Pressure Wound Therapy (NPWT) is an active method for wound treatment for necrotizing fasciitis and other severe soft tissue defects [20-24]. NPWT accelerates the process of wound repair and wound bed preparation until definitive coverage is made [25,26], as shown in a series of 35 patients with FG [27]. Despite special dressings, the use of NPWT can lead to the wound management process being three times less expensive than with conventional dressings [26,28]. Other management includes drainage, dressing changes, and pain relief [2,4,5]. Nevertheless, data about the use of SNPT for FG are still scarce. This study summarized and analyzed FG's diagnosis and treatment for the first diagnosis and referral at a tertiary hospital.

Methods

Study design and patients

This retrospective study included all patients diagnosed with FG between January 1999 to December 31, 2018, at the authors' tertiary medical institution. The study was approved by the local ethics committee. The requirement for individual consent was waived by the committee because of the retrospective nature of the study. FG diagnosis depends on clinical symptoms/signs such as erythema, rash, swelling, crepitus, and local skin necrosis in the perineum, perianal or genital parts, combined with emergency B-ultrasound or CT and MR examination results and tests [6-11].

Data collection

Age, sex, etiology, comorbidities, time from the appearance of symptoms to the first debridement, operation time, number of operations, culture results, hospitalization time, ICU hospitalization days, and clinical results were extracted from the medical charts. During the diagnosis process, the patients' general conditions were recorded and included in the diagnostic criteria for sepsis. If there was no obvious soft-tissue expansion or necrosis, isolated perianal, periurethral, and scrotal abscesses were excluded. Tissue culture was routinely carried out during debridement to identify pathogenic microorganisms and determine antibiotic therapy.

Management

All patients were treated with aminoglycosides or third-generation cephalosporins, metronidazole, and other drugs, covering Gram-positive and -negative and anaerobic bacteria. Wound secretion cultures were regularly reviewed, and the antibiotic plan was revised according to the culture results. All patients underwent abscess drainage and extensive surgical debridement. Debridement included removing all necrotic skin, subcutaneous tissue, fascia, and muscle, and extension of incision exploration until living tissue is found. Patients were closely monitored, and patients with necrotic tissue, delayed wound healing, or clinical deterioration (leukocytosis, elevation of procalcitonin, renal insufficiency, etc.) underwent debridement as many times as necessary. Colostomy was performed when severe fecal contamination or gangrene extended to the anal sphincter. Wet dressing change or NPWT dressing was routinely applied to the wound site.

Statistical analysis

All analyses were performed using SPSS 22.0 (IBM, Armonk, NY, USA). Continuous data are presented as median (range) and were analyzed using the Mann-Whitney U-test. Categorical data are presented as n (%) and were analyzed using Fisher's exact test. P-values <0.05 were considered statistically significant.

Results

Characteristics of the patients

Table 1 describes the 22 patients. Their average age was 56.7 (range, 23-81) years. There were one female and 21 males. Eighteen patients were admitted to the emergency department and four to the outpatient department. Eighteen patients cases were first diagnosed, and four were referred.

In addition to the systemic application of antibiotics, extensive debridement and open drainage were performed in all patients. Seventeen patients underwent surgical treatment (10 patients underwent one operation, one patient underwent two operations, three patients underwent three operations, and three patients underwent more than three operations), and finally, the wound surface was repaired. These patients required an average of 1.6 debridement operations. There were seven cases of debridement + skin grafting + advancement flap, nine cases of debridement + drainage, and one case of debridement + dermal scaffold + skin grafting. Orchiectomy was performed in two patients. Most testicular fascia was intact. If there was residual necrotic tissue, it was necessary to perform debridement again. Eight cases were treated with NPWT after debridement, and 14 patients were subject to dressing change many times a day and wet compress with povidone-iodine gauze. For patients with skin defects at the base of the wound and the formation of healthy granulation tissue, wound repair operations such as skin transplantation, scrotal advancing flap transfer coverage, and allogeneic dermal scaffold

transplantation + tomographic skin transplantation were performed. The scrotal abscess in five patients has broken before admission. After full bedside debridement, removal of necrotic tissue, sufficient drainage, and multiple dressing changes, the wounds healed. One patient underwent suprapubic cystostomy, and the other patients achieved good urine diversion by a catheter. One patient underwent stool diversion after ileostomy or colostomy.

The average hospitalization time was 22 days (range from 3 to 128 days). A total of 8 patients were admitted to ICU, with an average hospitalization time of 9.3 days.

Treatments: 1) debridement (removal of skin and subcutaneous necrotic tissue debridement); 2) skin grafting (reticular skin grafting with thick scalp blade split-thickness, mesh skin graft); 3) dermal scaffold graft (acellular allogenic dermal scaffold graft); 4) negative pressure wound treatment; 5) local advance skin flaps; 6) excision of anal fistula; 7) fistulotomy (rectum or ileum); 8) dressing change; 9) excision of testis and epididymis; 10) excision of cyst of the vulva; and 11) cystostomy.

Comparison of the patient characteristics according to the outcomes

Nineteen patients survived, and three died, for a mortality rate of 13.6% (Table 2). There were no significant differences between the two groups regarding the patients' demographic, clinical, and biochemical characteristics.

Table 1: Characteristics of the patients.

#	Sex	Age	Length of stay	Treatment	Comorbidities	Lesion site	Negative pressure
1	Male	59	31	1+2+3+4	None	Perineum	Yes
2	Male	52	26	1+2+4+5+6+7	Hypertension	Scrotum	Yes
3	Male	61	37	1+2+4+5	Hypertension, prostatic hyperplasia	Scrotum	Yes
4	Male	81	4	1	Malnutrition, malignant tumor	Abdominal wall of the perineum	Yes
5	Female	72	128	1+2+4+7	Malignant tumor, hypertension	Vulva	Yes
6	Male	39	27	1+2+3+4+5	None	Perineal testis	Yes
7	Male	61	17	1+8+5	None	Scrotum	No
8	Male	32	25	1+8	Hypertension, gout	Scrotal abdominal cavity	No
9	Male	63	4	1+8	Malignant tumor	Scrotum	No
10	Male	23	19	8	Malnutrition, malignant tumor	Scrotum	No
11	Male	53	37	9+8	Hypertension	Scrotum	No
12	Male	48	3	10+8	None	Scrotum	No
13	Male	66	6	8	Diabetes, hypertension	Scrotum	No
14	Male	71	9	1+8	None	Scrotum	No
15	Male	34	9	8	None	Scrotum	No
16	Male	44	4	1+8	None	Scrotum	No
17	Male	36	8	1+8	None	Scrotum	No
18	Male	68	21	1+2+4+5	Diabetes	Scrotum	Yes
19	Male	45	21	1+8+5	None	Scrotum	No

Table 2: Comparison of the groups.

Characteristic	Overall (n=22)	Survival (n=19)	Death (n=3)	P
Male, n (%)	21(95.5)	18(94.7)	3(100)	>0.999
Age (years)	54.5 (23,81)	53 (23,77)	66 (34,81)	0.523
BMI (kg/m^2)	22.6 (16.37,29.07)	22.89(16.37,29.07)	20.20(17.30,22.04)	0.138
Systolic blood pressure at admission (mmHg)	128 (85,188)	128.5 (89,188)	128 (85,146)	0.669
Diastolic blood pressure at admission (mmHg)	77 (50,103)	76.5 (50,103)	78 (56,93)	0.887
Hospitalization (days)	18 (3,128)	21 (3,128)	6 (4,9)	0.087
Location of the lesion, n (%)				0.470
Scrotum	18 (81.8)	16 (84.2)	2 (66.7)	

Others	4 (18.2)	3 (15.8)	1 (33.3)	>0.999
Negative pressure, n (%)				
No	14 (63.6)	12 (63.2)	2 (66.7)	
Yes	8 (36.4)	7 (36.8)	1 (33.3)	
Comorbidities, n (%)				
Fever	21 (95.5)	18 (94.7)	3 (100)	>0.999
Budd-Chiari syndrome	15 (68.2)	12 (63.2)	3 (100)	0.523
Purulent secretion	19 (86.4)	16 (84.2)	3 (100)	>0.999
Malnutrition	2 (9.1)	1 (5.3)	1 (33.3)	0.260
Malignant tumor	3 (13.6)	2 (10.5)	1 (33.3)	0.371
Laboratory indicators				
CRP, mg/L	112.3 (4.7,390.7)	60.5 (4.7,390.7)	270 (113.2,320)	0.101
WBC, $\times 10^9$/L	11.95 (0.8,28.1)	11.6 (0.8,23.5)	18.6 (7.2,28.1)	0.356
Hgb, g/L	122 (5.4,162)	122 (5.4,162)	76 (72,132)	0.586
HCT, l/L	369 (152,479)	370 (152,479)	228 (214,428)	0.408
Na, mmol/L	136.75 (42.8,144.1)	136.8 (42.8,144.1)	132.0 (130.0,138.9)	0.408
BUN, mmol/L	6.41 (2.83,42.57)	5.73 (2.83,33.04)	7.65 (6.82,42.57)	0.226
Cr, µmol/L	62.5 (3.96,442)	65 (3.96,442)	59 (56,208)	0.857
Glucose, mmol/L	6.97 (3.85,56)	6.89 (3.85,56)	8.61 (6.7,8.66)	0.412
Lactic acid, mmol/L	1.6 (0.5,3.1)	1.45 (0.5,3.1)	1.9 (1.4,3)	0.371
Procalcitonin, ug/L	1.9 (0,41.42)	1.8 (0.04,41.42)	2.09 (0,18.23)	>0.999
INR	1.11 (0.95,1.56)	1.1 (0.95,1.56)	1.11 (0.98,1.18)	0.765

All continuous data are shown as median (range)

BMI: Body Mass Index; CRP: C-Reactive Protein; WBC: White Blood Cell; Hgb: Hemoglobin; HCT: Hematocrit; BUN: Blood Urea Nitrogen; Cr: Creatinine; INR: International Normalized Ratio.

Table 3: Culprit pathogens.

Species	No of isolates	% of isolates (n=25)
Gram-positive bacteria	9	36
Enterococcus faecalis	3	12
Enterococcus faecium	1	4
Enterococcus avium	2	8
Staphylococcus epidermidis	1	4
Staphylococcus haemolyticus	1	4
Corynebacterium striata	1	4
Gram-negative bacteria	12	48
Escherichia coli	5	20
Proteus mirabilis	1	4
Proteus vulgaris	1	4
Acinetobacter baumannii	1	4
Salmonella enteritidis	1	4
Klebsiella pneumoniae	1	4
Klebsiella acidogenes	1	4
Pseudomonas	1	4
Fungus	4	16
Candida tropicalis	2	8
Candida parapsilosis	1	4
Candida albicans	1	4
Total	25	100

Figure 1: Male, 61 years of age. He developed Fournier's gangrene from a perianal abscess. He was treated with debridement, skin grafting, continuous negative pressure treatment, and local advance skin flap.

Wound cultures

Culture of wound samples showed a variety of microorganisms, of which Gram-positive bacteria accounted for 36%, Gram-negative bacteria accounted for 48%, and fungi accounted for 16% (Table 3). Among Gram-positive bacteria, *Enterococcus faecalis* accounted for 12% of the total bacteria. Among Gram-negative bacteria, *Escherichia coli* accounted for 20%. Among fungus, *Candida tropicalis* was the most common, accounting for 8%.

Typical cases

There were three typical cases: two male patients, including one with a perianal abscess (Figure 1, patient #3) and one with perineal injury (Figure 2, patient #21), and one female patient with perineal surgery (Figure 3, patient #5).

Figure 2: Male, 56 years of age. He developer Fournier's gangrene after a perineal injury. He was treated with debridement, skin grafting, continuous negative pressure treatment, local advance skin flap, and cystostomy.

Figure 2: Female, 72 years of age. She developed Fournier's gangrene after a perineal surgery. She was treated with debridement, skin grafting, continuous negative pressure treatment, and fistulotomy.

Discussion

This retrospective study aimed to analyze FG's diagnosis and treatment for the first diagnosis and referral at a tertiary hospital. The results revealed that FG is a rare but severe necrotizing soft tissue infection. Early accurate diagnosis and early debridement surgery are necessary to reduce hospitalization time, course of disease, complications, and mortality.

Necrotizing soft tissue infections are a group of diseases related to necrotizing changes in any layer of soft tissue lumen, including simple skin necrosis and life-threatening fascia and muscle infections [1-3]. It features acute onset, rapid progression, and high mortality. Necrotizing fasciitis is a severe infectious condition, mainly involving superficial fascia and subcutaneous tissue [1-3]. Necrotizing fasciitis that occurs in the perineal, genital, and perianal regions are often called FG. The disease is characterized by rapid progress and explosive infection, accompanied by sepsis. If the diagnosis is delayed and the operation is not carried out in time, the mortality rate will be high. Literature reports that 40% of patients have sepsis, and the mortality rate ranges from 20% to 70%-80% [11-16]. In the present study, there were cases of respiratory failure. After a period of anti-infection treatment, the local abscess was broken. The local infection was controlled, and the whole body condition deteriorated in three patients, ultimately leading to death. Nevertheless, the mortality rate was 14%, which is lower than the reported 15% to 70%-80% [11-16,29-32]. Of note, Kuzaka et al. 33 reported no deaths among their 13 patients. This could be due to an early diagnosis and treatments in a tertiary hospital. Four patients were referred from primary and secondary hospitals. Still, we cannot exclude the possibility that some patients were not recognized in time in other hospitals and that the patients died before being referred to our tertiary hospital. Many pathogenic bacteria are often isolated and cultured locally in FG lesions, cooperating to destroy the tissues and secrete various toxins and metabolites, resulting in occlusive endarteritis and skin and subcutaneous vascular thrombosis, causing necrosis. Tissue necrosis and the infection spread along the fascia plane, initially involving the superficial (Colles fascia) and deep fascia of the genitals [34]. Later, it spreads to the covered skin and even involves muscles. Colles fascia infection can spread to the penis and scrotum through Buck's and Dartos fascia or to the anterior abdominal wall through Scarpa's fascia [34]. Because of the

different blood supply sources and fascia levels of the scrotum, penile skin, testis, and corpus cavernosum, the testis and corpus cavernosum are less involved. Once testis is infected, it indicates retroperitoneal origin or transmission of infection [35-37]. In the present study, orchiectomy had to be performed in two patients. There are many sources of FG, such as anorectal, genitourinary, or gynecology. The most common anorectal source is the perianal abscess. Genitourinary factors include an indwelling catheter, traumatic catheter insertion, long-term urethral stricture, perineal trauma, and human bite or scratch. Female FG patients often originate from infected Babbitt glands, septic abortion, perineal incision wound, sexual intercourse injury, or genital resection. Inducing factors are mainly patients' comorbidities such as diabetes, malnutrition, medical immunosuppression (such as chemotherapy, long-term use of steroids, malignant tumors), HIV infection, leukemia, liver diseases, and uremia [12,14,17]. A study from Chinese Taiwan reported that the most common source of infection is the gastrointestinal tract (30%-50%), followed by the genitourinary tract (20%-40%), and skin injury (20%). The morbidity proportion of males to females was 10:1 [13]. In this study, 21/22 patients were males, as supported by the literature. The exact source of infection was unfortunately unclear in many patient charts and could not be analyzed. Early and correct diagnosis includes complete laboratory tests, imaging examination, and bacteriological examination, such as blood routine, coagulation spectrum, CRP, PCT, blood sugar, and renal function. The examination includes package expansion ultrasound, plain film, Computed Tomography (CT), and Magnetic Resonance Imaging (MRI). A plain film can show gas in soft tissue [2,4,5,18]. CT may show fascia air or gas, soft-tissue edema, or enhancement of fascia. CT and MRI are time-consuming and can easily delay surgery. CT is associated with a sensitivity of 94.3% (95% CI 81.2%-98.5%) and a specificity of 76.6% (95% CI 21.3%-97.5%) for the diagnosis of necrotizing fasciitis [38]. Point of care ultrasound (POCUS) is a relatively new bedside diagnosis method, which can even find deep image changes that cannot be captured by CT and MRI [39,40]. It should be investigated in future studies Early correct diagnosis, active surgical expansion, the correct treatment of inducing factors and comorbidities, combined application of broad-spectrum antibiotics, and comprehensive treatment of severe sepsis are the keys to successful treatment [2,4,5,18]. If blisters, hypotension, and other systemic changes occur within a few hours, surgery should be performed as soon as possible under adequate fluid resuscitation [2,4,5,18]. If the progression is not obvious, a tissue biopsy should be performed. During wound exploration, tissue integrity and infiltration depth need to be evaluated. Necrotic skin and subcutaneous fascia tissue of the scrotum, penis, and perineum need to be removed, leading to a severe loss of skin and soft tissue and require reconstruction surgery. Some authors reported that an average of 3-3.5 operations is required per patient [10,37]. Still, only 1.6 was performed in the present study, which could be due to the intervention's higher initial aggressiveness. Early diagnosis and aggressive treatment are advocated by Yucel et al. [41] and Heijkoop et al. [42]. Koukouras et al. reported that the colostomy rate was 55.5%, the cystostomy ratewas 37.7%, and the orchiectomy rate was 26.6% [43]; the rates of such operations were lower in the present study, possibly because of early diagnosis and intervention.

NPWT is an active way to help wound repair. Nevertheless, although there was no significant difference in survival rate between NPWT and non-NPWT, the application significance of NPWT cannot be discussed because one of the three patients who died underwent local incision and drainage, one did not have surgery, one had local ulceration before admission, and there was no complete debridement surgery. Nevertheless, Iacovelli et al. [44] indicated that the use of NPWT had advantages in terms of wound closure and overall survival. Additional studies are necessary to examine this point. This study has limitations. It was a single-center retrospective study in a small number of patients. The data that could be analyzed was limited to those in the charts. Multicenter studies are necessary.

Conclusion

FG is a rare and life-threatening necrotizing infection that requires early diagnosis to reduce morbidity and mortality. A high degree of clinical suspicion, combined with anatomical knowledge, risk factors, and etiology, is necessary for an accurate diagnosis and management. Although FG is still a clinical diagnosis based on medical history and physical examination results, relevant laboratory, and radiological investigations can be used as useful auxiliary means. FG treatment is based on emergency surgical consultation for debridement of necrotic tissue, broad-spectrum antibiotics, intravenous infusion when necessary, and hemodynamic resuscitation of vasoactive drugs.

Declarations

Competing interests: All authors declare that they have no any conflict of interests.

Funding: This study was supported by the Project of the Education Department of Zhejiang Province (No. Y201431351), and the Project of the Science and Technology Department of Zhejiang Province (No. LGF20H190004).

Acknowledgements: None.

References

1. Andrews L, Arora S. Images in emergency medicine. Male with throat pain and neck swelling. Necrotizing fasciitis in association with Ludwig's angina. Ann Emerg Med. 2015; 65: e5-6.
2. Stevens DL, Bisno AL, Chambers HF. Practice guidelines for the diagnosis and management of skin and soft tissue infections: 2014 update by the infectious diseases society of America. Clin Infect Dis. 2014; 59: 147-159.
3. Morgan MS. Diagnosis and management of necrotising fasciitis: a multiparametric approach. J Hosp Infect. 2010; 75: 249-257.
4. Bonne SL, Kadri SS. Evaluation and Management of Necrotizing Soft Tissue Infections. Infect Dis Clin North Am. 2017; 31: 497-511.
5. Peetermans M, de Prost N, Eckmann C, Norrby-Teglund A, Skrede S, et al. Necrotizing skin and soft-tissue infections in the intensive care unit. Clin Microbiol Infect. 2020; 26: 8-17.
6. Ersoz F, Sari S, Arikan S, Altiok M, Bektas M, et al. Factors affecting mortality in Fournier's gangrene: experience with fifty-two patients. Singapore Med J. 2012; 53: 537-540.
7. Aridogan IA, Izol V, Abat D, Karsli O, Bayazit Y, et al. Epidemiological characteristics of Fournier's gangrene: a report of 71 patients. Urol Int. 2012; 89: 457-461.

8. Bednarek M, Drozdz W. [A rare case of the extensive Fournier's gangrene developed in the course of a perianal abscess]. Przegl Lek. 2008; 65: 410-412.

9. Mazur A, Karbowski M. [Fournier's gangrene--a case report]. Wiad Lek. 2013; 66: 260-261.

10. Sroczynski M, Sebastian M, Rudnicki J, Sebastian A, Agrawal AK. A complex approach to the treatment of Fournier's gangrene. Adv Clin Exp Med. 2013; 22: 131-135.

11. Sabzi Sarvestani A, Zamiri M, Sabouri M. Prognostic Factors for Fournier's 14 Gangrene; A 10-year Experience in Southeastern Iran. Bull Emerg Trauma. 2013; 1: 116-122.

12. Thwaini A, Khan A, Malik A, Cherian J, Barua J, et al. Fournier's gangrene and its emergency management. Postgrad Med J. 2006; 82: 516-519.

13. Chen SY, Fu JP, Wang CH, Lee TP, Chen SG. Fournier gangrene: a review of 41 patients and strategies for reconstruction. Ann Plast Surg. 2010; 64: 765-769.

14. Mallikarjuna MN, Vijayakumar A, Patil VS, Shivswamy BS. Fournier's Gangrene: Current Practices. ISRN Surg. 2012; 2012: 942437.

15. Stephens BJ, Lathrop JC, Rice WT, Gruenberg JC. Fournier's gangrene: historic (1764-1978) versus contemporary (1979-1988) differences in etiology and clinical importance. Am Surg. 1993; 59: 149-154.

16. Garcia Marin A, Turegano Fuentes F, Cuadrado Ayuso M, et al. Predictive factors for mortality in Fournier' gangrene: a series of 59 cases. Cir Esp. 2015; 93: 12-17.

17. Yanar H, Taviloglu K, Ertekin C. Fournier's gangrene: risk factors and strategies for management. World J Surg. 2006; 30: 1750-1754.

18. Sugihara T, Yasunaga H, Horiguchi H. Impact of surgical intervention timing on the case fatality rate for Fournier's gangrene: an analysis of 379 cases. BJUInt. 2012; 110: E1096-1100.

19. Zhao JC, Zhang BR, Shi K, Zhang X, Xie CH, et al. Necrotizing soft tissue infection: clinical characteristics and outcomes at a reconstructive center in Jilin Province. BMC Infect Dis. 2017; 17: 792.

20. Baharestani MM. Negative pressure wound therapy in the adjunctive management of necrotizing fascitis: examining clinical outcomes. Ostomy Wound Manage. 2008; 54: 44-50.

21. El-Sabbagh AH. Negative pressure wound therapy: An update. Chin J Traumatol. 2017; 20: 103-107.

22. Paula FM, Pinheiro EA, Oliveira VM, Ferreira CM, Monreal MTFD, et al. A case report of successful treatment of necrotizing fasciitis using negative pressure wound therapy. Medicine (Baltimore). 2019; 98: e13283.

23. Novelli G, Catanzaro S, Canzi G, Sozzi D, Bozzetti A. Vacuum assisted closure therapy in the management of cervico-facial necrotizing fasciitis: a case report and review of the literature. Minerva Stomatol. 2014; 63: 135-144.

24. Steinstraesser L, Sand M, Steinau HU. Giant VAC in a patient with extensive necrotizing fasciitis. Int J Low Extrem Wounds. 2009; 8: 28-30.

25. Argenta LC, Morykwas MJ. Vacuum-assisted closure: a new method for wound control and treatment: clinical experience. Ann Plast Surg 1997; 38: 563-576.

26. Lima R, Coltro PS, Farina JAJ. Negative pressure therapy for the treatment of complex wounds. Rev Col Bras Cir. 2017; 44: 81-93.

27. Czymek R, Schmidt A, Eckmann C, et al. Fournier's gangrene: vacuum-assisted closure versus conventional dressings. Am J Surg. 2009; 197: 168-176.

28. Huang C, Leavitt T, Bayer LR, Orgill DP. Effect of negative pressure wound therapy on wound healing. Curr Probl Surg. 2014; 51: 301-331.

29. Wetterauer C, Ebbing J, Halla A, et al. A contemporary case series of Fournier's gangrene at a Swiss tertiary care center-can scoring systems accurately predict mortality and morbidity? World J Emerg Surg. 2018; 13: 25.

30. Wang L, Han X, Liu M, et al. Experience in management of Fournier's gangrene: a report of 24 cases. J Huazhong Univ Sci Technolog Med Sci. 2012; 32: 719-723.

31. Benjelloun el B, Souiki T, Yakla N, et al. Fournier's gangrene: our experience with 50 patients and analysis of factors affecting mortality. World J Emerg Surg. 2013; 8: 13.

32. Madsen MB, Skrede S, Perner A, et al. Patient's characteristics and outcomes in necrotising soft-tissue infections: results from a Scandinavian, multicentre, prospective cohort study. Intensive Care Med. 2019; 45: 1241-1251.

33. Kuzaka B, Wroblewska MM, Borkowski T. Fournier's Gangrene: Clinical Presentation of 13 Cases. Med Sci Monit. 2018; 24: 548-555.

34. Katib A, Al-Adawi M, Dakkak B, Bakhsh A. A three-year review of the management of Fournier's gangrene presented in a single Saudi Arabian institute. Cent European J Urol. 2013; 66: 331-334.

35. Eke N. Fournier's gangrene: a review of 1726 cases. Br J Surg. 2000; 87: 718-728.

36. Eke N, Echem RC, Elenwo SN. Fournier's gangrene in Nigeria: a review of 21 consecutive patients. Int Surg. 2000; 85: 77-81.

37. Chawla SN, Gallop C, Mydlo JH. Fournier's gangrene: an analysis of repeated surgical debridement. Eur Urol. 2003; 43: 572-575.

38. Fernando SM, Tran A, Cheng W, et al. Necrotizing Soft Tissue Infection: Diagnostic Accuracy of Physical Examination, Imaging, and LRINEC Score: A Systematic Review and Meta-Analysis. Ann Surg. 2019; 269: 58-65.

39. Kehrl T. Point-of-care ultrasound diagnosis of necrotizing fasciitis missed by computed tomography and magnetic resonance imaging. J Emerg Med. 2014; 47: 172-175.

40. Magalhaes L, Martins SRP, Nogue R. The role of point-of-care ultrasound in the diagnosis and management of necrotizing soft tissue infections. Ultrasound J. 2020; 12: 3.

41. Yucel M, Ozpek A, Basak F, et al. Fournier's gangrene: A retrospective analysis of 25 patients. Ulus Travma Acil Cerrahi Derg. 2017; 23: 400-404.

42. Heijkoop B, Parker N, Spernat D. Fournier's gangrene: not as lethal as previously thought? A case series. ANZ J Surg. 2019; 89: 350-352.

43. Koukouras D, Kallidonis P, Panagopoulos C, et al. Fournier's gangrene, a urologic and surgical emergency: presentation of a multiinstitutional experience with 45 cases. Urol Int. 2011; 86: 167-172.

44. Iacovelli V, Cipriani C, Sandri M, Filippone R, Ferracci A, et al. The role of vacuum-assisted closure (VAC) therapy in the management of FOURNIER'S gangrene: a retrospective multi-institutional cohort study. World J Urol. 2020.