Abdominal Radiology (2020) 45:3838–3848
https://doi.org/10.1007/s00261-020-02549-9

REVIEW

Fournier gangrene: pictorial review

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Published online: 27 April 2020

Abstract
Fournier gangrene is an emergency condition that is associated with a high mortality rate. It is defined as a rapidly progressing infective necrotizing fasciitis of the perineal, perianal, and genital regions. Early diagnosis, broad-spectrum antibiotic coverage, and adequate surgical debridement are crucial and lead to better prognosis and patient survival. There is increasing utilization of computed tomography (CT) in the initial evaluation of Fournier gangrene. CT can confirm the diagnosis in equivocal cases, determine the source of infection, and evaluate the disease extent. In this pictorial review, we discuss the pathogenesis of Fournier gangrene and display the imaging spectrum with an emphasis on CT findings, including asymmetrical fascial thickening, soft tissue stranding, soft tissue gas, collection, and abscess formation. The infection originating from colorectal pathology, the affected anatomy, and the involvement of the abdominal wall are important predictors of mortality. The familiarity of the varied imaging appearance of Fournier gangrene is necessary to provide an accurate diagnosis, and evaluation of disease extent is crucial for optimal surgical debridement.

Keywords Fournier gangrene · Computed tomography · Necrotizing fasciitis · Perineum

Introduction

Fournier gangrene is a urologic emergency with high mortality [1, 2]. The initial description in 1883 by Jean Alfred Fournier, a French venereologist includes three essential features: (1) abrupt onset in a young healthy male, (2) rapid progression to gangrene, and (3) absence of an identifiable cause [3]. Nowadays, the term "Fournier gangrene" is used to define a broader condition of a rapidly progressing infective necrotizing fasciitis of perineal, perianal, and genital regions [4, 5].

Epidemiology

Fournier gangrene typically affects middle-aged men (mean age 50–60 years). The overall incidence is approximately 1.6 cases per 100,000 males [6]. Although males are more commonly affected, this condition can also affect females, with male-to-female ratio of 10:1 [1]. This is thought to be due to different perineal anatomy between males and females. Female perineum has more robust lymphatic drainage via a vaginal route which may prevent disease development [2]. It is also believed that Fournier gangrene is underreported because some clinicians continue to strictly apply the term as per its original description [1, 5].

Pathogenesis

The most common predisposing factors of Fournier gangrene are diabetes mellitus and chronic alcohol abuse [4]. Immunocompromised status, steroid therapy, indwelling catheter, surgical procedure, trauma, and chemotherapy or radiation therapy to the perineal region are also known to be associated with Fournier gangrene [2, 7, 8]. Recently, the use of sodium-glucose cotransporter-2 (SGLT2)

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inhibitors, which is an antidiabetic medication, has been reported to be a risk factor for Fournier gangrene [9, 10].

Fournier gangrene represents a polymicrobial infection. The most commonly isolated species is *Escherichia coli*, followed by Bacteroides and Streptococci. *Staphylococcus, Enterococcus, Clostridium, Pseudomonas, and Proteus* species are also frequently identified [11, 12]. Synergistic activity between the aerobic and anaerobic bacteria may result in rapid bacterial growth and spread of infection [13, 14]. The soft tissue gas, which is the byproduct of anaerobic metabolism, is mostly composed of hydrogen sulfide, nitrogen, and nitrous oxide [15].

The underlying cause of Fournier gangrene is usually identified and is most often due to the spread of local infection from three main ports of entry: (1) anorectal causes, (2) genitourinary causes, and (3) trauma/iatrogenic causes [1, 16] (Table 1). Only about 10% of cases are considered idiopathic [4]. The rapid progression of the pathology is secondary to the impaired host resistance against bacterial infection. Soft tissue inflammation and edema lead to a suppurative infection and obliterative endarteritis of the cutaneous and subcutaneous arteries, followed by necrosis and gangrene of the overlying soft tissue and skin [13, 14, 17]. The infection tends to spread along the deep fascial planes, therefore, the extent and severity of fascial and soft tissue necrosis cannot be reliably predicted by the extent of cutaneous changes [18, 19]. The rate of fascial necrosis has been reported as high as 2–3 cm per hour, making early diagnosis very crucial for patient survival [4, 7, 20].

Table 1 Possible etiologies of Fournier gangrene

Anorectal and gastrointestinal causes	Ischioanal/ischiorectal abscess Perianal abscess/fistula Anorectal perforation Rectosigmoid cancer Diverticulitis Appendicitis
Genitourinary causes	Lower urinary tract infection Periurethral abscess Urethral calculi Urethral stricture Indwelling catheter Bartholin abscess Prostatic abscess Scrotal abscess
Trauma/iatrogenic causes	Post-surgery/procedure/biopsy Intracavernosal injection Urethral/perineal injury Genital piercing Coital injury

Clinical manifestation

Fournier gangrene typically starts in the scrotal region and rapidly progresses to the penis, perineum, and inner thighs [5]. Patients usually present with rapid onset and fulminant progression. Local signs of inflammation such as pain, heat, edema, and erythema are found involving scrotum in more than 90% of patients and involving perineum and perianal region in 37% of the patients [13]. Crepitus, due to soft tissue gas, can be found upon clinical examination in 19–64% of cases [5, 15, 21]. As the disease progresses, soft tissue necrosis and systemic signs become evident. Fever, tachypnea, and tachycardia are generally present and diagnosis of systemic inflammatory response syndrome (SIRS) can be made in up to 85% of cases [13, 15, 17]. In severe cases, sepsis can progress to septic shock and lead to multiple organ failure. Laboratory studies may show acidosis, leukocytosis, thrombocytopenia, anemia, and abnormal biochemical profiles which are secondary to sepsis [15].

Patients with Fournier gangrene usually die from severe sepsis and its sequelae which include metabolic acidosis, multiple organ failure, coagulopathy, acute kidney failure, and diabetic ketoacidosis [2, 22]. The mortality rate is between 3 and 45%, as high as 88% in some series [1, 2, 6, 23]. Several factors have been found to associate with mortality. In one study, the mortality rate associated with the colorectal source was as high as 33% and was greater than other sources [23]. The area affected by the pathology is one of the important prognostic variables, of which the higher extent of affected body surface area is associated with higher mortality [24–26]. The involvement of the abdominal wall by the infection was also found to be a predictor for mortality [27–29].

Fournier gangrene in the female is uncommon and usually underreported [21]. The incidence is estimated at 8.2–23% [30]. Although uncommon, the female gender has been reported to be a risk factor of mortality in patients with Fournier gangrene [31]. The etiologies of the disease are generally the same as in male patients: polymicrobial infection of the genitourinary and anorectal tract. However, some unique causes in females have also been reported. These include Bartholin gland abscesses, complications of episiotomy, cesarean section, hysterectomy, or septic abortion [32, 33].

Role of imaging

In the past, the diagnosis of Fournier gangrene is made by the constellation of clinical findings: fever, pain, swelling, and crepitus in the scrotum and perineum. However, with

expanded criteria, there is increased use of the imaging to (1) confirm the diagnosis in clinically equivocal cases, (2) to reveal underlying etiology, and (3) to evaluate the disease extension [7, 13, 15].

Understanding the complex perineal and pelvic fascial anatomy is the key to determine the potential pathways of disease spread and predict the extent of gangrenous tissue. The perineum is bounded by the pubis anteriorly, the coccyx posteriorly, the ischial tuberosities anterolaterally, and the sacrotuberous ligaments posterolaterally. Based on this anatomical relationship, two anatomical triangles were coined: the urogenital triangle and the anorectal triangle. The urogenital triangle lies anterior to the imaginary line between the ischial tuberosities and contains the penis and scrotum in males and mons pubis, labia majora, clitoris, and vaginal and urethral orifices in females. Posterior to this line is the anorectal triangle which contains the anus and the sphincters.

The infection in Fournier gangrene usually spreads along the fascial plane. Primary infection in the anorectal triangle can penetrate Colles fascia and Dartos fascia to involve the penis and scrotum, or spread along Scarpa fascia to involve the anterior abdominal wall. If the Colles fascia is disrupted, the infection can involve the ischiorectal fossa and subsequently the buttocks and thighs. An infection originating from the urogenital triangle may involve the periurethral glands with subsequent spread to the corpus spongiosum. The infection may be initially contained to the fibrous tunica albuginea and the Buck fascia which acts as a natural barrier. If the Buck fascia is penetrated, the process spreads rapidly along Colles and Dartos fasciae to penis and scrotum, or upwards along Scarpa fascia to the anterior abdominal wall [7, 15, 34].

Although naming the specific fascial planes may or may not aid surgeons' operative approach, radiologists should describe the extent of the fascial air and soft tissue inflammation when interpreting Fournier gangrene cases [35].

Radiograph

In the early stage of the disease, only nonspecific soft tissue swelling may be seen. With disease progression, soft tissue gas may be seen on the radiograph as a thin linear lucent streak overlying scrotum or perineum (Fig. 1). The radiograph may demonstrate soft tissue gas before it is evident on clinical examination. Radiography has a sensitivity of 90–100% in the detection of soft tissue gas in patients with Fournier gangrene, while clinical examination shows gas in only 19–64% of the patients [13, 15]. In extensive disease, soft tissue gas may extend from the scrotum and perineum to the inguinal areas, abdominal wall (Fig. 2), chest wall, buttock, and thighs (Fig. 3). However, overlapping gas with the hollow viscera of the pelvis may cause a false-positive

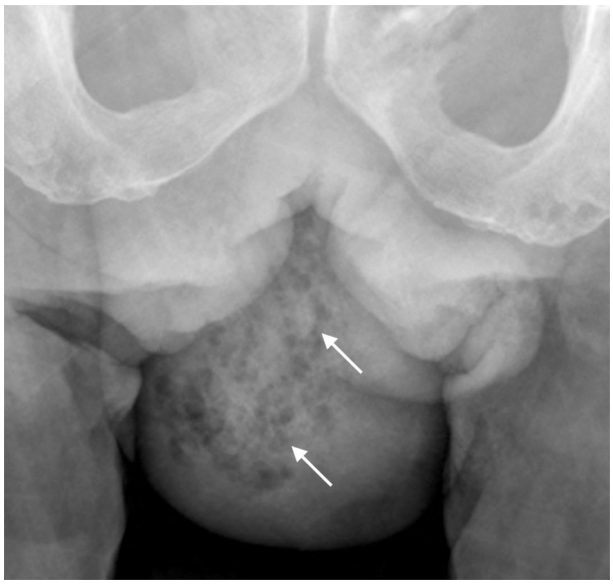

Fig. 1 Fournier gangrene with soft tissue gas in the radiograph. Anteroposterior pelvic radiograph shows mottled lucent streaks of gas in the right hemiscrotum (arrow)

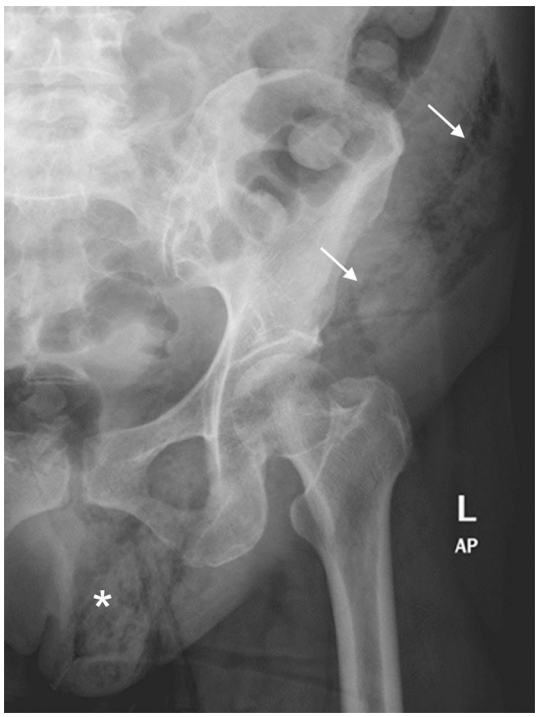

Fig. 2 Fournier gangrene with gas extension to the abdominal wall. Anteroposterior abdominal radiograph shows an extension of subcutaneous gas from the left hemiscrotum (*) to the left abdominal wall (arrow)

Fig. 3 Fournier gangrene with gas extension to the thigh. Anteroposterior radiograph of the right thigh shows soft tissue gas at right perineum (*) and extensive intramuscular gas and gas along the fascia at the right thigh (arrow)

interpretation [35]. Bowel gas in a hernia sac may be mistaken for soft tissue gas. The patient positioning, coverage, and adjustment of exposure parameters may be suboptimal. Another major drawback of the radiograph is that it relies on the detection of only superficial soft tissue gas which is present in the later stage of disease. Therefore, the radiograph should not be used to rule out the diagnosis [36]. The absence of radiographic soft tissue gas does not exclude Fournier gangrene [5, 13, 37].

Ultrasound (US)

US may be useful in distinguishing Fournier gangrene from other causes of acute scrotal pain such as scrotal cellulitis, epididymitis, orchitis, and incarcerated inguinal hernia [15, 38]

US findings in Fournier gangrene correlate very well with the disease pathology. Thickened, edematous, and hyperemic scrotal soft tissue can be seen. The thickened soft tissue may contain hyperechoic focus with a reverberation artifact or dirty shadowing, which represents soft tissue gas (Figs. 4, 5) [7, 14, 15, 39]. Gas in the scrotal wall can be detected on US before clinical crepitus. The hyperechoic foci of gas are not within the testicle and should not be confused with testicular microlithiasis, or calcifications within a tumor or

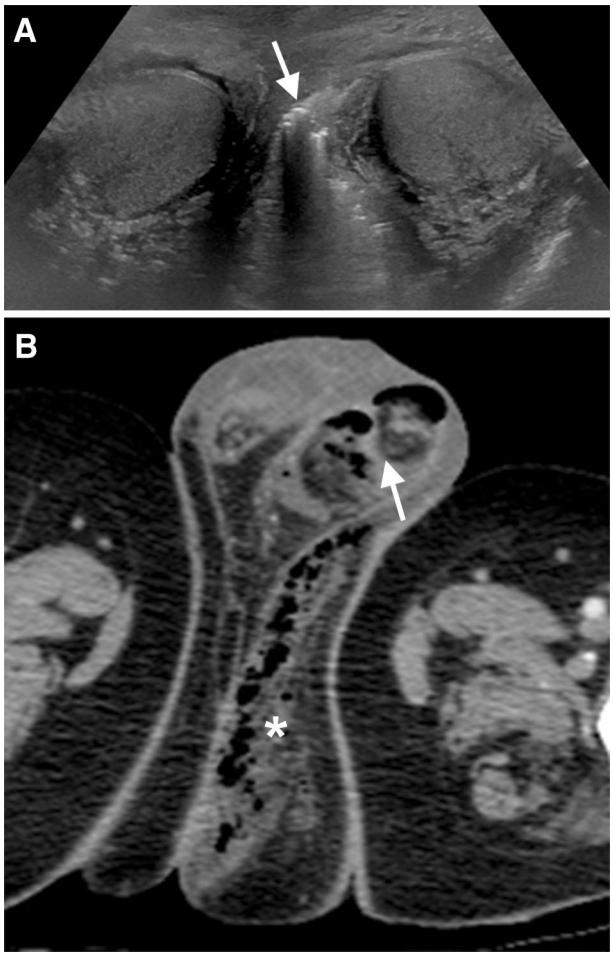

Fig. 4 Fournier gangrene in the US. **a** US image shows bilateral scrotal wall edema with multiple hyperechoic foci of gas in the left hemiscrotum (arrow). **b** Axial enhanced CT images confirm soft tissue gas in left hemiscrotum (arrow) and left perineum (*)

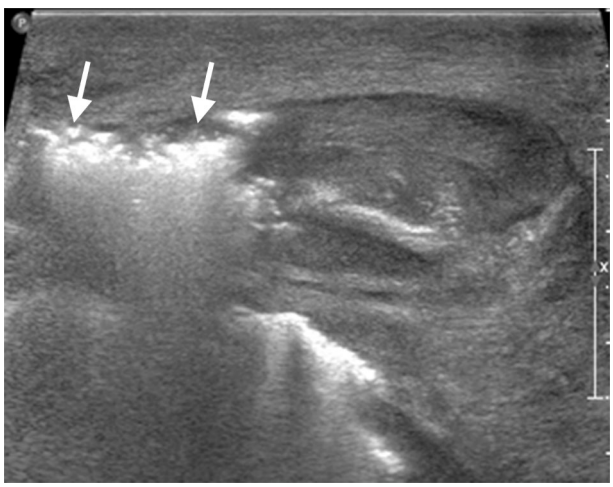

Fig. 5 Fournier gangrene in the US. US images show hyperechoic foci with posterior dirty shadowing of soft tissue gas in the perineum (arrow)

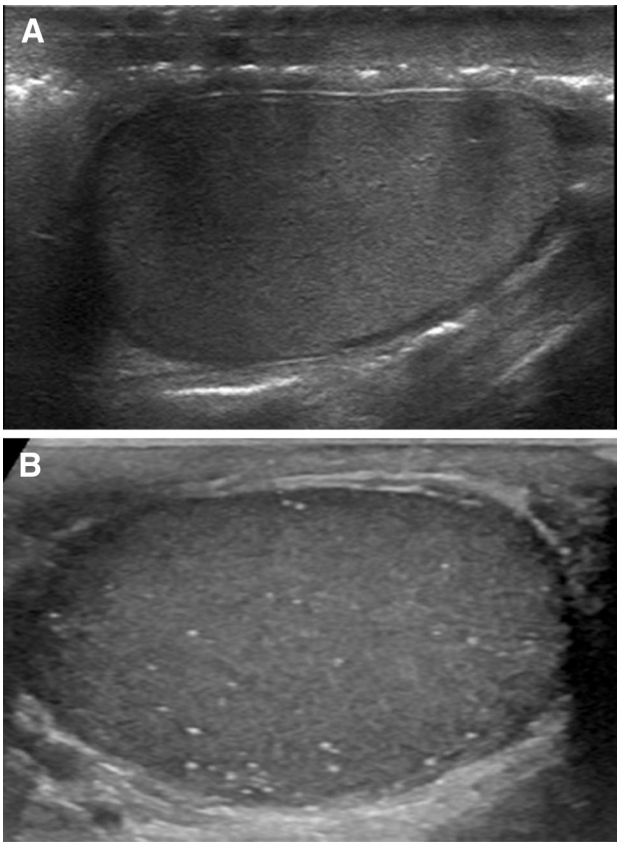

Fig. 6 Comparison between scrotal soft tissue gas and testicular microlithiasis. **a** US image in a patient with Fournier gangrene shows multiple hyperechoic foci of gas in the scrotal soft tissue. The testicular parenchyma is normal. **b** US image in another patient with testicular microlithiasis shows multiple punctate microcalcifications in the testicular parenchyma. The scrotal wall is normal

granulomatous disease (Fig. 6) [12]. A reactive hydrocele may be present, either unilaterally or bilaterally. The testis and epididymis are usually spared due to a separate blood supply (Fig. 7) [15]. The scrotum is supplied by the pudendal artery which is a branch of the internal iliac artery, whereas the testis and epididymis are supplied by the testicular artery which is a branch of the abdominal aorta.

CT

CT is very helpful for evaluation of the disease extension, depiction of the underlying disease, and confirm the diagnosis in patients whose diagnosis is unclear [40]. CT is superior to the plain radiograph and US in the diagnosis of Fournier gangrene [7]. Ideally, the field of view of CT scan should include the abdomen and pelvis and extending through the perineum and scrotum to evaluate the disease extension and the underlying source of infection. Limited pelvic CT scan may miss the abdominal source of infection

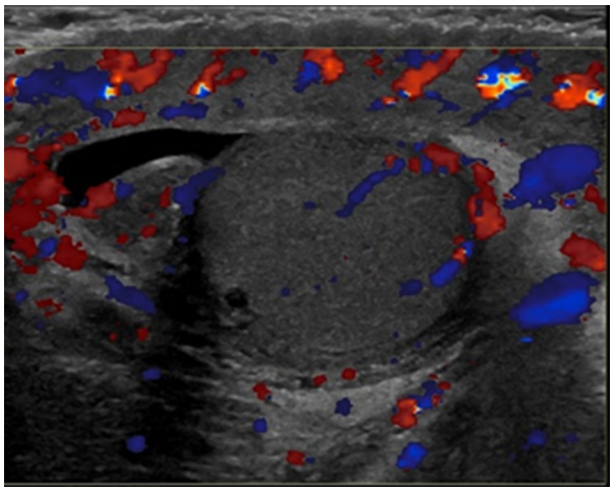

Fig. 7 Spared testis in Fournier gangrene. Color Doppler US image shows scrotal wall edema, hyperemia, and hydrocele. The testicular parenchyma is spared

and lead to inadequate treatment [41]. Intravenous contrast material should be given in all cases, unless contraindicated. Typical CT findings include asymmetric fascial thickening, skin thickening, and soft tissue and fat stranding (Fig. 8) [7, 15]. The infection in the perineum can spread along Colles fascia and Dartos fascia to involve the scrotum and the penis (Fig. 9) [14]. Soft tissue gas may be seen as secondary to the gas-forming bacterial infection (Fig. 10). This soft tissue gas can dissect along superficial and deep fascial planes from the scrotum and perineum to the buttock, inguinal areas, abdominal wall, extraperitoneal or retroperitoneal spaces (Fig. 11), or even chest wall in extensive case (Fig. 12). Laparotomy is required if there is associated pathology in the peritoneal cavity [35]. Identification of retroperitoneal extension is also crucial as it requires an abdominal exploration with colonic medial visceral rotation to gain access to the retroperitoneal space for adequate debridement [42]. Temporary abdominal closure device may be needed which adds burden to patient and resource in the intensive unit care [43]. CT can also help to evaluate both superficial and deep fascia and can differentiate Fournier gangrene from other less aggressive entities such as soft tissue edema or cellulitis which may have similar clinical manifestation to Fournier gangrene.

When interpreting the CT images, one should always look for the underlying etiology of Fournier gangrene, as the underlying cause is frequently identified. There is a possibility of recurrence, even years after treatment if the underlying cause is not eliminated [44, 45]. The underlying causes which can be demonstrated on CT include perianal or ischiorectal abscess (Figs. 13, 14), perianal fistula, diverticulitis, periurethral or penoscrotal abscess (Fig. 15), intraabdominal or retroperitoneal infection/abscess, and colorectal perforation. Fournier gangrene can also occur as a complication of

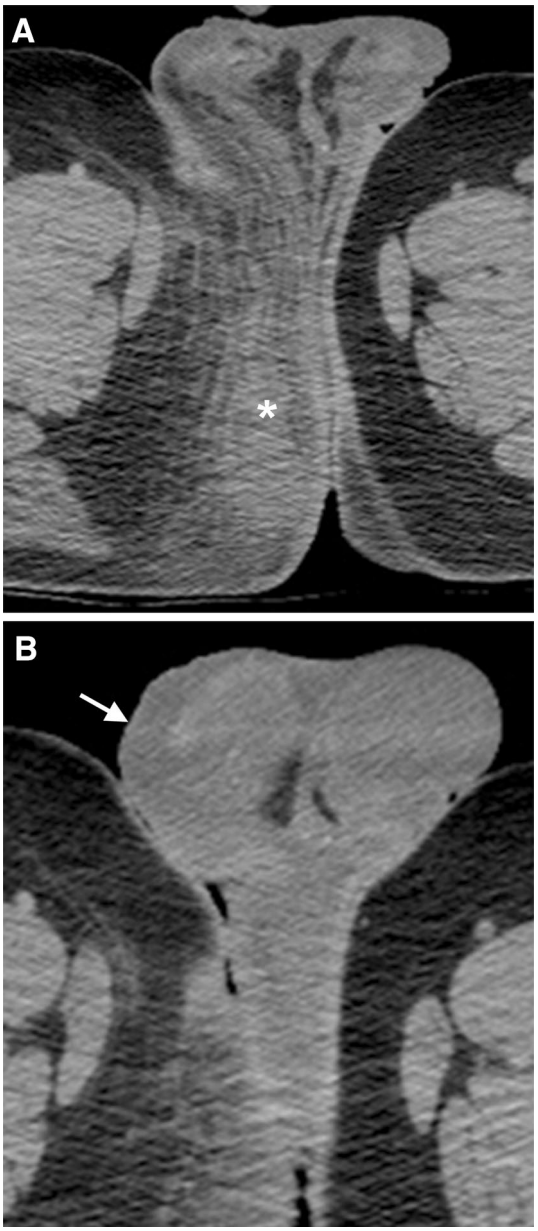

Fig. 8 Early Fournier gangrene without soft tissue gas. **a**, **b** Axial enhanced CT images show skin and fascial thickening along right perineum (*) as well as bilateral scrotal edema (arrow)

hernia repair [46], scrotal surgery, or gender reassignment surgery [30] (Fig. 16).

Generally, CT findings of Fournier gangrene in the female are not different from those findings in males. Fascial and soft tissue thickening, fat stranding, and soft tissue gas are evident on CT scan (Fig. 17). However, the spread pattern seems to be different. The abdominal cavity and retroperitoneal space are more likely to be involved in more than half of the female patients, compared to less than 20% in males [31]. When the cascade of inflammatory process and necrosis occurs, the rich lymphatic network

Fig. 9 Penile involvement in Fournier gangrene. Axial enhanced CT image shows soft tissue edema and fascial thickening along the penile shaft (arrow)

Fig. 10 Typical findings of Fournier gangrene in CT. Axial enhanced CT image shows soft tissue edema and fascial thickening in the right perineum (*) and soft tissue gas in the right hemiscrotum (arrow)

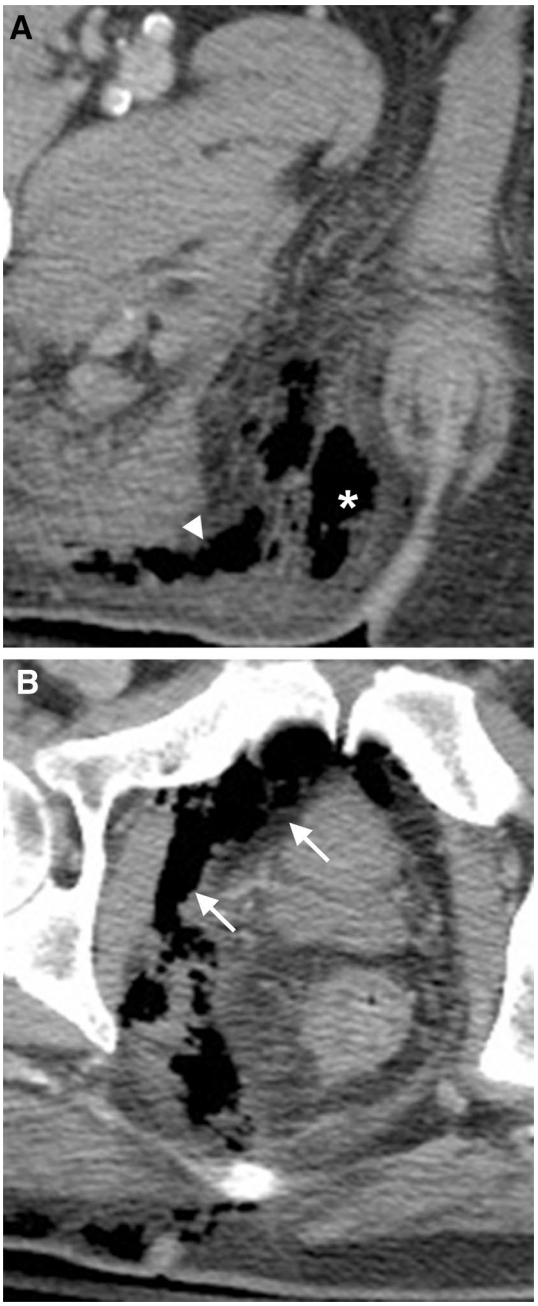

Fig. 11 Fournier gangrene with extraperitoneal gas extension. **a**, **b** Axial enhanced CT images show an extension of the soft tissue gas into the right ischioanal fossa (*), right buttock (arrowhead) as well as fluid tracking in the prevesical (arrow) and pararectal spaces

in the female pelvis may become a fatal disadvantage by allowing the inflammatory process to spread quickly into the abdominal cavity and retroperitoneal space. Therefore, abdominal and pelvic CT scan is important in female patients with Fournier gangrene, in order to evaluate for any disease extension beyond the pelvis into the abdominal cavity and retroperitoneal space.

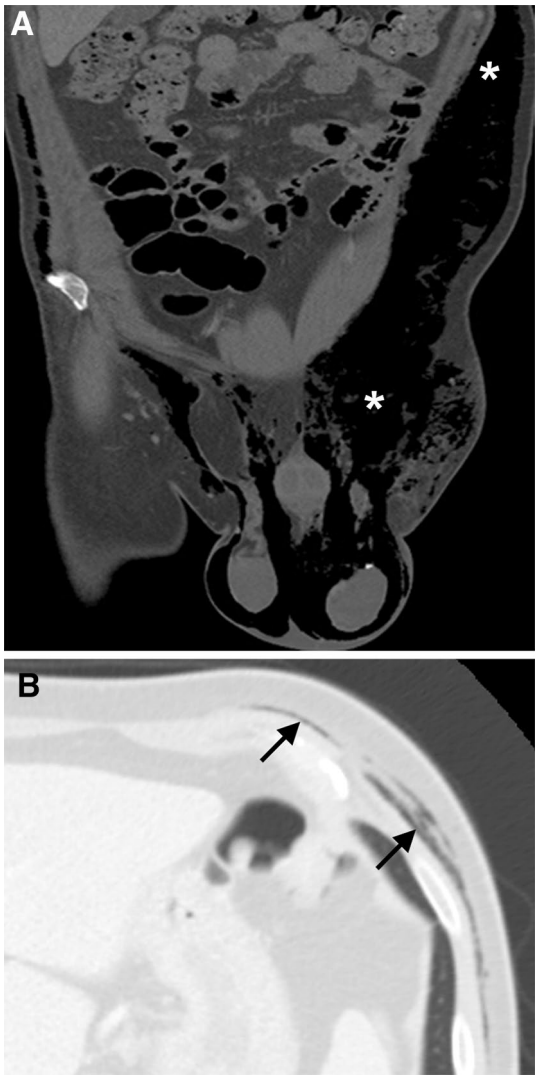

Fig. 12 Fournier gangrene with extension to the abdominal wall and chest wall. **a** Coronal enhanced CT image shows extensive soft tissue gas involving the scrotum, bilateral inguinal areas, and left anterior abdominal wall (*). **b** Axial enhanced CT image in lung window demonstrates soft tissue gas along the left anterior thoracoabdominal wall (arrow)

Magnetic resonance imaging (MRI)

Magnetic resonance imaging (MRI) offers superior soft tissue contrast and resolution than US and CT and can aid as an adjunct in the management of Fournier gangrene. MRI can reveal the extension of infection to the perineum, buttocks, fascial planes, and abdominal wall more precisely than the US and CT and offers increased detail for delineating perianal fistulae and abscess [47]. MRI can be a problem-solving tool when US or CT findings are equivocal or inconclusive. In advanced cases, MRI may be able to demonstrate the initial site of infection. The large field-of-view and multiplanar capability of MRI

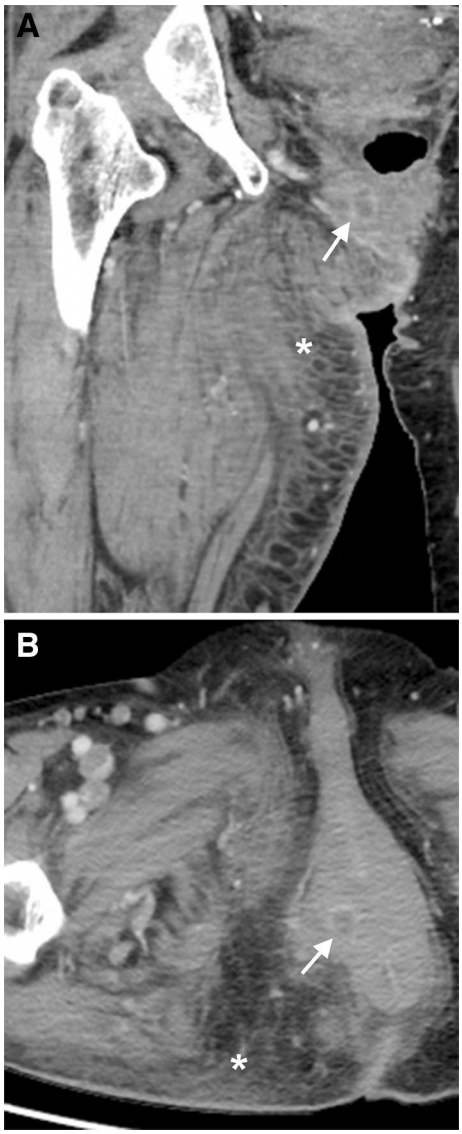

Fig. 13 Fournier gangrene secondary to a perianal abscess. **a** Coronal and **b** Axial enhanced CT images show a perianal abscess (arrow) with extensive fat stranding and fascial thickening along right perineum, right buttock, and right thigh (*)

Fig. 14 Fournier gangrene secondary to an ischioanal abscess. **a**, **b** Axial enhanced CT images show a horseshoe ischioanal abscess (*) with an extension of soft tissue gas to the extraperitoneal spaces (arrow)

allow better determination of disease extension and in some cases it can identify unexpected source of infection which may help surgeons to perform adequate surgical debridement to achieve a better outcome and prevent disease recurrence [14, 48]. On MRI, soft tissue edema and fascial thickening appears hyperintense on fluid-sensitive sequences [49, 50]. Intravenous Gadolinium injection can increase sensitivity for detection of soft tissue necrosis. The abnormal fascia generally enhances and may be surrounded by non-enhancing islands of tissue. Associated rim-enhancing collection or abscess may be present in some cases [49]. Some authors also encourage using MRI to reassess residual disease after surgical debridement [51]. However, there are some caveats which concern the MRI performance. The sensitivity of MRI in detection of soft tissue gas is very limited and the differentiation of soft tissue gas from signal void due to vascular flow or a phlebolith can be challenging [14]. The extent of deep fascial involvement tends to be overestimated on MRI which can result in unnecessary surgical explorations [52]. In critically ill or intubated patients, MRI may not be feasible due to the limited availability, longer acquisition time, and limited ability for patient monitoring [37].

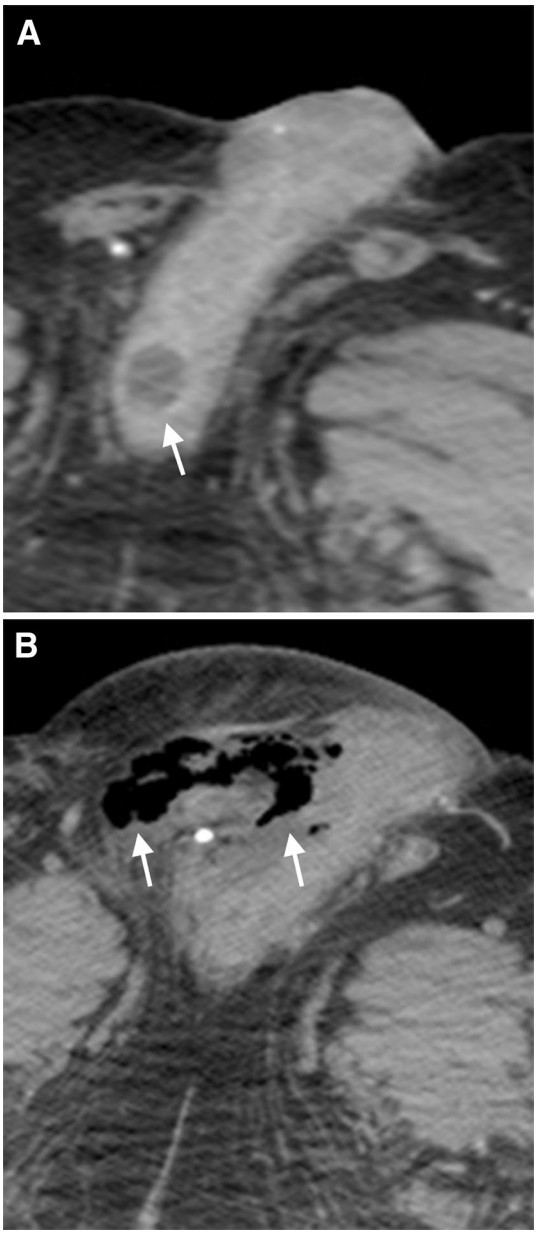

Fig. 15 Fournier gangrene secondary to a cavernosal abscess. **a** Axial enhanced CT image shows a small cavernosal abscess (arrow). **b** Axial enhanced CT image in the same patient obtained 3 months later shows progression of the abscess into Fournier gangrene (arrow)

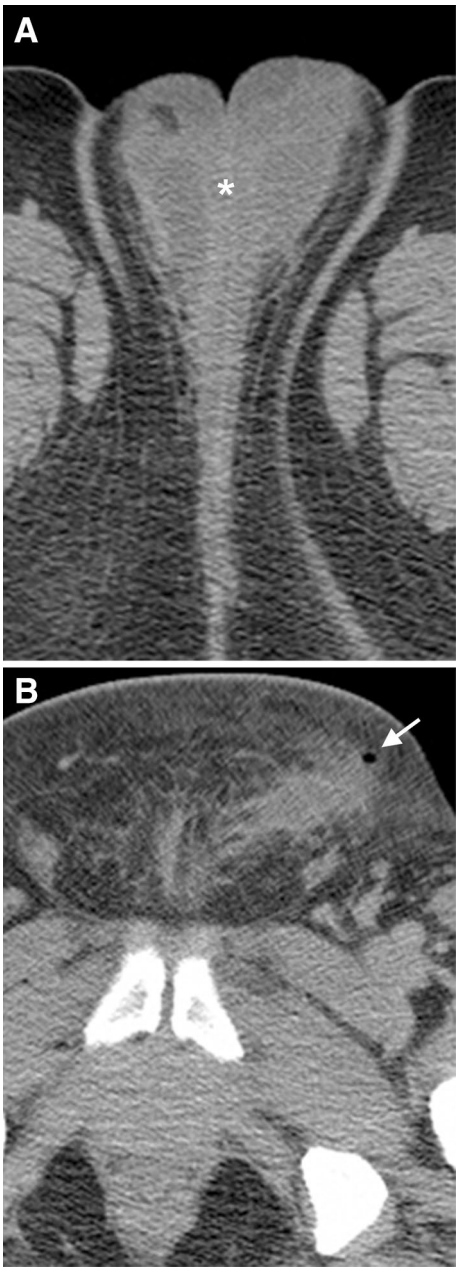

Fig. 16 Fournier gangrene after gender reassignment surgery. **a**, **b** Axial enhanced CT images in a patient after gender reassignment surgery show a large abscess at bilateral labia majora (*) with soft tissue gas (arrow)

Management

Hemodynamic stabilization, broad-spectrum antibiotics, and aggressive surgical debridement to remove all necrotic tissue is the mainstay treatment of Fournier gangrene. Adequate surgical debridement has been found to be the most important factor to improve the survival rate [1, 2].

Patients with Fournier gangrene require multidisciplinary care teams, including radiologists, urologists, general surgeons, plastic surgeons, internists, intensivists, and wound care specialists. Pre-operative cross-sectional imaging is crucial and can aid the surgeon's decision. Debridement of the perineum and perirectal regions with diverting colostomy is often necessary in cases where the perineum or perirectal tissue is involved. Aggressive debridement may result in extensive soft tissue loss, in which skin grafting or flap is required to cover the defect. Patients who have multiple comorbidities have to stay in the intensive care unit for hemodynamic stabilization and recovery after the surgery.

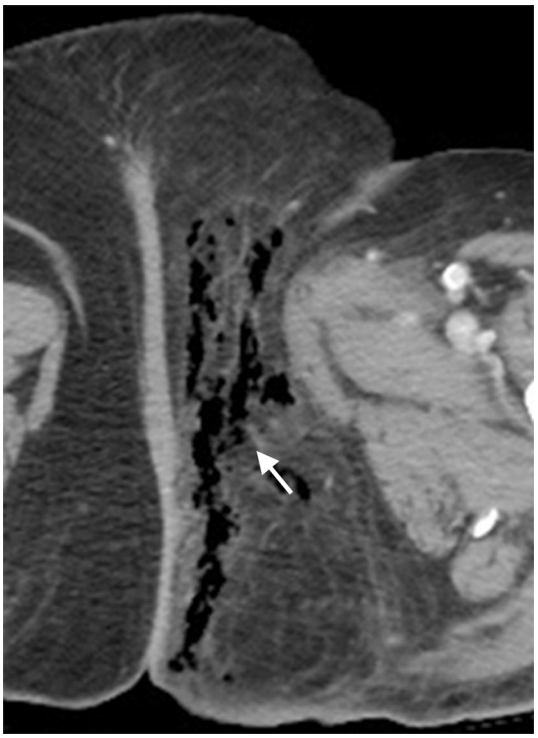

Fig. 17 Fournier gangrene in a female. Axial enhanced CT image shows fat stranding and soft tissue gas in the left perineum (arrow)

Conclusion

Imaging plays an important role in the diagnosis, evaluation of disease extent, and prognostication in patients with Fournier gangrene. The key US findings are edematous, hyperemic soft tissue, and hyperechoic foci with reverberation artifact which represent soft tissue gas. Findings on CT include asymmetrical fascial thickening, soft tissue stranding, soft tissue gas, fluid collection, and abscess formation. Familiarity with the various CT features of Fournier gangrene is essential for accurate diagnosis and providing useful information for adequate surgical planning.

Author contributions SW contributed to conceptualization, literature review, draft the article, critically review the article, and approve the final manuscript; SK, MH, YN, and AS contributed to conceptualization, critically review the article, and approve the final manuscript.

Funding Not applicable.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interests.

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