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Penile and Genital Injuries

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Genital injuries are significant because of their association with injuries to major pelvic and vascular organs that result from both blunt and penetrating mechanisms, and the chronic disability resulting from penile, scrotal, and vaginal trauma. Because trauma is predominantly a disease of young persons, genital injuries may profoundly affect health-related quality of life and contribute to the burden of disease related to trauma. Injuries to the female genitalia have additional consequences because of the association with sexual assault and interpersonal violence [1]. Although the existing literature has many gaps, a recent Consensus Group on Genitourinary Trauma provided an overview and reference point on the subject [2]. This article reviews the mechanism, initial evaluation, and operative management of injuries to the male and female external genitalia including the penis, scrotal skin, and vaginal structures.

Prevalence

The incidence of genital injuries has not been determined, but in civilian centers is likely to be low, given that most case series span many years and include relatively small numbers of patients [3]. In the battlefield, the massive destruction caused by fragmentation devices, combined with the use of protective torso armor, has led to survival of soldiers with increasingly severe pelvic and genital organ injury [4]. Penile fracture is the most commonly described blunt injury to the penis, and over 1300 cases have been reported in the literature [5].

Mechanisms

The male genitalia have a tremendous capacity to resist injury. The flaccidity of the pendulous portion of the penis limits the transfer of kinetic energy during trauma. In contrast, the fixed portion of the genitalia (eg, the crura of the penis in relation to the pubic rami, and the female external genitalia in their similar relationships with these bony structures) are prone to blunt trauma from pelvic fracture or straddle injury. Similarly, the erect penis becomes more prone to injury because increases in pressure within the penis during bending rise exponentially when the penis is rigid (up to 1500 mm Hg) as opposed to flaccid [6]. Injury caused by missed intromission or manual attempts at detumescence can cause penile fracture [7]. Less severe bending injuries may still lead to long-term disability related to tunica albuginea disruption (Peyronie's disease) or arterial insufficiency. Firearms and missiles have an excess of kinetic energy, which overcomes the protective mechanisms of flaccidity.

Another characteristic of the male genitalia particularly pertinent to injury mechanisms is the looseness and laxity of genital skin. Although this generally has a protective role, allowing the skin to deform and slide away from a potential point of contact, in the case of machinery injury, rotating or suction devices can grab hold of a portion of the genital skin [8]. Laxity of skin becomes a liability because the entire penile and scrotal skin can be trapped and avulsed.

The vascular supply of the genitalia also predicts outcomes of other forms of injury, such as chemical, radiant, and infectious injury. Deep structures have multiple sources of arterial inflow. The penis derives a triple blood flow from the dorsal, cavernosal, and bulbourethral arteries. Ischemic loss

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of this organ because of injury is only seen with complete amputation or prolonged constriction injury. Likewise, the testis derives blood supply from the cremasteric, testicular, and vasal arteries. In cases of Fournier's gangrene neither of these organs is lost. Conversely the skin, although richly vascularized through multiple sources, receives its arterial perfusion from deeper fascial layers, and when these are affected by synergistic bacterial infection during Fournier's gangrene, total skin loss is inevitable. Because burns start superficially and progressively spread their damage down into deeper tissues in the opposite fashion from Fournier's gangrene, preservation of some portion of the vascular integrity of the skin is likely in most chemical and thermal burns.

A particularly unusual cause of penile injury is amputation, which is discussed separately because of its unique considerations [9,10]. When assault is the cause, appropriate police reporting is required. Other cases require special input from psychiatric and psychologic experts. Penile amputation may be a manifestation of depressive and psychotic behavior, either caused by schizophrenia or illicit drug abuse. Others amputate the penis to initiate the process of gender conversion. Finally, constriction rings can cause loss of superficial skin, deep urethral necrosis, or complete penile loss.

Blunt injuries cause much less damage to the phallus than firearm and stab injuries. The laxity of the genital skin usually protects the deep penile structures from avulsion, so that after car crashes superficial lacerations of the skin are more common. Pelvic fractures with symphyseal or pubic ramus displacement can cause severe injury to the deep structures of the penis, including avulsion of the crus of the corpus cavernosum from its vascular and neural supply [11]. Less severe crush injuries may also occur. The long-term consequences of these injuries are more significant than their initial presentation suggests. Although extensive bleeding may occur, angioembolization of the internal pudendal arterial tree can control such hemorrhage. More importantly, the delayed consequences of arterial injury are erectile dysfunction or penile ischemia. Tables 1 and 2 show the characteristics of injuries to the penis and scrotum, and corresponding AIS scores.

Table 1
Organ injury scale for penile injury

AAST grade	Penile injury	AIS-90 score
I	Cutaneous laceration or contusion	1
II	Laceration of Buck's fascia (cavernosum) without tissue loss	1
III	Cutaneous avulsion, laceration through glans or meatus, or cavernosal or urethral defect <2 cm	3
IV	Partial penectomy or cavernosal or urethral defect = 2 cm	3
V	Total penectomy	3

Abbreviations: AAST, American Association for the Surgery of Trauma; AIS, Abbreviated Injury Scale.

From Moore EE, Malangoni MA, Cogbill TH, et al. Organ injury scaling VII: cervical vascular, peripheral vascular, adrenal, penis, testis, and scrotum. J Trauma 1996;41:523; with permission.

Presentation

Penetrating injuries to the external genitalia require special consideration because of the high likelihood of associated injuries to the spermatic cord and testis, urinary bladder and urethra, rectum, and vascular structures of the iliac and femoral region. Blood at the urethral meatus implies injury, whereas its absence can be misleading. Urethral injury occurs in 10% to 38% of penile fractures and up to 22% of penile gunshot wounds [12,13].

A delayed presentation is not uncommon after penile fracture and constriction ring use, usually caused by patient embarrassment. The constellation of missed intromission, acute bending, and

Table 2
AAST organ injury scale for scrotal injury

AAST grade	Scrotal injury	AIS-90 score
I	Contusion	1
II	Laceration <25% of scrotal diameter	1
III	Laceration = 25% of scrotal diameter	2
IV	Avulsion <50%	2
V	Avulsion = 50%	2

Abbreviations: AAST, American Association for the Surgery of Trauma; AIS, Abbreviated Injury Scale.

From Moore EE, Malangoni MA, Cogbill TH, et al. Organ injury scaling VII: cervical vascular, peripheral vascular, adrenal, penis, testis, and scrotum. J Trauma 1996;41:523; with permission.

a popping sound followed by immediate detumescence of the penis and acute pain are characteristic of this entity. In the Middle East and other regions, penile fracture may occur as a result of excessive bending of the shaft in an attempt to achieve rapid detumescence of an embarrassing penile erection [7]. Penile swelling is usually limited to the attachments of Buck's fascia and only the shaft of the penis is ecchymotic; a localized hematoma is evident in such cases and has been termed an "eggplant deformity" [2]. When the deep investing fascia of the penis has been ruptured by penetrating or blunt trauma, a perineal butterfly hematoma or scrotal bleeding can occur. Entrapment of the genitalia by industrial machinery including augers, power takeoff from farm tractors, and suction devices can lead to avulsion of the penile and scrotal skin (Fig. 1).

Genital and perineal burns are present in less than 5% of burn victims, and patients hospitalized for burns involve the genitalia and perineum [14].

Initial evaluation

The evaluation and initial management of genital injuries involves recognition of associated injuries, control of hemorrhage, and certain mechanism-specific interventions. Penetrating injuries to the penis have associated injuries in up to 83% of patients. Those with associated urethral injury usually present with blood at the urethral meatus and inability to void; the absence of these signs does not exclude urethral injury [2]. Retrograde urethrogram is the appropriate test for suspected urethral injuries caused by either penetrating or blunt injuries, in particular penile fracture. In the absence of obvious signs of urethral injury, urethral catheterization should be attempted before exploration and can help maintain orientation when structures are distorted by hematoma. The presence of hematuria should alert the trauma team to the possibility of a bladder or upper urinary tract injury in cases of penetrating firearm injuries. Finally, rectal injuries must be sought out if complications, such as fistulae and Fournier's gangrene, are to be avoided.

Fig. 1. Patient with scrotal and penile skin avulsion after pants were caught in posthole digger.

Bleeding from the penis can usually be controlled in the emergency department with gauze wraps to tamponade any bleeding. Excessively tight compressive dressings that compromise blood supply to the distal penis must be avoided.

The mechanism of injury is important. Burns should be covered with appropriate dressings depending on the mechanism. For thermal injury, 1% silver sulfadiazine cream is appropriate. Chemical burns can be irrigated with saline; lye burns should not be irrigated with water, which can cause further caustic damage. For alkaline burns, dilute acetic acid should be used. For acid burns, sodium bicarbonate is recommended [15].

Bite injuries by animals or humans require appropriate antibiotic coverage for the species and tetanus toxoid administration [15]. Empirical broad-spectrum antibiotics, such as amoxicillin–clavulinic acid are appropriate for dog, rat, cat, bat, skunk, and raccoon bites and human bites. In cases of animal bites, the possibility of rabies transmission must be considered. Dog and cat bites most commonly lead to pathogenic infection with *Pasteurella* organisms; anaerobic organisms may also be present [16]. Many rare pathogens can be transmitted from dogs. Human bites are morel likely to cause complications than dog bite wounds. The predominant human oral bacterial organism is *Eikenella corrodens*; however, transmission of viral infection including hepatitis and HIV is possible [17].

After penile amputation or self-mutilation, appropriate experts must be involved to ascertain the competence of the patient and allow appropriate decision making when considering replantation of the penis. Urinary diversion should be established with a suprapubic cystostomy. The stump should be covered with compressive sterile saline-soaked gauze dressings. Bleeding can be extensive and transfusion may be required [2]. Once the patient has been resuscitated, surgical planning for replantation can continue. The amputated phallus is treated with a two-bag system [9]. In the inner bag, the amputated organ is wrapped in sterile saline gauze, and then the entire first bag is placed into a second bag containing ice. With this approach, appropriate transfer to

tertiary centers can be accomplished with successful reimplantation over 24 hours after injury.

Cavernosography has been proposed as an adjunct to the diagnosis of penile fracture and may also have specific applications to cases of penetrating trauma [18]. Most cases require operative repair, however, and such ancillary tests, with limited sensitivity and specificity, are not clinically useful. If one repairs all penetrating and blunt ruptures of the tunica albuginea and superficial penile structures, radiographic studies of the corpora cavernosa are not necessary. Cavernosography, ultrasound, and MRI may be useful in selected cases to confirm that a penile fracture is absent and that a nonoperative approach is appropriate [2]. Once associated urethral, scrotal, bladder, and rectal injuries have been excluded or identified, then appropriate management of penile injuries can occur.

Operative management

The goal of surgery is to restore penile function and appearance. The operative repair of genital injuries involves appropriate irrigation, debridement, and closure of all wound layers, taking into account associated injuries that may influence treatment, the degree of contamination and tissue damage, and the time from injury to repair. For example, in the absence of gross contamination or delayed presentation, the presence of a rectal injury or even a human bite injury may not preclude an excellent functional and cosmetic outcome. Conversely, prioritization must take place in the face of multiple vascular or other organ injuries.

Exposure of the deep cavernosum and tunica albuginea can be achieved through either a circumferential subcoronal incision by degloving, or for deeper wounds a penoscrotal, infrapubic, or even perineal incision. For penile fracture, the injury occurs almost exclusively distal to the penile suspensory ligament [2]. The degloving incision allows complete inspection of the urethra and cavernosa [5]. Beginning with the deepest structures, namely the corpora cavernosa and corpus spongiosum, primary closure can be achieved in virtually all cases. The authors usually close injuries of the tunica albuginea in a transverse fashion to prevent narrowing of the corpora. With highly destructive bullet injuries, defects in the tunica albuginea may be so large as to preclude primary closure. In such instances, which are rare in civilian practice, off-the-shelf fascia, pericardium, or other collagen matrix type products may be helpful in achieving both hemostasis and a long-term functional outcome. For severe disruptions of the deep crural structures, plication maneuvers to exclude proximal crus may be feasible. Given the high likelihood of arterial injury with both blunt and penetrating disruption of the crura, arterial insufficiency and erectile dysfunction may occur regardless of techniques to repair the tunica albuginea.

Active bleeding, hematoma, and a defect in the fibers of the tunica albuginea all are characteristic of penile fractures and penetrating injuries to the corpus cavernosum (Fig. 2). The tunica albuginea

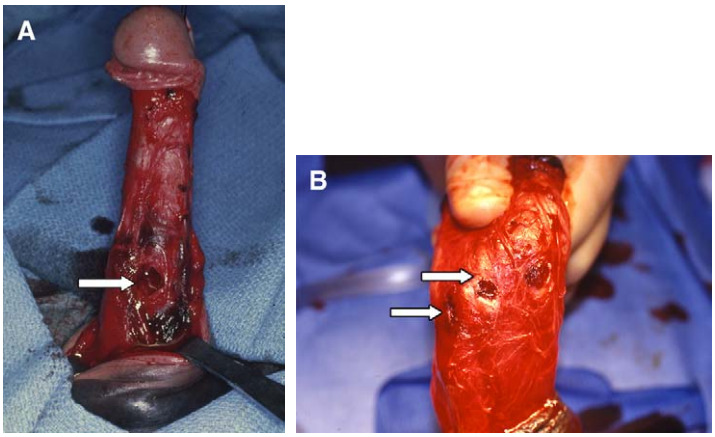

Fig. 2. Appearance of injuries to tunica albuginea. (*A*) Penile fracture exposed by degloving incision. Note clear disruption of tunica albuginea on lateral aspect of cavernosum extending toward corpus spongiosum (*arrow*). (*B*) Entry and exit wounds (*arrows*) to tunica albuginea from a low-velocity weapon.

is closed with interrupted slowly absorbable sutures. Although debridement and curettage may be indicated in cases presenting in a delayed fashion, most acute injuries do not require such maneuvers. Extensive irrigation, usually with a pulse lavage system and normal saline, is appropriate to remove any foreign body. In cases of penetrating impalement injuries or gunshot wounds, foreign material including clothing, missile fragments, or pieces of bone may enter into the deep structures of the penis and urinary tract [19]. These must be actively sought in such cases and removed (Fig. 3).

Injury to the glans penis presents a special challenge because of cosmetic concerns. Defects of glandular tissue do not preclude a good outcome. Debridement and trimming of skin edges to create a clean wound allow for closure of fairly large defects (Fig. 4A). Although the size of the glans may be reduced, its overall contour can usually be maintained. Circumcision injury in children often involves only the distal glans, which can be reattached as a free graft with acceptable results.

Most lacerations of the genital skin can be closed primarily (Fig. 5). The extensive and redundant blood supply of genital skin allows a greater flexibility and safety in wound closure than in other body areas. Simple uncontaminated bite injuries can be irrigated and closed primarily if appropriate antibiotics are administered, contamination is minimal, and the wound is closed within 6 to 12 hours [20]. Grossly contaminated bite injuries should be left open and allowed to granulate (Fig. 6). Similarly, most penetrating injuries to the penis and genitalia can be closed primarily as long as devitalized tissue is debrided, foreign material is removed, and appropriate antimicrobial coverage is given. Xeroform gauze and bulky fluffs loosely wrapped around the penis complete the dressing. Although some authors advocate pharmacologic treatment to prevent erections in the postoperative period, the authors have not found this approach to be necessary [21]. Local application of antibiotic ointments should be started once the dressings are taken down. Wound infections are uncommon after repair of penile injuries.

Fig. 3. Impalement of scrotum by stick. (Courtesy of Dr. Robert M. Sweet, Minneapolis, MN.)

Injuries in uncircumcised patients present wound management issues. The redundant prepuce makes dressings more difficult; sometimes postoperative adhesions of the proximal shaft skin can lead to skin deformities. Nevertheless, the authors rarely perform simultaneous circumcision to preserve genital skin for possible future reconstruction.

A penile wound that requires special consideration is the circumferential full-thickness injury to the penile shaft skin (Fig. 7). Whether caused by an acute laceration, amputation, or constriction ring injury, the full-thickness loss of skin, subcutaneous tissues, and lymphatics can lead to permanent and disabling distal penile edema or skin sloughing. Simple lacerations of the base of the penis, even when circumferential, usually do not lead to complete interruption of lymphatic drainage, and should be closed primarily without immediate concern for distal penile edema. In contrast, after prolonged constriction ring placement with resulting ischemic necrosis, when full-thickness skin loss occurs there exists a much higher likelihood of subsequent lymph edema. Even in such circumstances, local care to the area of skin loss is the best initial management. If subsequent disabling edema occurs, the skin can be removed and replaced with a split-thickness skin graft. Fairly dramatic improvements have been observed with conservative therapy, however, and early aggressive debridement of viable skin is contraindicated. In cases of penile amputation, the best chance for skin survival is when complete microvascular reattachment including venous anastomosis is performed. When a simple cavernosal reanastomosis, without microvascular repair, is performed, skin loss is guaranteed.

Likewise, surgical management of burns, electrical injuries, and other skin injuries of the genitalia should be conservative [22]. The rich vascular supply may allow a greater degree of skin preservation than is expected in other areas of the genitalia. The authors' single institution experience with genital burns suggests that skin grafting for such injuries is a rare event (Fig. 8). Complete loss of genital skin usually implies a devastating burn from which patients may be unlikely

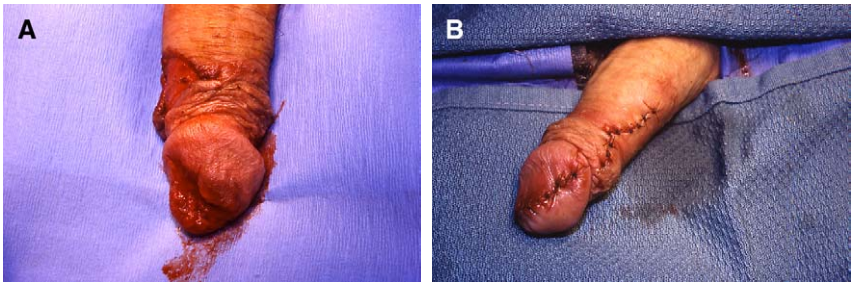

Fig. 4. Penile gunshot wound. (*A*) Injury to glans and superficial shaft of penis. (*B*) Final appearance of wounds after debridement of glans and primary skin closure with chromic suture.

to survive. In contrast, less than complete surface area burns of the genitalia have a remarkable capacity for recovery, and skin grafting is the exception rather than the rule [23].

Penile amputation requires precise management of urethral, cavernosal, neurovascular, and skin transsection in all but the most distal injuries. Simple urethral and tunica albugineal reapproximation of complete shaft amputation usually leads to survival and function of the organ, although skin loss is unavoidable and sensation of the glans and accompanying ejaculatory function is lost. Urethral stricture is also more common. Whenever possible, the authors advocate complete reattachment with microvascular and nerve reattachment. Critical issues include the quality of the amputated shaft and stump. With a clean cut, virtually no preparation is required (Fig. 9). If the penis has been avulsed or cut with a blunt instrument, or purposefully mutilated by the patient or the assailant, however, then reattachment may be problematic. Reattachment begins at the most ventral portion of the penis. Reapproximation starts with the tunica of the corpus spongiosum, the urethral epithelium over a catheter, followed by the ventral-most aspect of the tunica albuginea of the corpus cavernosum.

Fig. 5. Superficial skin lacerations caused by skill saw injury.

Reanastomosis of the deep arteries of the cavernosum usually is not required or easy. The authors only perform dorsal arterial reanastomosis. Once the tunica albuginea of the corpus cavernosum has been reapproximated, then the dorsal structures have brought in to proximity. The authors perform microvascular reanastomosis of one or both dorsal arteries, the dorsal nerves, and the deep dorsal vein. Failure to reanastomose the deep dorsal vein may lead to glans hyperemia and venous congestion of the shaft skin, which can compromise the success of the reattachment. Postoperatively, venous congestion is a major problem even with microvascular reattachment. The authors have found that the use of medical leeches is very helpful in reducing swelling and hematoma related to venous congestion and postoperative bleeding.

Injuries to the scrotum

Lacerations and avulsions of the scrotum not involving the testis may occur because of blunt trauma, machinery accidents, and stab wounds and occasional firearm injury. Complete avulsion of the scrotal skin is rare and is usually the result of power takeoff, auger, or devastating motor vehicle crashes involving widespread skin avulsion and degloving. Evaluation of the testis for potential rupture is mandatory and involves physical examination, scrotal ultrasonography, or direct exploration.

Scrotal skin lacerations can be closed primarily in the absence of gross infection or heavy contamination, and like penile skin, the scrotum is very resistant to ischemia and infection. Meticulous hemostasis is important because the scrotum accepts a large capacity of bleeding without tamponade. Layered closure of the deep fascia and skin, with a Penrose drain brought out dependently, limits postoperative hematoma (Fig. 10). Interrupted

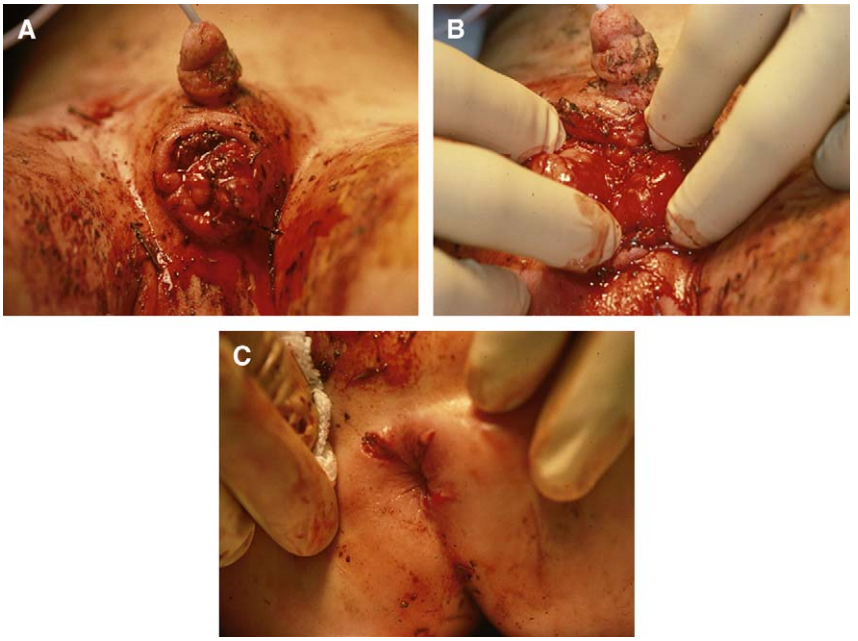

Fig. 6. Dog bite injury to male infant with gross contamination (*A*), intact tunica vaginalis (*B*), and perianal puncture wounds (*C*). Wounds were left open initially. Anoscopy revealed no other injuries.

closures reduce the likelihood of ischemia and may allow further drainage between the sutures. The authors always close the deep layer with an absorbable suture. Skin closures vary; usually, absorbable monofilament, such chromic or synthetic substitutes, works well. In some cases with challenging wound characteristics, nonabsorbable sutures, such as nylon, may be preferable. Xeroform gauze or other antibacterial dressings and ointments should be placed on the incisions, and the scrotum should be surrounded with fluffed gauze and a supporting meshed panty.

Complete scrotal avulsion is a devastating injury. It may be possible to preserve avulsed skin sheared off in a motor vehicle crash, and prepare it for immediate full- or split-thickness skin grafting. Machinery injuries with rotating mechanisms may damage the intrinsic microvasculature of the skin and make it unsuitable for grafting. In the absence of devastating burns or massive skin injuries, the authors do not advocate immediate grafting but rather favor an interval of local care and dressing changes with saline-soaked gauze. This ensures that contamination is removed

Fig. 7. Constriction device with distal edema and duskiness.

Fig. 8. Caustic chemical burn to the scrotum and penis. (Courtesy of Dr. Robert M. Sweet, Minneapolis, MN.)

Fig. 9. Appearance of penile stump after amputation. Note well-delineated cavernosal anatomy that allowed replantation. (Courtesy of Dr. Jack W. McAninch, San Francisco, CA.)

and allows the bed to granulate, after which very successful results can be obtained with split-thickness skin grafts obtained from thigh donor sites [24]. Testicular transplantation into subcutaneous thigh pouches is not frequently required for traumatic injuries to the scrotum. It can be a temporizing or permanent measure, however, dependent on patient age, sexual function, and overall prioritization of trauma injuries.

Injuries to the female genitalia

Female genital injuries are especially morbid given their mechanisms involving severe pelvic fractures or sexual assault and interpersonal violence. Many vulvar lacerations are the result of sports-related straddle-type injuries [25–28]. Genital trauma, however, is reported in 20% to 53% of sexual assault victims [1,29]. Such a history must be sought. If elicited, appropriate support services and police involvement must be secured [30]. Furthermore, informed consent for the rest of the patient assessment should be obtained if a history of sexual assault has been verified. Required assessment includes history, physical examination, and collection of laboratory and forensic specimens as outlined by the American College of Obstetrics and Gynecologists [31].

Fig. 10. Primary closure of penile and scrotal lacerations (same patient as in Fig. 5) with dependent drainage of wounds.

Table 3 shows the characteristics of injuries to the vagina and vulva, and corresponding AIS scores. Regardless of the mechanism, all female patients with external genital injuries should be suspected of having injury to the internal female organs and the lower urinary tract and urethra. Many female urethral injuries are associated with vaginal bleeding, and the possibility of pelvic fracture or impalement injury should prompt especially diligent evaluation [32]. This includes cystourethrography, proctoscopy, and laparotomy as indicated. The failure to identify associated urinary tract and gastrointestinal injuries in the face of vaginal trauma may lead to abscess formation, sepsis, and death.

Table 3
AAST organ injury scale for female genital injury

Injured structure	AAST grade	Characteristics of injury	AIS-90 score
Vagina	I	Contusion or hematoma	1
	II	Superficial laceration (mucosa only)	1
	III	Deep laceration (into fat or muscle)	2
	IV	Complex laceration (into cervix or peritoneum)	3
	V	Injury to adjacent organs (anus, rectum, urethra, bladder)	3
Vulva	I	Contusion or hematoma	1
	II	Superficial laceration (skin only)	1
	III	Deep laceration (into fat or muscle)	2
	IV	Avulsion (skin, fat, or muscle)	3
	V	Injury to adjacent organs (anus, rectum, urethra, bladder)	3

Abbreviations: AAST, American Association for the Surgery of Trauma; AIS, Abbreviated Injury Scale.

Perineal and vulvar lacerations can usually be managed in the emergency department. Large hematomas should be incised and drained, with ligation of any bleeding vessels. As with the male genital skin, closure with interruptive absorbable sutures is standard. Drains can be used if there is a large cavity, if hemostasis is suboptimal, or if there is suspected contamination [27].

Internal lacerations to the vagina and cervix can be closed in the emergency department as long as there is not severe bleeding. Large lacerations associated with bleeding and hematoma require speculum examination under anesthesia to completely assess and repair the injuries. Vaginal lacerations are closed with continuous absorbable sutures, and vaginal packing is critical for hemostasis.

Complex vaginal and perineal lacerations, associated with pelvic fracture, rectal injury, or other adverse features require a more systematic approach. Evaluation under anesthesia is mandatory including speculum examination, cystoscopy or cystography, and rigid proctoscopy. Diversion of the fecal stream is rarely indicated unless perineal injuries extensively involve the rectum, anus, or external sphincter. Bladder ruptures should be repaired if associated vaginal lacerations are present, to prevent deep pelvic infection and abscess or formation of vesicovaginal fistulae.

Summary

Genital anatomy has evolved to maximize protection of reproductive function from blunt trauma. When weapons, excessive bending, or shear forces exceed the threshold for deformation, however, rupture and bleeding are inevitable. Important contextual issues include potential criminal violence, associated pelvic organ injury, and importance of preserved function and cosmesis. The ultimate goal of reconstructive surgery is to preserve genitalia with normal function and appearance. Prompt operative management of deep injuries to the penis and vagina controls bleeding and reduces the likelihood of later sexual dysfunction. Primary closure of most wounds including uncomplicated bites and penetrating injuries is possible with appropriate antibiotic administration. Delayed closure and skin grafting can salvage wounds complicated by a delay in diagnosis, avulsion, contamination, or secondary necrotizing infection. Finally, complete amputation is best treated at tertiary centers that can perform microvascular complete reattachment.

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