Abdominal Radiology

Published online: 1 September 2018

Abdom Radiol (2019) 44:739–748
https://doi.org/10.1007/s00261-018-1764-0

CT imaging of inflatable penile prosthesis complications: a pictorial essay

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Abstract

Purpose: Inflatable penile prostheses (IPPs) are widely used in the United States, for patients with erectile dysfunction refractory to other treatments. Complications subsequent to IPP insertion include infection, hematoma, fluid leak, component (cylinder/pump/reservoir) complications, and retained previous IPP components. Radiologists are often called upon to identify and characterize these complications utilizing CT prior to intervention. Our paper aims to provide a guide to familiarize radiologists with normal IPP component imaging and review the CT findings of commonly encountered complications.

Methods: In this study, we retrospectively reviewed CT reports with descriptions of IPPs from 108 patients. We collected CT images of normal IPP components as well as reevaluated the CT findings of 33 patients with an IPP complication and correlated with immediately subsequent operative report.

Results: The CT appearance of appropriately positioned normal IPP components in asymptomatic patients and each complication were described and compared to previous literature.

Conclusions: CT is a very useful modality to assess an IPP-related complication. It is inexpensive, fast, and immediately available in emergent situations, e.g., infection, hematoma, and component erosion. Additionally, CT is very sensitive and makes it easier to diagnose a system leak. It can identify most cylinder complications and pump malposition and can be extremely helpful to the surgeon in preoperative planning if revision is needed. After this review, the radiologist should be able to identify normal IPP components and their complications.

Key words: Erectile dysfunction—Inflatable penile prosthesis—Complication—Computed tomography

Erectile Dysfunction (ED) is a very common clinical diagnosis that frequently affects men older than 40 years of age. Roughly 52% of men between 40 and 70 years old report some degree of ED [1]. In men older than 70 years old, the prevalence of ED ranges from 50 to 100% [2]. Treatments for ED may include lifestyle modification, psychosexual/couple therapy, testosterone supplementation, phosphodiesterase type 5 inhibitors (PDE5-I), intravenous or intraurethral vasodilators, and vacuum tumescence devices. If conservative measures fail, penile prosthesis insertion is documented to be a safe and effective treatment [3].

Penile prostheses first appeared in the 16th century for a traumatic penile amputation patient [4]. Beginning in the 1930s, penile prosthesis was used as a treatment of ED. In the United States, inflatable penile prostheses are most commonly used. Because of this, we focused on inflatable penile prostheses (IPPs) in our study.

Approximately 25,000 IPP procedures are performed in the USA each year [5]. IPP is a safe, well-tolerated procedure with high rates of user and partner satisfaction [6]. The IPP-related complication rate is generally low: 0.46% to 5.3% for infection [7] and 0.2%–3.6% for bleeding or hematoma [8]. System leaks and component (cylinder, reservoir, and pump) complications usually lead to device malfunction, which generally requires replacement. Mechanical survival rates of IPP are 97.6%, 86.2%–93.2%, 68.5%–85.0%, and 59.7%–79.2% at 3, 5, 10, and 15 years, respectively [8].

Previous studies show that magnetic resonance imaging (MRI) offers good anatomic detail and plays an important role for patients with a IPP malfunction [9–13]. However, computed tomography (CT) is less expensive and more available, particularly in emergent settings, for patients with IPP and suspected infection or postsurgical hematoma. We have found no prior radiologic publication which focused on the CT findings in patients with IPP. Consequently, we carried out a retrospective review of normal IPP CT findings as well as IPP complications in 33 patients seen in a University teaching hospital from 2006 to 2018.

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Materials and methods

We searched the keywords "penile prosthesis" OR "penile implant" and "CT" in our radiology reports database. There were 118 radiology reports in the system, which belonged to 104 patients. The CT protocols for these cases were varied due to different clinical indications. For outpatient CT ordered to evaluate IPP malfunction, CT pelvis without contrast was performed; for ER cases concerning for IPP infection or hematoma, CT pelvis with contrast was performed; Other cases with incidental findings regarding IPP were performed according to different clinical indications whichever brought the patients to hospital. We reviewed the descriptions regarding penile prosthesis for each report and identified 34 cases with IPP complications. The clinical documents, including operative reports, were obtained from the medical records database. One case was excluded because the IPP was incompletely imaged, and the clinical documentation was unclear, leaving 33 cases for review. Each of these cases was reviewed again and reported independently by an experienced diagnostic radiologist and an experienced implanting urologist. Detailed clinical information of each complication, such as clinical symptoms, signs, CT findings, and surgical reports findings were analyzed and concluded. Several pelvic CTs and clinical documents of asymptomatic patients with a normal incidental IPP were also reviewed in order to obtain images of normal IPP.

We used Excel (Microsoft Office 2011 version) to statistically analyze the demographic and clinical information of 33 patients with IPP complications. The statistical results of patient's ethnicity, age, reason for IPP placement, and different types of complication were described and listed in a table (Table 1).

Table 1. Demographic

Case date	2006–2018
Ethnicity	
African American	18 (54.5%)
Caucasian	12 (36.4%)
Other/unknown	3 (9.1%)
Age	41–78
Mean	64.8
Median	66
Reason for IPP placement	
Organic Erectile impairment	30
Priapism	1
Peyronie's disease with corporal fibrosis	3
Corporal fibrosis with nonspecific reason	3
Unknown	3
Complication	
Infection	13
System leak	13
Cylinder complication	7
Pump complication	5
Reservoir complication	1
Hematoma	2
Retained previous IPP components	2

Demographics and statistics

The 33 cases with IPP complications occurred from 2006 to 2018. Each of the cases was from a different patient. The age range of these 33 patients was 41–78 years of age. Eighteen of the patients were African-American and 12 were Caucasian. Table 1 lists the reasons for these patients having IPP placement. Different complications with numbers of patients involved are also mentioned. Noting that some patients have multiple IPP complications. Thus, the total number of complications is greater than the total number of patients. For example, one patient with reservoir complication was also found having infection; Two patients with infection also had pump complications, et al.

Normal IPP position and CT findings

In order to identify IPP complications, it is important to understand the normal structure and components of a multiple component IPP (Figs. 1, 2). All IPPs include cylinders, a scrotal pump, a separate fluid reservoir or combined reservoirs, and connecting tubing. The paired inflatable cylinders are placed into the corpora cavernosa. In normal position, bilateral cylinder or bilateral tip extender should be symmetric (Fig. 3). The pump is ideally placed in the midline scrotum between the testes. [14] (Figs. 4, 5). The reservoir can be placed in different

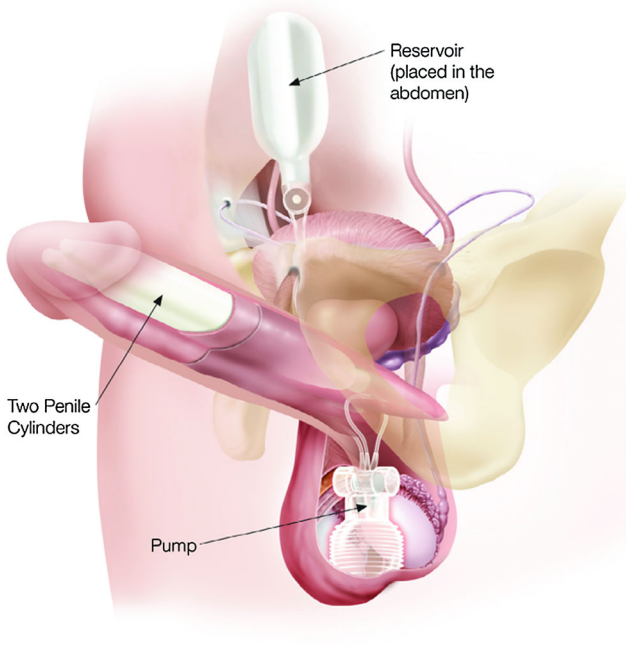


Fig. 1. Artist rendering of 3-component IPP (Titan-OTC) includes reservoir, cylinders, and pump. Reproduced with permission from Coloplast Corporation, MN, USA.

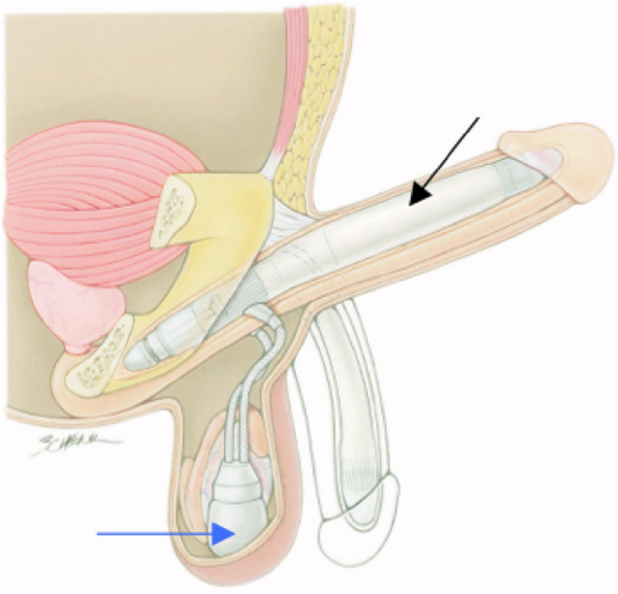


Fig. 2. Artist rendering of 2-component IPP(AMS Ambicor). Small fluid reservoirs are in the proximal portion of each cylinder (black arrow). There is a separate pump (blue arrow). Reproduced with permission from American Medical Systems, MN, USA.

locations according to the patient's body habitus and comorbidity. The traditional location is the retropubic space of Retzius (Figs. 6, 7). Other locations include abdominal wall anterior to the transversalis facia and posterior to the rectus abdominis [15] (Figs. 31, 32), subcutaneously (Figs. 8, 9, 10), or inguinal canal (Figs. 11, 12, 13). In classic three-component IPPs such as the Coloplast Titan and AMS 700, each of these three components is present in the above separate locations (Fig. 1). For the two-component Ambicor implant, there are only two cylinders and a scrotal pump; there is no separate intra-abdominal reservoir (Fig. 2).

When patients want to use the IPP, they need to squeeze and release the pump bulb intermittently several times to inflate. When they want to deflate the IPP, they either momentarily squeeze the deflation button next to the pump bulb (AMS 700 and Tian OTR) or continuously squeeze the release bars of the pump (Titan) or bend the penis for 6–12 s (AMS Ambicor).

Fig. 3. Axial image of normal symmetric IPP cylinder tip extenders (red arrow).

CT findings of IPP complications

Infection

The infection of IPP can result in major disfigurement and serious psychological trauma [16]. Therefore, it is important to identify the complication when the clinical concern raised. IPP infection generally presents with localized swelling, erythema, discomfort or pain, fever, tenderness, purulent drainage, and leukocytosis. The infection may occur anywhere from a few weeks post-surgery to more than 10 years thereafter.

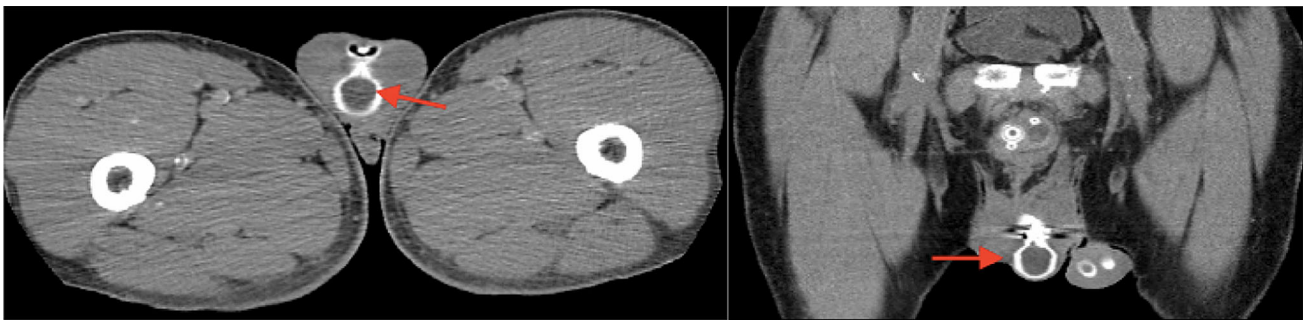
CT typically reveals skin thickening, soft tissue swelling, or fat stranding. In patients with abscess formation, a rim-enhancing fluid collection with or without gas may be visualized surrounding the IPP components (Fig. 14). Skin irregularity and ulceration with IPP components exposure through the skin also may occur (Fig. 15).

In our study, among the 13 patients with IPP infection, only one of them recovered solely with intravenous antibiotics. The rest of the patients had to further receive surgery to remove the IPP. Noting that 2 of them had a new IPP during the same surgery with no further complication at follow-up.

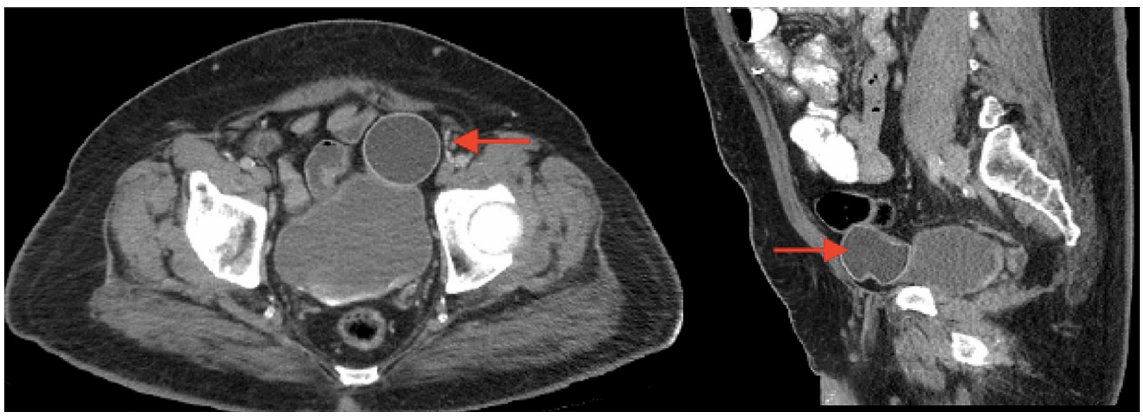
Hematoma

Two patients in our study presented with post-operative hematomas. In both cases, the patients had IPP surgery for the first time, and the hematoma occurred within 2 weeks post-surgery. Patients had pain, swelling, tenderness, and serosanguinous drainage from the incision site. CT revealed a collection of blood with fat stranding and soft tissue swelling (Figs. 16, 17). Both cases required surgical hematoma evacuation; cultures from the evacuated hematoma revealed no infection.

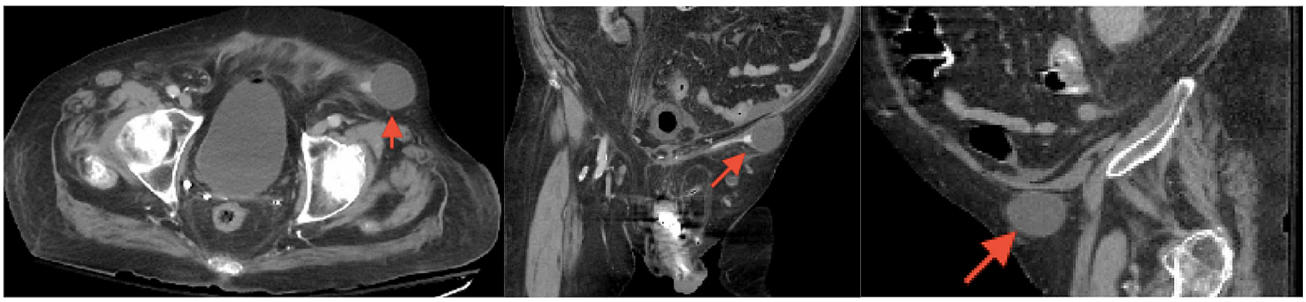
CT images for both infection with abscess formation and hematoma show fluid collection, soft tissue swelling, and fat stranding. It is difficult to distinguish between them solely by CT imaging. However, they are easily distinguished clinically. Postsurgical hematoma has been reported to occur within a few days after surgery [17], but both of our cases developed approximately 2 weeks after surgery. Patients with infection usually had local erythema, fever, leukocytosis, positive culture, purulent drainage, or skin ulceration. In contrast, patients with hematoma had lack of the above clinical findings, but instead presented with sanguineous discharge from the surgical incision.



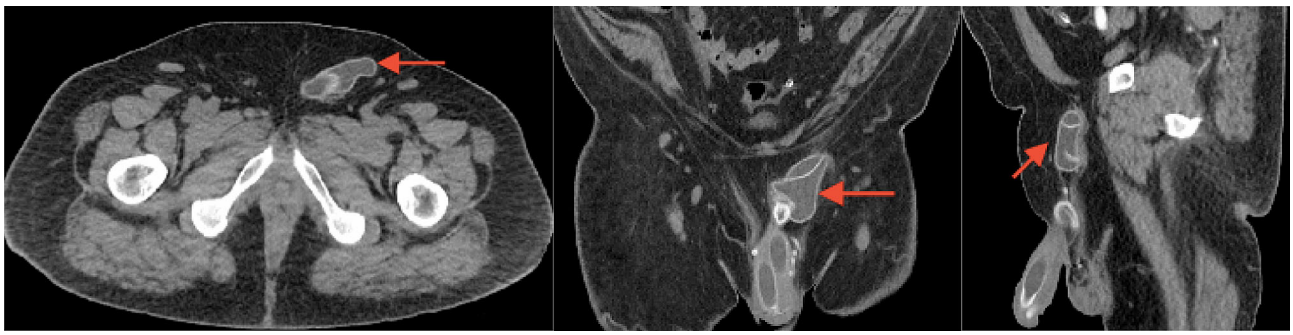
Figs. 4 and 5. Axial and coronal image of normal IPP pump location in the midline inferior scrotum between the testes (red arrow).



Figs. 6 and 7. Axial and coronal image of normal IPP reservoir location in the retropubic space anterior to the bladder (red arrow).



Figs. 8, 9, and 10. Axial, coronal, and sagittal images of normal IPP reservoir in left lower quadrant subcutaneous tissues (red arrow).



Figs. 11, 12, and 13. Axial, coronal, and sagittal images of normal IPP reservoir in the left inguinal canal (red arrow).

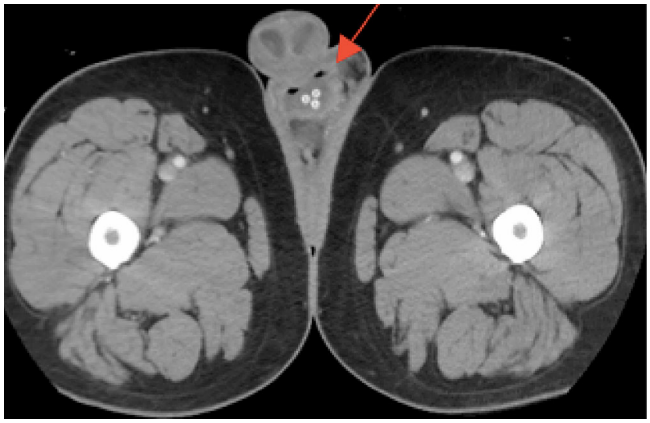


Fig. 14. Axial CT image shows a rim-enhancing fluid collection surrounding connecting tubing with two foci of gas within the collection (red arrow), consistent with abscess formation.

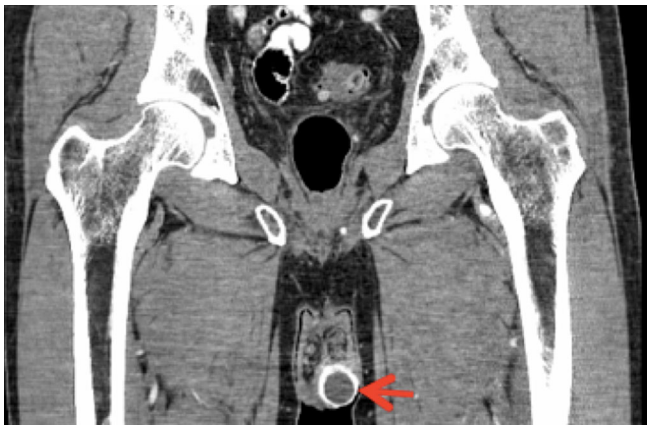


Fig. 15. Coronal CT image shows the pump eroding through the left hemi-scrotal skin (red arrow). There is scrotal skin thickening and fat stranding adjacent to the pump, consistent with scrotal cellulitis, and ulceration caused by IPP infection.

Mechanical failure

Besides infection and postsurgical hematoma, other complications of IPP include mechanical failure. This broad term can be further divided into fluid leaks, cylinder complications, reservoir complications, and pump and tubing complications [9].

System fluid leak

An IPP fluid leak presents as inability to inflate the device; this usually occurs years after implantation. Cracking, rupturing, or disconnecting of any part of an IPP, but most commonly the connector tubing, can lead to a system leak. CT cannot usually identify the exact location of a fluid leak. But CT is very sensitive detecting a leak by secondary signs. Those signs include simultaneous collapse of the cylinders and the reservoir or gas in or surrounding the IPP components. In our study, 53.8% of cases with fluid leak had gas within or surrounding the IPP components (Figs. 18, 19).

Reservoir complications

Reservoir complications include reservoir leak and erosion. Reservoir leak has been discussed in the previous system fluid leak section. In this section, I will concentrate on reservoir erosion. We found one case with penile implant infection complicated by reservoir erosion into the bladder (Figs. 20, 21). The patient had undergone 5 IPP surgeries and complained of scrotal pain, scrotal incision drainage, fever, and gross hematuria at presentation. In such emergent scenario, CT is the best modality as it sufficiently demonstrated the complication and was readily available.

Cylinder complications

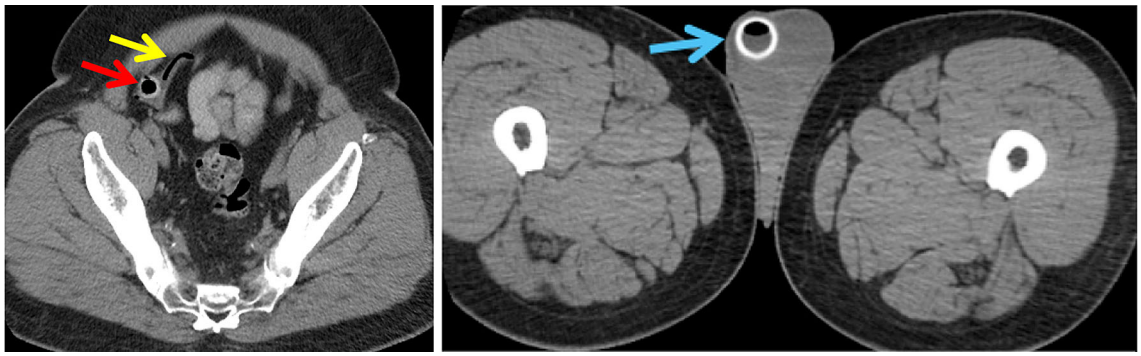
Cylinder complications include aneurysm formation, migration, erosion, and excess length. The clinical presentation is usually device malfunction or cosmetic abnormality. Cylinder erosion through the skin is also associated with device infection. In our study, patients complained of difficulty using the IPP. These complaints occurred from 9 months to 5 years after the surgery. CT can often identify a cylinder aneurysm (Fig. 22) or kinking and enfolding of a cylinder malformation (Figs. 23, 24). Cylinder migration can be medial (Fig. 25), anterior (Figs. 26, 27), or posterior. Anterior or posterior migration is suggested by asymmetric position of the rear tip extenders.

Pump complications

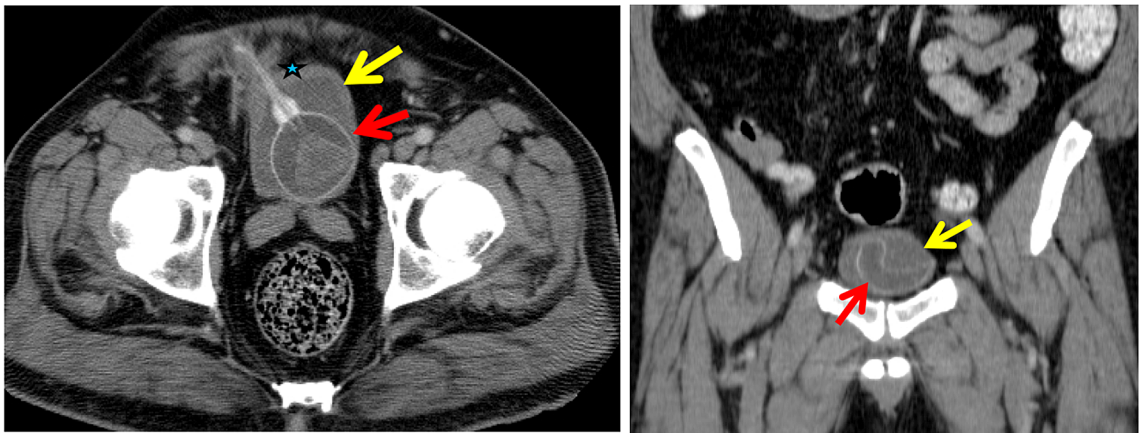
Pump complications include malposition, migration, and erosion. A malpositioned pump can make the implant difficult to operate [14]. Also, pump complications are sometimes associated with other complications such as a fluid leak or infection.

a. Pump erosion: In our series, one patient had pump erosion through the scrotal wall with a scrotal skin defect identified by CT (Fig. 15), in association with infection.
b. Pump malposition/migration: The pump is ideally located in a dependent portion of the scrotum usually in the midline. Pump migration or malposition can be diagnosed on CT if the pump is in any other position (Figs. 28, 29, 30). Pump malposition does not often occur in isolation. Commonly, it is secondary to other complications, such as a large hematoma or abscess displacing the pump. Therefore, when pump malposition is identified by the radiologist, it should spur additional search for the

Figs. 16 and 17. Axial (left) and sagittal (right) CT images demonstrate an intermediate density fluid collection surrounding the IPP connector tubing, located in the anterior pelvic subcutaneous soft tissue (red arrows). These findings are most consistent with a post-operative hematoma.



Figs. 18 and 19. Axial CT images demonstrate air within the IPP reservoir (red arrow), connector tubing (yellow arrow), and scrotal pump (blue arrow). This is indicative of a fluid leak, leading to device malfunction.



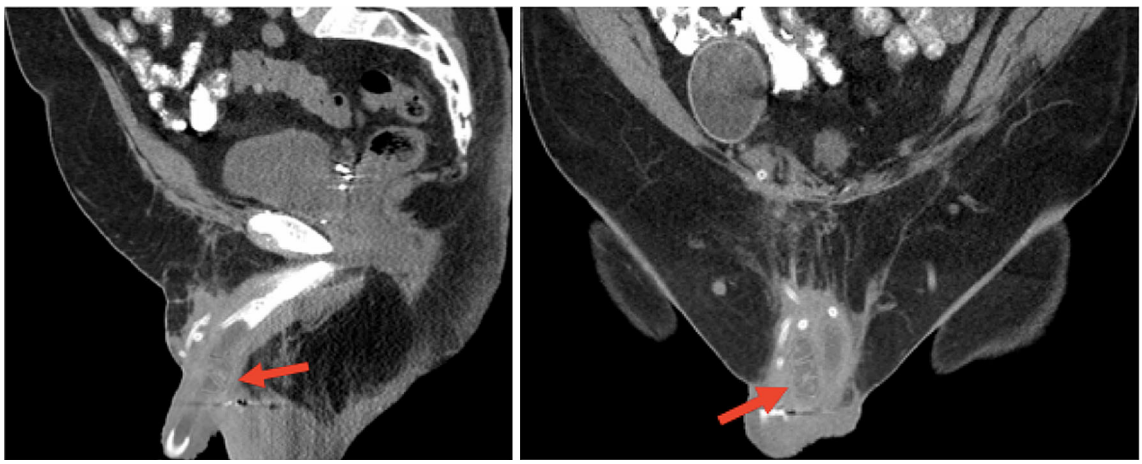
Figs. 20 and 21. Axial (left) and coronal (right) CT images demonstrate erosion of the reservoir (red arrows) into the urinary bladder (yellow arrows). Bladder wall thickening (small blue star) and perivesical inflammatory reaction are clearly visible.

Fig. 22. Coronal CT image shows an aneurysm (red arrow) of the proximal right cylinder.

cause. In our series, one of the patients' pumps was pushed to a transverse position due to a large adjacent abscess.

Retained IPP components from previous IPP implantation

Retained IPP components can be easily seen on CT (Figs. 31, 32). When an IPP is being replaced, some surgeons leave the old reservoir in situ, then place a new IPP. This results in a retained, deflated, nonfunctioning old reservoir. Occasionally, rear tip extenders may be inadvertently left in the proximal corpora. Retained reservoirs may cause complications such as bladder erosion, infection, adhesions, or compression of adjacent structures [18, 19]. Retained reservoirs are easily identified and should be described.



Figs. 23 and 24. Sagittal (left) and coronal (right) CT images demonstrate infolding of the right cylinder (red arrows).

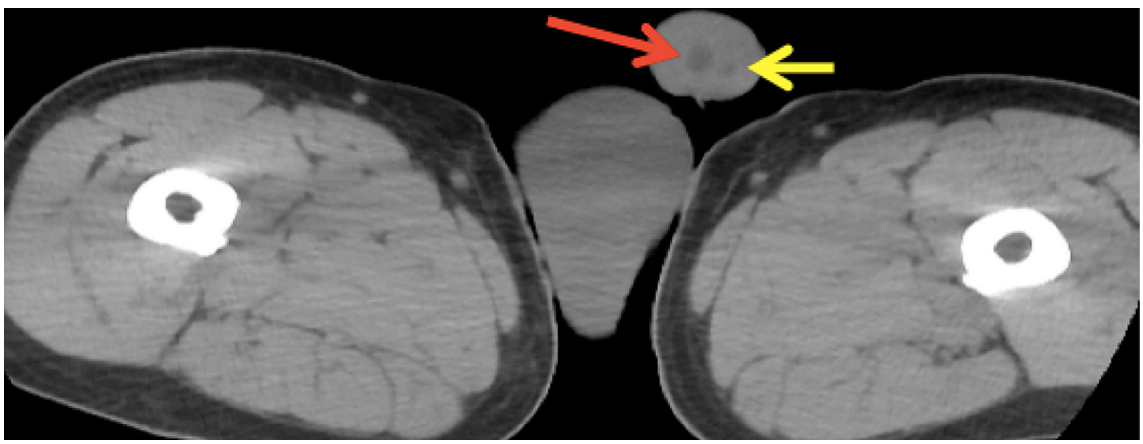
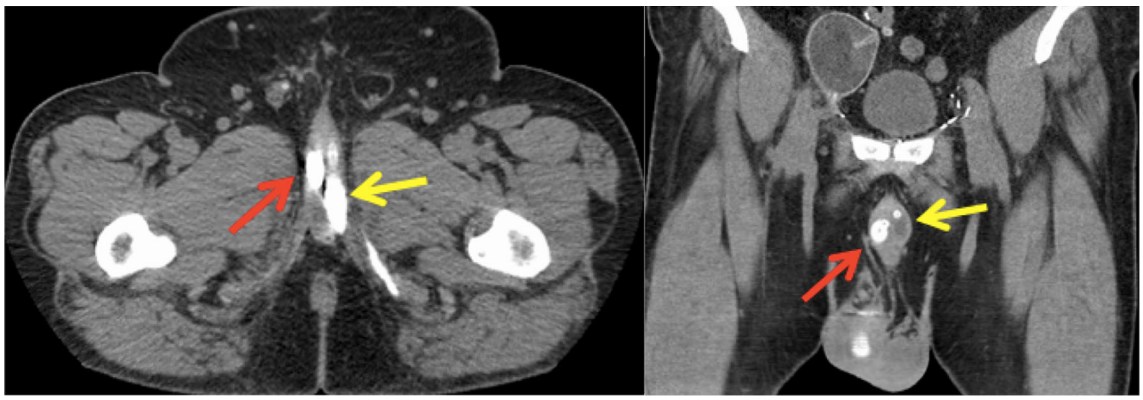


Fig. 25. Axial CT image demonstrates the left cylinder (yellow arrow) is located more lateral than the right cylinder (red arrow). Erosion of the right cylinder into the urethral lumen was identified during surgery.



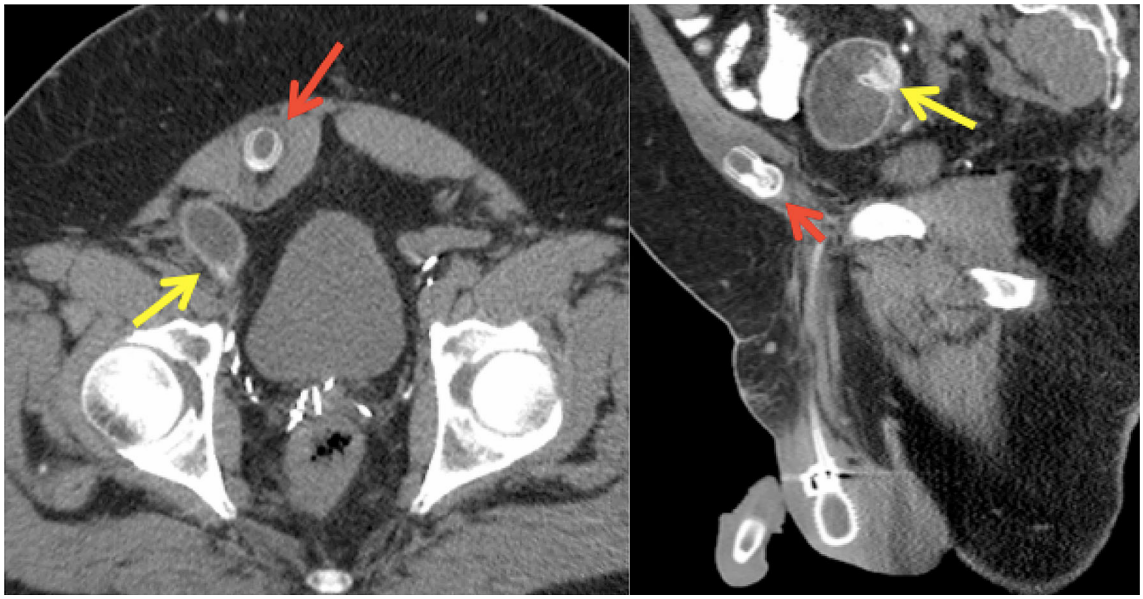
Figs. 26 and 27. Axial (left) and coronal (right) CT images show right cylinder rear tip extender (red arrow) and left cylinder/rear tip extender (yellow arrow). At the axial image (Fig. 26), the right rear tip extender is anteriorly migrated due to kinking and enfolding of the right cylinder (Figs. 23, 24). On the coronal view (Fig. 27), we already see the rear tip extender on the right. However, on the left, the cylinder is visualized. This indicates right cylinder anterior migration.

Fig. 28. Axial CT image demonstrates cephalad pump migration (red arrow), adjacent to the penile shaft base. Expected pump location is in the midline within the scrotum.

Conclusion

IPP has been widely used in the US as safe and effective treatment for ED. Complications, while uncommon, can be devastating, especially in the setting of infection. CT is a very useful modality to assess IPP-related complications. Although CT cannot depict subtle soft tissue details and is with disadvantage of radiation exposure, it is inexpensive, rapid, and immediately available in emergent settings for IPP-related infection, hematoma, and component erosion. It is also very sensitive and makes it easy to diagnose a fluid leak. Last but not least, most cylinder complications such as aneurysm, kinking, folding, migration, and erosion can be identified on a CT scan with careful inspection. Radiologists should be aware of the normal IPP CT findings and its complications.

Figs. 29 and 30. Axial (left) and coronal (right) CT images reveal scrotal pump (red arrow) is transverse lying high in the scrotum abutting the skin surface. The right testicle (yellow arrow) appears superiorly displaced into the inferior aspect of the right inguinal canal, just posterior to the transversely oriented pump.



Figs. 31 and 32. Axial (left) and sagittal (right) CT images reveal a fluid filled intra-pelvic reservoir (yellow arrow) posterior to the right rectus muscle, along with a retained reservoir from a previous IPP located in the abdominal wall posterior to the rectus abdominis and anterior to the transversalis facia (red arrow).

Acknowledgements None.

Compliance with ethical standards

Funding None.

Conflicts of interest None.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Obtaining consent was waived and approved by IRB due to the following reasons described in the IRB protocol: (A) The research is with minimal risk: it involves retrospective collection of existing data collected for non-research purposes. (B) The waiver would not adversely affect the rights and welfare of the subjects. The data will be stored using encrypted and password-protected excel files on a computer only accessible to the study team. All identifying information will be separated and destroyed at the earliest opportunity to ensure subjects are protected. These will maintain privacy and confidentiality of data. (C) Data are going to be collected from subjects who may no longer be receiving follow-up care. Obtaining consent would require additional collection of information that could increase the risk to subjects' privacy. (D) Whenever appropriate, the subjects will be provided with additional pertinent information.

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