



Narrative review of immediate salvage for penile prosthesis infection

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Background and Objective: Implantation of a penile prosthesis is a reliable option for men with erectile dysfunction (ED) refractory to less invasive therapies. While the frequency of penile prosthesis infections have decreased, they remain a devastating complication. Herein we discuss why immediate salvage surgery is an essential technique for the management of implant infections. We will also describe the relevant advancements to this technique.

Methods: We conducted a narrative review via computer based search of PubMed for all relevant articles on penile prosthesis infection management, including guidelines, case series, reviews, and expert opinions. Search terms used included: “inflatable penile prosthesis”, “IPP”, “penile prosthesis”, “salvage”, “treatment”, “delayed”, “immediate”. Only English peer-reviewed publications were included.

Key Content and Findings: Historically, patients who presented with penile prosthesis infections were exclusively managed with complete removal of the prosthesis without replacement. Although this strategy is safe, it hastens immediate ED and corporal fibrosis, resulting in loss of penile length and increased difficulty with subsequent prosthesis replacement. Previous case series have reported successful treatment of localized penile prosthesis infections with nonsurgical treatment, but the role of conservative treatment remains limited. The current standard of immediate salvage entails removal of the infected prosthesis and washout followed by immediate replacement with a new penile prosthesis. This technique has been demonstrated to be safe and effective, thus allowing patients to resume intercourse and maintain penile length.

Conclusions: Immediate salvage surgery is safe and effective, and has emerged as the preferred strategy for the management of most patients with a penile prosthesis infection.

Keywords: Penile prosthesis; penile implant; infection; salvage surgery; erectile dysfunction (ED)

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Introduction

Erectile dysfunction (ED) is a common problem and is associated with numerous comorbidities and lifestyle factors (1). Implantation of a penile prostheses is a reliable

treatment for men with ED refractory to less invasive therapies (2-4), as well as for female to male transgender patients (2). Improvements over the past decades in penile prosthesis technology and surgical techniques have

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Table 1 The search strategy summary

Items	Specification
Date of search	1/25/2023
Databases and other sources searched	PubMed
Search terms used	IPP, inflatable penile prosthesis, penile prosthesis, salvage, infection, treatment, explant, replace, replacement
Timeframe	Up to January 2023
Inclusion criteria	Only English language
Selection process	Selection was performed first by the co-first authors with review by A.C.L. prior to inclusion

IPP, inflatable penile prosthesis.

improved the safety, reliability, and patient satisfaction rates for implants (2,3). Recently reported rates of patient and partner satisfaction with penile prosthesis are high (5), and frequency of penile prosthesis implantation has increased steadily since the mid-2000's (4). The rate of penile prosthesis infections has also decreased over time due to improvements in both prosthesis technology (e.g., antibacterial coating of prostheses) as well as in surgical technique (e.g., the "no touch" technique) (3). However, despite the decreasing rate of penile prosthesis infections, infections occur and remain a devastating complication. Herein we review the management of patients with a penile prosthesis infection with a focus on immediate salvage surgery and its utility in management of penile prosthesis infection. This article provides a contemporary and comprehensive review of current management strategies and provides a centralized resource to guide clinical decision making in this complex patient cohort. We present this article in accordance with the Narrative Review reporting checklist (available at <https://tau.amegroups.com/article/view/10.21037/tau-23-277/rc>).

Methods

A narrative review was performed using computer based search of PubMed for all relevant articles on penile prosthesis infection management, including guidelines, case series, reviews, and expert opinions. Search terms used included: "inflatable penile prosthesis", "IPP", "penile prosthesis", "salvage", "treatment", "delayed", "immediate". Only English peer-reviewed publications were included.

The search strategy is summarized in *Table 1*.

Salvage surgery for management of inflatable penile prosthesis (IPP) infections

Early in the history of penile prosthesis implantation surgery, patients with infection were exclusively managed with complete removal of the prosthesis without replacement. Although this management strategy reduced the risk of reinfection it led to the immediate return of severe ED and corporal fibrosis. Corporal fibrosis results in loss of penile length and makes subsequent prosthesis implantation more challenging. Studies have demonstrated that penile prosthesis explantation with delayed replacement leads to a 15% to 30% reduction in penile length (6,7). This loss of penile length is significantly more than patients who undergo salvage surgery with immediate replacement (6).

The first documented report of salvage surgery with immediate prosthesis replacement was at the American Urological Association (AUA) annual meeting in 1987 by Dr. Fishman, Dr. Scott, and Dr. Selim. The trio reported they attempted salvage surgery with immediate replacement for 44 patients, 5 of which had two attempts at salvage totaling 49 surgeries and a 73% infection-free success rate (8). This concept was popularized in 1996 by Dr. Brant, Dr. Ludlow, and Dr. Mulcahy (9). This technique became known as the "Mulcahy Salvage", and Dr. Mulcahy subsequently published successful treatment without reinfection in 45 of 55 patients (10). Since then, additional authors have reported similarly high rates of infection-free success after immediate salvage (11,12). Case series on immediate salvage surgeries are summarized in *Table 2*.

The malleable implant substitution technique (MIST) has been reported to have a better infection-free success rate than immediate replacement with an IPP (13-15,19). Köhler *et al.* reported success in 6 of 6 patients (13), and Gross *et al.*, reported success in 54 of 58 patients (14). In addition to better success rates, MIST is technically easier and does not require placement of a scrotal pump or reservoir. Patients and their partners may experience decreased satisfaction with a malleable prosthesis, but the majority of patients (67% and 69% respectively) in the series reported by Köhler *et al.*, and by Gross *et al.*, did not opt for additional surgery (13,14). For patients who undergo replacement of their malleable prosthesis with an IPP, the malleable prosthesis prevents fibrosis of the corpora, loss of penile length, and facilitates future surgery.

"Delayed" salvage surgery was previously proposed as an

Table 2 Published case series of penile prostheses salvage

Reference	Year	No. patients in series	Total No. salvage attempts in series	Technique & replacement device, type [N]	Infection-free success rate, n/N (%)
Fishman, Scott and Selim, (8)	1987	44	49	Immediate salvage with IPP [NR], immediate salvage with Malleable [NR]	36/49 (73%)
Brant, Ludlow and Mulcahy, (9)	1996	11	12	Immediate salvage with IPP [12]	10/12 (83%)
Kaufman, Kaufman and Borges, (11)	1998	7	7	Immediate salvage with IPP [7]	6/7 (85%)
Knoll, (12)	1998	41	41	Delayed salvage with IPP [31], immediate salvage with IPP [10]	22/31 (71%), 8/10 (80%)
Mulcahy, (10)	2000	55	55	Immediate salvage with IPP [55]	45/55 (81%)
Köhler <i>et al.</i> , (13)	2009	6	6	Immediate salvage with malleable [6]	6/6 (100%)
Gross <i>et al.</i> , (14)	2016	58	58	Immediate salvage with malleable [58]	54/58 (93%)
Peters, Carlos and Lentz, (15)	2018	6	6	Immediate salvage with IPP [1], immediate salvage with Malleable [5]	1/1 (100%), 5/5 (100%)
Shaeer, Shaeer and Soliman AbdelRahman, (16)	2019	18	18	Immediate salvage with Malleable [18] (using extracapsular reimplant technique)	17/18 (94.4%)
Chandrapal <i>et al.</i> , (17)	2020	26	26	Immediate salvage with IPP [4], immediate salvage with Malleable [22]	3/4 (75%), 21/22 (95%)
Jiang <i>et al.</i> , (18)	2023	19	19	Immediate salvage with IPP [19]	16/19 (84%)

IPP, inflatable penile prosthesis; NR, not reported.

alternative to “immediate” salvage surgery, particularly for patients who were contraindicated to undergo immediate salvage surgery. In 1998, Dr. Knoll proposed a protocol of delayed salvage consisting of complete prosthesis removal, intraoperative wound culture, antibiotic irrigation, placement of drains, intermittent antibiotic irrigation of drains for 3 days, and subsequent reimplantation of a new IPP (12). They concluded immediate salvage was more practical than delayed salvage because immediate salvage requires one surgery and had a higher success rate (12). A more recent “delayed” salvage strategy is the “Carrion Cast” utilizing calcium sulfate mixed with antibiotics as a temporary intracavernosal antibiotic eluting spacer for several weeks until interval reimplantation of a penile prosthesis (20,21). It is important to note that this approach does set itself apart from other “delayed” salvage techniques in that the use of the cast works to preserve the intracavernosal space and decrease corporal fibrosis. The use of “delayed” salvage has not gathered momentum or popularity as recent studies have supported immediate replacement even in high-risk patients (15,17,18).

Historical contraindications to immediate salvage

surgery included purulence on the device, necrotic tissue, severe diabetes, erosion of device components, and rapidly developing infections (within 2 weeks after implantation) (9,15). However, these historical contraindications have been challenged by more recent case series (15,17,18). In 2018, Peters and colleagues reported a case series of patients with insulin dependent diabetes and purulent infections who all underwent successful immediate salvage surgery (15). More recent series continue to demonstrate high success rate even with expanded inclusion criteria including purulent infections, severe diabetes, device erosion, and infection within 2 weeks of implantation (17,18). Chandrapal *et al.* reported an overall an infection-free success of 92% using expanded criteria with mostly malleable prostheses (17). Shaeer *et al.* report 94.4% infection free rates following immediate salvage using an extracapsular implantation technique of a new malleable prosthesis (16). Similarly, Jiang *et al.* reported a multi-institutional case series in 2022 which included patients with severe diabetes and purulent infection and still had an overall infection-free success rate of 84% (18). It should be noted that patients chosen for IPP-to-IPP salvage generally have less severe presentations than those

Table 3 Published case series of non-surgical treatment strategies for infected penile implants

Reference	No. patients in series	Infection presentations: signs/symptoms [n]	Treatment strategy	Mean time to infection resolution	Success rate, n/N (%)
Deroue <i>et al.</i> , 2002 (24)	3	Local abscess with purulent drainage, and further confirmed on imaging [3], elevated CRP with normal WBC [1]	Long term antibiotics including daily antibiotic wound irrigation until wound closure	NR (mean time to wound closure: 24 days)	3/3 (100%)
Henry <i>et al.</i> , 2014 (22)	15	Incisional wound drainage [14], significant swelling [3], fixation of device to skin [1], significant increase in IPP pain/tenderness [4]	Long term antibiotics	76 days	13/15 (87%)
Luján <i>et al.</i> , 2016 (23)	2	Open scrotal incisions with exposed pumps and clear discharge [2]	Long-term antibiotics and Incision with drainage and irrigation	NR (patients received 42 days of antibiotics)	2/2 (100%)
Habous <i>et al.</i> , 2016 (25)	37	Local erythema, tenderness, or swelling [14], incision purulent discharge [19], superficial gangrenous patches on glans and frenulum [1]	Long term antibiotics	49 days	31/37 (83%)

CRP, C-reactive protein; WBC, white blood cell; NR, not reported; IPP, inflatable penile prosthesis.

salvaged with a malleable implant.

Potential role of non-surgical treatment for IPP infection

A limited number of small case series have reported successful treatment of localized penile prosthesis infections using non-operative management (22–25). We have summarized the reported case series of non-surgical treatment without IPP removal for penile prosthesis infections in *Table 3*. Of importance, all patients selected to undergo non-surgical treatment had isolated local signs of infection without systemic signs of infection (e.g., elevated WBC count, fever, chills, rigors, or malaise).

Considering the paucity of data, the authors have concluded that a trial of non-surgical treatment with long-term antibiotics has a very limited role in select patients (26). The current recommendation from the International Consultation on Sexual Medicine in 2016 included the statement: “In stable patients with infected PPs, reasonable attempts should be made to remove all device components” (5). Non-surgical management should only be offered to patients with localized infectious symptoms without systemic infectious symptoms and who are very reliable to comply with the necessary close follow-up and long-term antibiotics.

Utilization of immediate salvage surgery for IPP infection

Salvage surgery with immediate replacement has emerged as the preferred approach for penile prosthesis infection in stable patients (27). Nevertheless, the utilization rate of immediate salvage surgery is disappointingly low despite the high success rate and proven advantages. Zargaroff *et al.* reported that only 17.3% of patients who underwent surgery for treatment of an infected penile prosthesis underwent immediate salvage surgery between 2000 and 2009 (28). The authors found that immediate salvage surgery was more likely to be performed for patients at urban teaching centers, and for patients with younger age and with less severe infections (28).

There are several barriers to immediate salvage. Institutional barriers include the inaccessibility of replacement implants and/or surgeon availability. Patient medical and/or surgical barriers include patient instability, severe and/or extensive tissue damage (glans necrosis), or extraordinarily high risk for reinfection. Furthermore, patients may prefer not to undergo immediate salvage surgery due to fear of repeat infection or concerns related to the direct and indirect costs of surgery.



Figure 1 Penile prosthesis pump extrusion through scrotal wall.



Figure 2 Penile prosthesis cylinder extrusion at the urethral meatus.

Identification of IPP infection and patient selection for immediate salvage surgery

The first essential step in assessing a patient's immediate salvage candidacy is to differentiate whether their symptoms are attributable to infection or not. Given that penile implant infections may present in a variety of ways including delayed or indolent course, it is important to maintain a high index of suspicion for infection, especially in patients predisposed to infection—as in patients with a history of smoking (29), diabetes (30), spinal cord injury (31), immunosuppression (32), substance abuse (33),

and/or housing insecurity (33). More common than overt sepsis, an indolent course of infection after IPP surgery may be characterized by localized persistent or worsening pain, clear drainage with or without erythema, localized edema and/or tethering of implant to skin. Surgeons must consider the complete clinical picture as well as the risks of repeat surgery, often within the first 6–12 weeks after initial implantation. This includes carefully considering whether a patient's complaints may be from non-infectious origins such as diabetic neuropathy which may require a longer course of analgesics while the patient heals. Therefore, surgeons should have a low threshold for an infectious work-up for any patient with symptoms which persistent longer than expected or significantly worsen after their initial recovery.

As discussed in the previous sections, there has been growing evidence that immediate salvage surgery can be successfully performed when severe diabetes, device erosion/extrusion, and overt purulence are present (15,17,18,34). For example, patients with diabetes who are already at a higher risk of penile shortening and corporal fibrosis due to delayed healing are historically less likely to undergo immediate salvage despite reports of successful and safe salvage in the literature (15,18). *Figures 1,2* depict device erosion/extrusion via scrotal wall and penile shaft respectively in two patients who underwent successful salvage at our institution. A recent multicenter investigation of patients who underwent surgery for penile prosthesis infections found no correlation between the timing of surgery for infection and responsible microorganisms (35). Therefore, the clinical features of the patient's presentation including their stability and severity of infection should determine whether a patient is a reasonable candidate for immediate salvage surgery, not how quickly the infection developed.

The work-up for suspected penile prosthesis infection should include a thorough physical exam supplemented by laboratory tests and consideration for imaging. A physical exam in search of any obvious skin changes or fluctuance may not reveal any noteworthy findings in a less acute scenario. As such, levels of white blood cell (WBC) count in addition to acute-phase reactants are useful to help complete the clinical picture. Both erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) are known reliable markers for inflammation and should be obtained (36). An increase in WBC and ESR should increase suspicion of an infection (37). Rarely, atypical organisms such as brucellosis can lead to infection and may only be suspected

when inflammatory markers are elevated (38). Imaging by way of ultrasound (US), computerized tomography (scan) or magnetic resonance imaging (MRI) are all reasonable modalities to assess the status of underlying tissue and prosthesis. Imaging findings should be interpreted within the context of the patient's presentation and may include soft tissue stranding/enhancement, fluid collection or gas along the distribution of the prosthesis. In the large majority of cases, a stable patient presents with local wound concerns. Sometimes it is reasonable to initiate a trial of oral or intravenous (IV) antibiotics and monitor closely for clinical improvement or decompensation (39). In the event where symptoms initially resolve with antibiotic therapy but subsequently recur, the diagnosis of infection is confirmed and the patient should be counseled on non-emergent surgical treatment options including salvage surgery.

Preoperative counseling and considerations prior to salvage

Surgeons should have an extensive discussion with their patients regarding advantages, disadvantages, and risks of the available treatment options before surgery. It is important for surgeons to be honest with patients and manage expectations (15,17,18). The known risks in explanting without salvage include corporal fibrosis, loss of penile length, return to complete ED, and more formidable future surgery. Of note, one review found that patient satisfaction with delayed penile implantation attempts were around 58% (40). This is distinctly lower than the 75–98% commonly reported for virgin implants (41). The decision to explant the infected device without salvage replacement of a new prosthetic is always appropriate if the patient does not want another implant.

The risks involved in salvage therapy for an infected device are similar to those in the initial surgery with the exception of increased operative time and higher risk of infection (42,43). As such, cultures should be obtained via wound swab or collection of draining fluid. Patients planning to undergo salvage therapy and device explantation may undergo needle aspiration to obtain cultures as accidental puncture of the inflatable component is no longer a concern in these cases (5). The data obtained from these samples may be beneficial in providing culture-guided antimicrobial treatment long-term and improving antibiotic stewardship. Notably, next-generation sequencing is an emerging modality that may play a pivotal role in more confidently and reliably identifying infectious

culprits on IPP biofilms (44). Prior to salvage therapy, parenteral antimicrobial therapy is an essential component of treatment. The preferred regimen at our institution is piperacillin-tazobactam, vancomycin and fluconazole. This antimicrobial regimen has the broadest coverage for implant-associated infections and has been shown to be efficacious while microbial culture data is pending (45). This broad-spectrum antimicrobial combination combats the causative infection and may concomitantly alter the tissue landscape to a more favorable one for salvage surgery. After a few days of parenteral antibiotics wounds which were otherwise deemed unsalvageable may be appropriate candidates (26,46). If appropriate, inpatient admission for 24–48 hours of parental antibiotics ensures clinical stability and may be followed by transition to oral therapy before delayed surgical intervention. Delay in immediate intervention with an initial period of antimicrobial therapy is often a reasonable approach. After antibiotic therapy, hemodynamic stability, reduced tissue edema, decreased erythema, pain alleviation, or an overall improvement in the patient's clinical condition may suggest their suitability for salvage. Some rare exceptions that may necessitate more immediate intervention may include radiographic evidence of a drainable fluid collection, concern for necrotizing fasciitis or disseminated/rapidly expanding infection in a hemodynamically unstable patient unresponsive to antimicrobials and resuscitation.

Non-emergent salvage provides several other benefits. Among these are the ability to perform an elective procedure during regular hours with a more fully prepared and informed patient, a familiar operative team and if necessary, a device company representative. This short delay in surgery allows time for thorough surgical planning or transfer to a center with a urologist more experienced in prosthetic salvage therapy if needed.

Treatment selection and technique for immediate salvage surgery

Different modifications have been described for immediate salvage surgery with penile prosthesis replacement including replacement with a new IPP or with a malleable prosthesis (19). The original Mulcahy Salvage Protocol employed a seven-step series of antiseptic irrigation solutions using kanamycin/bacitracin, half strength hydrogen peroxide (H₂O₂), half strength povidone iodine (PVI) along with vancomycin and gentamicin pressure irrigation (9). This empiric protocol was employed following

complete device explantation for thorough washout of all areas where the prosthesis was present. An expert panel on management of infected penile prosthesis infections in 2013 agreed unanimously that vigorous irrigation to remove biofilm and microbial presence is essential, but there was no consensus on the optimal irrigation steps or irrigation solutions (47). While no standardized irrigation protocol exists, some authors have reported modified techniques of antiseptic washout during removal and replacement of infected prosthetic with high reinfection-free success rates (>80%) across various cohorts (11,12,14). What's more, there have also been reported successes with salvage surgery without any antibiotic irrigation (48). This begs the question whether antibiotics are necessary during manual irrigation. Either way, the Mulcahy Salvage Protocol irrigation steps originally developed were strictly empiric and not based on antibiotic nomograms or tested on infectious biofilms. It seems that high-volume, catheter directed irrigation serves to disrupt the biofilm and provide a beneficial effect.

Commonly available antiseptic solutions include H₂O₂, PVI, and chlorohexidine gluconate (CHG). Pan *et al.* performed a review in which they outline the cytotoxic effects and antiseptic action of H₂O₂ and half strength PVI (49). Reports indicate that H₂O₂ confers significant *in vitro* cytotoxicity and inferior antimicrobial activity (50). Additionally, experts have noted that the foam produced by hydrogen peroxide can occlude suction and obscure the surgical field. The possibility of a fatal air embolism is also a risk known to H₂O₂ irrigation (50).

PVI on the other hand has shown to counteract a variety of microbes including biofilm formation and there is compelling data to support its use. The currently preferred concentration of 0.35–3.5% is much lower than in the original Mulcahy Salvage solution (49). PVI should be avoided in patients with a documented iodine allergy and its time in implant spaces should be limited to no more than 3 minutes.

CHG is rapidly gaining popularity for its anti-biofilm properties in addition to activity against gram positive and negative bacteria, fungi and selected virus (49). This solution is sold under the trade name, IriSept (Irrimax Corporation, Lawrenceville, GA, USA) and is packaged as a pre-mixed 0.05% CHG solution in a 450 mL bottle for a “jet lavage” style directed irrigation well suited for the surgical spaces of interest. At this time, there is still no consensus on which washout protocol or irrigation solutions is best in these clinical scenarios (47,51–53).

Proven infection lowering techniques should be used in salvage surgery just in the same way they are employed with

virgin implants. These include preoperative antibiotics, use of pre-operative checklist for prosthetic surgery (54), alcohol-based skin prep, minimizing operating room traffic, use of antibiotic-coated prosthetic devices, “no touch” or modified “no touch” technique, irrigation prior to closure, and “mummy wrap” bandaging to decrease swelling and promote healing among others (55). Following the advent of infection retardant coatings in the early 2000s, the device infection rates dropped significantly (34). As such, these reliable devices and techniques should always be employed during salvage procedures with special attention to the additional washout of the corporal, scrotal, and reservoir spaces.

The surgeon must determine what implant to use in the event immediate salvage surgery is undertaken. In order to assist with this, we have summarized these treatment strategies in *Table 4*. In 2009, Kohler and colleagues published their pilot study on MIST (13). Early studies revealed that most patients (up to 70%) opt to maintain their malleable prosthesis (14,19). We acknowledge that a reluctance to attempt another 3-piece implant by be out of a desire to avoid additional surgery. The malleable implant preserves the corporal spaces and since there is no intrascrotal component, further eliminates a source of recurrent infection. What's more, when compared to patients with a two-piece inflatable prosthesis, patients with a malleable prosthesis reported similar outcomes in ease of use, confidence in engaging in sexual activity and meeting the expectations of the patient and partner (56,57). Overall satisfaction rates generally appear highest with the three-piece inflatable implant although rates of mechanical failure are also higher when compared to the malleable prosthesis (56). Others have reported similar satisfaction rates between the malleable prosthesis and the three-piece implant in patients with Peyronies disease and ED (58). In the case of a patient undergoing salvage surgery for an infected prosthetic, the malleable prosthesis becomes an excellent tool to both decrease operative time and provide a lasting solution for ED. Notably, some malleable prosthetics have a hydrophilic coating as is the case with the Coloplast Genesis and the Rigicon Rigi10. This allows the treating surgeon to select their preferred antibiotic dip. With malleable implants, extended corporotomies are recommended to facilitate placement and incisions may be closed with running suture (50). The final component following salvage procedure is the employment of a scrotal drain. Scrotal drains have been shown not to increase risk of infection in prosthesis naïve patients undergoing penile implant surgery (59). At our institution, a Bard 10 French

Table 4 Treatment strategies for management of penile prosthesis infection

Treatment strategy	Advantages	Disadvantages
<ul style="list-style-type: none"> • Penile prosthesis removal only <ul style="list-style-type: none"> - With or without prosthesis reimplantation in ~6–12 weeks • Penile prosthesis removal with immediate replacement with an IPP 	<ul style="list-style-type: none"> • Lowest risk of continued infection because no hardware remains in place • Shorter surgical time than removal with immediate replacement • Allows patient to have continued treatment of ED with an IPP 	<ul style="list-style-type: none"> • Untreated ED and need for another surgery in the future • Corporal fibrosis leads to decreased penile length and more difficult reimplantation • Most extensive surgical option requiring replacement of entire IPP device • Higher failure rate
<ul style="list-style-type: none"> • Penile prosthesis removal with immediate replacement with a malleable penile prosthesis <ul style="list-style-type: none"> - With or without interval surgery to replace malleable prosthesis with an IPP 	<ul style="list-style-type: none"> • Allows patient to use malleable prosthesis for ED as possible definitive treatment, or until replaced by IPP • Prevents corporal fibrosis & loss of penile length • Does not require replacement of scrotal pump, reservoir, or tubing 	<ul style="list-style-type: none"> • Lower patient satisfaction with malleable prosthesis than IPP • Patient would require a second surgery in the future if they desire replacement with an IPP
<ul style="list-style-type: none"> • Antibiotics without penile prosthesis removal <ul style="list-style-type: none"> - With or without excision and drainage 	<ul style="list-style-type: none"> • Less extensive surgery than penile prosthesis removal and replacement • Allows continued treatment of patient's ED • Does not cause corporal fibrosis & loss of penile length • If unsuccessful, other treatment options are still available 	<ul style="list-style-type: none"> • Limited evidence for successful utilization in literature • Many patients are not good candidates for this strategy • If non-surgical treatment is unsuccessful, the patient suffers a delay in definitive treatment

ED, erectile dysfunction; IPP, inflatable penile prosthesis.

Channel Drain is placed using the designated trocar and patients generally remove these at home on post-operative day two. These drains serve to decrease hematoma and seroma formation which is particularly important during these salvage cases given copious irrigation and tissue edema.

Postoperative management after immediate salvage surgery

Routine penile prosthesis implantation is increasingly performed as an outpatient surgery, but patients who require salvage surgery warrant hospital observation prior to discharge. Patients remain in the hospital until systemic symptoms have resolved and intraoperative cultures result. While awaiting culture results patients continue on empiric piperacillin-tazobactam, vancomycin, and fluconazole (45). When feasible, patients are discharged on oral antibiotics. If the intra-operative cultures are resistant to oral antibiotic options, the infectious disease service is consulted and patients continue on parenteral antibiotics (50).

The duration of antibiotics after salvage surgery with

immediate penile replacement is a topic of limited evidence. The initial “Mulcahy Salvage” protocol included a one-month course of post-operative oral antibiotics (10), and other authors similarly used a one-month course of antibiotics for their case series (13). Neither the AUA nor European Association of Urology (EAU) guidelines on sexual dysfunction provide guidance on management after salvage prosthesis surgery (60,61). The current recommendations from the International Consultation on Sexual Medicine stated that they could not make a recommendation on length of postoperative antibiotic regimen (5). In the North American Consensus Document on Infection of Penile Prostheses, all experts agreed patients should receive 2–4 weeks of post-operative antibiotics based on intraoperative culture results. Our institution uses a two-week course of antibiotics after salvage surgery, and in 2020 published that this resulted in an excellent infection-free success rate of 92% despite expanded salvage criteria (17). Antibiotics should be prescribed for the shortest effective duration (62), we propose that patients should be given a two-week course of culture directed post-operative

antibiotics unless there is an indication for a longer course (e.g., delayed wound healing or immunocompromised). Where culture data is negative, we prescribe a two-week course of trimethoprim/sulfamethoxazole (standard dosage 800 mg/160 mg) twice daily and amoxicillin/clavulanic acid (standard dosage 875 mg/125 mg) twice daily for antimicrobial coverage. Patients may be seen in follow up at this two-week post-operative time point for wound check and to determine whether further antimicrobial therapy is warranted. Following this visit, subsequent follow up would be determined on a case-by-case basis but generally at increasing time intervals until full recovery based on provider preference.

Conclusions

The results of the review search were limited to articles written in English and it is possible articles in other languages or databases were not captured for review. It is also important to recognize that even with our outlined steps for management of an infected prosthetic, not all settings provide the capacity and support to admit and monitor patients. Additionally, a level of expertise and comfort with removal and replacement of a penile prosthetic is necessary for this approach to be feasible, otherwise referral to a specialized center or reconstructive urologist serves at the best next step in management. Future research and multi-institutional trials are necessary to determine the optimal timing of surgery, antimicrobial treatments and salvage techniques. That said, infection will continue to be an ever-present risk and immediate salvage is safe and effective. It is our hope that prosthetic surgeons will adopt a structured and reproducible approach to salvage surgery that better utilizes this essential technique.

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Footnote

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Reporting Checklist: The authors have completed the

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All clinical procedures described in this study were performed in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patients for the publication of this article and accompanying images.

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