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Infection Prevention Considerations for Complex Penile Prosthesis Recipients

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Abstract

Purpose of Review The purpose of this review is to critically analyze and summarize recent studies in the area of penile prosthesis surgery outcomes with a focus on infection prevention in high-risk patients.

Recent Findings Reduction of surgical time in complex prosthesis surgery may reduce infection risk. Concomitant implant surgery is not associated with increased infection risk. Certain immunocompromised patients may be more likely to have penile implant infections, but these may not include patients with well-controlled HIV, well-controlled diabetes, or transplant recipients. Substance abuse is correlated with increased risk of infection after penile implant surgery. Careful patient selection and preoperative optimization can reduce infection risk in spinal cord injury patients.

Summary In the last 5 years, there have been several important studies investigating the risk of penile prosthesis infection in complex patients, clarifying which patient categories are at increased risk and how that risk can be mitigated.

Keywords Penile prosthesis · Penile prosthesis infection · Diabetes · Biofilm · Erectile dysfunction · Revision surgery

Introduction

Penile prosthesis infection remains a rare but devastating complication of urologic prosthetic surgery that results in loss of sexual function, increased healthcare costs, and physical and emotional morbidity for patients [1, 2]. The modern era of inflatable penile prosthesis surgery dates to 1973 [3], yet there remain no firm guidelines to assist in identifying patients at high risk for infection or to mitigate risk. Upwards of 25,000 penile prostheses are implanted yearly in the USA and improvements in device durability as well as infection-retardant

coatings have reduced the incidence of infection and created a 10-year survival for penile prostheses of 90% [4, 5]. Despite these advancements, penile prosthesis infections continue to occur and the rates of infection may be underreported for several reasons. These include the voluntary nature of infection reporting, the inability to capture data when salvage procedures are performed at hospitals different from the primary implant surgery, or when salvage is performed using devices of a different brand from the primary implant [6, 7•]. Surgeons and device manufacturers have explored a variety of methods to reduce infection risk for all patients and concerted efforts have been made in the literature to identify which patient groups are at highest risk.

In this review, we critically analyze the available literature on penile prosthesis surgery in complex patients with a focus on infection risk. We identify which patient groups are at increased risk as supported by the literature and which complex surgical patients may no longer be considered at increased risk of penile prosthesis infection. We summarize the potential measures that can be taken to reduce infection risk in these specific patient groups based on the limited number of studies available (see Table 1) and discuss the need for larger prospective studies that could allow prosthetic surgeons to formalize guidelines for the prevention of penile implant infections.

This article is part of the Topical Collection on *Surgery*

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Table 1 Penile implant infection risk prevention by high-risk patient group

Patient group	Suggested risk reduction strategies
Complex surgery • Penile implant revision/salvage • Reconstruction/Peyronie's disease • Female-to-male transgender • Concomitant artificial urinary sphincter	• Reduce operative time [8] • Irrigation to remove biofilm [9] • No-touch technique [10] • Prepare grafts in advance [8] • Reduce hematoma risk (closed suction drain, compressive dressing, partial cylinder inflation) [11]
Polysubstance abuse [12••]	• Careful patient selection, caution if injection drug user • Smoking cessation, if possible • Drug cessation and counseling
Immunocompromised	• Careful patient selection • If HIV positive, confirm on antiretroviral therapy with good CD4 count (no threshold established) [13••]
Diabetes mellitus	• Consider hemoglobin A1C threshold (e.g., < 8.5%) [14••] • Consider perioperative serum glucose threshold (e.g., < 200 md/dL) [12••] • Antifungal perioperative prophylaxis [15]
Spinal cord injury	• Careful patient selection • Achieve negative preoperative urine culture [8] • Optimize bladder control/avoid indwelling catheters • Patient education on skin integrity exams and early treatment of genital wounds

Complex Surgery

The risk of postoperative infection in primary penile implants is estimated at 1–3%, and the risk for revision surgery on a previously placed implant can potentially approach 18% [16–18]. The predisposing factor in this situation is the presence of biofilm on the primary device [17, 19]. Removal of the indwelling device disrupts this biofilm and allows previously sequestered bacteria to adhere to the new implant [9]. Even in clinically uninfected prostheses, device surface cultures are routinely positive for biofilm and demonstrate skin flora (the most common causative pathogens in penile implant infections) in 70% of cases [20••]. Additionally, the avascular nature of the primary implant's capsule may reduce the penetration of intravenous antibiotics and immune system mediators once the new implant is seated within the existing capsule. One means of mitigating this risk is copious irrigation of the surgical site immediately following explant of the primary device as this can remove residual biofilm.

As with all implant surgeries, bleeding and hematoma formation should also be mitigated when possible. The incidence of hematoma in penile implant surgery ranges from 0.2 to 3.6% and theoretically blood products can serve as a source of nutrients for thriving infections [11]. Measures to reduce hematoma formation include watertight corporotomy closures, use of hemostatic agents, compressive dressing partial cylinder inflation, and closed suction drainage. Closed suction drainage has remained a topic of heated debate among implanters as it is thought that the placement of a drain may itself be a source of infection as identified in non-urologic literature [11]. Proponents of drain cite studies show no increased infection risk when a drain is placed [15], but no randomized controlled studies have yet been performed to add clarification.

Penile implant surgeries with concomitant reconstructive procedures carry a greater risk of postoperative infection. In one study comparing primary implants, revision cases for mechanical malfunction, and patients requiring corporal reconstruction for Peyronie's disease, fibrosis, or neophallus for transgender patients, the rates of postoperative infection were 1.8%, 13.3%, and 21.7%, respectively [8]. The author concluded that the most important variable between these groups that altered infection risk was increased operative time. The mean primary implant operative time in the series was 98 ± 37 min, compared with 110 ± 25 min for revision for mechanical malfunction and 225 ± 71 min for complex reconstruction. Longer operative time increases the exposure time of the tissues and the implant to the environment. There may also be increased manipulation of the genitals by the surgeon during implant placement, thus potentially increasing contact with skin surfaces and the introduction of bacteria into the wound. Additionally, reconstructive surgery in the presence of tissues with decreased viability such as fibrosis may reduce perfusion and accessibility of intravenous antibiotics and immunologic response to infection [21]. Prevention strategies that are relevant in these cases include minimizing skin contact (e.g., no-touch technique), as well as ensuring operative time is minimized by preparing grafts in advance and confirming instrument counts [10].

Another common scenario in which surgical complexity and operative time are increased is in the dual implantation of a penile prosthesis and artificial urinary sphincter (AUS). The presumed benefit of dual implant surgery in appropriate candidates is omitting the need for a second prosthetic procedure in which the surgeon may disrupt indwelling biofilm or encounter fibrotic tissue [22]. Multiple small case series, however, have been published demonstrating no apparent increase in postoperative infection [22–24]. A more recent larger-scale retrospective study confirmed this, comparing 55 dual implant surgeries with 336 single-device penile implant surgeries and 279 single-device AUS surgeries. At a single institution with high-volume implanters, there was no significant difference between combined surgery and single implant surgery in terms of infection rates, malfunction, and erosion [25••]. Dual implant surgery does increase operative time and

complexity, with mean operative time in one study of 113 min compared with 78 min for penile implant and 72 min for AUS [26]. In theory, taking measures to reduce operative time can only further mitigate infection risk.

The Substance Abuse Patient

Until recently, the impact of substance abuse on penile implant infection risk was not well understood. The orthopedic literature shows that patients who abuse opioids or engage in illicit intravenous drug use are at increased risk of both immediate surgical site infection and delayed infection due to prosthetic seeding [27, 28]. Alcohol abuse is also an established risk factor for periprosthetic joint infection [29]. Patients who chronically abuse drugs are more likely to have compromised nutritional status and immunity, and higher rates of bacteremia for intravenous drug abusers in particular [30, 31]. In 2016, Balen et al. published the first study to investigate penile implant infection risk in patients with active drug abuse [12••]. This was a retrospective analysis of 602 primary inflatable implant procedures performed by a single surgeon with a postoperative infection rate of 2% for these cases. Patients without postoperative infection were similar to patients who did experience infection in terms of mean age, surgical prep used, and postoperative drain placement. Polysubstance abusers were found to have a ninefold higher probability of postoperative infection compared with those patients who did not abuse multiple substances at the time of surgery. Interestingly, this study also examined several other factors and found that serum glucose > 200 mg/dL at the time of surgery and homelessness were both positively correlated with increased risk of infection, fivefold and 12-fold, respectively. Although the study had a small sample size (infection in 12 of 602 patients), it represented the first and thus far only study to examine the impact of substance abuse on penile prosthesis surgical outcomes. Careful patient screening and preoperative optimization have improved outcomes, for example, in the field of bariatric surgery [32], and it stands to reason that penile implant surgeons should consider not only medical comorbidity but also patient social history in the careful selection of penile implant candidates.

The Immunocompromised Patient

The available literature on infection rates among medically immunosuppressed patients is limited. Wilson and Delk conducted a retrospective review of over 1300 patient charts and found that 50% of patients with a penile prosthesis on immunosuppressive therapy for chronic diseases such as leukemia, lupus, chronic obstructive pulmonary disease, and rheumatoid arthritis developed implant infections. On the contrary, none

of the patients in the cohort who were immunosuppressed for a history of solid organ transplant developed infections [17]. It may be that patients with chronic diseases such as those listed above are overall in worse health than transplant recipients, leading to this disparity. Other studies have shown similar findings regarding transplant recipients, including 46 patients who underwent penile implant after solid organ transplant with a mean follow-up of 2 years. In this series, the incidence of infection was no different than for patients without organ transplant [33]. In 2018, a retrospective study with non-transplant age-matched controls demonstrated no significant increase in postoperative device infection in transplant recipients with 30 months of mean follow-up, even though transplant recipients were more likely to have peripheral vascular disease, history of stroke, and diabetes [34••]. Based on these limited data, it is still reasonable to consider transplant recipients on immunosuppression as potentially good candidates for penile prostheses. The available studies are not powered sufficiently to suggest transplant recipients are at no increased risk despite the use of immunosuppressive medication, but these few small series have encouraging results.

HIV-positive patients represent another population of potentially immunocompromised patients. Again, data is sparse in the literature. In 2018, a large-scale cross-sectional analysis of the Premier Perspective Database examined risk factors for penile prosthesis removal in 5085 implants placed between 2003 and 2015. HIV-positive status was significantly associated with device removal due to infectious complication [13••]. While HIV-positive patients on appropriate antiretroviral therapy with undetectable viral titers and appropriate CD4 counts should be considered reasonable candidates for implant surgery, care should be taken to counsel these patients on a potentially increased risk of long-term infectious complication.

The Diabetic Patient

Historically, prosthetic surgeons have considered the diabetic patient as high risk for penile prosthesis infection, despite conflicting data in the literature. Recent literature has generated a more nuanced appreciation for the impact of diabetes on penile prosthesis outcomes. In 1992, a study of 90 implanted patients, five were diabetic and four of those five had hemoglobin A1C levels greater than 11.5% [35]. This raised the possibility that poorly controlled diabetics may be at higher risk than those whose disease is well managed. A larger-scale study of 40,000 primary prosthetics from a manufacturer database determined that diabetic patients were significantly more likely to have revision surgery as a result of infection at 7 years, but it is important to note that these data were obtained via voluntary patient response forms [36].

Currently, the majority of studies reporting on diabetic patient outcomes demonstrate no significant increased infection risk for primary implant procedures [17, 37–39]. Wilson and colleagues published a prospective study of 389 patients undergoing penile implant surgery and found no significant association between A1C level, fasting glucose, or insulin dependence on infection risk [39]. A larger retrospective study of 1337 consecutive implants by Wilson and Delk found no significant difference in infection rates between diabetic and non-diabetic patients undergoing primary implant surgery. This study, however, did reveal an increased rate of infection for diabetic patients when undergoing a revision implant surgery (8% in non-diabetics, compared with 18% for diabetic patients) [17]. In 2018, Habous et al. reported a multicenter prospective study of 902 implant procedures confirming that poorly controlled diabetes is indeed a risk factor, and that risk is directly correlated with hemoglobin A1C level [14••]. The authors determined that an A1C threshold of 8.5% could predict infection with 80% sensitivity and 65% specificity leading them to recommend a hemoglobin A1C threshold of 8.5% for risk stratification and patient selection in the clinical setting.

Others have reported the potential for perioperative glycemic control to perhaps be a more important indicator of risk. Balen et al. published a retrospective study of 602 patients undergoing penile prosthesis surgery at one center with 12 infections. Diabetic patients with A1C < 6% but with a serum glucose level > 200 mg/dL at the time of surgery were fourfold more likely to have postoperative infection than those with serum glucose < 200 mg/dL perioperatively [12••]. Ultimately, a large-scale, prospective and multi-institutional study would be needed to definitively identify diabetes as a risk factor for primary penile implant surgery and which laboratory measures or patient characteristics best allow for risk determination.

Pathogenic organisms may also differentiate diabetic patients from those without diabetes and thus change perioperative antimicrobial prophylaxis. Cotta et al. published two case reports of insulin-dependent diabetic patients presenting with penile prosthesis infections found to be caused by *Candida* species [40]. The authors suggested the use of antifungal prophylaxis in device coatings, dips, and washout irrigation solutions at the time of prosthetic surgery in diabetic patients. In a seminal retrospective multi-institutional study of penile implant salvage procedures by Gross et al. [20••], 227 explanted prosthetics were cultured to identify causative organism. It was determined that 33% of explanted devices were culture-negative, 25% were cultured for multiple organisms, and interestingly 11% of cultures grew *Candida* species. The authors speculated that fungal species may be a more common cause of penile prosthesis infection in diabetic patients, though the study design was not intended to capture that data. The study does however suggest the potential role for antifungal prophylaxis for primary and revision implant surgery,

particularly in patients who may be at increased risk such as diabetics or the immunocompromised. The choice to use antifungal or other special prophylaxis specifically for diabetic patients remains at the discretion of the surgeon, and no specific societal guidelines currently exist that address this.

The Spinal Cord Injury Patient

Patients with spinal cord injuries (SCI) are generally thought to be at higher risk for penile prosthetic infection for a variety of reasons. These include changes in tissue perfusion, increased risk of urinary tract infection due to indwelling or intermittent catheterization as well as neurogenic voiding dysfunction, and diminished skin sensation that may lead to delayed diagnosis of early infection or erosion. Several studies have reported on infection rates in patients with SCI, with variable results. Zermann et al. reported an infection rate of 5% in 245 SCI patients status post penile prosthesis placement with a mean follow-up of 7.2 years [41]. In Wilson and Delk's [17] retrospective series of 1337 implant recipients, 66 of these were SCI patients. Infection occurred in 6 (9%) of these patients compared with 1% for non-SCI patients. Jarow reported no infections in his 1996 series which included 24 SCI patients, attributing this to a strict requirement for negative preoperative urine cultures [8]. This population may be best served by increased vigilance on the part of both the patient and surgeon for breaks in skin integrity, adherence to negative urine cultures before surgery, and optimization of bladder management.

Conclusions

Penile prosthesis infections are devastating to patients and also to prosthetic surgeons. Recent literature has shed light on which patient groups are at increased risk, allowing surgeons to better select appropriate candidates for penile prosthesis surgery, optimize their patients, and mitigate risk of penile prosthesis infection. There remains a need for large-scale, prospective, multi-institutional studies that will bolster efforts to reduce the incidence and impact of penile prosthesis infection.

Compliance with Ethical Standards

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