ABSTRACT

Introduction: The preferred treatment for inflatable penile prosthesis (IPP) infection includes antibiotic therapy, device removal, and immediate replacement. While this is an accepted procedure, the delivery and length of postoperative antibiotics are not standardized. Furthermore, historical salvage criteria may be overly restrictive given the new salvage techniques.

Aim: Our aim is to determine if an expanded salvage criteria and shorter course of antibiotics demonstrate acceptable IPP infection rates.

Methods: We retrospectively reviewed 466 consecutive IPP cases from a single surgeon between March 2014 and March 2019. Salvage and reinfection were determined by current procedural terminology codes, and the final cohort was individually reviewed for integrity. Demographic, operative, and culture data from each patient were obtained. All patients were discharged on oral antibiotics after initial salvage. Patients were not excluded for exposed hardware, immunosuppression, tissue necrosis, severe diabetes, or corporal purulence. Owing to the small sample size, only descriptive statistics were used to describe the final cohort.

Main Outcome Measures: The main outcome measures were classification of microorganisms cultured at the time of salvage and salvage failure rate.

Results: A total of 26 cases of IPP infections (6%) were identified. The median (interquartile ratio) age and body mass index were 62 (58–66) and 32 (28–34), respectively. During initial salvage, gross purulence was noted in 9 patients (35%), and 22 patients (84%) had a malleable prosthesis placed. The most prescribed postoperative antibiotic was Bactrim/Augmentin with a median (interquartile ratio) antibiotic duration of 14 days (11–14). After IPP salvage, 2 patients (8%) developed a reinfection while on oral antibiotics. One of those patients was immunosuppressed, and the other was infected with Candida glabrata.

Conclusion: Expanded salvage criteria and postoperative oral antibiotic duration of at least 14 days demonstrated an acceptable infection rate. This suggests that a longer antibiotic therapy may not be necessary. Chandrapal J, Harper S, Davis LG, et al. Penile Implant Infection: Experience With Expanded Salvage Criteria and a Shortened Course of Postoperative Antibiotics. Sex Med 2020;8:383–387.

Key Words: Erectile Dysfunction; Penile Prosthesis; Infection; Salvage; Antibiotics
replacement. This technique is preferred to explantation because it minimizes corporal fibrosis and penile shortening.2–6

After IPP salvage, postoperative antibiotics are recommended; however, there is considerable variability regarding route and duration. Much of the current practice is based on the orthopedic implant literature, which recommends prescribing oral antibiotics for 28 days or intravenous (IV) antibiotics for 6–8 weeks after prosthetic joint infection.7–9 Our standard protocol is 14 days of broad-spectrum oral antibiotics which are adjusted as culture results return. This shorter duration of oral antibiotics has not been previously characterized in postsalvage patients. Therefore, the aim of this study is to determine infection rates with a shorter course of postsalvage antibiotics.

**MATERIALS AND METHODS**

**Patients**

We performed a retrospective review of IPP cases from a single surgeon at our institution from March 2014 to March 2019. IPP salvage was queried using current procedural terminology (CPT) codes 54,411 or 54,417. Postsalvage infection was defined by another salvage procedure or explantation without replacement for infectious reasons using CPT codes 54,406, 54,415, 54,411, or 54,417. Within in the final cohort, each patient’s outpatient, inpatient, operative, and wound cultures were individually reviewed for integrity and outcomes of interest.

**Antiseptic Techniques and Culture Collection**

Patients with suspected IPP infections were either taken to operating room the day of presentation or admitted to the hospital and taken to surgery the next day. All patients were placed on empiric or preoperative antibiotics before surgery. Our standard empiric antibiotics for salvage cases consist of IV vancomycin, piperacillin/tazobactam, and fluconazole. The operative field was prepped with a chlorhexidine scrub followed by chlorhexidine- and alcohol-based paint. The Mulcahy salvage protocol consisted of culture and removal of all components of the infected implant, thorough washout with stepwise antiseptic irrigants, and change in all gloves, gowns, drapes, and instruments.5–10 Our salvage irrigation protocol for this study consisted of the following in order: bacitracin irrigation, half-strength Betadine (Avrio Health, New York City, NY), antibiotic irrigation, half-strength Betadine, and bacitracin irrigation. The bacitracin irrigation was 50,000 units per 1 L of saline. The antibiotic solution consisted of 50 mg of amphotericin B, 1 gm vancomycin, 3.375 gm piperacillin/tazobactam, and 1 L of saline. With the recent Food and Drug Administration withdrawal of injectable bacitracin in January 2020, we have changed our irrigation protocol to 0.05% chlorhexidine gluconate in sterile water (Irisipept; Innovation Technologies, Lawerenceville, GA), 1% Betadine solution, antibiotic irrigation, 1% Betadine solution, and dilute chlorhexidine gluconate (Irisipept). Irrigation was performed through a catheter and was directed into the corpora (proximally and distally), the reservoir space, and pump space. The salvage prosthesis was then placed. All noncoated implants were dipped in a solution of gentamicin and rifampin or a solution of vancomycin/amphotericin B/piperacillin-tazobactam. Patients were admitted to the urology service and discharged on postoperative day 1. Antibiotic selection at the time of discharge was based on culture data when available via scrotal aspiration or intraoperative cultures. In the cases when culture results were not finalized at the time of discharge, patients were discharged on 2 oral broad-spectrum antibiotics which were narrowed once culture sensitivities were finalized.

**Analysis**

Owing to the small cohort size, only descriptive statistics were performed.

**RESULTS**

During this time period, a total of 466 IPP cases were performed. Within this group, 411 cases were excluded based on

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Table 1. Patient demographics, previous history, and discharge antibiotics after surgery

|                                      | N/Median | Interquartile range |
|--------------------------------------|----------|---------------------|
| Total number of infections           | 26       |                     |
| Number of infections after salvage   | 2 (8%)   |                     |
| Age (years)                          | 62       | 58–66               |
| Body mass index                      | 32       | 28–34               |
| Ethnicity                            |          |                     |
| White                                | 13 (50%) |                     |
| Black                                | 11 (42%) |                     |
| Hispanic                             | 1 (4%)   |                     |
| No response                          | 1 (4%)   |                     |
| Comorbidities                        |          |                     |
| Diabetes                             | 11 (42%) |                     |
| Hypertension                         | 18 (69%) |                     |
| Charlson Comorbidity Index           | 3        | 2–5                 |
| History of radiation                 | 3 (12%)  |                     |
| Immunosuppression                    | 1 (4%)   |                     |
| Number of previous pelvic urologic surgeries | 2   | 1–2                 |
| Postoperative oral antibiotics       |          |                     |
| Augmentin/Bactrim                    | 9 (35%)  |                     |
| Bactrim/rifampin                     | 5 (19%)  |                     |
| Fluoroquinolone                      | 5 (19%)  |                     |
| Augmentin                            | 3 (12%)  |                     |
| Bactrim                              | 2 (8%)   |                     |
| Cephalexin                           | 1 (4%)   |                     |
| Clindamycin                          | 1 (4%)   |                     |
| Duration of oral antibiotics (days)  | 14       | 11–14               |
Infection After Prosthesis Salvage

| Table 2. Type of prosthesis infection and implants used for salvage |
|-------------------|-----------------|
|                    | N/Median        |
| Exposed hardware   | 4 (15%)         |
| Intraoperative purulence | 9 (35%)         |
| Explanted prosthesis |                |
| Coloplast Titan    | 17 (69%)        |
| AMS 700CX          | 7 (27%)         |
| AMS 700LGX         | 1 (4%)          |
| AMS (unspecified)  | 1 (4%)          |
| Salvage prosthesis |                 |
| Coloplast Genesis  | 19 (63%)        |
| AMS Spectra        | 3 (12%)         |
| Coloplast Titan    | 2 (8%)          |
| AMS 700 LGX        | 1 (4%)          |
| AMS 700 CX         | 1 (4%)          |
| Malleable          | 22 (84%)        |

CPT codes because of nonsalvage prosthetic surgeries. Of the 45 cases remaining, we excluded 19, based on individual chart review as these patients did not undergo salvage despite their CPT code classification. Exclusion of these patients consisted of mechanical malfunction with removal/replacement, IPP revision, primary explantation, or drainage of a culture negative seroma or hematoma without direct prosthesis manipulation.

The final cohort consisted of 26 salvage cases (Table 1). The median age and body mass index of this group were 62 and 32, respectively. Hypertension and diabetes were present in 18 (69%) and 11 (42%) patients, respectively. The median Charlson Comorbidity Index score was 3. Three patients had a previous history of radiation, which was performed before implant surgery for biochemical recurrence of prostate cancer. One patient was considered immunosuppressed from daily use of oral azathioprine. Most patients were discharged on a combination of Augmentin/Bactrim (n = 9, 35%), Bactrim/rifampin (n = 5, 19%), or a fluoroquinolone (n = 5, 19%) for a median duration of 14 days.

Four patients (15%) had exposed hardware, and 9 (35%) had purulence identified in the operative field at the time of salvage (Table 2). Twenty-two patients (84%) were salvaged using a malleable prosthesis, with Coloplast Genesis implantation in 19 (63%) of these patients.

Cultures obtained at the time of initial salvage grew gram positive, gram negative, and fungal organisms in 29 (81%), 5 (14%), and 2 (5%) patients, respectively. 8 patients (31%) had polymicrobial cultures. When these cultures were speciated, coagulase negative Staphylococcus, Diptheroids, and Staphylococcus aureus were the most prevalent and isolated in 22%, 14%, and 14% of cultures, respectively. Gram negative microorganisms consisted of Morganella, Fusobacterium, Escherichia coli, Pseudomonas fluorescens, and Klebsiella pneumonia, all at 3% each. 2 patients had positive fungal cultures, Candida glabrata and albicans (Figure 1).

Of the 26 patients who underwent IPP salvage, 2 patients (8%) developed subsequent infections and underwent explantation (Table 3). Age and associated comorbidities of this group were similar to the patients with a successful salvage. Patient 2 was diabetic; however, he demonstrated normal blood glucose levels before implantation and salvage. Patient 1 was the only patient on oral immunosuppression with azathioprine for Crohn’s disease at the time of salvage, and patient 2 had undergone 6 prior prosthetic genitourinary surgeries. Patient 1 received a 3-piece inflatable implant, and patient 2 received an AMS Spectra malleable prosthesis (Boston Scientific, Marlborough, MA). As for cultures, patient 1’s culture grew fluoroquinolone-sensitive S. aureus and developed a secondary infection approximately 3 months after a 28-day course of ciprofloxacin. Patient 2, on the other hand, was the only patient in the cohort whose culture grew Candida glabrata and was reinjected 19 days later. After his second procedure, he was discharged on antifungals. This occurred before we initiated a preoperative IV antifungal and antifungal irrigation for salvage cases.

**DISCUSSION**

Our study demonstrates a successful salvage rate of 92% with a shortened course of postoperative antibiotics. Before salvage, 4 patients (15%) had hardware exposure, and 9 (35%) had purulent infections. As expected, the most common microorganisms from the infected hardware were gram positives, but there were some gram negative and fungal elements present. After surgery, the most prescribed oral antibiotics at discharge were a 14-day course of Augmentin/Bactrim, Bactrim/rifampin, or fluoroquinolones. Further analysis of the patients who developed infections after salvage demonstrated that one patient was the only one in the cohort on immunosuppression, and the other had an extensive urologic history and C. glabrata infection.

Since the initial infection rate of 18% reported in the earliest salvage data, implant technology has advanced in the last
Table 3. Descriptive information of the 2 patients that developed an infection after salvage

|                      | Patient 1 | Patient 2 |
|----------------------|-----------|-----------|
| Age (years)          | 61        | 66        |
| Body mass index      | 28        | 35        |
| Diabetes             | No        | Yes       |
| Hypertension         | Yes       | Yes       |
| Charlson Comorbidity | 5         | 5         |
| Index                |           |           |
| Previous urologic    | 1         | 6         |
| surgery              |           |           |
| Previous radiation   | No        | No        |
| Immunosuppression    | Yes       | No        |
| Exposed hardware     | No        | No        |
| Intraoperative       | No        | No        |
| purulence            |           |           |
| Explanted prosthesis | AMS 700 LGX | AMS 700 LGX |
| Salvage prosthesis   | AMS 700 LGX | AMS Spectra |
| Primary salvage      | Ciprofloxacin | Ciprofloxacin |
| discharge antibiotics |           |           |
| Primary salvage      | 28        | 5         |
| antibiotic duration  |           |           |
| Culture at initial   | Staphylococcus aureus* | Candida glabrata |
| salvage              |           |           |
| Culture at second    | Group B Strep | Candida glabrata |
| salvage              |           |           |
| Days between         | 92        | 19        |
| surgeries            |           |           |

*Sensitive to fluoroquinolones.

20 years. Antibiotic coatings and hydrophilic layers decrease bacterial adhesion and have reduced infections when compared with nonantibiotic or non–hydrophilic-coated implants in both initial and salvage settings. In addition, surgical technique has also evolved. While the original Mulcahy salvage replaced the infected prosthesis with an IPP, many prosthetic urologists now prefer replacement with a malleable prosthesis. This technique, initially described by Kohler et al in 2009 allows for preservation of the corporal space and lowers the risk of infection by reducing the amount of implanted hardware, obviating the need for scrotal manipulation, and providing another opportunity to disinfect the implant field if subsequent IPP placement is desired. Subsequently, Gross et al published a retrospective, multicenter study looking at salvage outcomes in 58 patients with malleable prostheses, reporting an infection rate of 7%. Our infection rate after salvage of 8% is comparable to that in these studies and consists of expanded salvage criteria which include patients with exposed hardware, tissue necrosis, purulence on the device, purulent infections in diabetic patients, or severe diabetes that were traditionally excluded from salvage. These traditional salvage criteria do not reflect the improvements in implant design, surgical technique, corporal irrigation protocols, and perioperative antibiotics that have been implemented since the initial recommendation. A previous case series by our group found that patients with type 2 insulin-dependent diabetes mellitus and purulent infections did not develop subsequent infections 15–39 months after salvage. Taken together, the utilization of expanded salvage criteria provides a safe and effective treatment in these high-risk patients.

In our study, most organisms cultured at the time of salvage were gram positives, but some gram negatives and fungal elements were appreciated. Infection with gram positive organisms is not unusual given many of these organisms colonize on the skin, and this is consistent with the literature. The emergence of gram negative and fungal infections appears to be a trend. Gross et al performed one of the largest multicentered studies of microorganisms cultured from 227 intraoperative samples from IPP salvage or explantation and found 39% gram negative bacteria and 11% fungi. In addition, a more recent multi-institutional study described an IPP fungal infection rate of 12% and that the infection was more likely to occur in diabetic or overweight patients. The current American Urologic Association guidelines do not recommend fungal coverage for IPP surgery; however, based on the current data, we use IV fluconazole before IPP salvage and amphotericin B in our irrigation solution.

Although many standard antiseptic techniques are used in IPP surgery, limited information regarding recommendations for antimicrobial therapy at discharge currently exists. Owing to the greater number of procedures reported in the orthopedic implant literature, many current IPP antimicrobial practice patterns follow the orthopedic standards for infection, which can range from 28 days of oral antibiotics to 6 weeks of systemic antibiotics after prosthesis infection. Specific to IPP infections, Darouiche looked at surgical implant infections and recommended 10–14 days of systemic antibiotics for uncomplicated infections after salvage but did not define complicated infections or route of administration. We generally prescribe an antibiotic duration of 14 days, which produced a success rate consistent with longer term protocols. Therefore, the need for IV or prolonged oral antibiotics may be obviated.

Our study is novel in that we reported IPP salvage outcomes using both expanded salvage criteria and a shortened duration of home antibiotics. Despite this, our study has several limitations. The retrospective nature of the study precludes us to definitely state that a shorter postoperative antibiotic course has equivalent postsalvage infection rates to IV antibiotics or prolonged antibiotic therapy. Another limitation of retrospective analysis is the validity of the data. Patients who underwent initial salvage at our institution could have presented to another hospital with a subsequent infection. However, this is unlikely as our electronic health record system receives information from outside hospitals which was included in our review. A limitation of the electronic health record system is that abstracted information may be subject to incorrect coding or mislabeling. To ensure validity, we evaluated each chart within the salvage cohort for data integrity. Furthermore, our study was limited and underpowered by the
small cohort of patients with IPP infections requiring salvage. This reflects the overall low prevalence of IPP infections, and further stratification of this cohort results in smaller sample sizes. In addition, though most patients were prescribed 14 days of postoperative antibiotics, poor compliance may have affected the total duration of treatment. Our results may not be generalizable to a broader population, as our study was a single-institution and surgeon study.

Future directions for this study include expansion of this retrospective study to a multiinstitutional phase to account for the low disease prevalence and to increase study power.

CONCLUSION

IPP salvage with expanded salvage criteria and a 14-day course of postoperative oral antibiotics was successful in 92% of patients. This may obviate the need for prolonged or IV antibiotic therapies and reduce the incidence of severe corporal fibrosis after infection. Further multiinstitutional and prospective studies are needed to verify these findings.

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