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Infection/Inflammation

REVISION WASHOUT DECREASES PENILE PROSTHESIS INFECTION IN REVISION SURGERY: A MULTICENTER STUDY

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ABSTRACT

Purpose: Reoperation of penile implants carries a higher risk of infection (7% to 18%). Positive cultures and visible bacterial biofilm have been shown to be present on clinically uninfected inflatable penile prostheses (IPPs) at revision. A salvage irrigation protocol has proved to rescue patients with a clinically infected IPP. During revision surgery for noninfectious reasons we investigated washing out the implant space at revision surgery and using an antibiotic coated replacement prosthesis to determine if it would decrease subsequent infection rates.

Materials and Methods: At 3 institutions 183 patients with a penile prosthesis underwent revision surgery for noninfectious reasons between June 2001 and October 2003. Of these patients 140 had the entire implant removed and then underwent antiseptic solution lavage of the implant spaces (revision washout), followed by replacement with a 3 piece IPP. This revision washout is a modification of the original Mulcahy salvage procedure. In the remaining 43 patients the implant was removed but they did not undergo antiseptic irrigation before replacement with an antibiotic coated IPP. Patients were followed for 6 to 33 months, while observing for failure.

Results: Four of the 140 patients (2.86%) who underwent removal of the entire implant with irrigation of the implant spaces with antiseptic solutions and replacement with an IPP have had infection. In the remaining group 5 of the 43 patients (11.6%) who did not undergo antiseptic irrigation had infection. The difference was statistically significant at the 5% level (Fisher's exact test $p = 0.034$).

Conclusions: Early results of combining complete implant removal and modified salvage protocol indicate a markedly decreased incidence of infection in patients with a penile prosthesis undergoing revision for noninfectious reasons.

KEY WORDS: penis, prostheses and implants, impotence, infection, bacteria

Prosthetic devices are a well established form of treatment for medically refractory erectile dysfunction. Postoperative infection is the most feared complication of genitourinary prosthetic surgery. While the incidence of infection during the original implant is only 1% to 3%, revision surgery carries a 7% to 18% risk.[1–6] It is believed that in most cases of infection associated with primary implantation bacteria are introduced at surgery.[7,8]

In 1995 Licht et al reported that 43% of penile prostheses and 36% of artificial urinary sphincters cultured organisms from clinically uninfected devices during revisions.[2] In 2003 our group reported that culture positive bacteria were found in 54 of 77 patients (70%) with clinically uninfected penile prostheses at reoperation.[9] We also noted that several patients had visible biofilm despite no signs of clinical infection preoperatively. In 2003 Silverstein et al used scanning laser microscopy and noted that all 7 inflatable penile prostheses (IPPs) removed for mechanical failure had bacterial biofilm on the implants.[10] The new InhibiZone antibiotic coating of the AMS 700 penile prosthesis (American Medical Systems, Minnetonka, Minnesota), a combination of rifampin and minocycline, on the outside of IPPs has been shown to decrease infection rates for primary implantation surgeries.[11]

Salvage rescue by vigorously washing out the implant space with an antibiotic irrigation protocol has been shown to be effective in cases of infected IPPs.[12] Since bacterial biofilm is present on the IPP in most patients at revision surgery, we evaluated antiseptic washout and replacement with an anti-

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biotic coated prosthesis at revision surgery to determine if the infection rate would decrease.

MATERIALS AND METHODS

The study consisted of 183 patients who underwent reoperation of a penile prosthesis at 3 centers between June 2001 and October 2003. Patients underwent revision or explantation/replacement of the prostheses for mechanical failure, patient dissatisfaction or poor functional outcome. There was no clinical evidence of infection in any patient before reoperation. Patients were separated into 2 groups for analysis. At all 3 centers there was a similar a ratio of patients in the 2 groups. The study consisted of 169 white, 10 black, 3 Hispanic and 1 Arab-American men.

In the 140 group 1 patients the implant was completely removed and all implant spaces were washed out with the antiseptic solutions of the Mulcahy salvage rescue protocol before replacement with a 3 piece IPP. One Asepto syringe (Becton Dickinson, Parsippany, New Jersey) (approximately 100 cc) of each solution was used in each implant space. Unlike the original Mulcahy protocol a high pressure Waterpik (Waterpik Technologies, Chicago, Illinois) was not used, and the instruments, drapes, gowns and gloves were not changed. In the 43 group 2 patients the entire implant was removed but no antiseptic irrigation was performed before replacement with an antibiotic coated IPP.

The majority of the patients in group 1 (73%) underwent reoperation because of mechanical breakdown of the prosthesis. Table 1 lists the indications for reoperation. Of the patients 72 had a Mentor Alpha, 2 had a Mentor Titan, 1 had a Mentor Mark II (Mentor Corp., Santa Barbara, California), 54 had an AMS700, 3 had a Dynaflex, 4 had an Ambicor, 1 had a Hydroflex (American Medical Systems), 1 had a Flexiflate (ACMI Corp., Racine, Wisconsin) and 2 had malleable rods. Average patient age was 66.4 years (range 33 to 91). The mean interval to reoperation in the group was 62 months (range 1 to 190). Of the 140 patients in group 1 38 (27%) were diabetic and 89 (63.6%) were undergoing the first revision. There were no significant differences in the rate of diabetes and first revision between the 2 groups ($p > 0.6$).

All patients received perioperative intravenous antibiotics and underwent 10-minute skin preparation with a povidone-iodine scrub. Antiseptic solutions used during revision washout were similar to those described by Brant et al.[12] Four antiseptic solutions were prepared, that is 1) 50% peroxide/50% normal saline (NS), 2) 50% povidone-iodine/50% NS, 3) 1 gm cefazolin and 40 mg tobramycin sulfate in 1 l NS and 4) 500 mg vancomycin and 80 mg gentamicin sulfate in 1 l NS. The lavage protocol began with 50% peroxide, then 50% povidone-iodine, then the cefazolin/tobramycin mixture and then the vancomycin/gentamicin mixture, followed by the same solutions in reverse order (cefazolin/tobramycin mixture, 50% povidone-iodine and 50% peroxide) with the final lavage solution a combination of the 2 antibiotic mixtures together. One Asepto syringe full of each solution used in the protocol was irrigated into the different implant spaces. For example, a 3 piece penile prosthesis had the 2 cylinder spaces, the pump space and the reservoir space flushed with all solutions. A large rubber catheter was placed in the reservoir space to assist in the lavage of that area.

Patients were followed for IPP failure and specifically for implant infection. Penile implant infection in groups 1 and 2 was compared using the Fisher exact test.[13] Nonparametric infection-free duration curves were calculated using the Kaplan-Meier product limit method. Patients were separated into 2 groups for analysis, namely group 1—those undergoing the revision washout protocol and group 2—those who did not. Separate curves were estimated for patients with and without revision washout, and the 2 curves were compared using the log rank test.[14] Data management and analysis were performed using the Stata statistical package, version 8.0 (Stata Corp., College Station, Texas).[15]

RESULTS

In 4 of the 140 patients in group 1 (2.9%) who underwent removal of the entire implant with irrigation of the implant spaces with antiseptic solutions and replacement with a 3 piece penile prosthesis infection developed within 6 to 33 months of observation. In the remaining group 5 of the 43 patients (11.6%) who did not undergo antiseptic irrigation had infection. The difference was statistically significant at the 5% level (Fisher's exact test $p = 0.034$, table 2). Table 3 lists isolates cultured from patients with an infected penile prosthesis at reoperation. In group 1 there were only 2 revisions for any reason other than infection for a noninfectious revision rate of only 1.4%. One patient underwent revision due to auto-inflation at 11 months. The other patient had a corporeal aneurysm at 4 months. The figure shows Kaplan-Meier infection-free survival curves. Overall the infection-free duration was worse in patients who did not undergo antiseptic irrigation (log rank $p = 0.031$).

DISCUSSION

Inflatable penile prostheses are a well established treatment for erectile dysfunction. Multiple product enhancements in the last 30 years have resulted in prostheses with markedly decreased mechanical failure rates. In fact, most authorities now believe that the devices are more often revised for human factors, such as infection and medical problems, than for mechanical ones.[16] Despite these mechanical improvements infection has remained a significant complication of prosthetic surgery.

Multiple studies in the medical literature have indicated an increased risk of infection when repeat operations (revisions) are performed on genitourinary prostheses (table 4). This increased incidence of infection associated with reoperation has been postulated to be due to decreased host resistance factors, impaired antibiotic penetration of the area because of the capsule surrounding the components and decreased wound healing related to scar formation. The organism most often found responsible for the infection in reoperation is Staphylococcus epidermidis.[2] This bacterium is also the most common cause of infection during the original implantation, accounting for 35% to 80% of all positive cultures.[2, 7]

TABLE 1. *Indications for reoperation in group 1 patients who underwent revision washout*

Indication	No. Pts (%)
Mechanical (tubing fracture, fluid loss)	102 (73)
Pt dissatisfaction	5 (3.6)
Chronic prosthesis pain	2 (1.4)
Impending cylinder erosion	8 (5.7)
Tissue lengthening	5 (3.6)
Penile deformity (SST or S-shaped)	9 (6.4)
Other (reservoir hernia, proximal migration, cylinder aneurysm, hematoma, pump induration)	9 (6.4)

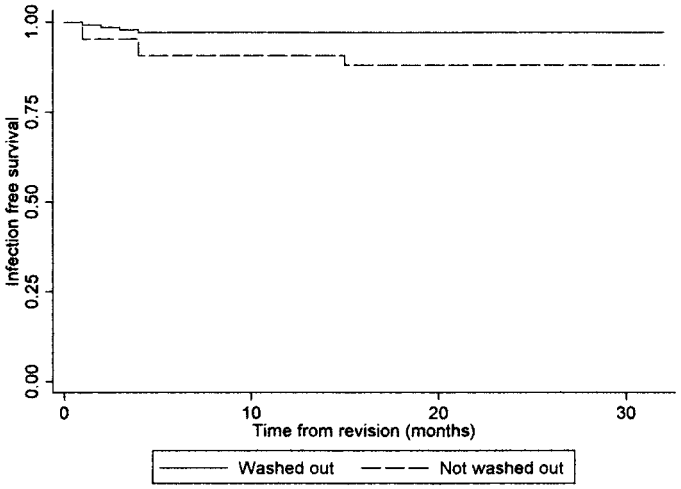
TABLE 2. *Revision penile prosthesis surgery infection rates in patients who did vs did not undergo revision washout*

Washout	No. Infection (%)		Total No.
	Yes	No	
Yes	4 (2.9)	136 (97.1)	140
No	5 (11.6)	38 (88.4)	43
Totals	9 (4.9)	174 (95.1)	183

Fisher's exact $p = 0.034$.

TABLE 3. *Isolates cultured from infected penile prostheses at reoperation*

Revision Washout	Presentation (mos)	Diabetes	Revision No.	Isolate Cultured	Tetracycline/Rifampin Sensitive
Yes	Erosion + swelling (3)	No	1	S. epidermidis	Sensitive/sensitive
Yes	Adherence + pus (1)	No	1	Citrobacter freudii, Enterococcus faecalis	Sensitive/not available, resistant/sensitive
Yes	Erythema + swelling (2)	No	1	S. epidermidis, Escherichia coli	Sensitive/sensitive, resistant, not available
Yes	Erosion + pus (4)	No	1	Neg	
No	Erythema + pus (4)	No	2	Light yeast	Not available
No	Erosion + pus (15)	Yes	1	Not cultured/removed	
No	Erosion + pus (4)	Yes	1	Light yeast	Not available
No	Overt exudate (1)	No	3	Streptococcus agalactiae	Resistant/resistant
No	Overt exudate (1)	No	4	E. faecalis	Resistant/resistant



Revision washout Kaplan-Meier product limit estimated infection-free duration.

Most authorities believe that genitourinary prosthetic infection is caused by contamination of the implant space at surgery. Studies suggest that preoperative nasal swab cultures of certain staphylococcus species significantly correlated with postoperative surgical site wound infections.[17] Hematogenous late infections occur but rarely.[18] After adherence to the implant and colonization many bacteria, including staphylococcus species, produce a protective mucin coat or biofilm.[8] Bacteria present within the biofilm may survive at a lowered metabolic rate chronically and without the patient realizing that bacteria are present in the implant spaces. Occasionally bacteria are released from the biofilm to become free floating or planktonic, which may cause symptoms.[8] Antibiotics or the body defense mechanisms can kill these planktonic bacteria. Organisms present within the biofilm are protected and cannot be eradicated except by implant removal and implant space lavage. In 1996 Brant et al reported salvage success for clinical infections.[12] Their method, since successfully repeated by others, involves removing the infected device, using sequential lavage of antiseptic solutions to sterilize the implant space and immediately reimplanting a sterile replacement device. Only after the complete implant has been removed and the entire capsular space has been thoroughly irrigated is the new implant placed. We believe that the success of this technique in eradicating infection is predicated on removing the bacteria and the biofilm by vigorous lavage of the implant spaces.

Carrying this thought 1 step further, perhaps the increased infection rate seen in revision prosthetic surgeries is due to the activation of preexisting biofilm. Bacteria are introduced at the original surgery. They multiply and secrete their mucinous biofilm and then live in symbiosis with the host, not demonstrating signs of clinical infection. Theoretically something about revision surgery stimulates the bacteria and they become clinically active and symptomatic to the patient, resulting in a revision infection.

Staphylococcus epidermidis has been shown to be the most common organism found at removal of a penile prosthesis for infection.[3] Moreover, Licht et al found that 40% of uninfected penile prostheses and 36% of artificial urinary sphincters had low colony counts of S. epidermidis.[2] Three patients with positive culture results later had infection and higher colony counts of the organism were found at explantation. None of the patients with a penile prosthesis and a negative culture at reoperation had a subsequent prosthetic infection. Therefore, ensuring that the replacement implant has a sterile environment in which to be placed at revision/replacement may lower the rate of prostheses reoperation infection. Even better, using the salvage protocol of irrigation with antiseptic solutions at replacement combined with insertion of an antibiotic coated prosthesis could help ensure a sterile environment for the new implant, while the antibiotic elution could address bacterial contamination at revision surgery.

While the solutions used are antiseptic, it is possible that the most important part of washout is mechanical débridement of the bacteria/biofilm in the implant space. For example, povidone-iodine only becomes bactericidal when it dries. A possible future study could compare antiseptic solutions vs normal saline as the washout irrigant. It is possible that some irrigants cause tissue irritation or disruption, making patients more susceptible to infection.

Recent studies show that most implants have bacteria/biofilm present on them at revision surgery.[9,10] Therefore, if the entire implant is not removed at revision surgery, there

TABLE 4. *Published penile prosthesis revision infection rates*

References	% Infection	No. Revision Cases	Entire Prosthesis Always Removed	Other Findings
Quesada and Light[1]	6.6	90	New CX cylinders placed in all pts	Claimed 0.5% primary implant infection rate
Licht et al[2]	7	87	No	If IPP was culture neg, no infections occurred
Wilson and Delk[3]	10	428	No	18% Diabetic revision infection rate
Jarrow[4]	13.3	30	Not available	Similar revision + corporeal reconstruction infection rates
Govier et al[5]	6.5	46	No	High pt satisfaction with IPPs
Lotan et al[6]	18.8	69	Not available	Frequent implanters had superior results

is a possibility of reactivation of the biofilm existing on the original implant retained components. While complete removal of all components seems ideal, we acknowledge the difficulty involved in removing the reservoir on occasion. Reservoir removal should not be construed as the standard of care. If reservoir removal proves difficult and there is no evidence of biofilm/infection on the pump and cylinders, the original reservoir could be retained. A recent study showed no added incidence of subsequent infection in a large series of retained reservoirs.[19]

While the antibiotic coating InhibiZone (a combination of rifampin and minocycline) on the outside of IPPs has been shown to decrease infection rates for primary implantation surgeries, it appears to have a less dramatic effect on revision cases.[11] The 11.6% infection rate found in cases in which revision washout was not performed is similar to published results (table 3). The established biofilm found during revision surgery could be too overwhelming a bacterial colony count for the antibiotic coating. The amount of antibiotic used to coat the outside of the AMS 700CX InhibiZone penile prosthesis is less than a single oral pill, which is potentially enough to lower infection rates in primary surgeries but not enough for the established biofilm found in secondary cases. Moreover, 2 isolates cultured were S. epidermidis, which is sensitive to tetracycline and rifampin, indicating that these bacteria would not survive in the presence of these bactericidal antibiotics. Therefore, washing out the implant spaces to remove the biofilm and sterilize the surgical site prior to replacement with an antibiotic coated IPP should decrease the bacterial presence and lower infection rates.

CONCLUSIONS

The majority of clinically uninfected genitourinary prostheses have organisms growing in the implant space at reoperation. Salvage rescue by vigorously washing out the implant space with an antiseptic irrigation protocol has been shown to be effective in cases of infected IPPs. Early results show that removing the entire prosthesis and washing out the implant space with a similar irrigation protocol appears to decrease the infection rate of clinically uninfected IPPs at revision surgery.

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