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Reservoir Placement Considerations During Inflatable Penile Prosthesis Surgery

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Abstract

Purpose of Review To discuss emerging alternative strategies for reservoir placement during inflatable penile prosthesis surgery.

Recent Findings Innovations in penile prosthesis design have facilitated the development of various alternative approaches for reservoir placement. Avoiding the space of Retzius is particularly appealing in patients with a history of pelvic surgery and/or radiation. The high submuscular technique utilizes a low-profile reservoir in combination with the implant's lockout valve to allow for safe placement in the potential space between the anterior abdominal wall musculature and the transversalis fascia, far cephalad from the external inguinal ring and without the need for a counter-incision. Multiple recent publications have demonstrated the safety and efficacy of the high submuscular technique.

Summary High submuscular inflatable penile prosthesis reservoir placement is a safe and effective alternative to placement within the space of Retzius.

Keywords Inflatable penile prosthesis · Reservoir · Ectopic · High submuscular

Introduction

Evolutions in prostate cancer care and innovations in inflatable penile prosthesis (IPP) design have led to a new era of IPP reservoir placement [1]. For decades, the standard IPP reservoir location was the space of Retzius, accessed via either blunt perforation through the transversalis fascia comprising the floor of the inguinal canal or direct incision through the rectus fascia in the midline suprapubic region. However, empowered by novel IPP reservoirs and lockout valves, many prosthetic surgeons have sought to avoid the space of Retzius all together and thus decrease the risk of catastrophic vascular or bowel complications encountered while developing the space for an IPP reservoir within a hostile pelvis [2]. Various non-descriptive terms, such as "ectopic" or "alternative," have been used to describe IPP reservoir placement locations outside of the space of Retzius. However, anatomically descriptive terms, such as "submuscular," "high submuscular," or "subcutaneous," are preferred due to their anatomical clarity. The objective of this review is to discuss the anatomy, technique, and outcomes of high submuscular (HSM) IPP reservoir placement.

Surgical Anatomy and Prosthesis Design

Prior to the advent of robotic-assisted radical prostatectomy (RARP), the space of Retzius was an ideal location for IPP reservoir placement in most men as it provided an easy-to-access, non-palpable, low-pressure space. However, RARP has ultimately surpassed open radical prostatectomy as the preferred modality for the surgical treatment of prostate cancer [3]. During RARP, the parietal peritoneum overlying the bladder and anterior pelvis is typically incised, thus "dropping" the bladder and exposing the space of Retzius to the peritoneal cavity. The re-peritonealization of this exposed space is unpredictable, thus increasing the risk of inadvertent entry into

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the peritoneum as the transversalis fascia of the groin is perforated during conventional IPP reservoir placement [4]. Most alternative reservoir placement techniques, including the HSM technique, avoid this risk by maintaining the plane of dissection superficial to the transversalis fascia [1]. Avoiding transversalis perforation may also be beneficial in a multitude of other situations leading to inguinal or pelvic fibrosis, such as in men with a history of inguinal hernia repair, radical cystectomy, and/or pelvic radiation, among others.

Recent IPP design changes have greatly facilitated prosthetic surgeons' ability to investigate and employ novel alternative reservoir placement techniques. Standard among three-piece IPPs manufactured by both Coloplast and American Medical Systems are lockout valves that prevent autoinflation when the reservoir is placed in a location prone to compression, such as between the layers of the anterior abdominal wall [5]. Additionally, both companies have reservoirs available which maintain a flat configuration when filled (or partially filled), thus rendering them non-palpable when placed in alterative locations for most men [6]. HSM reservoir placement monopolizes on each of these IPP innovations with the goal of minimizing complications among patients with risk factors for inguinal and pelvic fibrosis.

Surgical Technique

While several authors have published a myriad of alterative reservoir placement techniques [7–9], we prefer a modified version of the technique originally reported by Morey et al. [10]. Briefly, the IPP cylinders are placed in the usual manner via a penoscrotal technique. The bladder is drained and the external inguinal ring is identified and retracted anteriorly with a small Deaver retractor. The conjoint tendon is identified within the inguinal canal first medially, then followed cephalolaterally. It is bluntly elevated with the surgeon's finger, thus developing the space deep to the transversus abdominis muscle but superficial to the transversalis fascia; this is the "submuscular space." The Deaver retractor is repositioned into the submuscular space, thus retracting all muscular layers of the anterior abdominal wall (rectus abdominis, external oblique, internal oblique, and transversus abdominis) anteriorly. The submuscular space is developed as cephalad as possible in the direction of the ipsilateral nipple, first digitally, then by advancing a #14 Brooks dilator, taking care to follow the anticipated internal contour of the abdominal wall and thus avoiding perforation of the transversalis fascia and/or peritoneum. Safe passage of the Brooks dilator can be aided by temporarily placing the bed into the reverse Trendelenburg position [11••], a maneuver which is especially helpful for obese patients with an exaggerated anterior protrusion of their anterior abdominal wall and abdominal cavity. The Brooks dilator should pass with gentle, constant, smooth pressure as it insinuates into the potential space between the transversalis fascia and the transversus abdominis muscle. If unexpected resistance is met, it should be redirected anteriorly to prevent unintentional entry into the peritoneal cavity. If this is not successful, an attempt via the contralateral groin can be made. If bilateral groins are inaccessible, a muscle-splitting lateral abdominal counter-incision can be used.

After successful passage, the Brooks dilator is removed, and the IPP reservoir is grasped opposite the tubing entry site with a Foerster lung grasping clamp (Scanlan International, St. Paul, MN, USA) [10] and advanced through the tract just created by the Brooks dilator until the handle of the clamp is reached. The clamp is opened slightly and the reservoir is filled to the maximum volume specified by the manufacturer, thus deploying the reservoir out of the clamp and unfurling the folds in the reservoir created when the reservoir was advanced through the narrow submuscular channel. The clamp is kept in place during reservoir filling to prevent inadvertent descent of the reservoir. Once the reservoir is full, the Foerster clamp is carefully withdrawn, keeping the jaws slightly open to prevent inadvertent grasping of the reservoir or tubing as it is removed. The abdomen is examined to determine the palpability of the reservoir (if any) and the reservoir fluid is adjusted to the final desired volume, at the surgeon's discretion. Tubing connections are made and the procedure is completed in the usual manner. A full-duration video demonstration of the above technique is available as a supplementary material.

Postoperative Reservoir Position

Despite a number of studies reporting the safety of HSM IPP reservoir placement [6, 8, 10–13], the technique has been recently criticized due to the potential for unintentional placement into a space other than the actual HSM position [14•]. The rationale for this criticism was tested in a cadaveric study by Ziegelmann et al. IPP reservoir placement into the HSM space was attempted bilaterally in 10 fresh male cadavers. The abdominal cavities and abdominal walls of the cadavers were then dissected to determine the precise final anatomic position of each reservoir. Notably, only 35% were identified in the intended HSM location. The remainder were identified between the external oblique fascia and the internal oblique fascia/musculature (45%), retroperitoneal (10%), preperitoneal (5%), or intraperitoneal (5%) [14•].

Given the blind nature of HSM placement, well distant from the penoscrotal incision, concern for the ultimate position of IPP reservoirs placed via this technique is warranted. Having employed the HSM technique routinely for more than 7 years, we have encountered a number of patients in whom radiographic and laparoscopic evaluations for other purposes have incidentally identified the previously placed IPP reservoir, typically in the expected position (Figs. 1 and 2).

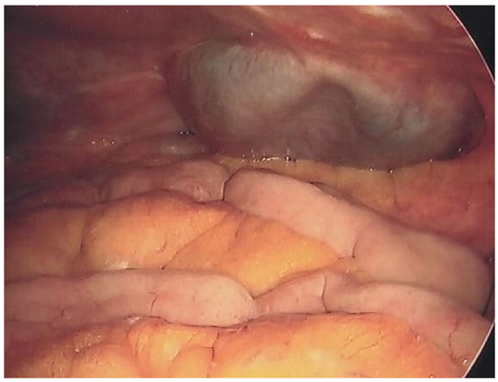

Fig. 1 Incidental laparoscopic view of a well-placed HSM reservoir, confirming the flat configuration and extraperitoneal location

Additionally, we have begun routinely performing limited abdominal sonography in the urology clinic at the time of the first postoperative appointment following IPP placement. An abdominal ultrasound probe is used to identify the location and configuration of the reservoir, most commonly non-palpable, fully inflated, flat, and well opposed to the posterior surface of the transversus abdominis muscle (Fig. 3). However, the reservoir is not in the anticipated HSM space in approximately 10% of patients (unpublished data). In these men, non-contrast computed tomography is performed to clarify the exact position of the reservoir which aids in patient counseling and preoperative planning for surgical repositioning (if needed). Repositioning should be considered for reservoirs inadvertently placed into the peritoneal cavity. However, inadvertent intraperitoneal placement is possible with many of the conventional and alternative reservoir placement techniques and frequently goes unrecognized until the time of routine IPP revision. Therefore, the need to preemptively reposition intraperitoneal reservoirs is debatable at best.

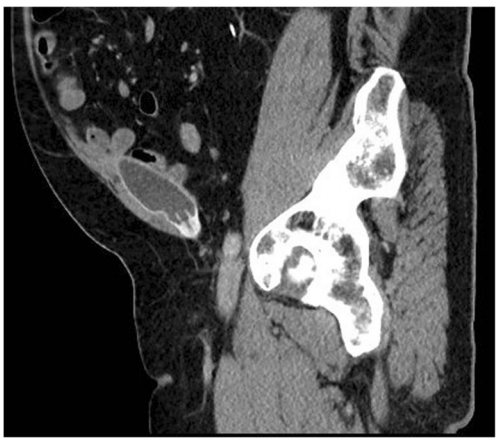

Fig. 2 Computed tomography scan, performed for reasons unrelated to the IPP, revealing a well-placed HSM reservoir, flat in configuration, and well opposed to the posterior surface of the transversus abdominis muscle

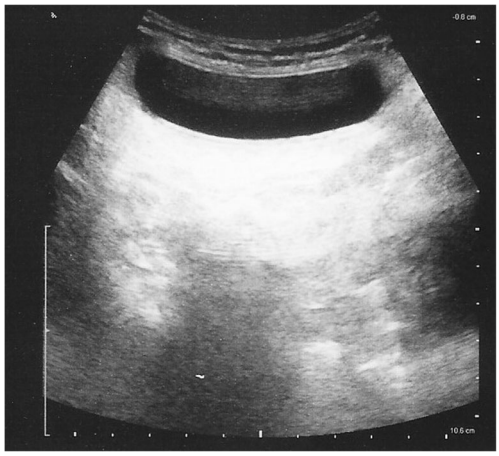

Fig. 3 Sonographic appearance of a well-placed HSM reservoir performed during the first postoperative clinic visit

Considerations During IPP Revision

Another criticism of HSM reservoir placement is the challenge created by the long distance between the reservoir and the penoscrotal incision faced at the time of IPP revision or removal. Conversely, a reservoir placed into the space of Retzius is in closer proximity to the penoscrotal incision, and thus may be less likely to require a counter-incision at the time of IPP removal or revision. However, accessing the space of Retzius for IPP reservoir removal is challenging and potentially morbid, given the dense nature of the inguinal floor and the close proximity of the bladder medially and external iliac vessels laterally [15]. HSM reservoir placement violates no fascial planes and thus firm traction on the tubing will often deliver a deflated IPP reservoir downward into the penoscrotal incision, making injury to pelvic viscera and major vasculature virtually impossible. If reservoir removal is essential and delivery into the penoscrotal incision is unsuccessful, a small incision can be made directly over the reservoir, guided by intraoperative ultrasound when it is not palpable on examination.

We tailor our approach to a HSM reservoir based on the clinical scenario at the time of IPP reoperation. When performing IPP revision for mechanical problems in patients without clinical evidence of infection, the reservoir is deflated and a careful attempt at removal via the penoscrotal incision is attempted. When unsuccessful, the reservoir tubing is placed on traction and divided as close to the reservoir as possible. This technique, known as the "drain and retain" strategy, has been shown to be a safe and effective alternative to reservoir removal, regardless of reservoir type or location [16, 17]. Furthermore, removal of a defunctionalized reservoir is possible without harm to the functional implant in the rare cases of delayed infection of the defunctionalized device [16, 18].

Clinically infected IPPs with HSM reservoirs are approached differently. The IPP cylinders and pump are removed in the usual manner. Traction is then placed on the

reservoir tubing via the penoscrotal (or infrapubic) incision. If the HSM reservoir does not descend, a counter-incision is made directly over the HSM reservoir, guided by either preoperative CT scan or intraoperative ultrasound. The above approach ensures appropriate management of the HSM reservoir, tailored to the clinical scenario and reserving counter-incisions for only when absolutely essential.

Postoperative Outcomes

The first published series reporting outcomes after submuscular IPP reservoir placement evaluated a small subset of patients from a larger group in whom the efficacy of a novel lockout valve was investigated [5]. In this study, 8 men had the novel reservoir placed superficial to the transversalis fascia but deep to the abdominal wall musculature (not using a long clamp, as described for the HSM technique). Among these 8 men, 3 had palpable but not bothersome reservoirs, none reported cylinder autoinflation, and no reservoir-related IPP revisions were needed at 1-year follow-up [5].

Morey and colleagues were the first to report on the technique and outcomes of HSM IPP reservoir placement [10]. Over a 12-month study period, 74 IPP reservoirs were successfully placed using the HSM technique via a penoscrotal approach. Surgical repositioning was required in 2 patients and 85% of those who completed a postoperative non-validated survey were unable to palpate their reservoir. Reservoir palpability was not associated with reservoir type, final fill volume, or patient body mass index. No vascular, bladder, bowel, or ureteral injuries were reported [10]. The authors have continued to publish updates with ongoing experience and refinement of their HSM technique [6, 11]. Most recently, 619 prosthetic cases (IPP and/or artificial urinary sphincter) with HSM reservoirs were compared with 161 placed into the space of Retzius. Similar surgical revision rates were reported between the groups with fewer vascular injuries in the HSM group [11••].

Other investigators have reported on the efficacy of submuscular IPP reservoir placement via an infrapubic approach. Stember et al. compared 2239 patients with IPP reservoirs placed into the space of Retzius to 447 patients with submuscular reservoirs placed using a long nasal speculum and a pediatric Yankauer tip. While outcomes were excellent in both groups, bladder perforation was more common in the space of Retzius group and reservoir herniation was more common in the submuscular group. Surgical replacement for bothersome submuscular reservoir palpability was required in 2 patients (0.4%) while 15 others (3.4%) had palpable reservoirs not requiring surgical revision [8].

A recent multi-institutional evaluation of various alternative reservoir placement techniques reported similar rates of reservoir-related complications (1.1% vs. 2.0%, $p = 0.44$) when comparing 362 men with space of Retzius placement with 612 men with alternative placement (HSM or sub-Scarpa's), respectively. The most common findings at reservoir revision among the alternative placement group were leakage from a folded Conceal reservoir (5 patients) and torsion of the reservoir tubing (3 patients). Three additional men requested reservoir repositioning due to pain over the reservoir site [19•]. Large multi-institutional series such as this are essential to determine the long-term outcomes of the HSM and other alternative reservoir placement techniques.

Conclusions

The HSM IPP reservoir placement technique is a safe and effective alternative to conventional placement and may offer a number of safety advantages, especially for men with a history of pelvic surgery and/or radiation. Innovations in implant design have facilitated the development of various approaches to HSM reservoir placement. Long-term studies are needed to compare the durability of IPP reservoirs placed via the HSM technique versus more established approaches.

Compliance with Ethical Standards

Conflict of Interest The author declares that he has no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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- • Of importance
- •• Of major importance

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