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Urinary Incontinence After Radical Prostatectomy

Inkontinencija urina nakon radikalne prostatektomije

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Abstract. Urinary incontinence remains a frequent complication after radical prostatectomy, with significant implications for patients' physical health, emotional well-being, and social quality of life. Postprostatectomy incontinence manifests as stress urinary incontinence, typically resulting from injury to the external urethral sphincter and its supporting structures. Contributing factors include patient age, baseline urinary function, surgical technique, and anatomical variations. Management options range from conservative measures such as pelvic floor muscle training, pharmacotherapy, and lifestyle adjustments to surgical interventions, including male slings and artificial urinary sphincters for persistent or severe cases. Although advances in surgical technique and perioperative care have improved continence outcomes, postprostatectomy urinary incontinence remains a significant challenge, underscoring the need for personalized treatment approaches and continued research into preventive strategies.

Keywords: prostatectomy; quality of life; suburethral slings; urinary incontinence

Sažetak. Inkontinencija urina česta je poslijeoperacijska komplikacija nakon radikalne prostatektomije, s negativnim učinkom na fizičko zdravlje, psihološku dobrobit i socijalni život bolesnika. Postprostatektomijska inkontinencija najčešće se javlja u obliku stresne urinarne inkontinencije i nastaje kao posljedica oštećenja vanjskog uretralnog sfinktera i okolnih potpornih struktura. Na stupanj inkontinencije utječu dob, prijeoperacijska funkcija donjeg mokraćnog sustava, kirurška tehnika i anatomske značajke bolesnika. Liječenje obuhvaća konzervativne metode, poput vježbi mišića dna zdjelice, farmakoterapije i promjene životnog stila, te kirurške opcije koje mogu uključivati „slingove" u muškaraca i umjetne urinarne sfinktere koji se primjenjuju u perzistentnih i teških oblika inkontinencije. Unatoč napretku u kirurškim tehnikama i perioperacijskoj skrbi, postprostatektomijska inkontinencija i dalje predstavlja klinički izazov, što ukazuje na potrebu za individualiziranim terapijskim pristupima i daljnjim istraživanjima preventivnih strategija.

Ključne riječi: inkontinencija urina; kvaliteta života; prostatektomija; suburetralni slingovi

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INTRODUCTION

Prostate cancer is among the most frequently diagnosed malignancies in men, with radical prostatectomy (RP) representing a definitive treatment for localized disease. Advances in surgical approaches, including laparoscopic and robotic-assisted techniques, have enhanced oncological outcomes while reducing perioperative morbidity[1]. Despite these improvements, urinary incontinence (UI) and erectile dysfunction (ED) remain common postoperative complications with a substantial negative impact on patients' quality of life. Loss of bladder control following RP can be particularly distressing, impairing both physical function and emotional well-being. Reported rates of post-prostatectomy incontinence range from 4% to 8%, although actual prevalence may be considerably higher depending on the definition and the type of validated incontinence questionnaire used[2]. In most studies, the severity of urinary incontinence is quantified using the number of pads required per day as an objective indicator[3].

The primary mechanism underlying postprostatectomy urinary incontinence (PPUI) is sphincteric dysfunction resulting from surgical trauma to both intrinsic and extrinsic continence mechanisms[4, 5]. Additional factors, such as detrusor overactivity and bladder dysfunction, can further exacerbate urinary leakage[6]. The external urethral sphincter is particularly vulnerable to injury during RP, either directly through dissection of the dorsal vein complex, apical dissection, or urethral reconstruction, or indirectly, via damage to the autonomic nerves[7]. Beyond its physiological consequences, PPUI carries substantial psychosocial burden, often resulting in anxiety, diminished self-esteem, depression, and social withdrawal[8].

Although many patients experience spontaneous recovery of continence within the first postoperative year, others require long-term interventions to effectively manage their symptoms[9, 10]. Ongoing research is investigating innovative therapeutic strategies, including regenerative medicine and advanced surgical techniques, aimed at improving continence restoration[11].

Postprostatectomy urinary incontinence is a common and distressing complication. It occurs mainly due to sphincteric injury during surgery, compounded by bladder dysfunction and patient-related factors. Although most men regain continence within 12 months, 3–32% of patients experience persistent leakage that significantly affects quality of life.

URINARY INCONTINENCE

Urinary incontinence (UI) is defined as the involuntary loss of urine and can be classified into several types as it is explained below (Table 1)[12-16].

Stress urinary incontinence in males

Stress urinary incontinence in males most commonly results from intrinsic sphincter deficiency (ISD) which may arise from iatrogenic injury (e.g., radical prostatectomy, transurethral resection of the prostate), pelvic trauma, neurological disorders, or radiation therapy. Intrinsic sphincter deficiency refers to the inability of the urethral

Table 1. Classification of urinary incontinence

Type of urinary incontinence	Definition
Stress urinary incontinence (SUI)	Leakage that occurs with increased intra-abdominal pressure (e.g., coughing, sneezing, physical exertion) in the presence of a weakened sphincter mechanism[12].
Urge urinary incontinence (UUI)	Sudden, involuntary detrusor contractions resulting in an urgent, intense need to void, often associated with overactive bladder syndrome (OAB). Causes may include neurological disorders, aging, or idiopathic detrusor instability[13].
Mixed urinary incontinence (MUI)	The coexistence of both stress and urge incontinence symptoms. This is common in elderly individuals and in postprostatectomy patients with bladder dysfunction[14].
Overflow incontinence	Continuous dribbling or leakage due to incomplete bladder emptying, often related to detrusor underactivity or bladder outlet obstruction[15].
Functional incontinence	Urine leakage resulting from physical or cognitive impairments such as reduced mobility or dementia that prevent timely access to toileting despite normal bladder function[16].

sphincter to generate sufficient closure pressure to maintain continence under normal intraabdominal pressure. It leads to persistent or activity-related urine leakage, even in the absence of significant bladder dysfunction[17].

1. **Radical prostatectomy**, commonly performed for prostate cancer, remains the primary cause of male SUI. The procedure can disrupt urinary continence mechanisms by removing part of the proximal sphincteric unit and injuring the external urethral sphincter (rhabdosphincter) and its closely associated neurovascular structures at the prostatic apex. Sphincteric incompetence is the predominant cause of PPUI, although other factors, such as reduced urethral length, postoperative fibrosis, and bladder dysfunction (e.g., detrusor overactivity or poor compliance from bladder denervation or prior obstruction) may contribute[18]. Current evidence does not support a consistent advantage of robot-assisted radical prostatectomy (RARP) over conventional techniques in reducing postoperative urinary or, for that matter, sexual adverse effects[19].

2. **Transurethral resection of the prostate (TURP)**, widely used for the treatment of benign prostatic hyperplasia (BPH), can also cause SUI, although less commonly. Sphincter injury may occur if excessive resection is performed near the prostatic apex[20].

3. **Pelvic trauma** such as fractures sustained in motor vehicle accidents or falls can injure the pelvic floor muscles, nerves, and sphincteric structures essential for urinary control. Those injuries may result in a combination of stress, urge, or mixed urinary incontinence, depending on the specific anatomical and neurological structures affected. Furthermore, prior pelvic surgeries can compromise continence mechanisms through direct sphincter injury, ischemia, or fibrosis of surrounding tissues[15].

4. **Neurological disorders** including spinal cord injury, multiple sclerosis, Parkinson's disease, and stroke can impair voluntary sphincter control and/or disrupt normal detrusor function. Such deficits often result in mixed urinary incontinence, frequently with a prominent stress component[21].

5. **Radiation therapy**, a common treatment modality for prostate cancer, can worsen urinary incontinence by inducing irritation of the external sphincter, urethra, and bladder. Its mechanism of injury involves direct ionization induced cell death followed by fibrosis, as well as vascular damage leading to ischemia of surrounding tissues. These changes can impair bladder and urethral function, resulting in overactive bladder (OAB) symptoms and lower urinary tract symptoms (LUTS). Radiotherapy may also cause bladder outlet obstruction secondary to urethral strictures, presenting with weak urinary stream, hesitancy, or even retention[22]. While many symptoms improve after treatment, a subset of patients experience persistent or delayed incontinence months to years later, most likely due to progressive scar tissue formation[23].

> Management begins with conservative measures such as pelvic floor muscle training and lifestyle modification. If it is ineffective, surgical options like artificial urinary sphincters (gold standard) or male slings are used. Accurate diagnosis, tailored treatment, and multidisciplinary care are essential to restore continence and quality of life.

Epidemiology of postprostatectomy urinary incontinence

Postprostatectomy UI is a frequent complication after radical prostatectomy, although reported prevalence varies considerably due to differences in its definition and the timing of assessment. Immediately after surgery, nearly all men experience some degree of urinary leakage, which is typically transient. Continence is usually regained within the first few months, with the majority achieving complete control by 2-3 months postoperatively[24]. At 12 months, reported continence rates range from 68% to 97%, depending on study criteria and definitions[25, 26, 27]. Consequently, persistent PPUI at one year affects approximately 3% to 32% of men, with some continuing to show gradual improvement up to two years after surgery[10]. Severe, treatment-refractory incontinence requiring surgical management such as male sling or artificial urinary sphincter placement is less common, occurring in about 3% to 6% of patients in large cohort studies[28].

Impact of surgical approach on urinary incontinence

Open (retropubic) radical prostatectomy (RRP) was historically the standard surgical approach, whereas minimally invasive techniques such as laparoscopic radical prostatectomy (LRP) and robot-assisted radical prostatectomy (RARP) have become increasingly common. Several large multicentre and population-based studies suggest that RARP may facilitate faster, or more complete recovery of continence compared to open surgery. For instance, a meta-analysis reported the absolute risk of urinary incontinence was 11.3% after RRP (105 of 923 cases) and 7.5% after RARP (38 of 509 cases)[19]. The prevalence of urinary incontinence was influenced by preoperative patient characteristics, surgeon experience, surgical techniques, and methodological aspects such as continence definitions, tools used for data collection, and different follow-up intervals[19]. However, other studies have not confirmed this benefit. A Swedish nonrandomized study found no significant difference in one-year incontinence rates: 20.2% after open surgery versus 21.3% after RARP[29]. Similarly, a prospective randomized trial showed no significant differences between open and robotic techniques at 6 weeks (74.5% *vs.* 71.1%; p = 0.09) or 12 weeks postoperatively (83.8% *vs.* 82.5%; p = 0.48)[30]. Overall, surgical approach can influence early continence outcomes, with RARP often associated with better short-term recovery, LRP generally yielding the least favourable results, and open surgery occupying an intermediate position. Nevertheless, long-term differences between open and robotic procedures tend to diminish when performed by highly experienced surgeons[31].

Aetiology of postprostatectomy urinary incontinence

The aetiology of PPUI is multifactorial, involving both patient-related and surgery-related factors. These can be broadly categorized into preoperative and intraoperative factors.

Preoperative factors include elevated body mass index (BMI), advanced age, larger prostate volume, pre-existing intrinsic sphincter deficiency, previous TURP, diabetes mellitus, and neurogenic detrusor overactivity[32, 33].

Intraoperative factors encompass excessive blood loss, surgeon experience, preservation or resection of the neurovascular bundles, and the surgical technique used for vesicourethral anastomosis[34]. Regardless of whether the procedure is open, laparoscopic, or robot-assisted, surgery can compromise continence by disrupting the internal urethral sphincter (bladder neck), external urethral sphincter, pelvic floor support structures, and/or their innervation.

The external urinary sphincter encircles the membranous urethra just distal to the prostate, making it susceptible to injury during apical dissection. Rough apical dissection can damage or remove a portion of the sphincter, whereas even meticulous technique inevitably shortens the functional urethral length, thus increasing incontinence risk[2, 35]. In cases requiring wide apical excision for oncologic control or when inadvertent injury occurs, the resulting sphincteric deficiency leads to stress urinary incontinence (SUI). In standard radical prostatectomy, the bladder neck is often partially resected or widened during detachment of the prostate from the bladder. This damages the internal sphincter mechanism, shifting the full burden of continence to the external sphincter[36]. Bladder neck preservation, when oncologically safe, has been shown to improve outcomes, with a meta-analysis confirming significantly higher continence rates at both 6 and 12 months postoperatively[37]. Nerve injury to the sphincter or bladder neck can further impair continence, highlighting the importance of nerve-sparing techniques for both urinary control and erectile function[38]. Additionally, pelvic floor disruption through transection of ligaments, fascia, and muscular supports reduces outlet stability, allowing abnormal urethral mobility and diminishing the "backboard" against which the sphincter contracts. Increased outlet mobility makes it more difficult for the sphincter to remain closed during increases in intra-abdominal pressure[37].

Impact of urinary incontinence on quality of life

Urinary incontinence is not only a medical condition, but it also has profound psychosocial consequences. Affected individuals frequently experience depression, anxiety, social withdrawal, and diminished quality of life driven by fear of leakage, embarrassment, and reliance on absorbent products. Evidence links UI to reduced self-esteem, sleep disturbances, and impaired sexual function, effects particularly pronounced in post-prostatectomy patients[12, 39, 40]. Early recognition, appropriate support, and timely intervention, whether through pelvic floor muscle therapy, psychological counselling, or surgical correction, are essential to optimize recovery, enhance quality of life, and improve overall patient satisfaction.

EVALUATION AND DIAGNOSIS

Evaluation of a man with postprostatectomy urinary incontinence should include a detailed medical history, physical examination, post-void urine residual measurement, and urinalysis. Cystoscopy and urodynamic studies may be performed to assess urethra and bladder neck anatomy, as well as bladder storage and voiding functions.

History and patient-reported measures

When taking a medical history, attention should be given to the type, and severity of urinary incontinence, any previous surgical interventions, and signs that may indicate neurological disorders. Distinguishing between SUI and UUI is essential, and the use of a voiding diary can assist in this process[41]. A diary of at least three consecutive days provides key details, including daytime and nighttime voiding frequency, total urine output, the percentage of urine passed at night (nocturnal polyuria index), the volume of each void, and the number of incontinent episodes, as well as occurrences of urgency and urge incontinence[42].

Simple and inexpensive assessment is the pad test, which can quantify the severity of UI and, later on, monitor the patient's response to treatment[41].

The ICIQ-UI SF (International Consultation on Incontinence Questionnaire – Urinary Incontinence Short Form), together with the 24-hour pad test and the bladder diary, are considered the best evidence-based tools for establishing an initial diagnosis of urinary incontinence[43, 44]. The ICIQ-UI SF assesses both symptom severity and the impact of UI on quality of life by asking patients about the frequency of leakage, the amount of urine lost, and the average inconvenience caused during the previous four weeks. The first section addresses the frequency and amount of urine loss, while the second evaluates the interference with the patient's quality of life[45]. Scores are commonly categorized as follows: slight (1-5), moderate (6-12), severe (13-18) and very severe urinary incontinence (19-21)[46].

Physical examination

A thorough physical examination should encompass the abdomen, genitalia, perineum, rectum, and neurological system to identify potential contributors to urinary incontinence. In candidates for an artificial urinary sphincter (AUS), manual dexterity should be assessed to ensure adequate physical and cognitive ability to operate the device. The skin must be inspected for breakdown or bacterial or fungal infections, which should be treated before surgery. Surgical scars should be documented, as they may affect the placement of the pressure-regulating balloon (PRB). Inguinal hernias should be identified, with concurrent repair recommended if contralateral PRB placement is not feasible. A scrotal examination is also essential to detect conditions such as hydroceles, hernias, or masses that could interfere with pump placement[41].

Having the patient perform a Standing Cough Test (SCT) in the office may be helpful in demonstrating SUI. The test should be performed with the patient standing at least one hour after their last void to ensure sufficient bladder filling. A towel is held a few inches from the urethral meatus, and the patient is instructed to produce a series of four strong coughs while being observed by two examiners. Although the SCT was described more than two decades ago, standardized grading was introduced only with the development of the Male Stress Incontinence Grading Scale (MSIGS) by Allen Morey. The MSIGS distinguishes between leakage visible as drips versus a continuous stream during stress and grades severity on a scale from 0 (no leakage) to 4 (early and persistent urinary stream with cough). Leakage must be synchronous with coughing; persistent leakage after coughing may suggest cough-induced detrusor overactivity[47].

Laboratory

Before proceeding with surgical management of male urinary incontinence, urinalysis and urine culture should be obtained, and any abnormal findings thoroughly investigated. Urinary tract infections must be appropriately diagnosed and treated. Serum creatinine and prostate-specific antigen (PSA) testing are recommended to assess renal function and evaluate cancer status in patients following radical prostatectomy. Individuals with evidence of renal impairment should undergo comprehensive assessment prior to surgery.

Cystourethroscopy

Cystourethroscopy should be performed to exclude urethral and bladder pathology such as vesicourethral anastomotic stenosis, urethral stricture, or bladder cancer. Symptomatic vesicourethral anastomotic stenosis or bladder neck contracture should be treated before surgical management of urinary incontinence. Assessment of the external sphincter is useful in determining candidacy for male sling surgery. In patients with recurrent incontinence following AUS implantation, cystoscopy can help differentiate mechanical malfunction from alternative causes, such as urethral atrophy. If an AUS or sling has been explanted due to erosion or infection, repeat cystourethroscopy before reimplantation is advised to identify strictures, diverticula, or other urethral abnormalities.

Urodynamic assessment

Bladder capacity, compliance and contractility assessment is important before considering surgical management of UI. Intrinsic sphincter deficiency is present in nearly all cases[41]. Although 40–45% of men after RP have bladder dysfunction, it rarely causes incontinence by itself[48]. In men with severe incontinence, evaluation of compliance and detrusor function may require temporary occlusion of the bladder neck with a balloon catheter during filling cystometry. Reduced bladder compliance is of particular concern, as prolonged storage at high pressures can impair renal function. Detrusor hypocontractility on pressure–flow studies may indicate a preference for AUS implantation, if detrusor strength is insufficient to overcome the increased outlet resistance potentially caused by a sling[41].

TREATMENT FOR POSTPROSTATECTOMY URINARY INCONTINENCE

Conservative treatment

Following RP, surgical intervention for UI should generally be deferred for at least 12 months, as some patients will continue to improve during this period[49]. The proportion of men who regain continence increases steadily throughout the first postoperative year. Most studies evaluate continence rates at 12 months, by which time recovery has typically stabilized, although further improvement can still occur[7].

During this period, patients should be advised on lifestyle modifications, including reducing fluid intake by approximately 25% if consumption exceeds 1 L/day, smoking cessation, weight loss, and limiting caffeine, alcohol, and carbonated beverages that may irritate the bladder. Pelvic floor muscle training (PFMT) should be initiated to strengthen the pelvic floor muscles and aid recovery of sphincter function. These interventions should be continued for at least six weeks to achieve benefit and ideally maintained for three months[41].

If conservative treatment fails, pharmacotherapy may be offered, including antimuscarinics, β3-agonists, phosphodiesterase type 5 inhibitors (PDE5i), and duloxetine. However, these agents are not considered first-line therapy due to limited supporting evidence. Their role is primarily to provide temporary relief of symptoms related to overactive bladder and urgency[49].

After RP, reduced bladder compliance occurs in approximately 50% of patients which may justify the use of antimuscarinic agents to reduce lower urinary tract symptoms (LUTS). Their beneficial effect on LUTS may also shorten the time to continence recovery. Evidence for solifenacin in post-RP incontinence is limited; in a multicentre, randomized, double-blind trial of 640 patients, solifenacin 5 mg daily for 12 weeks was compared with placebo. Continence was defined as no pad use for at least three consecutive days. Overall, 29% of patients in the solifenacin group achieved continence versus 21% in the placebo group. The most common adverse events were dry mouth and constipation[49]. If patients cannot tolerate antimuscarinics or fail to achieve adequate symptom control, β3-agonists may be prescribed. Combination therapy with an antimuscarinic and a β3-agonist has also been shown to be effective[41].

PDE5i, such as tadalafil, increase levels of cyclic guanosine monophosphate (cGMP) and cyclic adenosine monophosphate (cAMP), promoting relaxation of smooth muscle in pelvic arteries and increasing blood flow to the urethral sphincter, bladder, and pelvic floor[49]. When administered shortly after surgery, they may transiently exacerbate urinary incontinence, however, their use has been linked to improved continence outcomes in the long term[50].

Duloxetine, a norepinephrine and serotonin reuptake inhibitor, may also be considered. Its mechanism involves stimulation of the pudendal nerve, resulting in increased urethral sphincter tone and relaxation of the detrusor muscle. It may be effective in patients who have undergone nerve-sparing prostatectomy[49]. However, its use for post-prostatectomy incontinence is off-label and, in most countries, is approved only for women with moderate to severe stress urinary incontinence. Evidence for efficacy in men remains limited[41].

Surgical treatment

Surgery is considered when conservative measures fail to control incontinence, and the patient remains significantly bothered by symptoms. The artificial urinary sphincter is the gold-standard treatment, achieving continence rates of approximately 80%. Alternatives for selected patients with mild to moderate incontinence include urethral bulking agents, fixed male slings, adjustable male slings, and, in rare cases, the ProACT device, a non-circumferential compressive implant. Bulking agents demonstrate inferior outcomes and lack proven long-term efficacy, regardless of the material used[41].

Circumferential compressive devices

The AUS is the gold-standard treatment for post-prostatectomy stress urinary incontinence, with studies reporting continence rates of approximately 79% and long-term (>10 years) patient satisfaction rates of 90%[51, 52]. Device survival without explantation or revision is reported at 72% at 5 years, 56% at 10 years, and 33% at 20 years[53]. The AUS comprises three components: a control pump, an elastic balloon reservoir, and a urethral occlusive cuff. The cuff is placed around the bulbar urethra via a midline perineal incision. A second incision in the right or left iliac fossa is used to position the reservoir in an extraperitoneal space, and the pump is placed in a subdartos pouch beneath the scrotal skin. All components are filled with saline or radiopaque contrast and connected with tubing to form a hydraulic circuit. When inflated, the cuff applies circumferential compression to the urethra, providing continence. The patient deflates the cuff by pressing the scrotal pump, allowing micturition. Within 1 to 2 minutes, fluid automatically returns to the cuff, re-establishing continence[54].

Although AUS survival rates are favourable, approximately 28% of patients require revision or removal within 5 years[53]. The most common indication for reoperation in the first 1 to 2 years is infection or erosion (25%), whereas malfunction (39%) and urethral atrophy (26%) tend to occur later[53]. Cuff erosion, while relatively uncommon, is particularly troublesome as it often occurs early and requires device removal. In a large retrospective study, the overall erosion rate for all cuff sizes was 11% over an 8-year period[55]. Risk factors for erosion include pelvic radiotherapy, prior AUS cuff erosion, history of urethroplasty, and the presence of an inflatable penile prosthesis[54]. Among available AUS devices, the AMS 800™ remains the most widely used and successful (Figure 1). Alternative devices, including the ZSI-375, BR-SL-AS 904, VICTO®, and Conti®, have shown promising early results, but longer-term studies are needed to confirm their safety and efficacy relative to the AMS 800™[56].

Non-circumferential compressive devices

The primary non-circumferential device currently available is the ProACT, which consists of two adjustable balloons placed adjacent to the proximal urethra at the bladder neck. Balloon volume can be modified via two scrotal ports, with reported continence rates of up to 68%[41, 49]. The EAU guidelines do not provide a recommendation for this device due to the limited quality and quantity of supporting evidence.

Male slings

The principle of the male sling is to restore continence by repositioning the urethral sphincter complex within the pelvis. The posterior urethra is advanced to a more proximal position without disrupting the sphincter mechanism, while the membranous urethra is shifted cranially and posteriorly within the pelvic outlet. Elevation of the proximal anterior urethra can result in up to a five-fold increase in functional membranous urethral length[57]. Suburethral slings are associated with less frequent and potentially less severe complications than artificial urinary sphincters[58]. The procedure is technically less complex, and, because no pump is required, patient dexterity and cognitive function are less critical when assessing suitability for surgery[54].

Male slings are available in fixed and adjustable designs and are generally recommended for mild to moderate urinary incontinence, although successful use has also been reported in severe cases. There is currently no evidence that one sling type is superior to another, and the added benefit of adjustability remains uncertain[59]. Slings may be placed via either a transobturator or retropubic approach[41].

Commonly used fixed-mesh slings include AdVance™, AdVance™ XP, Virtue®, and I-stop TOMS™. Among the retrourethral transobturator slings, AdVance™ and its next-generation AdVance™ XP are the most extensively studied and widely adopted (Figure 2). The AdVance™ sling is made of polypropylene mesh and is placed beneath the bulbar urethra using a transobturator approach. Its primary function is to reposition a displaced sphincter and posterior urethra back to their normal anatomical position, thereby improving the venous sealing mechanism and increasing functional urethral length[49]. The AdVance™ XP incorporates several refinements, such as sling-arm anchors to minimize early postoperative displacement, a design that eases placement in obese patients, longer sling arms, and protective sheaths. A history of pelvic radiotherapy is regarded as a relative contraindication

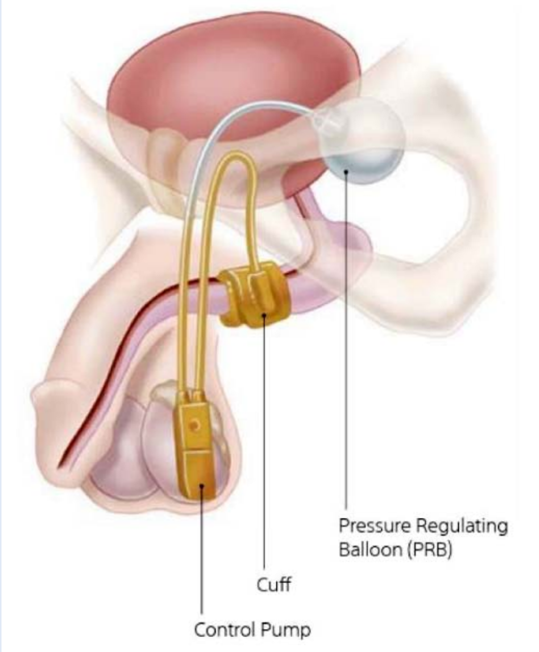

Figure 1. Artificial urinary sphincter (AMS 800™). Accessed August 20, 2025. Available from: https://www.bostonscientific.com/content/dam/bostonscientific/urowh/general/ams/Resources/URO-1914503-AA_AMS-800-Media-Kit.pdf (with permission from Boston Scientific)

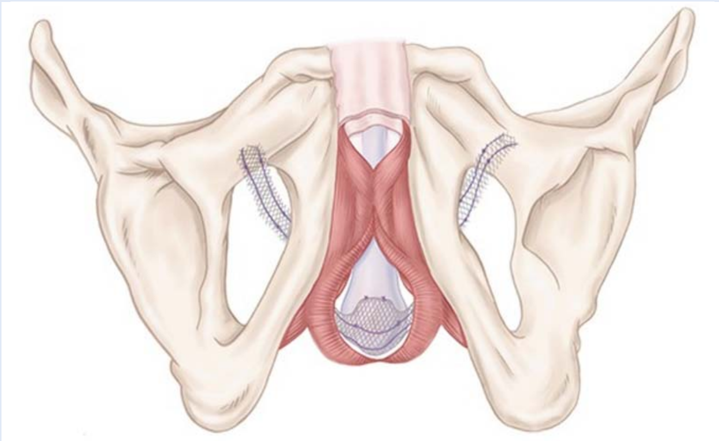

Figure 2. Sling with fixed mesh (AdVance™ XP). Accessed August 20, 2025. Available from: https://www.bostonscientific.com/en-US/products/slings- suburethral/advance-xp-male-sling-system/features--benefits.html (with permission from Boston Scientific)

because of the high reported failure rate, up to 50%, and the greater risk of complications compared with non-irradiated patients[49].

Adjustable mesh male slings were developed to enhance baseline continence, with the theoretical advantage of allowing postoperative tension adjustment to optimize outcomes[41]. These systems enable modification of urethral support by increasing tension or inflating a cushion positioned beneath the urethra. Currently available options include Argus Classic and ArgusT® (retropubic and transobturator approaches, respectively), Remeex® (retropubic approach), and ATOMS® (transobturator approach)[49]. According to the international guidelines, adjustable slings have not demonstrated superior efficacy compared to standard slings and have shown similar morbidity rates[42].

Adverse events associated with fixed male slings include elevated post-void residual urine, perioperative bleeding, and decreased patient satisfaction, often leading to subsequent incontinence procedures[60]. Approximately 10% of patients require a second intervention, most commonly implantation of an AUS[54].

Bulking agents

In patients unfit for invasive surgery and with mild incontinence, bulking agents may be a reasonable alternative[49]. Urethral injections have been used to treat UI since the early 20th century, with major advances beginning with cross-linked collagen and later water-based hydrogels. These agents improve continence by enhancing urethral coaptation through increased bulk at the sphincteric zone. The procedure is generally safe, well tolerated, and minimally invasive, often performed under local anesthesia. However, unlike the healthy female urethra, the male post-prostatectomy urethra is typically scarred, which may reduce its ability to coapt effectively[61].

Although generally safe, bulking agents may cause pain during injection, as well as transient urinary retention or voiding dysfunction after implantation[62].

In direct comparisons with more invasive treatments for post-prostatectomy stress urinary incontinence, surgical options consistently achieve superior outcomes. Furthermore, studies with follow-up beyond one year demonstrate a decline in bulking agent effectiveness over time[61]. Consequently, periurethral bulking agents should be reserved for selected cases, pending stronger evidence and greater standardization of injection technique, volume, and placement[49].

COMPLICATIONS OF SURGERY FOR MALE STRESS URINARY INCONTINENCE

Complications following surgical treatment of male stress urinary incontinence are generally categorized as intraoperative, early postoperative (<90 days), or late postoperative (>90 days). Intraoperative events may involve urethral trauma, most often occurring during urethral dissection or trocar passage in male sling placement. For minor injuries, the AUS or sling may be implanted at an alternative site to minimize the risk of erosion. More extensive urethral injuries should be repaired primarily, with the incontinence procedure deferred and a urethral catheter inserted. Bladder injury during trocar passage is typically managed by repositioning the trocar and maintaining a urinary catheter for several days. Intraoperative cystoscopy is advised during sling implantation to rule out bladder perforation[63].

A common early postoperative complication of scrotal surgery particularly after AUS placement is the development of a scrotal hematoma. This typically occurs within 1–3 days after surgery and may result from inadequate hemostasis before wound closure, early resumption of anticoagulation therapy, insufficient postoperative scrotal support, or other contributing factors[64]. Additional early postoperative complications may include urinary retention, infection with or without erosion, perineal pain, and new-onset detrusor overactivity. Urinary retention is most commonly due to postoperative edema and typically resolves spontaneously, while its persistence beyond eight weeks may indicate incorrect cuff sizing, excessive sling tension, or device malposition. Management generally involves intermittent catheterization, with suprapubic tube placement reserved for rare cases. After AUS implantation, indwelling urethral catheters should be avoided, and if catheterization becomes necessary, a small-caliber (12 F) straight catheter is recommended to reduce the risk of erosion. The reported rate of postoperative AUS infection is 1–3%[65]. Infection involving the AUS device or sling material may result from unrecognized urethral erosion or intraoperative contamination. Preoperative risk factors include multiple prior device placements, a history of erosion, and prior pelvic radiation therapy. The most common pathogens are Staphylococcus aureus, Staphylococcus epidermidis, Enterococcus species, methicillin-resistant S. aureus (MRSA), and various gram-negative bacilli[66]. Infections arising more than 90 days postoperatively may result from hematogenous bacterial seeding during subsequent procedures[63]. Early implant infection typically presents with scrotal pain, often accompanied by erythema, edema, or purulent drainage. Because implant infections rarely respond to antibiotic therapy, AUS or sling removal is recommended in cases of confirmed infection or erosion, with delayed reimplantation[67]. Immediate salvage of infected but non-eroded AUS can be performed using complete device removal, antiseptic irrigation, and immediate reimplantation, following protocols used for penile prosthesis salvage such as the Mulcahy protocol[68]. In the original series, Mulcahy and colleagues successfully salvaged 7 of 8 patients (9 procedures) with infected, non-eroded AUS[69]. The technique involves removal of the entire device and copious irrigation with a seven-solution sequence (bacitracin/kanamycin, half-strength hydrogen peroxide, half-strength povidone-iodine, pressure irrigation with vancomycin/gentamicin, followed by the first three solutions in reverse order) before placing the new system[70]. Contraindications to implant salvage include sepsis, ketoacidosis, necrotizing infection, device erosion, immunosuppression, and gross purulence at the time of removal[41]. Urethral erosion occurring early in the postoperative period is most often due to unrecognized urethral injury during device implantation[63]. This complication has been reported in up to 18% of AUS cases[71]. Device erosion requires explantation, even in the absence of infection. Repeat AUS or sling placement can be considered several months later, provided adequate tissue healing has occurred, and no urethral stricture is present[63]. Component migration is rare, occurring in approximately 1.5% of cases[72]. Reservoir migration may occur when the inguinal ring opening is large enough to permit complete or partial herniation of the reservoir through the external ring under increased intra-abdominal pressure[73]. Pump migration can result from inadequate closure of the scrotal space or as a secondary complication, such as following hematoma formation. While reservoir herniation usually does not impair device function, it can cause discomfort requiring surgical correction. Patients may present with difficulty operating the pump or with an inguinal bulge[74]. Postoperative perineal pain is more common after male sling placement than after AUS implantation, with some studies reporting rates of up to 100% and durations of up to 4 months. Patients may also develop *de novo* detrusor overactivity, which can be managed with antimuscarinic therapy when indicated[63]. Mechanical failure is a complication specific to AUS devices. In a long-term follow-up study of 100 patients, device failure-free survival rates at 5 and 10 years were 74.8% and 70.1%, respectively. Other studies with follow-up periods beyond 5 years report similar failure rates, ranging from 25% to 34%[75-77]. Urethral atrophy results from prolonged compression of the corpus spongiosum beneath the occlusive cuff. Unlike mechanical device failure, symptoms usually develop insidiously and progress gradually. It is one of the most common indications for AUS revision. Management options include cuff downsizing, repositioning of the cuff to a more proximal or distal urethral segment with greater spongiosal thickness, transcorporal cuff placement, or tandem cuff implantation[41].

Evaluation of persistent incontinence after AUS and male sling surgery

The evaluation of recurrent urinary incontinence (UI) after artificial urinary sphincter implantation should aim to identify the underlying cause, which may include inadvertent device deactivation, inadequate urethral compression (e.g. cuff oversizing), mechanical failure with fluid loss, cuff erosion, bladder storage dysfunction, urethral or bladder neck atrophy beneath the cuff, and less common issues such as a blocked delay-fill resistor or kinked tubing.

In such patients a detailed history, focused physical examination, and appropriate diagnostic testing are essential. A sudden loss of continence often points to inadvertent deactivation or mechanical malfunction. Actively cycling the device can rule out inadvertent deactivation. When the pump is deactivated but lacks adequate fluid for cycling, passive refilling may be attempted by squeezing the lateral edges of the pump, applying pressure with a cotton-tipped applicator to the side opposite the deactivation button, or pressing and holding the button for at least 30 seconds. Evidence of fluid loss suggests mechanical failure or leakage. Imaging of the pressure-regulating balloon (PRB) can help distinguish fluid loss from sub-cuff urethral atrophy—plain radiography is used for contrast-filled systems, and ultrasonography for saline-filled systems. During cycling, if the PRB changes size and refills passively, mechanical failure is unlikely, and urethral atrophy becomes the more probable diagnosis. Cystoscopy not only excludes erosion but also permits direct observation of cuff cycling, which can provide further confirmation of urethral atrophy. Urodynamic studies are indicated when bladder storage failure is suspected or when it is unclear whether incontinence is primarily due to detrusor overactivity. Revision surgery should be considered for patients with persistent or recurrent stress UI after AUS implantation. Evaluation of patients with a history of urethral sling placement is generally similar to that after AUS implantation, but several important distinctions exist. Identifying the specific sling type and determining the timing of symptom recurrence are essential for guiding further management[41].

In patients with an AdVance™ sling, evaluation should determine whether the sling has loosened within the first six weeks postoperatively, whether SUI is persistent without improvement, or whether symptoms are due to detrusor overactivity. If the patient reports initial improvement followed by a sensation of sling loosening within the first six weeks, re-exploration may be indicated. The perineum is reopened, the sling arms lateral to the bulbar urethra are identified and transected, and the central sling segment is carefully dissected from the surface of the corpus spongiosum. This step may require extensive dissection, particularly when the original sling placement caused significant elevation and invagination of the corpus spongiosum. A new sling can then be implanted using the standard technique[41].

In patients with persistent or delayed SUI after sling placement without early postoperative loosening of the AdVance™ sling evaluation should distinguish between detrusor overactivity and persistent SUI. If persistent SUI (i.e., sling failure) is confirmed, implantation of an AUS remains the gold standard and yields outcomes comparable to those of primary AUS placement[78]. Placement of a second AdVance™ sling in cases of late failure of the first has been reported with a 56% success rate at a median follow-up of 17.5 months[79]. This approach should be reserved for carefully selected patients in whom AUS implantation is contraindicated or declined[41].

Radiologic assessment of complications after continence surgery

Magnetic resonance imaging (MRI) provides excellent anatomic detail and can assess functional implant issues, however, its use in the acute setting is limited by availability, longer acquisition times, and the need to confirm MRI compatibility of implanted devices. Computed tomography (CT), by contrast, is widely available, rapidly performed, and is often the diagnostic modality of choice when complications arise.

While large hematomas may be clinically evident, CT is invaluable in cases where the diagnosis is uncertain. It can differentiate postoperative interstitial edema from drainable hematomas, thereby guiding conservative management versus surgical exploration. It also provides precise information about the size, location, and composition of hematomas. Imaging appearance varies with acuity: acute hematomas typically appear as hyperdense fluid collections. Additionally, it can detect active arterial or venous bleeding, as well as gas and fat stranding suggestive of superimposed infection. Although small amounts of periprosthetic air are expected in the immediate postoperative period, significant or increasing gas with associated fat stranding especially in the early to intermediate postoperative stages should raise concern for infection and prompt consideration of device explantation. Administration of intravenous contrast enhances the visualization of postoperative fluid collections within this small and highly compartmentalized anatomical region. An uncommon complication after AUS implantation is migration of device components, such as the reservoir or pump. When reservoir migration occurs, imaging is critical for surgical planning, as the exact location relative to the external inguinal ring can influence the operative approach. If the reservoir was originally placed in a submuscular position, slight palpability may be normal particularly in patients with a thin abdominal wall and should be distinguished from pathologic migration. Imaging not only confirms the diagnosis but also delineates the precise anatomic location of the displaced component and identifies any associated alterations in normal anatomy[74]. A leak from an AUS system typically results from mechanical failure or a tear in one of the connecting tubes, allowing fluid to escape. Clinically, patients may present with worsening incontinence. Imaging can support the diagnosis by revealing a low PRB volume; in a functioning system, the PRB typically contains 22–23 mL of fluid. Volume assessment is particularly helpful in equivocal cases. Gas within or around prosthetic components is observed in 53.8% of cases with fluid leaks[80]. Because the AUS is a closed hydraulic system, the presence of any intraprosthetic gas is abnormal and confirms a leak, requiring elective surgical reimplantation.

Foci of gas surrounding the cuff of an AUS on contrast-enhanced CT are highly suggestive of cuff erosion and should prompt further evaluation with retrograde urethrography and cystoscopy, which typically confirms the presence of cuff material within the urethral lumen. Although these complications are uncommon, they often require urgent surgical management. CT imaging plays a pivotal role in their detection, making it essential for radiologists to be familiar with both the normal and abnormal positioning of AUS components. As the number of implanted devices increases and their duration in situ lengthens, such findings will likely become more common. Early recognition of these complications, particularly subtle imaging signs, is critical for expediting diagnosis and guiding timely intervention[74].

CONCLUSION

Postprostatectomy urinary incontinence remains a frequent and distressing complication driven primarily by sphincteric injury but often compounded by bladder dysfunction and patient-related factors. Although most men recover continence within the first postoperative year, a significant subset experiences persistent leakage with profound quality-of-life implications. Accurate diagnosis, integrating history, validated questionnaires, physical examination, and targeted investigations are essential to guide individualized treatment. Conservative measures, including pelvic floor muscle training and lifestyle modification, form the cornerstone of early management, while surgical options such as the artificial urinary sphincter and male sling provide durable solutions for refractory cases. Advances in surgical technique, nerve preservation, and regenerative strategies hold promise for improving both prevention and treatment. Optimal care requires a multidisciplinary approach that addresses not only the physical but also the psychosocial impact of incontinence, ensuring that patients achieve the best possible functional recovery and quality of life.

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