Perineal Ultrasound: a Review in the Context of Ejaculatory Dysfunction

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ABSTRACT

Background: Ejaculation consists of the emission of semen from seminal vesicles and prostate, followed by expulsion. Ejaculatory dysfunction may take several forms including premature ejaculation, delayed or anejaculation, retrograde ejaculation, and painful ejaculation. Ejaculation is what we can see whereas orgasm is what we feel. The presence of ejaculate does not indicate the ability to experience orgasm. Hence, for the purpose of this work we consider orgasm and ejaculation as 2 separate neurobiological phenomena.

Aim: To review the role of advanced investigative techniques such as perineal ultrasound in the diagnosis and management of ejaculation and ejaculatory dysfunction.

Methods: We performed a PubMed search for key words individually and in combination: “ejaculation,” “ejaculatory dysfunction,” “delayed ejaculation,” “painful ejaculation,” “retrograde ejaculation,” “perineal ultrasound,” and “transrectal ultrasound.” We also share our local experience using perineal ultrasound in assessing ejaculation.

Outcomes: Perineal ultrasound can be used as an aid in the investigation of ejaculatory dysfunction.

Results: Evaluation of ejaculatory function hinges on a detailed psychosexual history and appropriate physical examination. Function of the ejaculatory center in the spine is androgen dependent; thus, hormonal evaluation is an important aspect of the workup. Disorders of ejaculation and orgasm require evaluation of neuromuscular reflexes activated during sexual activity. Dynamic ultrasonographic (US) ejaculatory-orgasmic studies allow for reproducible and detailed descriptions of the sexual response. Transrectal ejaculatory studies are useful in uncovering reasons for lack of antegrade semen emission, especially in men with poor sperm production or after vasectomy. Dynamic US studies contribute clinical utility in its non-invasive nature and can provide insight to the dynamic processes surrounding pelvic floor functioning in men.


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Key Words: Ejaculation; Ejaculatory Dysfunction; Retrograde Ejaculation; Anejaculation; Perineal Ultrasound
(ejaculation longer than 30 minutes). In our original theoretical framework, the time to ejaculation depends on the linear progression of arousal until the threshold for activation of spinal cord ejaculation center is reached (Figure 1). Such an approach allows classification of delayed ejaculation or anejaculation as a disorder of arousal, with premature ejaculation as one extreme of the spectrum and anejaculation as the other. The force of ejaculation is measured using our own patient-centered 4-point scale, (0 = no ejaculate, 1 = overflow beyond the meatus, 2 = ejaculate below the umbilicus, and 3 = ejaculate above umbilicus) (Figure 2). Little disagreement exists in the assessment of semen color. The quality of orgasm can be assessed on a linear 11-point scale (0 = best ever). This can be done verbally, or using a previously published visual scale such as the “orgasmmeter,” which also uses the numbers 0–10. Ejaculation-associated symptoms are descriptive in nature and include the sensation of pain, post-ejaculatory fatigue, headache, and many more. The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition and the International Classification of Diseases, Tenth Edition are limited in describing complexity of sexual response in men. Therefore, in 2015 the International Consultation on Sexual Medicine integrated approaches from the Diagnostic and Statistical Manual of Mental Disorders and International Classification of Diseases with expert opinions to provide consensus definitions for sexual dysfunctions for both sexes. According to the consensus group, the sexual dysfunctions related to ejaculation include premature ejaculation, anejaculation, delayed ejaculation, retrograde ejaculation, anhedonic ejaculation, anorgasmia, hypothalamic orgasm, and painful ejaculation/orgasm. However, that system does not fully incorporate neurobiological differences among ejaculation, orgasm, and arousal.

The most common type of ejaculatory dysfunction is premature ejaculation. Prevalence varies depending upon the definition used and population studied, but premature ejaculation may be experienced by 21% of men over their lifetime. The prevalence of other types of ejaculatory dysfunction are approximately 10% in the general population, although numbers vary widely among studies. Ejaculatory dysfunction becomes more prevalent with increasing age. In a survey of 12,000 men, those between the ages of 50–60 years report a prevalence of 30.1%. These numbers further increase to 74.3% in men between the ages of 70–80 years. However, older men more commonly report delayed ejaculation, lack of ability to reach orgasm, and decreased force and volume of ejaculation.

A neurobiological understanding of ejaculatory dysfunction is important in clinical evaluation and formulating a treatment plan. In this review, we will discuss normal physiology of ejaculation, ejaculatory dysfunction, and use of adjuvant imaging modalities, specifically perineal ultrasound and transrectal ultrasonography (US) to aid in the evaluation of men with ejaculatory dysfunction.

**NORMAL PHYSIOLOGY OF EJACULATION**

Ejaculation is a result of exceeding the threshold necessary for activation of spinal cord motor generator of ejaculation. Spinal cord motor generators are automatic motor reflexes that regulate walking, breathing, swallowing, and emesis. Classically ejaculation is divided into emission phase and an expulsion phase. During emission, closure of the bladder neck prevents retrograde movement of the ejaculatory fluid into the bladder. Closure of the bladder neck is under alpha-1 adrenergic control.

Next, ejaculatory fluid is transported into the proximal urethra. The ejaculatory fluid is composed of fluid from prostate and seminal vesicles. Prostatic secretions are released prior to other glands and comprise approximately 40% of the total volume. Prostate secretion is also activated by sympathetic nervous impulse. Spermatozoa contribute a small volume of the semen and are transported from the cauda of the epididymis to the urethra via the vas deferens and ejaculatory duct. This occurs through increased sympathetic signaling inducing increased intraluminal pressure within the proximal vas deferens, subsequently transporting the spermatozoa distally to the ampulla of the vas.

Contractile waves from the epididymis propel sperm to the vas deferens, and are modulated by adrenergic innervation, peptides, and hormones such as estrogen. This causes the ampulla of the vas to distend, which along with neural stimulation induces contraction of the ampullae’s contents into ejaculatory ducts and urethra. The seminal vesicle contributes approximately 50–60% of the seminal fluid, and is characterized by its alkaline and fructose-rich composition. A small proportion of seminal fluid is contributed by the bulbourethral and periurethral glands.

The expulsion phase involves the propulsion of semen from the urethral meatus via coordinated and rhythmic contractions of the bulbocavernosus and pelvic striated muscles. On average, men with normal sexual function have 10–13
contractions lasting 18–20 seconds during ejaculation. The smooth muscle fibers in the bladder neck tonically contract and functionally coapt the most proximal urethra, whereby increasing the intraurethral pressure by the contraction of the bulbocavernosal and bulbospongiosal musculature expelling the fluid from the urethra. However, the mechanisms of semen propulsion via the urethra may also involve contractions of the urethra itself. During this time, the external sphincter opens to allow the ejaculate to flow in an anterograde fashion. The sensation of orgasm is closely related to muscular contractions but presence of semen in urethra is not necessary for orgasm as evident from men after prostatectomy who experience sometimes enhanced orgasms. Orgasm was found to occur before the contraction of the bulbocavernosus muscles, and at the time of the first contraction of the ischiocavernosus muscles.11

Ejaculation occurs via activation of the spinal ejaculatory center in the spinothalamic neurons of the lumbar spinal cord (L3–4).13 Here, integration of sensory input from pelvic organs, and release of cerebral inhibition combined with progression of arousal, can trigger ejaculation where a combination of somatic and autonomic outflow signal the previously mentioned anatomic structures to synchronously fire. This process is heavily mediated by the sympathetic system with pre-ganglionic innervation originating in the intermediolateral cell column and dorsal gray column of the thoracolumbar spinal region (T12–L2).13 Parasympathetic neurons are thought to play a smaller role in ejaculation but pre-ganglionic neurons originate in sacral 2–4 regions. Similarly, motor output from the spinal ejaculatory center is transmitted by the pudendal nerve thought to originate in Onuf nucleus in the ventral horn of the sacral spinal region (S2–4).13 These processes may be further modulated by hormones such as testosterone, oxytocin, prolactin, thyroid hormones, estrogens, and glucocorticoids.6 Both clinical and animal studies suggest neurotransmitters may also modulate normal and dysfunctional ejaculation such as dopamine, serotonin, oxytocin, gamma-aminobutyric acid, substance P, and nitric oxide; these are reviewed in detail in the review of Clement and Giuliano.13

Normal ejaculation is heavily reliant upon a coordinated and properly functioning pelvic floor, particularly during expulsion. Orgasm is a separate entity, but often coincides with the timing of the rhythmic pelvic floor musculature contraction, specifically during contraction of the bulbocavernosus muscle.14 Hypertonicity, a form of increased contraction of the pelvic floor musculature, is found in women with sexual dysfunctions such as...
vaginismus. These findings in women coupled with pelvic floor dysfunction known to occur in men suggest that imaging research in the male analog of these sexual dysfunctions, such as painful orgasm/ejaculation, should be pursued. Further support implicating the importance of pelvic floor in male sexual dysfunction includes the benefit of pelvic floor muscular physiotherapy in enhancing control of ejaculation, with proponents encouraging its use for premature ejaculation.

Research into objective measurement of orgasm with US imaging is also ongoing. In women, US studies have discovered that different areas of the clitoris can be stimulated by vaginal or direct external clitoral stimulation, suggesting a physiologic basis for different orgasm types in women. Another study in women identified a thinner urethrovaginal space in women who do not experience vaginal orgasm, indicating a structural difference corresponding to subjective differences among patients, while further research has brought to light the complexity of the clitorourethrovaginal complex in its relationship to sexual stimulation and orgasm in women.

**EJACULATORY DYSFUNCTION**

As per the 2015 International Consortium of Sexual Medicine, the categories of ejaculatory dysfunction include: premature ejaculation, anejaculation, delayed ejaculation, retrograde ejaculation, anhedonic ejaculation, anorgasmia, hypohedonic orgasm, and painful ejaculation/orgasm. Premature ejaculation is defined as ejaculation occurring nearly always within 1 minute of vaginal penetration if lifelong, or with a decrease to less than 3 minutes if newly acquired, and is symptomatically bothersome. This disorder is both prevalent, affecting 20–30% of men, and bothersome. Premature ejaculation may be primary and lifelong or may be acquired. The etiology is variable but is thought to be an interplay of genetics, neurobiology, psychology, or relationship dependent. Inflammation has also been proposed as an etiology of premature ejaculation, with increased prevalence of prostatic inflammation found in men with premature ejaculation. Epidemiological studies have not found a definitive etiology for acquired premature ejaculation, but suggest that chronic prostatitis, hormonal disorders such as hypothyroidism, relationship stressors, and erectile dysfunction may contribute in some cases. Ultrasound may play a role in the diagnosis of prostatic-based etiologies in these patients. Treatment focuses on education and behavioral techniques, often in combination with pharmacological strategies to decrease penile sensation (ie, local anesthetic creams or barrier techniques with use of a condom) and modulate central mechanisms through use of selective serotonin re-uptake inhibitors. Premature ejaculation is further reviewed in Chung et al.

Retrograde ejaculation occurs when seminal fluid enters the bladder rather than exiting the urethra after normal activation of ejaculatory center. Retrograde ejaculation occurs when the bladder neck is incompetent during ejaculation and the failed bladder neck coaptation allows semen to travel toward the bladder rather than in an antegrade fashion. The diagnosis can be made by history, physical examination, and lack or very low volume of semen. Presence of sperm on post-ejaculate urinalysis is helpful but lack of sperm does not exclude retrograde ejaculation as men with diabetes mellitus with vassal hypotonia/atonia, men with non-obstructive azoospermia, and men after vasectomy may have retrograde ejaculation without sperm found on post-ejaculatory urine analysis. The etiology of retrograde ejaculation may be congenital as seen with posterior urethral valves, utricular cysts, and bladder extrophy. It may also be acquired with medications such as alpha-blockers or psychotropic medications, benign prostatic hyperplasia, surgical procedures such as transurethral prostatic resection or incision, or due to neurologic deficits resulting in an incompetent bladder neck such as spinal cord injuries, lumbar sympathectomy, multiple sclerosis, myelodysplasia, diabetic autonomic neuropathy, and prostatic urethral resection, or retroperitoneal lymph node dissection. Treatment hinges on correcting the underlying condition, treating with sympathomimetics, or urine centrifugation and collection of sperm in the case of desired fertility. This is reviewed further in the review of Parnham and Serefoglu.

Anejaculation is defined as "the absence of antegrade ejaculation during ‘orgasm’ (more precisely after spinal cord motor generator of ejaculation has been activated) owing to the absence of the emission and expulsion phases of the ejaculation reflex.” Similarly, delayed ejaculation was defined as an increase in latency time occurring more often than not, resulting in distress, and preceded by a period of normal ejaculatory function. This can be a lifelong or acquired disorder, and can range from the inability to ejaculate in all scenarios, to the ability to ejaculate but with increased difficulty, or after prolonged stimulation in some instances. Mean intravaginal ejaculatory latency times in most of men is 5.4 minutes, and 2 SD above the mean is 22 minutes, which may help with diagnosis. Incidence ranges from 2–11%, depending on the definition used. Anorgasmia or delayed orgasm is the most bothersome form of ejaculatory dysfunction to men. Etiologies include psychogenic in 28% of men, penile sensation abnormalities (7%), hyperstimulation in 2%, spinal cord injury, low testosterone in 21% of cases, or medications such as anti-psychotics, anti-hypertensives, and anti-depressants, particularly selective serotonin reuptake inhibitors, in 42% of cases.

Anhedonic ejaculation lacks the “pleasurable sensation of orgasm.” However, in our practice we describe orgasmic dysfunction numerically based on 11-point scale (0 = no orgasm, 10 = best orgasm ever). This descriptive method avoids more psychiatric-based definition such as anhedonia, which is described in association with depression. Hypohedonic orgasm, not surprisingly, is a “decreased or low level of sexual pleasure with orgasm.” This form of sexual dysfunction has been reported to be associate with medications and psychologic conditions.
Painful ejaculation, otherwise termed as dysejaculation, dysorgasmia, or odynorgasmia is "the occurrence of genital and/or pelvic pain during or shortly after ejaculation or orgasm." The prevalence of dysejaculation is thought to vary between 1–10% of men, but may be as high as 30–75% of men with chronic prostatitis or chronic pelvic pain syndrome. Pain may vary in both severity, from mild discomfort to significant pain, as well as location ranging along the region of pudendal innervation: penis, scrotum, and perianal and perineal regions. The etiology of painful ejaculation is variable and includes: seminal vesicle calculi, sexual neurasthenia, sexually transmitted diseases, pelvic radiation, inguinal hernia repair, benign prostatic hyperplasia, prostatic surgery, inflammation of the prostate, prostate cancer, anti-depressants, psychological distress, or idiopathic. Evaluation includes a thorough history and physical exam of the external genitalia, digital rectal exam to assess the prostate and pelvic floor tone, as well as semen and urine cultures and analysis as well as prostate-specific antigen. Clinical management is further reviewed by Parnham and Serefoglu.

Pleasure and pain related to orgasm are ultimately subjective sensations. The use of dynamic imaging among these men may help identify aberrant patterns of muscular or structural dysfunction that exist concurrently with the sensation experienced. Dynamic imaging techniques may also prove to be useful in assessing the coordinated events of the pelvic floor and associated anatomical structures during retrograde ejaculation and dysejaculation.

TECHNIQUES FOR EVALUATING EJACULATORY DYSFUNCTION

History, physical examination, and laboratory examination are used to rule out underlying general medical conditions such as common endocrinopathies. This may include testosterone levels, prolactin levels, and diabetes and dyslipidemia screening. If prostatitis is suspected, pre-prostatic and post-prostatic massage secretions may be tested for analysis and culture. In addition, selected functional and imaging studies may be of benefit in some cases of ejaculatory dysfunction.

Electromyography

Ejaculatory function has been evaluated using electromyography.13 This makes use of current measurements during ejaculation. Primarily used for understanding the physiology of ejaculation, it could theoretically also provide information about the musculature in disease states. However, this remains more invasive than imaging modalities such as dynamic US.

Transrectal Ultrasound

Transrectal ultrasound emerged in the early 1990s as a useful imaging modality for evaluating the physiology of ejaculation in dynamic fashion.14 It involves placement of an ultrasound probe into the rectum with visualization of the prostate, bladder neck, urethra, and its contents (Figure 3). Three phases of ejaculation were observed: pre-ejaculation, ejaculation, and post-ejaculation.34 The pre-ejaculatory phase involved changes in the echogenicity of the prostate gland, and the disappearance of a structure near the bladder neck that the authors termed the "anechoic wedge." They theorized that this structure represented closure of the bladder neck. The ejaculatory phase demonstrated movement of the ejaculatory fluid in a mostly antegrade fashion. Finally, during the post-ejaculatory phase, the bladder, prostate, and urethra showed a return to the resting configuration as visualized by ultrasound.34 These structural observations helped to reinforce the previously described conceptual framework of ejaculation.

More recently, color Doppler ultrasound has been used transrectally to obtain further information about human ejaculation in antegrade and retrograde ejaculation.35 In a healthy volunteer man, the phenomenon of antegrade ejaculation was observed.35 The landmark events in the emission and expulsion phases, including bladder neck closure, seminal fluid emission, and rhythmic muscle contraction were all observed in real time.35 This was contrasted with the US observation of retrograde ejaculation, wherein bladder neck closure did not completely occur (Figure 4).35 Throughout both sets of ejaculation, the direction of movement of seminal vesicle fluid could be observed.35

For delayed ejaculation, some authors have advocated for measurement of the bulbous urethral diameter on ultrasound as an indicator of arousal, although it should be noted that this is based primarily on opinion, small human studies, or animal studies only.36 True anejaculation is rare, and must be distinguished from anorgasmia.36 Dynamic US has been used in its diagnosis. This can confirm the presence of sufficient bulbocavernous muscle contractions consistent with the ejaculation phase, in the absence of the presence of ejaculatory fluid.36

Previously published literature has demonstrated the feasibility of transrectal ultrasound for the individualized diagnosis of ejaculatory dysfunction. In 2015, Hara et al17 described 2 cases of ejaculatory dysfunction that had treatment guided by ultrasound-based diagnosis of the specific type of dysfunction. One of the patients had transrectal ultrasound findings of retrograde ejaculation with incomplete bladder neck closure at the time of ejaculation.37 This helped to determine the next step in treatment. A submucosal collagen injection was performed, which resulted in 6 months of antegrade ejaculation.

In the same series, a second patient had a clinical diagnosis of anorgasmia and anejaculation. Transrectal ultrasound revealed a lack of striated pelvic floor muscle contraction during ejaculation, with clinical findings of erectile dysfunction.37 The patient had improved orgasm during ejaculation after 2 weeks of etilefrine hydrochloride daily and “as needed” sildenafil.
Perineal Ultrasound

Perineal ultrasound involves use of an 18-MHz linear probe placed in the perineum (Figure 5), and direct visualization of the bulbospongiosal, bulbocavernosal, pelvic floor, and bladder neck muscles (Figure 6). At our institution, the patient is placed in the supine position and is asked to stimulate themselves with use of visual aids. An abstinence period of 3 days is recommended. Measurements include: number of bulbospongiosal/bulbocavernosal muscle contractions (Supplemental Video 1), latency to ejaculation, number of semen expulsions, force of the ejaculate (0 = no ejaculate, 1 = overflow beyond meatus, 2 = ejaculate below the umbilicus, and 3 = ejaculate above umbilicus), changes in bulbourethral diameter from rest to ejaculation, change in bulbospongiosal muscle length from rest to ejaculation, and changes in bulbospongiosal muscle thickness from rest to ejaculation. Baseline muscle thickness, bladder neck coaptation, and contractions of the pelvic floor muscles may also be assessed. Perineal ultrasound offers an obvious advantage over transrectal ultrasound given its minimal invasiveness in men. However, transrectal ultrasound has a greater body of literature in ejaculatory dysfunction in men. Nevertheless, perineal ultrasound is a promising platform to aid in the objective evaluation of men with ejaculatory and orgasmic dysfunction for both research and the diagnosis and treatment of ejaculatory dysfunction.

Imaging of the prostate with perineal ultrasound has been compared to transrectal prostate ultrasound. Overall, it has good concordance for prostate visualization. Structural changes in the pelvic floor in men with chronic pelvic pain syndrome have been observed on perineal ultrasound. Compared to healthy controls, men with chronic pelvic pain were found to have a more acute anorectal angle, consistent with chronic tightening of the pelvic floor.

For more dynamic imaging, perineal ultrasound has been used to evaluate bulbocavernosus muscle contraction frequency during ejaculation in a small number of men with ejaculatory dysfunction. For those men treated with testosterone, an increase in bulbocavernosus muscle contraction number during ejaculation was observed. Although limited by sample size, this pilot study provided proof of concept of non-invasive perineal ultrasound as a clinical adjunct to assess treatment success.
Much of the research in perineal ultrasound in urology derives from the field of incontinence. Pelvic muscle floor activation has been observed on transperineal ultrasound in post-prostatectomy men, with specific dynamic changes, such as urethral sphincter shortening, found to be related to continence status. Overall voluntary pelvic floor muscle strength was correlated between ultrasound and findings on digital palpation in women, validating it as a metric. Transperineal ultrasound is also used in women to assess descent of pelvic organs. Although the studies on ejaculation in men are limited, transperineal ultrasound has even been used to observe the dynamic and controversial process of ejaculation in women.

A difficulty with all forms of dynamic ultrasound is the development of a reproducible system of evaluation of the ejaculatory process. A proposed solution is the development of a system of points on the ultrasound image that correspond to specific pelvic floor musculature structures. The movement of these points then represent the movement of 3-dimensional structures in the 2-dimensional US plane. This system has been previously validated in women for incontinence, and is under development for men. For this system, perineal ultrasound has an advantage over transrectal ultrasound as it is less intrusive to an individual attempting to ejaculate and allows for simultaneous imaging of more pelvic floor structures compared to transrectal ultrasound.

The field of voiding dysfunction is developing uses for this dynamic imaging. In this field, urodynamics provides a clinical standard for evaluating the dynamic process of voiding. Researchers have observed voiding in women with perineal US,
and cross-referenced their imaging findings with urodynamic findings.\textsuperscript{48} Urethral and bladder neck hypermobility, as well as urge incontinence, can be directly observed with perineal US in this population.\textsuperscript{48} These findings seem to correlate with urodynamics.\textsuperscript{48} Non-invasive US perineal urodynamics are touted by some as the future.\textsuperscript{49} An analog in the field of ejaculatory dysfunction is in its infancy but demonstrates significant promise as an objective platform for patient evaluation and research.

**CONCLUSIONS**

Ejaculation in men is a complex process characterized primarily by an emission and an expulsion phase. Ejaculatory dysfunction can arise when components of either of these phases fail to engage properly or in a temporally correct manner. The existing modalities for evaluation of the structural components of ejaculatory dysfunction would benefit from reduced invasiveness. Perineal ultrasound offers a less invasive approach to imaging in ejaculatory dysfunction that requires further validation. This modality may drive individualized treatment for patients with ejaculatory dysfunction based on dynamic analysis of their individual dysfunction and may provide a series of objective measurements when conducting research on ejaculatory dysfunction.

**ACKNOWLEDGMENT**

The authors thank medical illustrator Vanessa Dudley.

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**Conflict of Interest:** The authors report no conflicts of interest.

**Funding:** Supported by the Frederick J. and Theresa Dow Wallace Fund of the New York Community Trust and American Urology Association New York Section E. Darracott Vaughan MD, Research Scholar Award.

**STATEMENT OF AUTHORSHIP**

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**Category 2**

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(b) Revising It for Intellectual Content
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**Category 3**

(a) Final Approval of the Completed Article
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**REFERENCES**


SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.j.smtr.2017.12.005.