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Overactive Bladder treatment with Electrical Stimulation of posterior tibial nerve: A Narrative review

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ABSTRACT

Overactive bladder is a condition characterized by uncontrolled detrusor muscle activity. Electrical stimulation (ES) of the posterior tibial nerve is efficacious in reducing the symptoms of this condition. It is an effective alternative method for individuals who receive anticholinergic medications and other conservative methods without success. It is less invasive and expensive and should be used early in the treatment protocol for overactive bladders. Percutaneous tibial nerve stimulation (PTNS), transcutaneous tibial nerve stimulation (TTNS), and implantable devices are three methods used to perform electrical stimulation of the posterior tibial nerve. However, studies have shown that treating symptoms is more significant when combining PTNS with medications.

Keywords: Posterior tibial nerve; Electrical Stimulation; Overactive bladder

1. INTRODUCTION

Overactive bladder (OAB) is a worldwide problem that occurs in both women and men of different ages and affects their quality of life. Urge or overactive incontinence is the urgency to micturate, followed by sudden excretion of urine due to uninhibited detrusor muscles. Medication and behavioral therapy are common first-line treatments; however, some patients do not improve. According to multiple studies, the treatment of OAB by using electrical stimulation (ES) is efficient and effective (Yang et al., 2021; Burton et al., 2012). The anatomy of the urinary system is essential to understanding the problem, its treatment, and the normal micturition process. The two kidneys are situated below the ribs on the sides of the spine and function by filtering the blood, eliminating waste products and toxins, and controlling the body's fluid balance. The kidneys release specific hormones to regulate blood pressure and manage the erythrocyte manufacturing process.

The muscles in the ureter walls contract and relax to urge the urine to travel lower into the bladder. The ureters are small tubes that convey urine from the kidneys to the bladder. Approximately every 10–15 s, the ureters empty a small amount of urine within the bladder. Ligaments keep the bladder, a hollow, triangular organ, in place. The relaxation of bladder walls helps to collect urine, and its contraction by the detrusor muscle empties urine through the urethra. Usually, it can store 750 ml of urine "slightly less in women" for 2 to 5 hours in healthy adults (Hickling et al., 2016). There are two circular muscle sphincters, one of which is internal and one that is involuntary. It relaxes as the bladder is half-filled, and the second external sphincter is voluntary and can be controlled to prevent leakage. The urethra is the last part of the urinary system and permits urine to exit the body.

At the proper time for micturition, the micturition reflex was released by the spinal cord (increased parasympathetic nervous system activity, decreased sympathetic activity, and motor neurons in the external sphincter). The detrusor muscle contracts simultaneously, and the sphincters relax. When an individual delays urination (e.g., improper time), the pons will prevent the urination reflex in the spinal cord, and it will be delayed until the person can empty the bladder; when every signal appears in this order, normal micturition takes place; otherwise, the individual has a problem (Hickling et al., 2016). Urinary incontinence is a common problem. It is involuntary and unintentional excretion of urine from the body. According to population studies conducted in many different nations, the prevalence of UI varies from 5% to 70% and is more common in older adults, especially women (Milson, 2000).

Types of urinary incontinence

Overflow incontinence occurs when there is a problem emptying the bladder. Therefore, the bladder becomes overfilled with urine, resulting in an intermittent and weak urinary stream (dribble urine), which can be caused by blockage (hypertrophic prostate) or Ineffective detrusor muscle (Hickling et al., 2016). Functional incontinence and mental or physical problems affecting a patient's function, including dementia or arthritis, can alter and prevent the patient from getting to the bathroom on time (Milsom, 2000). Stress incontinence: Urine leakage due to weakened pelvic floor muscles. It can occur when the abdominal pressure on the bladder increases and overwhelms the sphincter muscles, such as during exercise, laughter, sneezing, or coughing.

Pregnant women or those who have delivered are more likely to have this type because their pelvic floor muscles are stretched and weakened (Demaagd et al., 2012). Overactive or urgent incontinence: People urgently need to go to the bathroom, followed by sudden urination caused by uninhibited detrusor muscle that contacts randomly, resulting in frequent urination, especially at night. Causes of OAB include minor conditions, including infection, or severe conditions, such as diabetes and neurological conditions (Yang et al., 2021; Lucas, 2014). Mixed Incontinence: This involves two previous conditions. Other conditions and procedures, for example, diabetes, Parkinsonism, bladder cancer, hysterectomy, and prostatectomy, can cause UI by damaging nerves and affecting the micturition reflex (Hickling et al., 2016; Lucas, 2014).

2. DIAGNOSIS OF URINARY INCONTINENCE

Urinary incontinence can be diagnosed using several methods according to the patient's state, and the physician will take the patient's history and perform a physical examination. Next, the subject might be asked to perform a specific test called a stress test that demonstrates incontinence, such as coughing. The doctor then will likely recommend performing other tests, such as:

Urinalysis

Urine samples were analyzed for signs of infection and other abnormalities (Hickling et al., 2016; Lucas, 2014).

Bladder diary

The patients record how much they drink, when they urinate, the amount of urine produced, whether they have the urge to urinate, and the number of incontinence episodes over several days.

Urodynamic tests

Multiple procedures can be performed to diagnose UI, including post-void residual measurement (PVR), uroflowmetry, cystometric tests, electromyography, and video urodynamic tests) (Rosier et al., 2017; Drake et al., 2018).

Video urodynamic tests

The bladder is imaged and video-captured using radiography and ultrasonography while filling and draining a catheter with contrast (Hijazi and Leitsmann, 2016).

Uroflowmetry

This is also known as the flow rate. It assesses how much urine is in the bladder and how quickly it empties. The patient urinates into a unique toilet with a scale and a container for the urine while the patient urinates, and uroflowmetry equipment will show the flow rate changes in the form of a graph. The physician sees the graph to determine the highest flow rate (Rosier et al., 2017).

Post-void residual measurement

The patients were asked to urinate in a specific container that measured the urine output. Then, the physician measures the residual urine in the bladder using a catheter or ultrasonic test. A significant amount of urine in the bladder may mean that the patient has an obstruction in the urinary tract that prevents the emptying or a problem within the bladder nerves or muscles (Drake et al., 2018).

Cytometric test

A catheter was used to drain the bladder. Then, a smaller manometer catheter is placed in the bladder to measure the pressure. It can also measure differences between the vagina and rectum (Rosier et al., 2017).

Electromyography

It is recommended that urinary problems are linked to muscle or nerve injury. The flow rate can be calculated by tracking how long it takes to urinate in a urine-measuring container. Sensors are positioned on the skin close to the urethra or rectum or on catheters to measure the electrical activity of the muscles and nerves within and surrounding the bladder and sphincters. The activity is recorded on a machine to show whether the bladder signals and pelvic floor muscles are normally coordinated (Lorenzo-Gomez et al., 2012).

3. OVERACTIVE BLADDER (OAB)

One of the most prevalent forms of urinary incontinence is OAB. An overactive urinary bladder is defined as increased pressure and hyperactivity of the detrusor muscle, which can cause nocturia, urgency, increased frequency of voiding during the day, and urinary incontinence (Corcos et al., 2017). The hyperactivity of the Detrusor muscle, known as neurogenic detrusor hyperactivity (NDH), is frequently associated with central or peripheral nervous system disorders such as stroke, Parkinsonism, and multiple sclerosis (Garcia and Pereira, 2018). The main symptom is urinary urgency, an intense, unexpected urge to urinate that is hard to postpone. Urgency is not confused with a strong need to urinate, which is the typical sensation when the bladder is full, indicating that functional bladder capacity is attained.

Urgency is characterized by involuntary urine leakage that is preceded by the feeling of frequent urination during the day (Abrams et al., 2003). Nocturia occurs when an individual wakes up once or more times at night to urinate (Van-Kerrebroeck et al., 2002). The International Continence Society (ICS) 2002 stated that specific irritating urinary symptoms accompany OAB. Urinary urgency is typically associated with frequent micturition and nocturia in the absence of other related illnesses or a lower urinary tract infection. The diagnosis was made based on an examination of the symptoms, the existence of urinary urgency, and complaints of unexpected and speedy urination. The urodynamic examination allows a better understanding of this illness since the detrusor muscle's involuntary contractions occur with the bladder-filling phase (Abrams et al., 2003). By 2018, 546 million individuals will be affected by OAB globally (20.1%) (Irwin et al., 2011).

Causes of OAB that increase OAB prevalence

Weak pelvic muscles

Pregnancy and delivery can strain and weaken the pelvic muscles and tissues that protect structures in the lower abdomen. As a result, the bladder might sag and fall from its ideal site. All these variables contribute to leakage (Aoki et al., 2017).

Nerve damage

The brain and bladder occasionally receive impulses that cause them to empty at the wrong moment. It can also occur because of trauma or disease. Examples include surgical intervention in the back or pelvis, disc prolapse, multiple sclerosis, certain drugs, Parkinsonism, and abuse of Alcohol, which can decrease the signal conduction velocity within the central nervous system. This may lead to bladder overactivity.

Infection

The bladder may suddenly compress due to irritation of its nerves caused by any infection, such as a urinary tract infection (UTI) (Liao et al., 2022).

Excess weight

Being overweight places additional strain on the bladder. Urge incontinence may result from excessive weight gain.

Estrogen insufficiency after menopause

This hormonal alteration may contribute to urinary incontinence. However, in most cases, OAB has no specific cause (Cardozo et al., 2004).

Treatment of OAB

Lifestyle modification (such as fluid consumption, smoking cessation, and dietary changes), physiotherapy (including pelvic floor muscle training) Fitz et al., (2017), medications (antimuscarinic drugs) Athanasopoulos et al., (2011), neuromodulation, Botox injection Orasanu and Mahajan, (2013), and surgical intervention have all been used to treat OABs.

Neuromodulation and its concept on the treatment of OAB

L2-S4 originates from the lumbar, sacral, and coccygeal segmental nerves, which innervate the lower urinary tract. After leaving the spinal cord, a vast network of sensory and motor fibers develops and supplies the organs within the pelvis. Fibers that descend to the lower extremities from L4 to S3 make up the sciatic nerve. The distal branch is the posterior tibial nerve (PTN). Neuromodulation results from cross-signaling between parasympathetic and sympathetic postganglionic nerve terminals and synapses, which modifies the nerve impulses responsible for the voiding reflex (De-Groat and Yoshimura, 2015). Peripheral nerve stimulation and subsequent "cross-talk" at postganglionic neuroeffector connections can alter conduction.

This suggests that exciting a part of the innervation system changes the neural activity of the remaining systems, resulting in bladder function changes caused by the stimulation of one of the peripheral nerves, as described by (De-Groat et al., 2015). One of the peripheral nerves that can be stimulated to change the abnormal nerve activity of the bladder is the PTN, which is thought to reduce incontinence episodes and improve the quality of life of individuals with OAB (Marchal et al., 2011). Stimulation of PTNS is a second treatment line for people with OAB. It is used when medication and bladder retraining with pelvic floor exercises fail to manage symptoms (De-Wall and Hessakkers, 2017). Percutaneous tibial nerve stimulation (PTNS), transcutaneous tibial nerve stimulation (TTNS), and implantable devices Bhide et al., (2020) are methods used to apply electrical stimulation at the PTN.

Percutaneous tibial nerve stimulation (PTNS)

From the sitting position, insert a 34-gauge needle 4–5 cephalad into the medial malleolus to activate the PTN. The needle is connected to a device that transmits low-level electrical stimuli to the PTN and the nerves that regulate the bladder (sacral nerves). When a current is passed, when the needle electrode is placed correctly, the big toe flexes, the other toes move, and the patient may experience tingling. In a cat model, Tai et al., (2011) established that stimulation of the PTN at 5 Hz and 30 Hz reduced bladder activity. The intensity of this first test stimulation was progressively raised until the big toe curls or toe fans. If there is a complaint “of pain” or "buzzing" at the needle site, it is possible that the needle is not in enough depth. The needle might be positioned too near the nerve if the stimulation is painful. The needle should be repositioned or reinserted into the ipsilateral or contralateral ankle.

Once the ideal location is determined, stimulation is delivered at a level the patient can handle and can be raised or lowered during therapy (DeWall and Hessakkers, 2017). Furthermore, Tai et al., (2011), established that when the tibial nerve was stimulated repeatedly with short-term stimulation, there was a long-lasting poststimulation inhibition, and the bladder capacity was improved. The patient's maximum tolerable level specified the current intensity. The stimulation treatments lasted 30 minutes, and the frequency was initially 12 treatments weekly. While most objective evidence supports a 12-week plan, shorter programs may also be successful (Bhide et al., 2020). Adverse effects related to PTNS are described as moderate, temporary, and relatively rare (1–2 percent). These adverse effects include slight discomfort, bleeding at the needle position, and tingling sensation (Peters et al., 2010; Peters et al., 2009).

Transcutaneous Tibial Nerve Stimulation (TTNS)

PTNS requires a prolonged treatment program (typically twelve sessions of 20-30 minutes) by trained professionals in a clinical setting, requiring high time expenses for the patient with OAB. Moreover, even though it is considered advantageous, the expense of implementing a treatment program and continuing maintenance therapy may prevent it from being readily available and regularly used in specific healthcare organizations and countries. Considering these constraints, many studies have examined the use of the TTNS (Booth et al., 2018). It is a non-invasive and safe method that utilizes surface electrodes. The patient can apply it at home, decreasing the treatment expenses.

It is advantageous since the program's implementation is entirely determined by the patient with OAB and may thus suit individuals' lifestyles. In this method, the PTN is stimulated by two 50 mm electrode pads. The active pad was positioned behind and above the medial malleolus, with the earth pad about 10 cm above it. Continuous stimulation was applied with a pulse width of 200 ls and a frequency of 10 Hz. The amplitude was chosen to provide sensory input to the foot at the same side as tolerated. The duration of stimulation is 30 minutes (Ramirez-Garcia et al., 2019).

Implantable devices

Van-der-Pal et al., (2006), described implantable devices that stimulate the PTN. This implant is put on the tibial nerve during an open surgical procedure while receiving prophylactic antibiotics, generally under local anesthesia. A 5 cm incision is made, 2 cm posterior to and 3 cm above the medial malleolus. After locating the bundle of the tibial nerve, the electrode was positioned close to the nerve and sewn to the fascia using non-absorbable sutures. To ensure that the electrode was properly functional and positioned, test stimulation was carried out while a motor response was observed (Janssen et al., 2013).

After a 24-hour pressure bandage application, the patients were instructed to increase their walking activity progressively. The operating system was triggered one month after insertion with the initial parameters of a 200 s pulse width and a 20 Hz frequency. The baseline intensity was adjusted to the intensity at which the patient felt an initial sense of stimulation, and the maximum intensity was selected as the maximum tolerated level. The patients were instructed to wear the rechargeable device for 30 min at a tolerable intensity six times weekly to provide therapeutic stimulation. Since the introduction of this method by Van-der-Pal et al., (2006) many new technologies and techniques for implantation (Van-Breda et al., 2017; Herbison and Arnold, 2009; Staskin et al., 2012).

4. CONCLUSION

In conclusion, PTNS successfully reduced urgency, frequency, and urge incontinence. PTNS is an alternative for individuals who use anticholinergic medication and other conservative methods that have failed to reduce their symptoms. It is less invasive and cheaper than other methods and should be included in the early treatment protocol for OAB. However, studies have shown that alleviation of symptoms is more significant with the use of PTNS combined with medication.

Limitations

This is a narrative review which heavily rely on the author's interpretation of the literature, which can introduce some degree of bias and subjectivity. The selection of studies, their inclusion criteria, and the interpretation of their findings may be influenced by the reviewer's opinions or preferences.

Recommendations

More comprehensive studies such as systematic review and RCT studies are recommended to be done on this area for more accurate results that will be more suitable for clinical interpretation.

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Author Contributions

Fahad H Alshehri: Writing and revising the manuscript, data collection, and analysis. Only one author completed the entire production manuscript.

Ethical approval

Not applicable as this study is a narrative review.

Informed consent

Not applicable.

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Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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