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REVIEW ARTICLE

Hyperhidrosis Update

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Abstract

Nearly 3% of the population has hyperhidrosis. Quality of life is affected, impacting on social relationships and professional activity, and social anxiety disorder can sometime develop.

We review the definition and causes of hyperhidrosis and the clinical evaluation of patients. After describing the different clinical aspects of the condition, we discuss the medical and surgical treatments. Of such treatments currently available, particular mention is made of the use of botulinum toxin in some forms of hyperhidrosis as an intermediate option between the traditional treatments and surgery. We also draw attention to the use of minimal access surgical techniques (videothoracoscopy), which, over the past decade, have become established as an effective, safe, and permanent approach for the treatment of hyperhidrosis when indicated.

PALABRAS CLAVE
Hiperhidrosis;
Métodos tópicos;
Iontoforesis;
Toxina botulínica;
Simpatectomía videotoracoscópica

Actualización en hiperhidrosis

Resumen

La hiperhidrosis afecta casi al 3% de la población. Hay una disminución de la calidad de vida que perjudica las relaciones sociales y las actividades profesionales, presentándose ocasionalmente fobia social.

En esta revisión se analiza el concepto y las causas de hiperhidrosis, así como la evaluación clínica del paciente que la padece. Tras discutir los distintos aspectos clínicos de la hiperhidrosis se revisan los diferentes tratamientos médicos y quirúrgicos.

Actualmente disponemos de varios tratamientos de tipo médico y quirúrgico. Se resalta la aportación de la toxina botulínica como opción intermedia en ciertas formas de hiper-

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hidrosis, entre los tratamientos clásicos y el tratamiento quirúrgico. También se destaca la contribución de las técnicas quirúrgicas de acceso mínimo (videotoracoscopia), que se han consolidado en esta última década como una opción efectiva permanente y segura para el tratamiento de esta afección en los casos indicados.

What Is Hyperhidrosis and Why Does It Occur?

Hyperhidrosis is excessive sweating in response to heat or emotional stimuli that are stronger than physiologic stimuli. Individuals who suffer from hyperhidrosis sweat even under unexpected conditions, for example, in an air-conditioned room, leading to serious psychological, social, and professional problems.

The cause of primary hyperhidrosis is unknown. Onset is usually in early childhood, and the condition gradually worsens until puberty before diminishing again as the individual gets older. It affects both sexes and all races. Secondary hyperhidrosis, on the other hand, seems to have a number of causes, and excessive sweating in this case is associated with an underlying disease process, as occurs with hyperhydrosis in conditions such as recurrent infection and endocrine disorders (eg, hyperthyroidism and diabetes mellitus).[1]

An early study from Israel reported the worldwide incidence of hyperhydrosis to be 0.6% to 1%.[2] More recent studies, however, suggest that the prevalence could be as high as 2.8% in the United States,[3] or even 4.6% in certain parts of China.[4] Most sweat glands are eccrine glands (there are approximately 3 million), and these are regulated by the neurotransmitter acetylcholine and inhibited by atropine or similar substances. The eccrine glands are found mainly on the palms, soles, and maxillary region. The apocrine glands, on the other hand, are fewer in number and are found mainly in the axillas and urogenital region. These become active during puberty and are regulated by adrenergic nerve fibers. Secretion in the apocrine glands takes place mainly in the hair follicles and the sweat produced is viscous and malodorous. The apocrine glands are more commonly involved in hyperhidrosis (mainly axillary hyperhidrosis) in younger people.[5]

A third type of human sweat gland—the apoeccrine glands—has recently been identified. These glands are only found in the axilla and share morphologic and functional characteristics with both the eccrine and apocrine glands.

The eccrine glands secrete a predominantly serous liquid (sweat), and are regulated mainly by acetylcholine. The apoeccrine glands may play a significant role in axillary hyperhidrosis, but not in excessive sweating in other parts of the body.[6]

The pathophysiology of primary focal hyperhidrosis is not fully understood, although it could arise from overstimulation of the eccrine glands through an abnormal neurologic pathway in response to disproportionate stimuli that increase basal sweat secretion. Although hyperhidrosis is often induced by emotional stress, in most cases it occurs spontaneously and intermittently. The sweating threshold may be lower than the normal daily sweating threshold, to the extent that normal activity is sufficient to maintain continuous secretion of sweat. The sudden onset of excessive sweating is often unpredictable and, therefore, can have major consequences for people whose work involves contact with others. It can lead to disability and social phobias, especially when accompanied by facial blushing.[7-9]

In the patient with hyperhidrosis, both the sympathetic chain and the eccrine glands are histologically normal. The study by Moya et al[10] is particularly interesting. These authors reported neuronal death in the sympathetic ganglia of patients with primary palmar hyperhidrosis, as well as lipofuscin deposits not associated with inflammation, which is uncommon in younger patients, unless the lesions are the result of functional hyperstimulation. Furthermore, in hyperhidrosis induced by drugs or heat, the sweat glands are normal. However, patients with this condition experience a more intense sympathetic sudomotor response in the skin, and this is sufficient to maintain continuous sweating.[11,12]

Hyperhydrosis has been thought to originate in the hypothalamus, which controls sweat production on the palms and soles and, to a lesser extent, in the axillas. At these sites, the origin of hyperhidrosis is different from that of sweating elsewhere on the body (controlled exclusively by the cerebral cortex, with no involvement of thermoregulating elements). In fact, emotional sweating does not seem to occur during sleep or pharmacologic sedation.

Thermoregulation is controlled by cerebral cortical structures, the anterior hypothalamus, and the sympathetic nervous system. The nerve supply originates in the preoptic sweat center of the hypothalamus, from where the nerve fibers run down the brainstem ipsilateral to their hypothalamic origin. These fibers synapse in the intermediolateral cell column of the spinal cord, and in their respective anatomical regions. The sweat glands are finally innervated by unmyelinated postganglionic sympathetic fibers. Noradrenaline intervenes in sympathetic supply as a peripheral neurotransmitter; however, in periglandular nerve endings, acetylcholine is the neurotransmitter that stimulates eccrine secretion. The most likely cause of primary focal hyperhidrosis is sympathetic hyperactivity, which is observed in normal eccrine glandular circuits. Hyperexcitability may be due to the complexity of sympathetic and parasympathetic dysfunction in the pathways of autonomic nervous systems. This dysfunction can occur at several levels, including the hypothalamic nuclei, prefrontal area, and final glandular

cholinergic synapse. Many studies have tried to determine the underlying autonomic dysfunction in hyperhidrosis.

The sympathetic nervous system is part of the autonomic nervous system, which supplies the smooth muscles, the striated muscle of the heart, and several glands, including the sweat glands. Efferent sympathetic fibers leave the central nervous system via the spinal branches to establish synapses with the fibers of the ganglia of the sympathetic chain (the so-called preganglionic fibers). The postganglionic fibers, which originate from these ganglia, synapse in the different target organs. Furthermore, the afferent (sensory) fibers connect many of these organs with the central nervous system.

The thoracolumbar sympathetic system is composed of fibers that originate in the dorsolateral region of the anterior horn of the gray matter of the spinal cord and run through the anterior root to form preganglionic fibers. These fibers enter the spinal white matter, before passing to the sympathetic chain, where many terminate in ganglia. Postganglionic fibers are widely distributed, and the distribution of sympathetic fibers is similar for the sweat glands in the hands and axillas. In their postganglionic pathway, the fibers of the sympathetic trunk pass through the gray matter as rami communicantes that reach all the spinal nerves and run alongside the cutaneous rami.

The sympathetic nervous system generally stimulates activities associated with energy consumption. Sympathetic responses are more evident during stress and situations of alarm. Acetylcholine is the neurotransmitter involved in the sympathetic preganglionic fibers, as in the parasympathetic system. However, these systems can be distinguished according to the neurotransmitter present in the postganglionic fibers (found between the nerve endings and effector cells of the organs involved). Noradrenaline is the neurotransmitter in the sympathetic nervous system; therefore, the sympathetic system is known as an adrenergic-type system. The only exception to this rule is the neurotransmitter that acts between the postganglionic fibers and the sweat glands, namely, acetylcholine (not noradrenaline). Therefore, sympathetic innervation of the sweat glands is of cholinergic-type.

Recent data point to the existence of a familial component in hyperhidrosis, and this could account for up to 50% of cases. One recent analysis reports a genetic link.[13]

Evaluation of the Patient With Hyperhidrosis

Both physicians and patients are often unaware that primary hyperhidrosis is a relatively common, treatable condition. Evaluation involves a complete clinical history and an exhaustive physical examination. This should allow the physician to distinguish primary focal hyperhidrosis from secondary generalized hyperhidrosis. A complete clinical examination of organs and systems should be made to rule out secondary hyperhidrosis and ascertain potential contraindications for some types of treatment, especially when the patient might be pregnant. Associated symptoms such as fever, night sweats, weight loss, enlarged lymph nodes, headache, or palpitations should alert the physician to the need for a more in-depth investigation to establish possible secondary causes. In addition, the impact of hyperhidrosis on quality of life should be evaluated.

The physical examination should attempt to confirm the distribution pattern of excess sweating, as well as rule out any possibility of secondary hyperhidrosis. In practice, there is no well-established quantitative definition of hyperhidrosis; therefore, it seems reasonable to apply a severity scale to diagnose this condition in individuals whose excessive sweating interferes with their daily activities.

The Minor starch-iodine test[14] is a simple test that measures the approximate volume of sweat production. The technique also helps to define the hyperhidrotic areas of the body before treatment is administered. This test is also useful for identifying the persistence of areas of sweating after treatment, for example, with botulinum toxin. Photographs of these areas can show the difference in appearance before and after therapy. Before the test, the target body area is carefully washed and dried. First, iodine-alcohol solution (1%-5%) is applied, and the skin is allowed to dry. Next, cornstarch is shaken over the area to be tested. In the presence of sweat, iodine and starch react to produce purple sediment. Thus, the purple areas show the orifices of the sweat glands. Depending on the severity of the hyperhidrosis, small purple spots—representing the eccrine pores—are immediately visible.

Gravimetric assessment is useful in patients in whom the diagnosis of hyperhidrosis has not been confirmed,[15] and so it can be used in everyday clinical practice, although it is mainly applied for research purposes. It is performed by means of filter papers that are weighed before and after contact with the affected area in order to measure the volume of sweat absorbed during a specific period of time. The patient rests for an interval of at least 15 minutes at room temperature (21°C-25°C), and the filter paper is applied to the affected area for approximately 1 minute before being reweighed. The rate of sweat production is then measured in milligrams per minute. Axillary hyperhidrosis is defined as a rate greater than 100 mg/5 min in men and 50 mg/5 min in women. Palmar hyperhidrosis is defined as a rate greater than 30-40 mg/min in both men and women.

Many validated and reliable methods that measure quality of life include parameters related to hyperhidrosis.[16-22] Validation of the results of quality-of-life surveys in patients with hyperhidrosis speak in favor of medical treatment, as quality of life has been shown to improve significantly after treatment.

According to the survey by Strutton et al[3] in the United States, hyperhidrosis interferes with activities of daily living in almost three-quarters of patients. Thirty-five percent of individuals with focal hyperhidrosis reduced the amount of time they spent on leisure activities, and a further 22% reduced the time they spent working due to their symptoms. Patients also made considerable efforts to hide their problem, and their ability to cope with this problem did not improve with time. These results show, therefore, that patients with hyperhidrosis have more emotional problems

and find it more difficult to manage general skills than other dermatologic patients or healthy controls.

Clinical Aspects of Hyperhidrosis

The wide range of therapeutic options available for this condition reflects the difficulty in obtaining satisfactory results. In 1996, Hospital Clínico y Universitario in Barcelona, Spain, set up a functional hyperhidrosis unit, comprising 4 medical specialties: dermatology, thoracic surgery, electromyography, and clinical psychology. Since then, more than 1500 patients have been evaluated. Our current protocol is shown in the Figure.

Excessive sweating can be classed as primary idiopathic or secondary. In terms of anatomical distribution it can be classed as focal or generalized.

Primary (Idiopathic) Hyperhidrosis

Primary hyperhidrosis is typically localized and affects the axillas, palms and soles, craniofacial region, and other specific areas. There are no associated causal pathologic

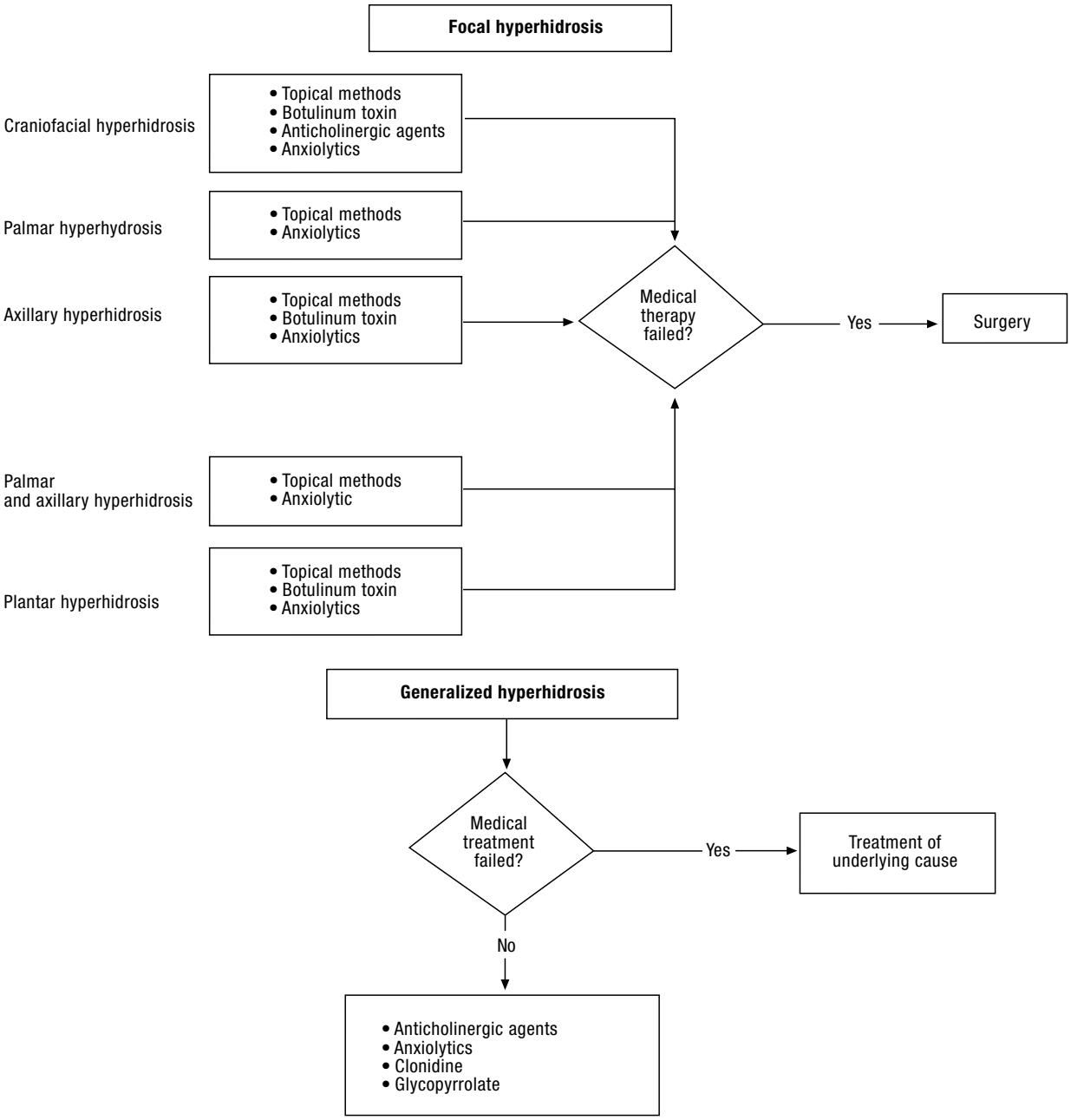

Figure 1 Treatment algorithm for hyperhidrosis.

processes, and it presents in healthy individuals. Some forms of hyperhidrosis, however, do have underlying causes.

A case of localized hyperhidrosis can worsen as a result of emotional processes, heat, and vasodilator stimuli. In addition, excessive humidity can lead to maceration of the skin and subsequent cutaneous infections or body odor (bromhidrosis).

Generalized Hyperhidrosis

Generalized hyperhidrosis affects most of the skin surface and is generally a manifestation of an underlying condition.

It is treated with systemic anticholinergic agents such as glycopyrrolate bromide, oxybutynin, atropine, and propantheline bromide. These agents block production of periglandular acetylcholine. However, the associated adverse effects somewhat limit their use.

Glycopyrrolate has the advantage that it does not cross the blood-brain barrier and, therefore, does not produce central anticholinergic effects. Atropine has a shorter action and a greater incidence of major central nervous adverse effects.

Benzodiazepines can also be administered. Their effect is indirect in that they control anxiety; however, they are not used habitually, as they induce dependence and somnolence.

The relaxation associated with homeopathic medicine, acupuncture, hypnosis, and biofeedback has had little or no effect in the treatment of hyperhidrosis.

Secondary Hyperhidrosis

Secondary hyperhidrosis is associated with acute and chronic infection, malignant neoplasm, respiratory failure, withdrawal symptoms (eg, drugs or alcohol), and other conditions associated with increased sympathetic discharge (cardiogenic shock and endocrine disorders such as thyrotoxicosis, diabetes mellitus, hyperpituitarism, and pheochromocytoma).

Secondary hyperhidrosis can manifest locally in severe lesions of the spinal cord with or without loss of autonomic reflexes. Patients can have symptoms of focal hyperhidrosis (face or upper trunk) for months or even years after the lesion.

Excessive ipsilateral or contralateral sweating is associated, respectively, with hemispheric cerebrovascular lesions or medullary infarction.

Other causes of secondary focal hyperhidrosis are lesions of the sympathetic chain through accessory cervical ribs or development of an intrathoracic tumor.

Gustatory sweating (Frey syndrome) leads to facial sweating and blushing, and is considered to result from interruption of the auriculotemporal pathway. In the parasympathetic system, the nerve fibers of the otic ganglion, which initially run to the parotid gland, form an aberrant anastomosis by which sympathetic sudomotor fibers are joined to nerve fibers of the skin supplying the facial sweat glands.

Treatment of Hyperhidrosis

Antiperspirants

Antiperspirants act by blocking the excretory ducts of the glands or as astringents, and there are several types, mostly based on metallic salts.

The most widely used are aluminum chloride, aluminum chlorohydrate, aluminum zirconium chlorohydrate, and aluminum sulphate. Aluminum chlorohydrate solution, 50% in anhydrous ethyl alcohol is the most effective. It is believed to obstruct the pores of the sweat glands and cause atrophy in secretory cells.[23] Treatment should be administered until symptoms resolve, and it should continue to be applied sporadically to maintain the effect. Its contraindications include hypersensitivity to the product and skin irritation. Aluminum chlorohydrate is the most widely used substance in axillary hyperhidrosis, although it is an irritant and its effectiveness is not constant.[24] One of the main disadvantages of metallic salts is their short action. Their principal side effect is skin irritation, which can lead to interruption of or nonadherence to treatment in a significant number of patients. Localized irritation is caused by the hydrochloric acid generated when sweat or residual water on the skin combines with aluminum, leading to pruritus and burns and making it difficult to apply the compound properly. In this case, sodium bicarbonate or triethanolamine can be applied to neutralize the effect of the hydrochloric acid; hydrocortisone cream, 1% or other topical corticosteroids have also proven effective for diminishing the irritation.

Toxicity is an unusual side effect of aluminum; however, this should not give cause for concern, as the amounts used in topical presentations are usually very small. Although toxicity resulting from transcutaneous administration of aluminum is unusual in young and healthy people, physicians should bear in mind that this substance does in fact present a greater risk for elderly patients with renal failure or those in whom aluminum phosphate hydroxides coexist as agglutinants in the body. However, there is no evidence to indicate that aluminum can generate mutations or DNA damage that would lead to cancer.

Other effective compounds are zinc salts, although these are not recommended due to the risk of formation of cutaneous granulomas.

Topical Anticholinergic Agents and Local Anesthetics

Propantheline, scopolamine, poldine methylsulfate, and other agents have been used. Results have varied widely, given the need to use high concentrations to achieve the desired effect, with the resulting risk of sensitization and absorption combined with adverse systemic effects. Glycopyrrolate applied using iontophoresis is another approach that has proven relatively effective in patients with palmoplantar hyperhydrosis. Side effects are unusual and reversible, and the most common are disorders of ocular accommodation. At our unit, we have performed 2 studies with topical glycopyrrolate to treat craniofacial

hyperhidrosis[25] and postsurgical compensatory sweating,[26] with excellent results.

Antiadrenergic Agents

The most widely used is clonidine, which has proven successful, especially in postmenopausal craniofacial forms.[27]

Astringents

Astringents denaturalize proteins in the stratum corneum by blocking the pore. This action persists for several days until desquamation. The most common therapeutic agents are tannic acid in 2% or 5% ethanol, formaldehyde, trichloroacetic acid, and glutaraldehyde. Although effective, these agents can cause skin coloring, thus making them less acceptable to patients.

Anxiolytics

Given that emotions play an important role in stimulating hyperhidrosis, the objective of treatment, which is based on sedatives and anxiolytics, has been to induce a certain degree of indifference to external emotional stimuli.

Oral Anticholinergic Agents

As the sweat glands also contain muscarinic receptors, they are sensitive to the inhibitory action of anticholinergic agents. Most patients with idiopathic hyperhidrosis improve with systemic anticholinergic agents, although these usually have side effects and are therefore reserved for special cases. The most common side effects are xerostomia, mydriasis, cycloplegia, and intestinal and vesical dysfunction. They can also cause glaucoma or urinary tract obstruction in patients with prostatic hypertrophy. Oxybutynin (Ditropan, 1 capsule every 8 hours) is the most common.[28] Other agents include tolterodine (Destrusitol, 1 qd; Urotrol-neo, 1 qd) and solifenacin (Vesicare 5, 1 qd).

Serotonin Reuptake Inhibitors

Although serotonin reuptake inhibitors have been proposed for treatment,[29] there is no scientific evidence to support their effect.

β-Blockers

The most widely used β-blocker is propanolol, which is a noncardioselective β-adrenergic blocker with marked membrane-stabilizing activity and no intrinsic sympathicomimetic activity. Propanolol has no specific action on the sweat glands. It eliminates the effects of anxiety and, therefore, improves the symptoms of hyperhydrosis, albeit moderately in some cases.

Iontophoresis

This transcutaneous approach involves passing an electric current through the skin. It facilitates molecular transport across the skin under the influence of an external continuous or pulsed electric field.[30] The electric current mobilizes the sodium ions of an aqueous solution in which the affected area is submerged, thus providing the sweat glands with a temporary resting period by a mechanism that is not fully understood. It has been suggested that this technique acts by inducing hyperkeratosis of the pores, with obstruction of flow and secretion. Alteration of the electrochemical gradient of sweat and a feedback mechanism have also been postulated.[31]

There are currently 2 types of iontophoresis for the treatment of hyperhidrosis, one based on normal water and one based on an anticholinergic agent in solution.

Iontophoresis is used to treat forms of localized hyperhidrosis in areas that can easily be submerged in water. Consequently, this method is of little use in axillary hyperhidrosis. As iontophoresis can irritate the skin, it is poorly tolerated by patients with a history of cutaneous disorders in the treatment area.

The contraindications to iontophoresis include wearing a pacemaker, pregnancy, prostheses or metallic elements such as orthopedic implants, and intrauterine contraceptive devices.

When anticholinergic agents are added to the solution to increase the therapeutic effect, additional contraindications must be taken into account. These include a history of arrhythmia and narrow-angle glaucoma.

The success of therapy depends on the current density —20 mA to 25 mA is assumed to be safe. The multidisciplinary group for the recognition, diagnosis, and treatment of primary hyperhidrosis and the Canadian Hyperhidrosis Advisory Committee recommend 3 to 4 iontophoresis sessions per week, with a duration of 20 to 30 minutes each using a device that supplies a current of 15 mA to 20 mA. If the conditions mentioned above are applied, euhidrosis should be reached after 6 to 15 sessions. The treatment effect usually lasts between 2 and 14 weeks after the last session, and maintenance treatment is generally administered every 1 to 4 weeks.

There have been reports of spontaneous resolution of plantar hyperhidrosis after treatment limited to the palms. The absence of compensatory hyperhidrosis after treatment is noteworthy.

Iontophoresis has few side effects, and these are mild in healthy patients if the treatment is administered correctly. The most common are dryness, erythema, or vesicular rash in the treatment area, although this is easily cured by applying emollients or topical corticosteroids. Inappropriate application of iontophoresis can cause serious problems, such as severe burns and cutaneous necrosis. Children require a smaller maximum current to achieve the same clinical effect as adults. This technique may not be suitable for patients who spend several hours per day engaged in manual work. Fortunately, this problem could be solved with iontophoretic devices for home use.

Some studies have shown that adding anticholinergic agents to the iontophoretic solution intensifies the anhydrotic effect in comparison with iontophoresis using normal tap water only.[32]

Botulinum Toxin

Application of botulinum toxin inhibits the release of acetylcholine at the nerve-muscle junction, thus involving the postganglionic sympathetic innervation of the eccrine glands.[33] This in turn leads to transient cessation of sweat production. The effects of treatment become noticeable within 2 to 4 days; symptoms remit in a week, although they reappear after a few months. Botulinum toxin is an intermediate option lying between conservative treatment and surgery, and it has revolutionized the treatment of some localized forms of hyperhidrosis.

It has proven particularly effective in the treatment of Frey syndrome,[34] which is characterized by erythema, sweating, and heat in the cutaneous territory of the auriculotemporal nerve as a response to gustatory stimuli resulting from a lesion of the parasympathetic fibers of this nerve.

Treatment with botulinum toxin type A consists of the application of intradermal injections of toxin every 1 cm to 2.5 cm. Anhidrosis appears after a few days in the 1.2-cm perimeter surrounding the injection site.

The recommended dose for palmar hyperhidrosis is between 100 U and 120 U in each extremity; for axillary hyperhidrosis, the recommended dose is 200 U to 250 U.

Botulinum toxin type A is safe and effective and can improve quality of life.[35] Complications are minor and transient and include hematoma at the injection site, temporary loss of muscle strength in the pincer grasp of the hand, or paresthesia that remits after a few weeks.

Botulinum toxin type B acts faster and over a larger area[36,37] than type A. The necessary dose is 7500 U to 9000 U for each upper extremity. Paresthesia and muscle weakness have been observed to disappear more quickly than with botulinum toxin type A. Botulinum toxin type B is currently considered to be an alternative in patients who present resistance to type A; however, the injection is more painful—its pH is slightly more acidic—and it is more expensive.

When this agent is administered on the palms, local anesthesia of the median and radial nerves is recommended, as the technique can prove painful. The results are excellent in the axilla and mean duration of the effect is 8 months. On the palms, most patients only achieve a subjective 60%-80% improvement and the effect does not usually last more than 3 months. Botulinum toxin has also been used successfully in craniofacial hyperhidrosis. Application over wider areas, as in hyperhidrosis secondary to sympatholysis, has not shown conclusive results.[38]

The main contraindication to botulinum toxin is hypersensitivity to albumin, which is an excipient in all the formulations used in the United States.

Relative contraindications include a history of peripheral motor neuropathy or involvement of the motor-end plate (Eaton-Lambert syndrome or myasthenia gravis). Botulinum toxin should not be administered to patients taking drugs that can enhance its effect, such as aminoglycosides, penicillamine, quinine, and calcium channel blockers.

Although infrequent, an increased seroconversion rate has been associated with repeated injections of more than 300 U.

Botulinum toxin type B has a faster action than type A, although its duration is shorter. It also has more side effects than type A, especially at doses of 4000 U to 5000 U. The most frequent side effects are autonomic (dry mouth and blurred vision) and neuromuscular (dysphagia). It has been speculated that botulinum toxin type B has greater affinity for autonomic nerve endings than type A; therefore, caution should be exercised when administering it to patients diagnosed with an autonomic dysfunction. Pilot studies with botulinum toxin type B used to treat hyperhidrosis are promising, although more studies are necessary to evaluate the dose–response relationship and clinical efficacy before it can be applied as first-line treatment.[36]

Surgery

The sympathetic chain extends from the base of the cranium to the coccyx. The thoracic section of the sympathetic trunk is formed by 12 ganglia located anteriorly to the rib heads and covered with a fine layer of parietal pleura. In videothoracoscopy of the sympathetic chain, these nerves are seen clearly once the lung has been collapsed towards the caudal region. The ganglia are subpleural and are observed as white strings measuring 1-2 mm in diameter and extending vertically and anteriorly to the posterior rib axes. The finding of double chains or Kuntz accessory fibers is exceptional; however, these anatomic variations are important in surgery for hyperhidrosis, since the outcome of the procedure could be poor if the presence of these structures is not taken into consideration.

Clipping, ablation, or cauterization of the sympathetic chain has different outcomes and undesirable effects depending on the level at which the intervention is performed. Most surgeons who treat patients with a history of blushing and facial hyperhidrosis perform sympathectomy at T2.

Sweat, which is secreted by the eccrine glands on the upper extremities, is produced by the sympathetic supply originating mainly from the second thoracic ganglion, and, to a lesser extent, from the third. Multivariate analysis reveals that patient satisfaction is associated with the severity of compensatory hyperhidrosis and excess palmar dryness.

Over the last few years, bilateral endoscopic thoracic sympathectomy has come to be an effective, permanent, and safe technique.[39] Thoracic sympathectomy is generally performed bilaterally during the same intervention, under general anesthesia and with selective intubation or orotracheal intubation under apnea.[40] Interruption of the sympathetic chain can be achieved using electrocautery, resection (endoscopic scissors, laser, ultrasonic scalpel), or metal clips.[41] The intervention can be performed using major outpatient surgery[42] or short-stay surgery, with a mean admission time of 24 hours. The immediate, medium-term, and short-term results are generally excellent[43]; however, there are some differences in satisfaction and quality of life depending on the location of the hyperhidrosis and the type of intervention performed.[44]

The most important complication of videothoracoscopy is severe postsurgical sweat reflex. In most cases, sweating is

usually more intense in other areas of the body, and in 10%-40% of cases it is severe. The most frequent locations are the lower back, buttocks, groin, and thighs. Onset is within 6 months of surgery and it can disappear spontaneously or persist indefinitely. Factors such as geographic area, work environment, humidity, and temperature can also affect the degree of postsurgical sweat reflex. Other complications, such as Horner syndrome, are exceptional with application of the ultrasonic scalpel.[45] The proportion of cases of gustatory sweating is very variable, although only exceptionally does it prove to be incapacitating and require treatment.[46]

Although plantar hyperhidrosis has been shown to improve after bilateral thoracic sympathectomy in some cases,[47] there is no convincing anatomical or physiological explanation. Perhaps reduced stress as a result of postsurgical palmar anhidrosis leads to improved emotional equilibrium and a reduction in plantar hyperhidrosis. Bilateral lumbar sympathectomy[48] is the only technique as effective as thoracic sympathectomy.

Laparoscopy makes it possible to perform node resection of the lumbar sympathetic chain (third and fourth lumbar ganglia). The first lumbar node must be preserved in men, as there is a theoretical risk of retrograde ejaculation.

Percutaneous sympatholysis by computed tomography-guided phenol injection or radiofrequency[49,50] is indicated in cases of relapse after surgery to treat hyperhidrosis, or when endoscopy is not viable due to pleuropulmonary adhesions. The figure shows the treatment algorithm used by the authors in cases of hyperhidrosis.

The table shows the treatment options available for facial hyperhidrosis and blushing.

Table 1 Treatment Options for Facial Hyperhidrosis and Blushing

	BB	TCA+BB	AP	BT	IP	BETS	BLS[a]
Facial blushing	[b]						[c]
Craniofacial hyperhidrosis		[b]					[c]
Axillary hyperhidrosis			[b]	[c]		[d]	
Palmar hyperhidrosis			[b]		[c]	[d]	
Plantar hyperhidrosis			[b]		[c]		[d]

Abbreviations: AP, antiperspirant; BB, b-blocker; BETS, bilateral endoscopic thoracic sympathectomy; BLS, bilateral lumbar sympathectomy; BT, botulinum toxin; IP, iontophoresis; TAC, topical anticholinergic agent.

[a]In women

[b]First option

[c]Second option

[d]Third option

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