Although new invasive procedures for the treatment of migraine have evolved during the past decades, the application of invasive procedures for this indication is not new. In this review, the history of non-drug treatments for migraine is discussed. Historical texts by physicians known to have written on headache and migraine (hemicrania), well-known books by physicians from the main historical periods up to 1900 and mainstream 20th century neurology handbooks were analysed. A large number of treatments have been tried, based on contemporaneous pathophysiological models that were not only applied to headache, but to medicine in general. Invasive procedures have been used for the more severe types of headache. Many treatments were based on ancient humoral theories up to the early 19th century. A new kind of invasive procedure appeared on the physician’s palette in the 19th and 20th century, following the development of new ideas that were based on solid pathophysiology, after the introduction of scientific method into medicine. After its introduction in the mid-18th century, medical electricity became even more popular for the treatment of migraine following the discovery of vasomotor nerves in the mid-19th century, but at the end of that century a more critical attitude appeared. The discovery of the lumbar puncture (1892) and roentgenogram (1895) and increased knowledge of intracranial pressure led to a new series of invasive procedures for therapy-resistant migraine in the early 20th century. Vasospastic theories of migraine led to surgical procedures on the sympathetic nerves. Following the experiments by Graham and Wolff in the 1930s that emphasized the vasodilatation concept of migraine, sympathicolytic procedures again became popular, including vessel ligation of the carotid and middle meningeal arteries. The influence of suggestion and psychological phenomena recognized at the end of the 19th century probably played an important role in many of the procedures applied. These placebo effects, generally more powerful in invasive treatments, are discussed against the background of present-day invasive treatments for headache, where they are still a matter of concern.

Keywords: headache; migraine; history of medicine; non-drug treatment; placebo effect

Introduction

Pharmacotherapy, the treatment of disease by the administration of drugs, is presently the principal treatment for headache and migraine and is as old as recorded history (Weatherall, 1997, p. 915). During the past few years, several non-drug treatments have been applied for pharmacoresistant headache, including deep brain stimulation (hypothalamus for cluster headache), occipital nerve stimulation (chronic migraine and cluster headache), nucleus caudalis dorsal root entry zone surgery (post-herpetic neuralgia of the trigeminal territory), patent foramen ovale procedures and transcranial magnetic stimulation (both for migraine). In most
historical reviews of headache, particularly of the last two centuries, drug treatments are discussed. The aim of the present paper is to determine which non-drug treatments have been applied for headache and migraine in the past and what lessons can be learned from comparing these methods and their indications, on the one hand, with recently applied therapeutic methods on the other.

Methods

Historical texts by physicians known to have written on headache and migraine (hemicrania), as well as well-known books by physicians from the main historical periods up to 1900 were analysed. In order to secure a representative list of books from this period, commonly known medical and neurological books in English, German, French and Latin were selected from two standard books, Garrison’s History of Neurology and the ‘Diseases of the nervous system’ section in Morton’s Medical Bibliography (McHenry, 1969; Norman, 1991). Additionally, mainstream neurological handbooks of the 20th century have been studied to review contemporary non-drug treatments. We defined ‘non-drug treatments’ as treatments that were not based on the administration of plant or other chemical substances that are applied in medicine (by mouth, skin, rectum or parenteral). We chose to start in the Hippocratic period, when naturally observable phenomena instead of magical explanations were held responsible for diseases and omitted prehistorical, Egyptian and Babylonian medicine. We confined ourselves to the western tradition, omitting Indian and Chinese medicine. Acupuncture was omitted, as it would be a study on its own and was rarely discussed in the sources that were consulted.

Results and discussion

Table 1 provides an overview of the procedures applied. Up to the mid-19th century, a clear distinction between headache and migraine, at least with respect to treatment, was not often possible and therefore we chose to report the treatment of headache in general, including migraine, in that period. After the final shift from humoral to solid pathophysiological models and a positivistic approach of medicine in the first part of the 19th century, migraine became more clearly distinguished from other types of headache. As dietetics, massage and gymnastics were advised throughout the periods under discussion; they were considered general methods and are not discussed in detail.

Headache treatment in the traditional period (humoral medicine)

The withdrawal of body fluids in order to restore the right balance (eukrasis) should be considered from the perspective of humoral medicine in which a balance of the four humours (blood, phlegm and yellow and black bile) was believed to determine health and disease. If drug treatments and other measures that sufficed in many instances failed, humoral substances could be withdrawn by several methods.

### Table 1  Non-drug treatments since the Hippocratic period

<table>
<thead>
<tr>
<th>Traditional period:</th>
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<tr>
<td>Bloodletting</td>
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<tr>
<td>Arm veins</td>
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<td>Head veins</td>
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<td>Head arteries</td>
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<td>Opposite side of the head</td>
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<td>(Byzantine period)</td>
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<td>Bleeding from nose</td>
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<td>Leeches</td>
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<td>Withdrawing other bodily fluids by</td>
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<td>Cupping</td>
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<td>Blistering</td>
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<td>More invasive procedures</td>
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<td>Cauterization</td>
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<td>Incisional garlic</td>
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<tr>
<td>Trepanation</td>
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<tr>
<td>Various</td>
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<tr>
<td>Oil in the ear</td>
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<tr>
<td>Warm baths, water</td>
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<tr>
<td>Binding dead mole on the head</td>
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<td>Magnets</td>
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<tr>
<td>Early electrical treatment</td>
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<tr>
<td>(Dietetics, gymnastics, massage)</td>
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<td>19th and 20th centuries:</td>
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<td>Electricity</td>
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<tr>
<td>To the head</td>
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<td>To the sympathetic nerves</td>
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<td>Physical treatments:</td>
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<tr>
<td>Arterial compression</td>
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<td>Vibration therapy</td>
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<tr>
<td>Hydrotherapy</td>
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<td>(Dietetics, gymnastics, massage)</td>
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<tr>
<td>Psychotherapy</td>
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<tr>
<td>Radiotherapy [pituitary (Bromley, 1944)]</td>
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<tr>
<td>Surgical procedures</td>
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<tr>
<td>Ear, nose and throat procedures</td>
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<tr>
<td>Lumbar puncture (intracranial pressure)</td>
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<td>Sympathectomy</td>
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<tr>
<td>Blood vessel ligation</td>
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<tr>
<td>(carotid and middle meningeal)</td>
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<td>Afferent sensory surgery</td>
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Bloodletting

With respect to headache, knowledge from the Greek-Roman period can best be demonstrated by Aretaeus’ work (first part of second century CE), which may be considered a basis for knowledge of the past twenty centuries. His books follow the well-known sequence a capite ad calcem (from head to heel) and his therapies for headache were referred to for centuries. Bloodletting was a regular treatment for many diseases, including headache. If the usual treatment did not succeed, not only was blood taken from veins in the arm, but a vein or even an artery of the forehead was incised. The treatments became more invasive if previous ones were ineffective. If subsequent cupping was unsuccessful, he bled sufferers from the nose:

‘... take the shaft of a thick goose feather, scrape off a bit from the outer layer and make notches into the fibres so that it
results in teeth like on a saw. Subsequently, push the shaft inside the nose up to the ethmoid bones, move it with both hands in order to create scratches at that site. In this way, a lot of blood will be discharged in a short time, as many small veins end there, and the site is soft and easy to injure (Aretaeus, 1958; Koehler and Van de Wiel, 2001).

During the subsequent centuries, not much changed. Three physicians from the Byzantine period will briefly be mentioned here, notably Oribasius of Pergamon, Alexander of Tralles and Paul of Aegina (Figure 1). Oribasius (325–403), the personal physician of Emperor Julianus Apostata, advised purging and bloodletting in hemicrania (Oribase, 1873). Alexander of Tralles (525–605), who had a great reputation in Rome, Spain, Gaul and Italy, advised bloodletting from the side opposite to the side of the headache (Tralles, 1878). Paul of Aegina (625–690) the famous obstetrician from the Greek island of Aegina, advised, among other treatments, to open the veins of the nose (Aegineta, 1844).

One of the ways by which the Greek–Roman medical tradition returned to Europe, in particular for the 11th century medical schools of southern Italy (including the Salerno), was through Arabic medicine. An important physician and polymath during this period was Maimonides (1135–1204); born in Córdoba, but expelled from Spain, he became Court Physician in Morocco, and then moved to Cairo where he became Royal Physician. Among his ten medical treatises, the 1500 medical aphorisms, mainly based on Greek sources, contain various references to the treatment of headache. In severe cases of migraine he advised bloodletting from ‘the pulsating arteries behind the ears’. If no benefit was seen after this procedure, he assumed that ‘the vapours which produce the illness rise to the brain through other pulsating arteries which are not visible on the surface substance, and which rise to the base of the brain’ (Rosner, 1993).

For hemicrania the ‘Dutch Hippocrates’ Forestus (1521–97) advised leeches among other treatments (Foreest, 1653). Thomas Willis (1621–75) distinguished three types of habitual headache, including continuous headache, intermittent headache and intermittent headache with vague and uncertain attacks (Isler, 1986). Accidental headaches often disappeared spontaneously and, if not, could be cured by phlebotomy (bloodletting); arteriotomy was also mentioned (Wills, 1674, p. 264). In ‘obstinate headaches, the Scottish physician Robert Whytt (1714–66) advised a large evacuation from the vessels of the nose’ (Whytt, 1765, p. 513). Headaches from suppression of the menses needed ‘bleeding, especially at the ancles’ (Whytt, 1765, p. 515). Sometimes leeches were applied to the temples, and for violent headaches an artery at the headache site needed to be opened in some cases. In plethoric patients, blood was taken from the jugular vein.

### Withdrawing other bodily fluids

#### Cupping and blistering

By placing heated glass tubes on the skin, blisters were drawn and this again was thought to restore the balance of the humours. In the Hippocratic works (ca. 460–370 BCE), a few references are found on what to do in cases of headache. In most descriptions...
the accompanying signs point to symptomatic causes, but other types of headache are also described:

‘Pour la douleur intense de la tête, quelle que soit celle des parties supérieures qui souffre, appliquez une ventouse’ (Aphorism. 59; Littre, 1861).

[For intense pain of the head, whatever of the upper parts that is suffering, apply cupping.]

‘Hippokrates’ warned against invasive procedures for benign types of headache.

‘Il faut savoir reconnaître les céphalalgies que proviennent des exercices du corps, des courses, des marches, des chasses ou de toute autre fatigue inopportune ou des excès vénériens, ... les douleurs intenses dont on ne peut pas triompher. Dans aucun de ces cas il ne faut purger ... ’ (Littre, 1840).

[One should recognize headaches that originate from physical exercises, running, walking, hunting or any other inconvenient fatigue or venereal excess, ... intense pains which cannot be overcome. In none of these cases one has to purge...]

Aretaeus likewise advised cupping if bloodletting from the arm or forehead was not successful. His work on headache was still referred to in the 17th century, for example by the Amsterdam physician Nicolaas Tulp (1593–1674, depicted in Rembrandt’s well-known ‘Anatomical Lesson’; Koehler, 1993). In Tulp’s book we find the case of a carpenter’s wife suffering from headache for a considerable period. It was accompanied by a warm feeling ascending from foot to head and vice versa to the big toe. Tulp ordered a cup to be set, inducing a sore, by which he believed a volatile spirit could drain from the body and the patient soon recovered. Johann Jakob Wepfer (1620–95) included the shaving of the whole skull and application of cantharides plasters all over it, but not for longer than eight hours, as it could cause dysuria (Isler, 1985). Apparently, cantharides not only caused blisters but were also absorbed.

In Thomas Sydenham’s work (1624–89), no discussion on headache or hemicrania was found (Sydenham, 1685; 1848). Herman Boerhaave (1668–1738) did not write much on headache and just referred to the work of Wepfer and Willis (Koehler and Bruyn, 1994), but in the work of his Dutch pupil, Gerard van Swieten (1700–72), we find an accurate description of what we now recognize as cluster headache, in a chapter on intermittent fever! Several treatments were tried, including bloodletting, anti-inflammatory purges, cups to the neck and blistering plasters, but all were in vain. Finally he applied quinine (Isler, 1993). Whytt distinguished headache of the whole head, one side or just one eye. ‘They generally return once a-day, nearly at the same hour, and as regularly as the fit of a quotidian ague. In some cases, they are attended with a visible swelling, not only of the affected eye, but also of that side of the forehead’, again complaints that could be interpreted as cluster headache (Whytt, 1765, p. 305). Headaches in sympathy with the stomach were treated by induced vomiting. For other head-aches ‘the properest remedies are blisters applied to the head or legs’.

More invasive procedures

Cauterization

If none of the treatments mentioned above gave relief, Aretaeus finally applied the red hot iron:

‘Consequently, you have to shave off the hair (which yet on its own is good for the head) and cauterize superficially down to the muscles. If you wish to cauterize down to the bone, carry it out at a site where there are no muscles. For if you burn muscles, you will provoke cramps. Some physicians incise down to the bone on the forehead along the border of the hair. They abrade or chisel the bone down to the diploe and let flesh grow over the place. Others perforate the bone down to the meninges. These are hazardous treatments. You have to apply them when the headache persists after all that has been done; the patient keeps courage and the body is vigorous’ (Aretaeus, 1958; Koehler and Van de Wiel, 2001).

Abulcasis (936–1013), who was born in the Córdoba area (Spain) and became surgeon to King Al-Hakam II of Spain, also applied the red hot iron, which was a popular method then. If this did not succeed, he advised to take garlic, peel and cut it at the two ends, make an incision at the temples with a large scalpel and make space underneath the skin enough to completely hide the garlic (Abulcasis, 1861). Blistering plasters and cautery were still applied by Claude Pouteau (1725–75), a French surgeon at the Hôtel Dieu hospital of Lyon, as described in his Mélanges de chirurgie (Pouteau, 1760).

‘N’est-il pas été plus expédient de donner une issue à cette humeur, en appliquant sur la tête des vésicatoires, ou en ouvrant un cautère?’

[Wouldn’t it be more expedient to allow the humour to issue forth, by applying a blister to the head, or applying cautery?]

Trepanation

The ‘Dutch Hippocrates’ Forestus generally advised just to help nature, but in an incurable case he ultimately applied the trepan and found a ‘black worm’ on the dura (possibly a chronic subdural haematoma). Willis applied several pharmacological treatments partly fitting into his iatrochemical theories on headache (Koehler, 2008), but if this ‘ars medica’ was not of any help, ‘chirurgia’ should be applied, in the first place ‘remedia topica’ or topical treatments (Willis, 1674, p. 274). He mentioned that ‘cal-varia [sic] apertio à multa praedicata sed raro aut nunquam ten-tata’, or that the opening of the skull is often advised but rarely applied at the time (Willis, 1674, p. 276), unless evident local disease is observed. This is in accordance with Arnott et al. (2003), who, in their book on trepanation, reported only a few cases of trepanation for intolerable headache in western medicine, including a case that appeared to be due to an infection, and several traditions of trepanations for headache following skull injury are mentioned. It was stated that ‘migraine and tension headaches are not among the reasons for recorded trepanations,
though surprisingly trepanning has been known to relieve such headaches’ (Martin, 2003).

**Various other methods**

Oribasius, mentioned above, advised the injection of soft oil into the ear (Oribase, 1873). An interesting treatment for headache was that recommended by the 10th century astronomer and physician Ali ibn Isa (ca. 940–1010 CE), who recommended binding a dead mole to the head (Ali ibn Isa and Wood, 1936). If diseases of the head occur because of a faulty warm constitution, Maimonides advised bathing in comfortable warm sweet water, because it dissolved the sharp vapours that rose to the head and improved the body disposition. If headache was localized, it was most appropriate to apply massage with oil of roses (Rosner, 1993).

In Samuel-Auguste Tissot’s (1728–97) influential *Traité des nerfs* we find an interesting case of migraine aura: an officer in Austrian service, aged 32 years:

‘Since the age of nine years . . . I have a migraine . . . It begins in the eyes; at the most unexpected moments, I suddenly see unclear, but more on one side than on the other, like a person who has looked in the sun. This lasts approximately ten minutes; subsequently an arm and a leg on the same side fall asleep, one day on one side and then on the other. . . . during this time I experience quite some trouble to talk. This lasts about half an hour; subsequently the headache starts, but only at the temples, where it remains for seven or eight hours very severe: if I am able to vomit, it provides relief. The migraine may attack me in every season and at every hour; bleeding only gives little relief . . .’ (Tissot, 1813, p.103–4, Engl. transl. in Koehler, 2005).

Next to bloodletting, Tissot applied the magnetic bar, but realized that with respect to the attacks there is ‘scarcely anything to be done . . . . Baths to the legs, enemas, applications to the forehead, do no good and only worry the patient’.

**Electricity**

**Early applications for headache**

It was not until the middle of the 18th century that scientists became aware of the electric nature of the benumbing effect of certain fish. This effect had, however, been known for some time e.g. by the Court Physician of Emperor Claudius, Scribonius Largus, who recognized the effects of the torpedo’s discharges in the first century CE, recommending it for gout and headache (Scribonius, 1983). The electric eel that was found in the northern parts of South America gave off more powerful shocks (up to 600 V) than European and African fish. The conscious application of electricity was introduced into medicine around the middle of the 18th century. In one of the letters in the *Treatises of the Haarlem Society of Sciences* we find the description of the effects of the eel (Van der Lott, 1762) (Figure 2):

When a slave complains of a bad headache, he has them put one of their hands on their head and the other on the fish, and they thereby will be helped immediately, without exception (Koehler et al., 2009).

Dutch scientists had experienced the effects of the Leyden jar in 1745 (with Pieter van Musschenbroek, 1692–1761) and, while working in the Dutch West Indies in the 1750s, they noted the resemblance between the benumbing effect of fish and the effect of the Leyden jar (Koehler et al., 2009). Electricity from these fish, but more often electrical machines, became widely applied for headache and other afflictions. In a book on medical electricity we read about a man who experienced intolerable pain above one of the eyes. He was relieved after drawing sparks from that site for 15 min (Paets van Troostwijk and Krayenhoff, 1788) (Figure 3).

The French physician Pierre Bertholon (1742–1800), friend of Benjamin Franklin (1706–90), was among the many physicians at the time who applied electricity.
‘... sometimes cephalalgia, migraine, cephaelea demand for its curing a negative electricity; because that condition depends on a too great influence of nervous fluid on the head. I have cured myself several times from various headaches by applying negative electricity, mainly directed to the temporal region’ (Bertholon, 1780; transl. PK).

Electricity in the 19th century: migraine and vasomotor theories

In the middle of the 19th century, the scientific method finally conquered medicine and humoral pathology was largely disappearing. Experimental physiology became an important source for new medical knowledge. The function of the vasomotor nerves was discovered by Claude Bernard (1813–78) and Charles Edouard Brown-Séquard (1817–94) (Bernard, 1852; Brown-Séquard, 1852; Laporte, 1996) in the 1850s (some consider it a rediscovery, as these nerves were exactly mapped by Lower and Willis; they observed and explained their function in the 17th century; see Spillane, 1981, p. 92). In the subsequent years a debate arose on whether migraine was a sympathicolytic or sympathicotonic affliction; the first theory was defended by Brown-Séquard, the latter was adhered to by the Berlin physiologist Emil du Bois-Reymond (1818–96), a migraine sufferer himself (Koehler, 1995). Brown-Séquard was supported by several other physicians, including Möllendorff, who referred to him and used the term ‘angioparalytic’ migraine (Möllendorff, 1867).

The discoveries gave a new impulse to electric treatment that remained popular for several decades. Rudolf Lewandowski mentioned it in his book Elektrodiagnostik und Elektrotherapie einschließlich der physikalischen Propädeutik (Lewandowski, 1887) (Figure 4A); and Elizabeth Garrett Anderson (1836–1917), an astonishing woman who became England’s first female physician in 1870 following medical studies in Paris, advised it in her doctoral thesis, Sur la migraine (Figure 4B).

She wrote: ‘There are reasons to suppose that in migraine, as well as in other cases of severe and recurrent pain, the central lesion consists of imperfect nutrition of nervous tissues. The immediate result of it is a too rapid discharge of electricity inherent to nervous molecules’. She believed that Voltaic electricity, next to air and exercise, was the most effective treatment (Garrett, 1870; a translation of her thesis can be found in Wilkinson and Isler, 1999). The Berlin neurologist (and temporarily professor of pharmacology in Greifswald) Albert Eulenburg (1840–1917) was positive about the effects of electricity on migraine. It was applied directly to the head or to the sympathetic ganglia in the neck, distinguishing the sympathicotonic and neuroparalytic forms of migraine from each other, as each required a special application (Eulenburg, 1878).

The vasomotor theories and resulting therapies reached the other side of the Atlantic, as shown in William Hammond’s (1828–1900) textbook (Hammond, 1889). He mentioned the ocu-lopupillary and vasomotor troubles leading to a dilated pupil (angiospastic) or, on the contrary, to a constricted pupil ‘and the upper eyelid droops’, calling it angioparalytic hemicrania. He advised ‘galvanization of the great sympathetic’ with different procedures for the angiospastic and the angioparalytic form of migraine (Hammond, 1889, p. 880). Hammond referred to various European physicians with experience in electrical therapy, including J. Benedict, Rosenthal and Frommhold, who advised faradic electricity (Frommhold, 1868). Hammond also advised that
Galvanism should be applied between attacks. Electricity was also mentioned by Charles Loomis Dana (1852–1935) in his textbook. ‘The daily use of a strong galvanic current 4–8 mA (8–10 cells) for 10 min is useful’ as constitutional treatment, and for the attacks he suggested: ‘Locally galvanic currents are sometimes helpful, and so are static sparks’ (Dana, 1892).

At the end of the century, several monographs on migraine were written, including the one by the German physician Paul Möbius (1853–1907), who was more critical about the effects of electricity. He reviewed physical treatments, including water therapy, massage and electrotherapy (galvanization of the sympathetic, faradization of the head, the electrical bath), being quite clear on the effects:

‘There is no other way out, here as with the miracles of massage, it concerns suggestion. I have occasionally pointed to the fact that in mild migraine attacks, psychic influences are important. Therefore, it is obvious that in such type of attack, electric manipulations will bring ‘immediate well-being’, in particular if it is carried out by an appropriate personality’ (Möbius, 1894, transl. by PK).

William Gowers (1845–1915) provided more critical opinions on electric treatments, including ‘sedative liniments of belladonna, aconite, etc., or simple counter-irritation by a mustard plaster to the nape of neck’ in his 1888 Manual. He was not enthusiastic about electricity, which ‘is not often of service. ... The voltaic current passed through the head occasionally gives transient, but rarely permanent, relief’. The value of repeated galvanization of the sympathetic as ‘recommended in Germany...is very doubtful’ (Gowers, 1888). Likewise, William Osler (1849–1919) in his Principles and Practice of Medicine (1892) wrote that ‘electricity does not appear to be of much service’ (Osler, 1892). In France, Jules Dejerine (1849–1917) did not provide information on treatment of migraine as would be expected from the title of his Sémiologie (‘Symptomatology’) (Dejerine, 1914), and although migraine and electrotherapy were discussed in Pierre Marie’s (1853–1940) 1911 Pratique Neurologique, the latter was not particularly mentioned for the treatment of migraine. It was advised for facial neuralgia amongst other indications (Marie, 1911). Eduard Flatau (1868–1932) commented that he had never been convinced of its efficacy during the attack or with respect to its prophylaxis (Flatau, 1914).

**Figure 4** (A) The hydroelectric bath was used amongst others for headache by Rudolf Lewandowski (Lewandowski, 1887). (B) Title page of Garrett Anderson’s thesis; she also advised electrical therapy (Garrett, 1870).

**Physical treatments: arterial compression, vibration therapy and hydrotherapy**

The vasomotor theories not only led to electrical treatments but also arterial compression. Möllendorff (1867) noted that

‘[i]f during a hemicranial attack the common carotid artery on the painful side is compressed at the level of the thyroid cartilage, so much that the pulse of the temporal artery starts to disappear, the head pain wears off as if by magic....the other way round, the pain, if not yet reached its full climax, increases by compression of the carotid artery on the other side...’ (Möllendorff, 1867; transl. by PK)

Carotid compression was not completely new, as it had been applied previously, in 1786, to a young lady with the intention to ‘intercept a considerable part of...[the] violent impulse of blood into the brain’ during paroxysmal attacks of various ‘nervous symptoms’, including headache, by the English physician Caleb Hillier Parry (1755–1822) (he published on it in 1788 and 1811, see Parry, 1811, p. 89–95). Combined compression of the carotid artery and vagus nerve was advised by Romberg and Schroeder
van der Kolk (Liveing, 1873, p. 471), and Hammond (1889, p. 880) recommended carotid compression during the attack, but Flatau (1914) mentioned that carotid compression was hardly applied anymore.

At the end of the 19th century, vibration therapy was used by Jean-Martin Charcot (1825–93) and later by his pupil Georges Gilles de la Tourette (1857–1904) for Parkinson’s disease, after it had been noticed that journeys in post coaches and trains could relieve the symptoms. Special vibrating chairs were designed for this purpose (Goetz, 2009). It was also applied for headache and migraine. In a book on vibration therapy of the period, we find that ‘hemicranial headache is best treated with the brush, applied very lightly on the scalp, and moved from below upwards and from before backwards, a few times in an orderly manner’ (Mortimer Granville, 1883) (Figure 5).

Hydrotherapy is an example of a non-drug treatment that has been applied for various afflictions, including headache, since antiquity (Jackson, 1990). It became more popular during the 19th century, as reflected in various textbooks. Pierre-Adolphe Piorry (1794–1879), successor to Trousseau at the Hôtel Dieu in Paris, wrote a treatise on hemicrania (1831) in which he advised stimulation of the feet by warm water: ‘A quick stimulation of the feet by warm water or the firelight has sometimes suddenly stopped the migraine’ (Piorry, 1831). The Berlin physician Moritz Romberg (1795–1873), in his well-known Manual (Romberg, 1853), wrote that ‘the natural and artificial waters of Marienbad, Kissingen, or even Karlsbad… are indicated’ if the secretions of the liver and intestinal glands are depraved. These were well-known spa cities that were visited by famous composers (Beethoven, Chopin) and authors (Gogol) in the 19th century. Gowers mentioned ‘water to the feet’ and ‘a hot bath of mustard’ in his Manual (1888). Oppenheim advised trying hydrotherapeutic measures and other physical methods, ‘that should be used in every case, though the results are not brilliant’ (Oppenheim, 1900). Moses Allen Starr (1854–1932) emphasized exercise and (Turkish) baths, but also mentioned ‘a course of treatment in Carlsbad’ and did not write on more invasive procedures (Starr, 1907). Flatau mentioned cold water therapy in his review (1914).

Psychological interventions

Neither Liveing (1873) nor Thomas (1887) listed psychological interventions in their reviews. At the end of the 19th century, several authors, including Möbius (1894, p. 92), noticed that several treatments were based merely on suggestion. Hypnosis was mentioned by various authors, including Oppenheim (1911, p. 1189), who advised it for ‘infrequent attacks of true migraine associated with attacks of psychogenic headache of a similar character’, and Flatau (1914), who wrote that it worked in only hysterical forms of migraine. Jelliffe and White (1917) mentioned psychoanalysis if recurrent migraines occurred in ‘neurotic individuals’, a treatment that was applied to various diseases in the early 20th century (Jelliffe and White, 1917). Although she was not found in the textbooks we consulted, it is important to mention Frieda Fromm-Reichmann (1889–1957), who applied psychoanalysis to migraine patients, explaining migraine as a result of repressed anger (Fromm-Reichmann, 1937). Freud wrote about the psychodynamic aspects of pain, headache and migraine between 1895 and 1926 (Karwautz et al., 1996); prior textbooks did not mention this treatment (Dana, 1892; Dercum, 1895; Church and Peterson, 1895). In later reviews psychotherapy is hardly mentioned for migraine, except where it occurred in combination with psychiatric diseases (Richter, 1935; Boag, 1968).

Surgical procedures

Ear, nose and throat procedures

In the early 20th century, the nose and throat area was often considered to cause migraine, leading to surgery of the adenoids and tonsils. The German neurologist Hermann Oppenheim
(1858–1919) wrote about ‘the treatment of chronic nasal diseases’ that ‘partly relieved and even cured the attacks in some of his cases’ (Oppenheim, 1900). However, Dana warned that ‘the reported cure of numerous cases of migraine by treatment of nasal hypertrophies and catarrh should not excite too much confidence in such measures. In fact, since migraine is a constitutional neur- osis, one cannot expect permanent results from removing reflex irritants alone’ (Dana, 1892). Although Samuel A. Kinnier Wilson (1878–1937) in his Neurology paid attention to mainly drug treatment, he stated that ‘any source of possible infection in teeth, sinuses, tonsils, etc., must be eradicated…’ (Wilson, 1940; 1955).

**Treatment based on intracranial pressure: lumbar puncture**

Among the central theories mentioned by Flatau was Quincke’s idea of angioneurotic hydrocephalus (Flatau, 1912, p. 173–82). One of the invasive procedures applied in the early 20th century and based on discoveries including lumbar puncture (1891) (Frederiks and Koehler, 1997), X- or röntgenrays (1895) and increased knowledge of intracranial pressure (Koehler and Wijdicks, 2008) was lumbar puncture for migraine, in which increased intracranial pressure was assumed. Schüller (1909) believed that increased intracranial pressure could be recognized on skull radiographs; he even proposed trepanation, craniotomy and palliative trepanation of sella with third ventricle puncture. Heinrich Irenaeus Quincke (1842–1922), the first person to perform a lumbar puncture, found relief in two of three patients whom he punctured during a migraine or periodic headache attacks. Flatau, who referred to these cases, was able to confirm this in a young boy, but he warned of the headache-inducing effect of lumbar puncture in weak and pale persons (Flatau, 1912, p. 227).

**Various**

In the fourth edition of his text, Osler added the following treatment in ‘obstinate cases’: ‘An ordinary tape seton may be inserted through the skin at the back of the neck, to be worn for three months, a plan of treatment which has the strongest possible recommendation from Mr. Whitehead, of Manchester (Osler, 1901). Osler probably referred to a paper in the *British Medical Journal* published by the English surgeon Walter Whitehead (1840–1913; Whitehead, 1901). In fact this method reverted to humoral medicine.

**Operations on the sympathetic nervous system**

In the 17-volume (18 books) *Handbuch der Neurologie* edited by Bumke and Foerster, Hugo Richter (1935) reviewed several surgical treatments. At the time, migraine was considered a vaso spas tic disorder, not a disorder of abnormal vasodilatation, and therefore a vasodilatory treatment was thought to be necessary (Tfelt-Hansen and Koehler, 2008). This resulted in procedures of the cervical sympathetic, including upper ganglion and periar terial sympathectomy, with the purpose to dilate the pertinent arteries. Several authors had applied and described these procedures. The French physicians Lermoyez and Jean Athanase Sciard (1872–1929) carried out periar terial sympathectomy of the temporal artery. The American neurosurgeon Walter Dandy (1886–1946) operated on the cervical and first thoracic ganglion (reporting two cases that were pain free for 7 and 4 months, respectively) (Richter, 1935). Surgery on the sympathetic nervous system was not unique for migraine, as it was applied, for instance, for the treatment of causalgia by Leriche and Tinel during World War I (Koehler and Lanska, 2004).

The English neurosurgeon Geoffrey Knight reviewed surgical treatments in Vinken’s and Bruyn’s *Handbook of Clinical Neurology* in the late 1960s (Knight, 1968). Even in this period, the vaso spastic theory of migraine was still used as a basis to carry out surgical procedures that included cervical sympathectomy bilaterally, inferior cervical and first thoracic ganglion, stellate gan glion excision, cervicothoracic ganglionectomy and periar terial sympathectomy of carotid bifurcation. Cases of what today we would call migraine with aura and hemiplegic migraine were included (Knight, 1968).

Following the vaso spastic theories of the early 1900s, John Graham (1879–1950) and Harold Wolff (1898–1962) showed that migraine should be considered a problem of abnormal vaso dilatation (Graham and Wolff, 1938; Wolff, 1948; Koehler and Isler, 2002; Tfelt-Hansen and Koehler, 2008). Therefore ligation of vessels rather than sympathico lytic procedures came into vogue. Middle meningeal vessel procedures were carried out by the Swedish neurosurgeon Herbert Olivecrona (1891–1980; reported in 1947) and common carotid artery procedures by Geoffrey Knight (1968). He warned that it should only be done in carefully selected cases and that the only indication was ‘relief of localized retro-orbital pain which can be consistently relieved by carotid compression’ (Knight, 1968). Surgical treatment of the sympathetic was also advised by Wilson if all ordinary measures were ineffective (Wilson, 1940; 1955).

**Operations on the afferent sensory pathways**

In his review on surgical procedures in migraine, Knight (1968) also reviewed procedures carried out on the afferent nerve pathways since the early 20th century. Neurosurgical procedures were mentioned, including those by the American neurosurgeon Harvey Cushing (1869–1939), who warned not to spare the ophtalmic division of the trigeminal nerve (1904); the Canadian neurosur geon Wilder Penfield (1891–1976), who treated the ophtalmic fibres (1932); Wilfred Harris (1869–1960), who injected around the gasserian ganglion (1936); George Frederick Rowbotham, treating the supraorbital and supratrochlear nerves (1942); Olivecrona, who performed intramedullary tractotomy (1947); and Knight himself, who stated that ‘sensory root section is justi fied when the pain is repeated and severe and…. [E]rgot leads to toxic features’. Other nerves have also been used as a target for neurosurgical procedures, including the occipital, post-auricular and auriculotemporal (Knight, 1968).

**Conclusion**

We found that non-drug treatment is a phenomenon of all ages and was reserved for headache and migraine that did not react to the usual treatments of the period. A large variety of treatments
Table 2 History of non-drug treatments in relation to pathophysiological theories of the period, completed with modern invasive procedures for various headache syndromes

<table>
<thead>
<tr>
<th>Period</th>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-1800 period</td>
<td>Based on <em>humoral</em> theories (balance of the four humours)</td>
</tr>
<tr>
<td></td>
<td>Often referred to Galen and Aretaeus</td>
</tr>
<tr>
<td></td>
<td>Electricity added in 18th century</td>
</tr>
<tr>
<td>Modern period</td>
<td>Based on new <em>solid</em> (organ-based) theories</td>
</tr>
<tr>
<td></td>
<td>Scientific method introduced into medicine</td>
</tr>
<tr>
<td></td>
<td>Electricity becoming an important tool</td>
</tr>
<tr>
<td></td>
<td>Vasogenic theories led to vascular procedures (carotid, sympathetic)</td>
</tr>
<tr>
<td></td>
<td>Awareness that effect of several non-drug treatments was due to suggestion</td>
</tr>
<tr>
<td>20th century</td>
<td>Psychological interventions</td>
</tr>
<tr>
<td></td>
<td>Vasospastic -&gt; vasoconstriction theory of migraine (new surgical procedures)</td>
</tr>
<tr>
<td></td>
<td>Old procedures still used (at least in alternative medicine)</td>
</tr>
<tr>
<td></td>
<td>Application of new methods (including radiographs of the pituitary for supposed endocrine origin of migraine, lumbar puncture)</td>
</tr>
<tr>
<td>21st century</td>
<td>Based on new theories of pain modulation (deep brain stimulation: hypothalamus for cluster headache; occipital nerve stimulation for chronic</td>
</tr>
<tr>
<td></td>
<td>migraine and cluster headache; nucleus caudalis dorsal root entry zone surgery for post-herpetic neuralgia)</td>
</tr>
<tr>
<td></td>
<td>Cortical hypersensitivity theories (transcranial magnetic stimulation for migraine)</td>
</tr>
<tr>
<td></td>
<td>Peripheral triggers (patent foramen ovale procedures for migraine)</td>
</tr>
</tbody>
</table>

(Table 2) have been tried, and these were based mainly on contemporaneous pathophysiological models that were applied not only for headache but for various other afflictions, some of which we have mentioned. Although success rates are not available, these treatments do not seem to have been very successful. After its introduction in the 18th century, electricity became more popular following the vasomotor theories of the mid-19th century, but toward the end of the 19th century, disappointing results were reported, e.g. from Gowers and Osler. Möbius believed suggestion played an important role, but his opinion should also be considered against the background of his fight against the neurolological establishment of Erb, Edinger and others. Wilhelm Heinrich Erb (1840–1921) complained that Möbius endangered materialist medicine, but Möbius said that suggestion could and should be used by physicians. Freud, who had used Erb’s ‘bible’ of electrotherapy (Erb, 1882) in his practice, came to the same conclusions, naming Möbius as a founder of psychotherapy. There was not just a ‘problem of suggestion’ that Möbius recognized, but also a chance for medical thinking to overcome its fixation on mechanism (Schiller, 1982, p. 24–5; Steinberg, 2005, p. 109).

Möbius’ idea may be applicable to many of the methods discussed above. It is well known that ‘placebo-associated improvement’, as discussed in a recent review by Diederich and Goetz (2008), occurs frequently when treating pain syndromes. Knowledge of the effect has advanced over past years. It depends on the invasiveness of the procedure and is influenced by the patient’s awareness of the procedure, suggesting an expectation or reward component. In pain syndromes, endogenous opioid release triggered by cortical activation, in particular the rostral anterior cingulate cortex, is associated with placebo-related analgesia. It can be reversed by opioid antagonists (Diederich and Goetz, 2008). Similar effects may have played a role in psychological interventions (psychoanalysis) that were applied in particular for neurotic migraine sufferers, again a treatment that was applied for other diseases that were considered psychogenic by some physicians at the time, e.g. dystonia (Munts et al., 2010). Best medical practice has always included an implicit role for ‘tender loving care’ as an important factor of all interactions between patients and caregivers (Diederich and Goetz, 2008).

After a period of relative silence in the 20th century, electricity has recently gained interest again, with new insights into pathophysiology and targets as well as the availability of refined procedures (Goadsby et al., 2010). It is called neuromodulation and includes deep brain stimulation, occipital nerve stimulation and transcranial magnetic stimulation. However, the problem of suggestion, recognized by Möbius at the end of the 19th century, still plays a role and, although better understood today (Diederich and Goetz, 2008), is still not easy to deal with, e.g. with respect to occipital nerve stimulation, where placebo effects are still a matter of concern (Burns et al., 2007) and need to be overcome by sophisticated methodology.

Present-day invasive treatments for headache should be considered against the background of the long list of procedures mentioned in this article, especially given that older theories such as the importance of sympathetic dysfunction in migraine (Peroutka, 2004) and electricity (Goadsby et al., 2010) with their inherent methodological problems are revived from time to time.

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