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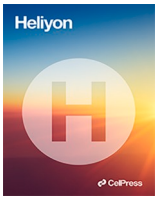

Review article

Can alternative medical methods evoke somatosensory responses and functional improvement?

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ABSTRACT

Background: Evidence-based scientific studies focusing on complementary alternative medicine (CAM) and potential functional improvement after an insult of the central nervous system are lacking.

Aims: We aim to demonstrate that functional recovery after stimulation applied as a CAM treatment through cauterization might trigger neural repair and regenerative paths similarly as acupuncture, cupping, electrical or magnetic stimulations. Those paths are important in recovery of function.

Procedures: Medical records and information of ten patients, with initial presentations of cerebral trauma or spinal cord insult inducing paralysis, were studied. Patients ages ranged from 17 to 95-year-old. Patients consulted for alternative medical treatment one year or more after initial diagnosis.

CAM treatment consisted in 10-point stimulation on the skull and 4-point stimulation located at the right and left calves and forearms. Stimulations consisted of a heated steel rod application (cautery) in a one-time session. The duration of each stimulation was about 0.5 s.

Results: Most studies using CAM stimulations (acupuncture, cautery, cupping, moxibustion, electrical and magnetic stimulations) describe improvement. In all 10 medical records and information from our practitioner, patients had improvement in their motor skills, including gain of weight support, unassisted small walks, independent and voluntary movements of limbs. Improvement was steady over a period of one to several years.

Conclusion: We compared our findings to acupuncture, electrical, magnetic field effects to highlight common paths and to provide scientific evidence for recovery of the function. We believe that CAM treatments triggered existing or new neuronal networks as well as synaptic efficiency or reactivation, through highly increased, sensory nociceptive coupled to proprioceptive, afferences. Those results also highlight the need to further investigate neural function of cortical and subcortical areas through indirect pathways stimulations.

1. Introduction

A frequent reason to resort to complementary alternative medicine (CAM) by patients was failure of medical treatment [1]. Despite

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List of abbreviations

rTMS	repetitive transcranial magnetic stimulation
tDCS	transcranial direct current stimulation
tDRS	transcranial direct stimulation
CES	cranial electrotherapy stimulation
FNS	Flexys neurotherapy system: Minute Pulse Electromagnetic Neurostimulation
PTSD	post-traumatic stress disorder
TBI	traumatic brain injury
SCI	spinal cord injury
SAH	subarachnoid hemorrhage
MS	multiple sclerosis
FDA	US food and drug administration
SSEP	somato sensory evoked potential
MEP	motor evoked potential (motor evoked activity)
BDNF	brain derived neurotrophic factor
Trk B	tropomyosine receptor kinase B (receptor for BDNF)
PT	Physical Therapy
BA	Brodmann Area
CST	cortico-spinaltract
CCx	Cerebral Cortex
n	neuron
VCST	ventral cortico spinal tract
ss	somato sensory
IPL	lobus parietalis inferior
PT	Planum Temporale
CAM	complementary alternative medicine
CM	conventional medicine
WHO	World Health Organization
CNS	central nervous system
MN	motoneuron or motor neuron
NT	neurotransmitter
EBA	extra-striate body area
LOTC	lateral occipito-temporal cortex
CPG	Central Pattern Generator
HSP	heat shock protein
NO	nitic oxide
NOS	nitric oxide synthase
nNOS	neuronal nitric oxide synthase

the worldwide interest in CAM, it is not adequately represented in medical education in Saudi Arabia [2] or even in developed countries [3], including in the US, where 36 % of adults are using CAM yearly [4]; this percentage is increasing. The definition of CAM varies in different countries. The most accepted definition is "practices of patient treatment that are not integral parts of conventional treatment that are taught in medical schools" [[1,5]]. CAM has been referred by the World Health Organization (WHO) as a broad set of practices that are not integrated into their dominant health care system. Intriguingly, publications related to CAM motivation have increased from 3 % in 2003 to 20 % in 2018 [6]. The practice of cautery as a traditional therapy is not science based, and there is lack of scientific data supporting its efficacy or safety. It is a common treatment in neurology patients in Saudi Arabia [[2,7,8]]. Benefits of CAM, through potential specific mechanisms of action, might lead to improved outcomes for actual and future neurological patients. There is need for efforts to promote research in the field of CAM and to address each practice individually [1], for example cautery, cupping, acupuncture and more. We aim here to provide scientific basis for CAM approach and limitations by studying medical reports and information of patients' cases and literature findings.

The general sensory somatic nervous system is concerned with transmitting information like touch, pain, temperature, vibration, pressure, position and stretch senses from physical structures to the brain. Ascending pathways act as the avenue helping in transferring information concerning the body and its interaction with the external environment to the brain. Additionally, cortical, subcortical, intra-hemispheric and inter-hemispheric connections are natural outputs for sensory systems and are particularly important during regenerative plasticity followed by functional recovery. Evidence-based scientific studies focusing on CAM and potential functional improvement after an insult of the central nervous system (CNS) are lacking.

We hypothesize that functional recovery after stimulations, applied as an alternative medical treatment, might evoke neural repair and regenerative paths important in recovery of function.

We aim to demonstrate that through studying those pathways in detail, and possible induced plasticity and reorganization, we can correlate patients' cases of empirical stimulations to anatomic neural routes and to the understanding of curative therapies. We aim to analyze cauterization potential effects and to compare them to electrical, magnetic and acupuncture treatments after a CNS insult.

Stimulations described here might have played important roles in enhancing multiple complementary routes in recovery of function. CAM treatments include cauterization and acupuncture. Other treatment comparisons include electrical and different magnetic field treatments. We are trying to provide here an explanation for the beneficial effect of those practices. We will therefore focus on studying involvement of ascending pathways, such as anterolateral tracts, dorsal columns-medial lemniscal tracts, and spinocerebellar tracts and their outputs in CAM studies.

2. Materials and methods

2.1. Patient population

We used anonymous medical reports and data provided by the medical practitioner in alternative medical (CAM) field. We studied patients' medical reports from conventional medical (CM) centers in Saudi Arabia mainly but also from other countries of the Arabian gulf, in addition to those from the alternative medical practitioner. The alternative medical practitioner treats at least 50 patients per year. Ten of those patients' cases medical information were retained for comparison with other CAM data. Medical information also included videos, photographs, patient letters, patients' and alternative medical practitioner's phone interviews. Patients were from diverse socio-economic and educational backgrounds. Economic burden had no impact on the choice of CM or CAM because CM health matters are free in SA, as well as the alternative medical practitioner treatments. Patients were either males or females and their ages ranged from 17 to 95-years old.

Patient diagnoses and initial treatments: All patients, were first treated through conventional medical avenues, including long term physical therapy. They consulted for alternative medical practice at least one year (1–12 years) after the initial diagnosis. Therefore, patients were in the chronic stage of their neural insult when seeking CAM. In the overall patient population, dominant initial diagnoses were traumatic brain injury (TBI), spinal cord injuries (SCI) and stroke. Specifically, in our study of selected 10 patients medical information, initial pathologies were occlusive or hemorrhagic cerebral strokes, sub-arachnoidal hemorrhage (SAH) of unknown etiology or induced by head trauma and, one patient had shearing cerebral lesions. Four patients had traumatic injuries, 3 traumatic brain injury (TBI) and one spinal cord injury (SCI). Those insults induced generalized or localized paralysis or paresis or pain.

Skin cauterization treatment in the selected 10 patients' medical information: Multiple points (up to 14 points) of stimulation were used. Ten points of stimulation were used for the skull: 4 bilateral and 2 sagittal points. There were 4 points of stimulation located respectively at the distal part of the right and left calves and on the right and left forearms. Stimuli were applied using the heated tip of a metallic rod. The duration of each stimulation was about 0.5 s. Stimuli applied were nociceptive heat shocks resulting in burning wounds of the skin. Stimulations had nociceptive and proprioceptive components. Stimulations were applied successively, one by one (legs, arms, skull). The treatment consisted in a one-time cauterization session. Exceptionally, when expected improvement did not occur the treatment was repeated one or two times shortly after the first cauterization treatment.

Comparison to other non-conventional treatments: We used WHO and pubmed data bases to search for terms such as complementary and alternative medicine (CAM), traditional medicine (TM) practices, Kaiy therapy (traditional cautery), skin cauterization, cupping, acupuncture, herbs. We also search for repetitive transcranial magnetic stimulations (rTMS), transcranial direct stimulation (tDRS), current electro-stimulation (CES), Flexys neurotherapy system (or Minute Pulse Electromagnetic Neurostimulation, FNS; with low energy/short period of time). None of the latter methods are approved therapies for central or peripheral nervous system neural insults. Countries of interests were focused on Saudi Arabia, and Arabic gulf countries, Asian countries such as China and Malaysia and, the United States of America (US). We also search for non-conventional practices in improving performance and recovery in healthy athletes, since it is used in the US (such as cupping and acupuncture).

3. Results

We studied all different CAM treatments involving stimulations (cautery, acupuncture, electrical, magnetic), as well as all cautery stimulations that were applied by the practitioner in order to compare results and identify pathways responsible for the improvement of the paralysis, paresis and pain, in stroke, TBI and, SCI.

1) Patient treated with Cautery and Acupuncture for neurological insults or diseases (TBI, MS, Pain, SCI) express satisfaction.

Although when CAM is used to treat diseases such cancer, diabetes, infection, or pain induced by those diseases, CAM delays CM and is dangerous as noted by the authors of those studies. There is a consensus that CAM (cautery) should be considered dangerous when prior or in replacement to CM as it delays conventional treatment. However, when used after neurological insults or disease diagnosis, cauterization and acupuncture show satisfaction of the patients in terms of recovery of the function such as: motor function, sensory function, improvement of pain, improvement of speech. It is important to note that the responses were not linked to the socio-economic level, nor the cost of treatment. Also, in the majority of cases, patients were dissatisfied with CM before turning to CAM and this might have influenced a more positive impression towards CAM treatments (Table 1).TABLE 1 should be here in paragraph 1) of the results

Table 1
Cauterization & Acupuncture studies. Our results are compared to other cautery and acupuncture studies.

Author/Year	City	Sample Description	Previous Therapy (CM)	Therapy (CAM = TM)	Reason	Satisfaction	Opinion
		(Size,sex,age)		prevalence (%)	(patient)	(patient)	(author)
Mohammad et al., 2015 [7]	Riyadh, Saudi Arabia (all clinics and hospitals)	M,F (adults)	Conventional therapy	Cauterization of skin	Neurology patients Failure medical CM Prevalence	yes	need understanding of efficacy and safety of CAM
Abou-Elhamd, 2009 [9]		M, F (adults)	No	Cauterization (first therapy)	Treat pain (non neurogenic)		dangerous in cases of malignancy
Elaobda et al., 2016 [10]	South Israel Negev region (Bedouins)	n = 250 F = 128 (51.2 %) M = 45.2 % Age: 18-86	No (not prior to CAM)	Cauterization (36 %) (first therapy, therapy of choice)	Diverse diseases	66 % very satisfied 19 % satisfied	need of systemic assessment of CAM
Farid et al., 2015 [11]	Benghazi, Libya	n = 50 M & F Non educated: 60 % Educated (moderate to high): 40 %	Yes	Cauterization	Pain/Cancer Failure CM CM too slow No hope with CM Rapid improvement with CAM	Improved: 36.5 % Not Improved: 63.5 %	Lack scientific data on efficacy & safety for Kaiy Delayed medical presentation
Alnahdi et al., 2020 [12]	Tertiary Health Center Central Saudi Arabia	n = 176 M = 51 F = 125 Age: 18–78 (35 y.o.) Education (university): 72 %	Yes Disease duration: 8 y.	Cauterization (7.9 % among other CAM)	Neurologic: MS Failure CM	Increased frequency of use CAM for MS	
Gau et al., 2012 [13]	Taiwan Medical Center	n = 101	Yes	Acupuncture (58 % of patients) Time post injury: 2.3 months (1–12 months)	Neurology: TBI	Satisfaction: 85 %	Increased usage of CAM
Li et al., 2017 [14]	N/A	Rats (M) n = 80	Sham and Placebo	Acupuncture (rat)	Acupuncture as Treatment of TBI - increased BDNF after TBI - TrkB increase after TBI peak at 12hrs After TBI + Acupuncture: - increased BDNF for 168 h		Acupuncture: improved sensory-motor and cognitive function during chronic phase of TBI

(*continued on next page*)

Table 1 (*continued*)

Author/Year	City	Sample Description	Previous Therapy (CM)	Therapy (CAM = TM)	Reason	Satisfaction	Opinion
		(Size,sex,age)		prevalence (%)	(patient)	(patient)	(author)
					-TrkB increase for 168hrs Functional Improvement: - Motor function -sensory function -cognitive functions -synaptic plasticity		
Otaif, Alshammari, Gerin	Saudi Arabia	n = 10	Yes, Coventional medicine	Cauterization	Failure of CM	100 % (of the 10 cases)	Is there a possible scientific explanation for the partial regain of function?
This Paper	(UAE, QATAR, KUWAIT)	50/year M = 6 F = 4 17-95 y.o. All socio-economic levels		multiple points	-TBI - stroke -SCI Symptoms -pain -Hemiplegia -Paraplegia -slurred speech	- regain motor function - regain sensory function - able to walk again - regain better speech	Similarities to acupuncture

Table 2

Comparison and effect of different type of stimulations: electrical and magnetic field. These therapies are either non-FDA approved or CAM. Although positive effects have been observed ([[14,15,16]]; and present article]). This table has been modified from Nelson et al. [15].

Feature	rTMS	tDCS	CES	FNS	Acupuncture	Cautery
	(1)(2)	(1)	(1)	(1)	(3)	(4)
Amount of Energy Stimulation Emitted in CNS	Very Large	Small	Small	Extremely Small	None	None
Energy Stimulation Linked to Ongoing measured brain activity	No- Not measured	No-	No-	Yes-	Yes-probably yes since response depends on initial state	Yes-probably yes since response depends on initial state
Effectiveness demonstrated for TBI (1); SCI (2)	Minimal for selected symptoms (1); Improve MEP & SSEP; Improve regenerative processes; improve motor function recovery in animals (2)	Minimal for selected symptoms	Minimal for selected symptoms	Yes-forTBI/ PTSD (clinical)	Yes-Decrease pain-Improve motor function-Gognitive function-Regenerative pathways enhancement-(clinical and animal research)	Yes-Patient interviews-Motor evoked activity-Sensory evoked activity-Motor control-No scientific explanation
FDA approvals for treatment specific disorders	Refractory Depression	None	Depression, Anxiety, Insomnia	None	Yes-pain management	No-
Relatively portable	No	Yes	Yes	Yes	Yes	Yes

Abbreviations: rTMS, repetitive transcranial magnetic stimulation; tDCS transcranial direct current stimulation; CES, cranial electrotherapy stimulation; Flexyx neurotherapy System: Minute Pulse Electromagnetic Neurostimulation (low energy/short period of time); PTSD, post-traumatic stress disorder; TBI, traumatic brain injury; SCI, spinal cord injury; FDA, US food and drug administration; SSEP, somato sensory evoked potential; MEP, motor evoked potential (motor evoked activity); BDNF, brain derived neurotrophic factor; Trk B, tropomyosine receptor kinase B (receptor for BDNF) [44; 45; 26].

This table has been modified from Nelson et al. [15].

Table 3
Descriptive pathologies that we treated with cautery and, proposed possible mechanism for improvement. All our stroke patients treated with cautery perceived improvement for stroke induced symptoms. TBI: Traumatic Brain Injury; SCI: Spinal Cord Injury; CCx: Cerebral Cortex; n.: neuron; CST: cortico spinal tract; VCST: ventral cortico spinal tract; ss: somato sensory; BA: Brodmann area; IPL: lobus parietalis inferior; PT: Planum Temporale; PT: physical therapy.

Nb patient	Patient ID	Age	Gender	Initial Insult	Original Pathology Conventional Treatment	Symptoms and Conventional Treatment	Number of Year post innitial pathology	Residual Chronic Pathology requesting Non conventional treatment (CAM)	Percieved Results	Explanation
1	Ga	Adult	Male	Stroke	stroke left hemisphere Broca's area, motor cortex (frontal left cortex)	No talking, no movement	several years	No talking, no movement	restore talking and some movement, immediate and continued progress	1) Evoked motor & sensory effects (?) from skull stimulations; 3) Bilateral effects (skull); 4) Heat shock effect (skull) => increase metabolism and increase regeneration; 5) Increase neurotrophic factors such as BDNF, TrkB such as in acupuncture; 6) Increase synapto-genesis; 6) reflex to pain effect (talking-noise/facial grimace)?
2	Abz	95 yo	Male	Stroke	Occlusive stroke on right hemisphere	Left Hemiplegia; Hypotension-Anticoagulant therapy-	>1year	Paralysis of left side	Partial Motor control recovery	1) Sensory effects from 4 limbs stimulations => induces some movement; 2) Nociceptive reflexes from 4 limbs susceptible to induce "spinal movements"; 3) Bilateral pre-frontal and frontal area stimulation might elicit motor effects in addition to synchronization; 3 + 4) Contributions of Parietal stimulations (BA 5,7 ss association) and Prefrontal Cortex (pre-planning) in improvement of movement; 5) Heat shock effect (skull) => Increase metabolism and increase regeneration; 6) Increase neurotrophic factors such as BDNF, TrkB such as in acupuncture; 7) Increase synapto-genesis; 8) Reflex to pain effect (involuntary movement);

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Table 3 (*continued*)

Nb patient	Patient ID	Age	Gender	Initial Insult	Original Pathology Conventional Treatment	Symptoms and Conventional Treatment	Number of Year post innitial pathology	Residual Chronic Pathology requesting Non conventional treatment (CAM)	Percieved Results	Explanation
										9) Spinal reflex due to pain; 10) Artifact?
3	Sao	49 yo	Male	Stroke	Stoke left hemisphere	Paresia (paralysis/ weakness) of the right side of the body	>1	Paresis of the right side of body	Improvement motor strength	(similar as above)
4	Ri	56 yo	Female	Stroke	Chronic hypertension and atherosclerosis- Occlusion of the left carotid artery- Occlusive stroke left hemisphere	Occlusion of the left carotid artery- Occlusive stroke left hemisphere	>1	(1) Speech impairment: due to Broca area (left hemisphere) insult, in frontal ccx (BA 45, 44), & involved in generation of speech; connection to Wernicke in the temporal left hemisphere; (2) Right body side paralysis	1) Patient was able to speak again; (2) CAM did not improve the right body side paralysis	Regarding Production and Processing Speech Recovery: 1) Evoked motor & sensory effects (?) from skull stimulations; 2) Bilateral effects (skull); 3) Bilateral frontal and parietal areas stimulation might elicit motor effects in addition to synchronization; 2 + 3+4) Contributions of parietal areas such as IPL bilaterally and temporal cortex such as the PT bilaterally as well as right (or bilateral) frontal cortex and the corpus callosum fibers => induce speech to progress through those reinforced path or new elicited paths and intra- and inter-hemispheric neural rearrangements; 7) Heat shock effect (skull) => Increase metabolism and increase regeneration; 8) Increase neurotrophic factors such as BDNF, TrkB such as in acupuncture; 9) Increase synapto-genesis; 10) Artifact?
5	NoN	33 yo	Female	Stroke	Cerebral vasculitis-	Multiple acute strokes: (1) Infarction of the corpus callosum; (2) Infarction of the supra tentorial white matter;	>1	(1)Gait problems; (lesion of corpus callosum and other white matter areas=> loss of communication between two hemispheres and specially	(1) Improved gait; (2) improve strength and motor function in legs	1) Evoked motor & sensory effects (?) from skull stimulations; 2) Bilateral effects (skull); 4) Bilateral pre-frontal and frontal area stimulation

(*continued on next page*)

Table 3 (*continued*)

Nb patient	Patient ID	Age	Gender	Initial Insult	Original Pathology Conventional Treatment	Symptoms and Conventional Treatment	Number of Year post innitial pathology	Residual Chronic Pathology requesting Non conventional treatment (CAM)	Percieved Results	Explanation
						(3) Right midbrain infarction		parietal sensory areas) (2) lower limbs paresis- (lesion of neural fibers from pyramidal neurons located in limbs motor and/or sensory cortices, affects pyramidal (lateral) tract, and perhaps ventral non-pyramidal (=>for gait/posture disturbance)		might elicit motor effects in addition to synchronization; 4 + 5) Contributions of Posterior Parietal (BA 5,7 ss association) and Prefrontal Cortex (pre-planning) in improvement of movement; 6) Bilateral sensory (nociceptive + proprioceptive) effects from 4 limbs stimulations => induce new neural path usage and intra- and inter-hemispheric neural rearrangements; 7) Heat shock effect (skull) => Increase metabolism and increase regeneration; 8) Increase neurotrophic factors such as BDNF, TrkB such as in acupuncture; 9) Increase synapto-genesis; 10) Artifact?
6	Ma	63 yo	Female	Stroke	Left hemisphere stroke-	Left fronto temporo parietal infarction	>1	Right side hemiplegia	Improved motor function on right side	1) Bilateral effects (skull); 2) Heat shock effect (skull) => Increase metabolism and increase regeneration; 3) Increase neurotrophic factors such as BDNF, TrkB such as in acupuncture

Table 4

Descriptive pathologies that we treated with cautery and, proposed possible mechanism for improvement. All our TBI patients treated with cautery perceived improvement for TBI induced symptoms. TBI: Traumatic Brain Injury; SCI: Spinal Cord Injury; CCx: Cerebral Cortex; n.: neuron; CST: cortico spinal tract; VCST: ventral cortico spinal tract; ss: somato sensory; BA: Brodmann area; IPL: lobus parietalis inferior; PT: Planum Temporale; PT: physical therapy.

Nb patient	Patient ID	Age	Gender	Initial Insult	Original Pathology Conventional Treatment	Symptoms and Conventional Treatment	Number of Year post innitial pathology	Residual Chronic Pathology requesting Non conventional treatment (CAM)	Percieved Results	Explanation
7	Mo	28 yo	Male	TBI	Car accident, Head trauma, Brain concussion	Right and Left facial paralysis involving facial nerves (VII) right and left => No cure and no progress after traditional treatments-	12 years	12 years of handicap without facial expression	Regained facial expression and movement “immediately” after CAM and continued progress.	1) Evoked motor & sensory effects (?) from skull stimulations; 2) Bilateral effects (skull); 3) Heat shock effect (skull) => Increase metabolism and increase regeneration; 4) Increase neurotrophic factors such as BDNF, TrkB such as in acupuncture; 5) Increase synaptogenesis; 6) Reflex to pain effect (facial grimace)?; 7) Artifact?
8	Ab	30 yo	Male	TBI	Car Accident- Head Trauma- Contusion forehead-	Hypertension- Coma- Physical Therapy (PT) during coma period-	>1year	Motor handicap: No postural support	Regained better control of movement	1) Sensory effects from 4 limbs stimulations => induces some movement; 2) Nociceptive reflexes from 4 limbs susceptible to induce "spinal movements"; 3) Do those nociceptive stimulations decrease spasticity therefore pain, therefore facilitating motor function?; 4) Bilateral pre-frontal and frontal area stimulation might elicit motor effects in addition to synchronization; 4 + 5) Contributions of Posterior Parietal (BA 5,7 ss association) and Prefrontal Cortex (pre-planning) in improvement of movement; 6) Heat shock effect (skull) => Increase metabolism and increase regeneration; 7) Increase neurotrophic factors such as BDNF, TrkB such as in acupuncture; 8) Increase synaptogenesis; 9) Reflex to pain effect (involuntary movement); 10) Spinal reflex due to pain; 11) Artifact?
						Spastic paralysis of 4 limbs treated with Botox- Improved with some movement but no postural support-				

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Table 4 (*continued*)

Nb patient	Patient ID	Age	Gender	Initial Insult	Original Pathology Conventional Treatment	Symptoms and Conventional Treatment	Number of Year post innitial pathology	Residual Chronic Pathology requesting Non conventional treatment (CAM)	Percieved Results	Explanation
						PT consisted of treadmill supported walk to initiate movement of the legs probably through the activation of the motor pattern generators- Maximum improvement (CM) was to be able to walk without complete weight support on treadmill for 300 m.Then no more progress. Still spastic contractions of the legs which might be due to lesion of the red nucleus bilaterally-		No independent walking, no weight support.	After cautery treatment: Short distance walk without wheel chair and with complete weight support- (we do not know if it is one treatment or a set of treatment, but the CAM practitioner usually only do one to a few treatments)	
9	Ba	17 yo	Male	TBI	Car Accident- Polytrauma- Head trauma	Subarachnoid hemorrhage (SAH); Intraventricular hemorrhage; Diffuse axonal injury in the brain	>1	(1) Only slight movement of 4 limbs; (2) but wheelchair ridden	General motor improvement (but we do not know to which extent)- Mechanism of improvement: Improvement from sheering injury, see acupuncture effect on BDNF/ TrkB path-	1) sensory effect through skull stimulation; 2) motor evoked effect through skull bilateral stimulations in motor and sensory areas; 1 + 2+3) Contributions of Posterior Parietal (BA 5,7 ss association) and Frontal Cortex in improvement of movement; 4) elicited bilateral plasticity at cerebral level; 5) elicited multiple cortical areas and layers stimulations through limbs stimulations and, sensory and motor "skull" areas & => bilateral increased inputs => regenerative processes; 6) Heat shock effect (skull) => Increase metabolism and increase regeneration of sheered axons; 7) Increase neurotrophic factors such as BDNF, TrkB such as in acupuncture => in sheered axons; 8) Increased plasticity and neural repair; 9) sensory effects from 4 limbs stimulation => induces some movement; 10) nociceptive reflexes from 4 limbs susceptible to induce "spinal movements"; 11) Artifact?

Table 5
Descriptive pathologies that we treated with cautery and, proposed possible mechanism for improvement. SCI patient treated with cautery perceived improvement for SCI induced symptoms. TBI: Traumatic Brain Injury; SCI: Spinal Cord Injury; CCx: Cerebral Cortex; n.: neuron; CST: cortico spinal tract; VCST: ventral cortico spinal tract; ss: somato sensory; BA: Brodmann area; IPL: lobus parietalis inferior; PT: Planum Temporale; PT: physical therapy.

Nb patient	Patient ID	Age	Gender	Initial Insult	Original Pathology Conventional Treatment	Symptoms and Conventional Treatment	Number of Year post innitial pathology	Residual Chronic Pathology requesting Non conventional treatment (CAM)	Percieved Results	Explanation
10	Sad	Adult	Female	SCI	SCI with contusion at T8-9	(1) Paraplegia, paralysis of both legs, (2) No control of bladder function and, (3) No control of bowel movement	>1	(1) No somato-motor control of legs-Lateral CST tracts lesion, bilateral, legs only; (2) No bowel/bladder control- lateral CST bilateral lesion for voiding and lateral funiculus bilateral lesion for sensory information to superior centers up to CCx	(1) Partial Motor control recovery for legs: Possible sprouting and synaptic plasticity, possible involvement of the CST n. from the VCST? (2) Partial bowel (bladder?) control: same. (1) & (2) Involvement of BDNF/TrkB path?	1) Sensory effects from 4 limbs stimulations => induces some movement; 2) Nociceptive reflexes from 4 limbs susceptible to induce "spinal movements"; 3) Motor evoked effect through skull bilateral stimulation; 4) Elicited bilateral plasticity at cerebral and spinal levels?; 5) Heat shock effect (skull) => Increase metabolism and increase regeneration; 6) Increase neurotrophic factors such as BDNF, TrkB such as in acupuncture; 7) Increase synaptogenesis; 8) Reflex to pain effect (involuntary movement); 9) Spinal reflex due to pain; 10) Artifact?

Fig. 1. Points of cauterization on the skull. 10 points on the skull and 4 on the limbs (not shown). This represents classic location of stimulations (less than 1 s duration) using a red heated rod. It is usually a one-time treatment but occasionally the treatment is repeated once.
The treatment is followed by some recovery of function soon after the treatment but also later in time. Patients were previously assessed, treated through conventional medical avenues prior to seeking cautery. All patients were in the chronic stage after their neural insult (one year or more), and previous treatments failed. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

2) Comparison of different therapies that are either non-FDA approved therapies or CAM.

The Minute Pulse Electromagnetic Neurostimulation (FNS) produces very little energy emitted in CNS when compared to other magnetic and electrical stimulation. Acupuncture and cautery produce none. None of the magnetic, transcranial direct current or cranial electrotherapy, acupuncture or cautery are approved treatments for SCI or TBI or stroke (Table 2). TABLE 2 should be HERE in paragraph 2 of the results not in paragraph 3)

3) Ten patients treated with cauterization perceived improvement.

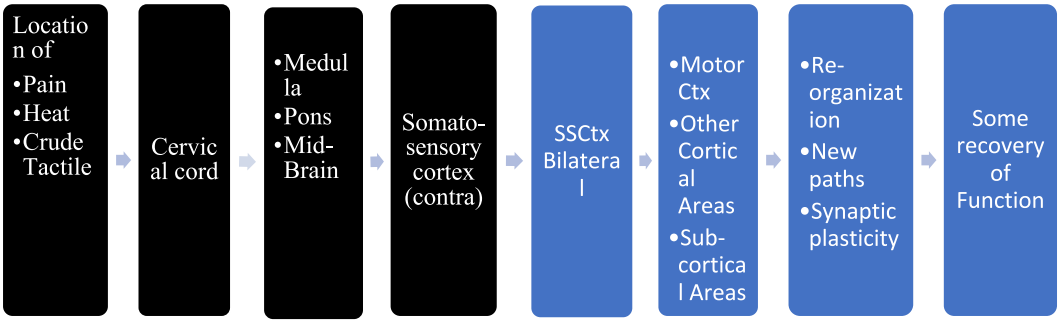

Fig. 2. Cautery intervention nociceptive and thermal path for recovery. The chart shows a simple representation of the proposed path to recovery due to cautery intervention through nociceptive and thermal stimuli that are eliciting a potential path for functional improvement.

In patients with TBI, SCI, motor function was perceived improved. This might be due to improved sensory paths and might reflect an artifact. Although, stimulation is thought to have induced: (1) Increase of metabolism; (2) increase of neurotrophic factors; (3) decrease of spasticity; (4) bilateral and multilayer cerebral neuronal reorganization; (5) globally enhancement of plasticity and regenerative processes (Tables 3–5). TABLES 3, 4, 5 SHOULD BE HERE in paragraph 3) of the results

4) Patient with TBI receiving cautery treatment for motor handicap and no independent walking.

This patient received 14 points of stimulations, (10 on the skull and 4 for the limbs). We see here, in this patient, that the points of stimulations are bilateral for areas related to (1) frontal cortex involved in motor movement; (2) parietal cortex, involved in somatosensory function: specifically touch. It should be noted that parietal cortex area received 4 stimulations close together, (3) temporal cortex, involved in processing sensory hearing, language and memory information. Also to be noted that the extra-striate body area (EBA), which is located in the lateral occipito-temporal cortex (LOTC), might as well be involved and is known to receive kinesthetic feedback for one's own action and might play a role in recovery of motor and sensory function, (4) a point of stimulation, sagittal or closely parasagittal located nearby caudal parietal or occipital areas is visible in this patient, (5) a point of stimulation, sagittal, located in the area of frontal/prefrontal cortex. Wounds appear recent and deep. This patient recovered some independent walking with weight support (Fig. 1).

4. Discussion

4.1. Neural paths and networks involved in the use of 14 points cautery stimulations

4.1.1. Path involved in the effect of nociceptive heat shock stimulation

The information of gross tactile stimulation and nociceptive stimulation induced by the heated beam used by the cautery practitioner ("our study") is running in the spinothalamic tract, and then the thalamo-cortical path, ending in the somatosensory cortical areas somatotopically. This information is carried out by sensory neuron fibers of small diameter (with lightly myelinated or unmyelinated; A delta or C) entering the spinal cord through the dorsal horn and synapsing with a deutoneuron in deep layers of the dorsal horn from layers IV to VIII on non-specific neurons. Sensory neurons run from the sensory receptors in the periphery and join the spinal cord, descending or ascending several segments before synapsing. The deutoneuron decussates in the spinal cord and ascend contralaterally within the antero-lateral or lateral tracts to the thalamus. The antero-lateral funiculus entails two distinct tracts: the anterior spinothalamic tract, which is responsible for carrying sensory modalities of pressure and touch [17], and the lateral spinothalamic tract that carries sensory modalities of temperature and pain [18]. The deutoneuron synapses in either the ventral thalamic nucleus or in the posterior nucleus of the thalamus. The thalamocortical neuron follows the pattern set by the radiations of the thalamus to end within the somatosensory cortex of the stimulated areas in a somatotopic manner.

4.1.2. Nociceptive effect of "heat shock stimulation" of the 4 limbs and head

The information of nociceptive and thermal stimulation induced by the heated rod by our practitioner is running in the lateral spinothalamic tract (temperature and pain, [18]) and then the thalamo-cortical path, ending in the contralateral somatosensory cortical areas somatotopically. The nociceptive stimulus produces retraction of the stimulated limb as a nociceptive spinal reflex. However, the somatosensory cortex is also involved in developing and initiating limb movement through intracortical connections to the contralateral motor cortex. Head points of stimulation might elicit trunk movements as well as limb movements. We do not know if the exacerbation through several ascending pathways, along with intra-cortices and inter-hemispheric communications could elicit neural and synaptic plasticity to facilitate recovery. Those nociceptive and thermal stimuli might be compared to some extent to stimuli induced by cupping, moxibustion or acupuncture [[19,20]].

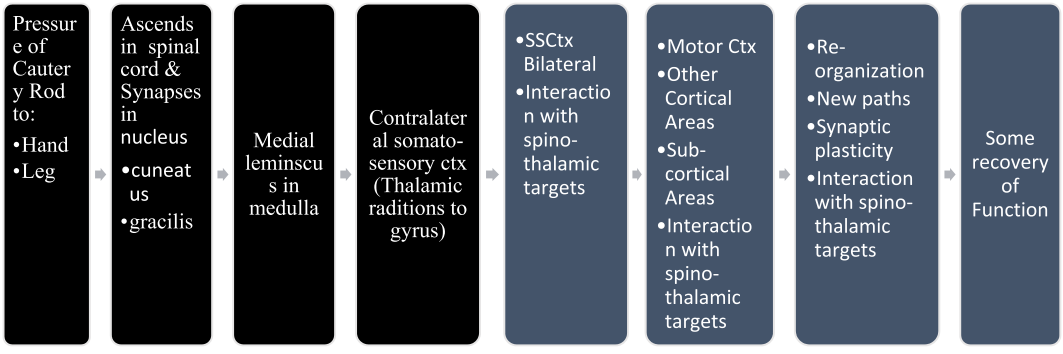

Fig. 3. Cautery intervention pressure path for recovery. The chart shows a simple representation of the proposed path to recovery due to cautery intervention through pressure of the rod that is eliciting a possible path for functional improvement.

4.1.3. Crude tactile and pressure stimulation due to the cautery rod

The information of gross tactile and pressure stimulation induced by the cautery rod is running through the anterior spinothalamic tract [17], ending in the contralateral somatosensory cortex. In this anterolateral system the spinoreticular tract causes alertness and arousal in response to painful stimuli, and the spinotectal tract orients the eyes and head towards the stimuli. The latter paths are susceptible to play an important role in reenforcing the general increase in connectivity during recovery.

As mentioned above for the nociceptive-specific part of the stimulus, several ascending pathways, intra-cortices, and inter-hemispheric communications could elicit neural and synaptic plasticity to facilitate recovery. Furthermore, those tactile and pressure stimuli might be compared to some extent to stimuli induced by cupping, or acupuncture (Fig. 2).

4.1.4. Pressure and vibration signals due to the application of the cautery rod

There is certainly deep and some vibratory effect occurring when applying the cautery rod. This stimulus would run through the dorsal column and ends up in the contralateral somatosensory cortex somatotopically, as well as previous paths seen in a), b), and c) [21]. It is important to also consider this ascending message, as it occurs simultaneously as the two previous ones (b and c) and might participate, also, in creating a multifaceted response with different cortical and subcortical networks in a bilateral manner allowing functional compensation and recovery. Importantly, this pathway ascends through large fibers and is able to block the nociceptive transmission induced by the cautery rod (Fig. 3).

4.2. Reasoning on how heat shock can restore functionality of paralyzed limbs

4.2.1. Importance of heat shock in eliciting corticospinal tract (CST) response, and cerebral cortices and subcortical areas rearrangements

The corticospinal tract constitutes a direct path from brain to effectors. As such, it is the primary system for controlling voluntary movements. For instance, paralysis is generally viewed as the main disconnection that exists between the brain circuits initiating movement orders travelling through the corticospinal system. This system is mostly responsible for restoring the functionality of the limbs. The cerebral cortex, in most cases, displays the mispositioning of various neurons underlying the superficial cortical layers [22]. Therefore, somatic heat shock might affect indirectly the cerebral cortex by overwhelming neuronal stimulations to restore limb (motor) function through different paths. In the cautery treatment used by the practitioner, i.e. a somatic heat shock method, the multiple cortical cellular groups that could assist in potential new neuroblast migration might be affected [[23,24]]. This somatic heat shock might be inducing production of growth factors and neurotrophic factors and increasing neural activity. Therefore, the somatic heat shock may be able to serves as a determinant and inducer in new neuroblast migration and differentiation.

4.2.2. Importance of heat shock in stimulating multiple paths necessary to restoration of the motor function

- Descending control regulation:

The somatic heat shock could act as neuro-prosthetic technology, which is known to be the most suitable method to restore cortical control of limb movements for paralyzed patients [[25,26]]. Cortical control and regulation of limbs originate from the brain, which is triggered by various heat shocks and coordinated by Central Pattern Generator (CPG). Use of artificial neural bypassing technologies decodes multiple cortical activities that emulate the spinal cord CPG activity, thus creating rhythmic limb movements [27]. During partial injuries, the CST circuits generally develop restorative mechanisms to the lost function, thus making CST circuits function as the prime target for injury and repair studies of the somatic body.

- Ascending pathways importance and bypass strategy:

Various neural bypasses are used in neuroprosthetic technology for restoration and regulation of movements for people living with paralysis [22] to bypass injuries of the spinal cord. CPG integrate specific input signals from the cortex with appropriate sensory feedback from the limbs to produce and regulate rhythmic movements. During the process of burning, various quadriplegic factors can initiate, sustain, and switch between various rhythmic movements. Intracortical signals triggered by various ascending or skull heat shocks could trigger neuromuscular electrical stimulation that causes functionality of limbs such as hand/foot movements [28].

- Ascending pathways triggering brain networks rearrangement able to modulate descending control of movement similar to microstimulating currents:

Ascending pathways represent the neural tracts by which sensory information is transmitted to the cerebral cortex and other subcortical areas of the brain. Burning triggers the brain to detect abnormal act or injury in the body, thus altering the neural circuits in the brain [27] or in the spinal cord as described by Courtine [[25,26]]. Eventually, motor cortices bilaterally will use altered paths to the spinal cord to reestablish a motor control of the paralyzed part. This response might be similar to the one observed through micro stimulation currents that evoke movement of the limbs [[26,29]]. Those mechanisms might be due to increased or simply changes in synapse efficiency in different targeted brain areas as a consequence of burning output effect. After treatment, synapses might resume more normal state and functioning. Recovery might involve a set of sensory-motor, as well as cognitive mechanisms modulating the brain to adapt to the new behavioral challenges and restore the normal functionality in the affected limbs. Sensory cues have also been described [[30,31]] in relation to acquired regenerative processes to compensate the loss of motor function. Specifically, authors

showed that in gait and in Parkinson's disease (PD) studies, when other sensory paths (or cues) were used, patients were able to develop an alternate neurological path to accomplish some motor acts. Authors describe that the alternate path is a combination of acquired regenerative processes to compensate the loss of motor function. These results are in line with the ability to induce a regenerative cascade by cautery, as it was demonstrated in other techniques inducing heating, such as magnetic stimulation [16], moxibustion and, acupuncture.

In conclusion, the cautery strategy reveals several aspects in modulating paths for recovery: (1) by modulation neural networks of the descending paths, (2) by restructuring intra and intercortical and subcortical neural networks and, (3) by ascending influence and perhaps overwhelming effects triggering change in descending paths.

4.3. Reasoning on how heat shock can induce neuronal homeostatic imbalance triggering neuronal changes: comparison with acupuncture effects

Sensory receptors in the body can be activated through exteroceptive, interoceptive, or proprioceptive input. Receptors are able to detect chemical, nociceptive, mechanical and, thermal stimuli. Heat shock response and homeostatic plasticity refers to two mechanisms that enable the functionality of cells in the case of stress. Here we can consider neurons and surrounding cells such as astrocytes, microglial cells and, oligodendrocytes and Schwann cells. Heat shock elicits and enables cells to be able to adapt to stress such as high temperatures, cold, reduced oxygen and, metabolic stress. The cellular response to heat shock includes the transcriptional up regulation of genes encoding for heat shock proteins. The heat shock results in the production of heat shock proteins which are necessary in maintaining normal cellular function, in modulating immune response and acting as neuroprotective agents [32]. Heat shock proteins (HSP) are thought to be essential in homeostatic plasticity enabling neurons, glia and their targeted cells to keep their levels of activity during stress and disturbances [33]. In the specific setting of SCI, for example, HSP induction has been shown to be beneficial. HSP are liberated by stressed microglial, endothelial, ependymal cells in the SCI, and it was described similarly for the brain. Finally, protection of MN and prevention of chronic inflammation after SCI have been shown to be regulated through HSP [34]. Additionally, sensory cues have been described [[30,31]] in relation to acquired regenerative processes to compensate the loss of motor function. Specifically, authors showed that in gait and in Parkinson's disease (PD) studies, when other sensory paths (or cues) were used, patients were able to develop an alternate neurological path to accomplish some motor acts. Authors describe that the alternate path is a combination of acquired regenerative processes to compensate the loss of motor function. These results are in line with the ability to induce a regenerative cascade by cautery, as it was demonstrated in other techniques inducing heating such as magnetic stimulation [16], moxibustion and, acupuncture.

4.4. Scientific basis of acupuncture improving neurological function after an insult: comparison to cautery, cupping, electrical and magnetic stimulations

- Brain-derived neurotrophic factor (BDNF) is a potent neurotrophic factor for MN. ItHERE NO MARGIN AS BackspacePLEASE ALIGHBackspaceN WITH NEXT PARAGRAPH ON LINE " WHEN K252a....exerts substantial protective effects for neurological disorders and has been shown to be elevated during regenerative processes after a CNS insult such as SCI [35]. BDNF binds to tropomyosin receptor kinase B (Trk-B) to elicit downstream signaling pathways. In a rat study, Li et al. [14] showed that level of BDNF and its TrkB were spontaneously elevated after TBI and reached up to a peak value at 12 h and declined to normal values at 48 h. Similar results were found in SCI with increased BDNF mRNA levels shortly after injury suggesting that potential treatments with BDNF administration might occurs prior to 3 days post-injury [[36–38]] in order to maintain the natural over expression induced by the injury and keep it steady for a 4–12-week period after injury [35]. Authors [14] demonstrate that after combined stimulation at the acupoints, BDNF and TrkB were still significantly elevated at 168 h (7 days) and downstream molecular *p*-Akt and *p*-Erk1/2 were significantly increased, suggesting that acupuncture could persistently activate the BDNF/TrkB pathway.

When K252a (specific inhibitor of TrkB) was stereotactically injected into the lateral ventricle there was a significant prevention of the acupuncture-induced amelioration of motor, sensation, cognition and, synaptic plasticity. Additionally, Li et al. [14] directly demonstrated an increased synaptic plasticity by acupuncture treatment. Authors concluded that improvement of memory and of synaptic plasticity in rats treated with acupuncture is mediated through the BDNF/Trk-B pathway.

Therefore, acupuncture can help sensory motor and cognitive recovery during the chronic phase of an injury which is mostly the case when people are seeking complementary alternative medicine treatments.

Patients who have received traditional cautery treatment report that it gives temporary relief of their symptoms followed by severe pain [9]. Cautery may possibly act in the same way as acupuncture or moxibustion, stimulating the release of endogenous opioids and other neurotransmitters that prevent the feeling of pain, a natural physiological body method for nociceptive protection. But this increase of opioids and other NT release, and therefore increase of neuronal activity, is triggering BDNF regenerative processes and plasticity to new target networks, enhancing recovery of the function.

All those data and observations are consistent with the fact that TrkB is increased in response to neuronal activity, suggesting a path for the beneficial effect induced by acupuncture, moxibustion, electrical and magnetic stimulations, and through cautery. We expect cautery to exert its beneficial effect by increasing BDNF and by also eliciting different neural networks, therefore increasing synaptic activity and plasticity along those paths similarly to acupuncture.

- Some neural mechanisms are thought to be involved in beneficial effect of cupping and HERE NO MARGIN PLEASE LIBackspaceALIGN WITH "DIFFERENCESBackspaceBackspaceT MECHANISMS...have been related to effects produced by acupuncture. Cupping increases pain thresholds immediately in patients and is effective for facial paralysis, for fibromyalgia, in headache and migraine [39], and neuro-dermatitis. It has been shown that cupping significantly reduces peripheral and local substance P and increases endogenous opioid production in the brain, leading to improved descending pain control [40].

Different mechanisms have been proposed for cupping beneficial effects.

(1) The first one is the pain mechanism blockage along with the theory of the gate control first described by Melzack and Wall [41], acting similarly as acupuncture, by stimulating bigger fibers in priority and therefore blocking nociceptive message. This is also a message that is involved in cautery due to pressure at the time of the application, and here pressure message occurs before burning pain.
(2) It has also been suggested that an additional mechanism of pain reduction, such as diffuse noxious inhibitory control, in which there is an inhibition of activity in convergent nociceptive spinal neurons triggered by a second, spatially remote noxious stimulus acting as if one pain would mask another one. The latter mechanism is thought to be involved in cautery, cupping and acupuncture, in which local damage of the skin and capillary vessels may cause a nociceptive stimulus to activate a diffuse noxious inhibitory control [40].
(3) In addition, stimulations of somatic structures, including skin such as in cautery and cupping act on several dermatomes. This is the case when there is an insult, in a complex interaction of ascending and descending neuronal networks that can either be excitatory or inhibitory, influencing both sensory but also motor paths through spinal, supra-spinal and cortical centers, as suggested earlier [42].
(4) Nitic oxide (NO) is thought to be a neurotransmitter or a signaling molecule with different intracellular effects and participating in cell differentiation. Neurons, glia and vascular cells can express NO synthase (NOS) and are potential sources of NO in the brain [[43,44]].
(5) NO content and (NOS) expression are consistently higher in the skin acupoints suggesting that enhanced NO in the acupoints is generated from multiple sources including neuronal NOergic system [45]. It is suggested that cupping and cautery could cause release of NO from endothelial, neuronal or glial cells, therefore supporting recovery. Mostly important in the context of stroke, TBI, SCI, neuronal NOS (nNOS) initially isolated from rat cerebellum shows a wide distribution in brain [46]. nNOS plays key roles in neuronal differentiation and pain [47]. Specifically, through its postsynaptic density zone (PDZ) domain, nNOS can anchor at the postsynaptic endings conferring to nNOS a crucial role in synaptic plasticity [44]. Therefore, nNOS in acupuncture, cupping, and cautery would favor regenerative processes through cell differentiation, as stated above, but also through synaptic plasticity and efficiency.

5. General conclusion, limitations and future directions

The present manuscript focused on demonstrating that, although cautery might be viewed as a simple burning, other local and more distant regenerative processes, within the nervous tissue, might occur, as shown in acupuncture, magnetic stimulation and moxibustion. The common path for those techniques being heat and/or burn induction. Generally, alternative medicine methods (cautery/acupuncture/moxibustion/cupping and stimulations) are used to improve or cure patients with traumatic spinal cord and brain injuries and, stroke. We tried to correlate those alternative methods to known neurological and potential regenerative pathways, improving paralysis, paresis and pain.

The conclusion from CAM is that opioid and other NT systems are stimulated by neural activity elicited by acupuncture, cautery, cupping. Acupuncture, cautery, and cupping might follow similar regenerative processes through the BDNF/TrkB path. It is thought that similar mechanisms occur for all 4 CAM - acupuncture, moxibustion, cautery, cupping and for electrical and magnetic field stimulations. It is also proposed that cupping, cautery, and acupuncture influence neuronal networks inducing direct rearrangement for recovery of function. Finally, the latter techniques are also inducing NO release which affects cell differentiation, synaptic plasticity, and efficiency.

However, the limitations of CAM treatments relate to the fact that they are used empirically and do not follow standardized methods, inducing variability, and it is difficult to reproduce treatments. Although, since Saudi Arabia has one of the most numerous cases of spinal cord and brain injuries due to trauma, it was important to give those empirical methods some credit, due to the high demand.

In order to overcome CAM limitations, future directions will require comparing different techniques including magnetic, electrical current, acupuncture, cautery and, moxibustion, in a scientific design and an approach allowing measurable similar parameters and biomarkers.

Consent

The complementary medical practitioner, Mr. Binder, obtained consent from his patients to provide authors of this article with conventional medical and complementary alternative medical treatments information, as well as pictures and movies.

Taxonomy

Central nervous system injury/paralysis, cautery, multiple successive cautery applications.

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CRediT authorship contribution statement

Alhasn Otaif: Writing – original draft, Resources, Conceptualization. **Mashan Alshammari:** Writing – original draft, Resources, Conceptualization. **Christine G. Gerin:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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