

## Regional Pain Syndromes of Spinal Origin: Pathophysiology, Symptomatology and Proposed Classification, Diagnostics and Treatment

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### ABSTRACT

Any pain in the body triggers a nervous reflex arch, which results in the strong contraction of all muscles in the area, including the local vasoconstriction. This self-defense mechanism is to localize the problem and to prevent a blood loss in the case of trauma. Therefore, the pain caused by back injury or course of micro injuries will result in the strong spasm of back muscles and in turn an increased mechanical pressure applied to the intervertebral discs. The pressure will flatten the discs what initially might be hardly seen on X-rays/scans, leading to the narrowing of neural foraminae and thereby compression of the nerve roots. The functional vicious circle is thus created with its all consequences: **pain-muscle** spasm (sore on its own, if prolonged) - increased mechanical pressure on intervertebral discs and thereby nerve roots - more pain. This proposed pathomechanism may explain why people without any radiologically visible spinal changes, especially the young ones or those after technically correct spinal surgeries, might still suffer from severe chronic back pains and **vice-versa** many, especially elderly people with proven degenerative spinal changes on X-rays/scans, might not have any back pains because they did not trigger that vicious circle. Based on the symptomatology specific for various affected levels of the spine, the classification of various regional pain syndromes of spinal origin (RPSSO) is proposed: lower back RPSSO with/without sciatica (including so-called piriformis syndrome), L2-3 neuralgia, or L1 neuralgia; dorsal back RPSSO with/without T11-12 neuralgia or intercostal neuralgia; upper back RPSSO with/without brachialgia, C3 neuralgia, or occipital neuralgia with/without cervicogenic migraine; so-called fibromyalgia syndrome. RPSSO diagnostics is discussed and therapeutic methods reviewed, based on their ability to stop/slow down the vicious circle: physiotherapy, chiropractic manipulations/manual medicine, pharmacotherapy/neural blocks, radiofrequency rhizotomy, reflexive physical therapies (including direct spinal cord **electro stimulation**), and surgical interventions.

**Keywords:** Back pain; Neuralgia; Neuropathy; Cervicogenic headache; Piriformis syndrome; Fibromyalgia syndrome

### INTRODUCTION

“One will never die because of persistent back pain, but one will also not want to live because of persistent back pain” [1]; it can be an excruciating and disabling sensation that can ruin one’s life. Yet there are practically no adults who have never experienced any back pain whatsoever. Also, from an economic point of view, back problems are among the most costly health issues in the world because most sick leaves and most disability grants are given due to back problems [2,3].

There is a lot of controversy surrounding the pathophysiology of persistent back pains; different explanations are given by neurologists, orthopaedists, neurosurgeons, rheumatologists, chiropractors, physiotherapists, and even psychologists. In fact, not everybody with evident changes on spinal X-rays/scans suffers pain, and **vice-versa**: many, especially young people, with perfectly looking X-rays/scans cannot even move because of back pain. Also, many patients after technically correct spinal surgeries still suffer [4-7], what cannot be directly explained by orthopaedists and neurosurgeons (‘failed back surgery

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syndrome'). Therefore, there is a need for a clear explanation of the persistent back pain pathophysiology that would finally allow for the optimization of treatment.

Many doctors and other health practitioners use the term 'back pain' even as a medical diagnosis, despite the fact that it is only a symptomatic description which says nothing about the nature of the problem. Because of the complexity of persistent back pains, which usually include both the neuralgias and the sore muscle spasms and sometimes even involve other organs in the neighbourhood, they should be rather referred to as Regional Pain Syndromes of Spinal Origin (RPSSO) [1].

## PATHOPHYSIOLOGY

RPSSO generally involve persistent mechanical pressure applied to the nerves entering the spinal cord (spinal nerve roots) and sometimes the cord itself by bulged/herniated/prolapsed intervertebral discs and/or other solid elements of the spinal column; local tumors, fractures, epidural abscesses, spinal TB, or other infectious/inflammatory spinal problems are relatively rare. Therefore, this kind of pain is rightfully regarded as "mechanical back pain."

Any pain in the body triggers a nervous reflex arch, which results in the strong contraction of all local muscles (e.g. 'acute abdomen'), including those small muscles in the arteries' walls [1,8-11]. This self-defense mechanism is to localize the problem and to prevent a blood loss in the case of trauma. Therefore, the pain caused by back injury or course of the so-called micro injuries (e.g. wrong body position at work or frequent elevating of heavy objects) will result in the strong spasm of back muscles and in turn an increased mechanical pressure applied to the intervertebral discs. The pressure will flatten the discs what initially might be hardly seen on X-rays/scans, leading to the narrowing of neural foraminae and thereby compression of the nerve roots. Secondary bulging/herniation of discs will add even more pressure to the nerve roots. The functional vicious circle is thus created: the pain causes muscle contractions/cramps and strong contraction of big muscles along the spine significantly increases the pressure applied to pinched nerves, causing even more pain [1,8]. Prolonged contraction of muscles makes them weak and painful on their own, with 'pressure/trigger points' located along the related dermatomes. Sometimes, in serious cases, reflexive muscle spasms include the internal organs in the neighborhood; severe lower back pain, for instance, can be a cause of spastic colon and/or neurogenic bladder. Reflexive vasoconstriction of cerebral arteries with limited oxygen supply to the brain, caused by compression of the C1/C2 nerve roots, will result in the so-called visual aura and dizziness (sometimes even fainting), which can then develop to a full picture migraine [1]. Functional closing of local arteries supplying blood to the affected areas will have an impact on both the pinched nerves and the intervertebral discs. With regard to the nerves, prolonged limitation of the blood supply can eventually lead to nerve degeneration (neuropathy), with paraesthesia - especially numbness, also severe hyperaesthesia, and typically burning pain, especially at the distal parts of the respective nerves where the blood supply is most limited [1,8]. With regard to the intervertebral discs, prolonged mechanical pressure and

limitation of the blood supply will eventually lead to the permanent flattening and dehydration of discs with bulging/herniation and secondary vertebral degeneration, including osteophyte formations and arthropathy of the facet joints [1].

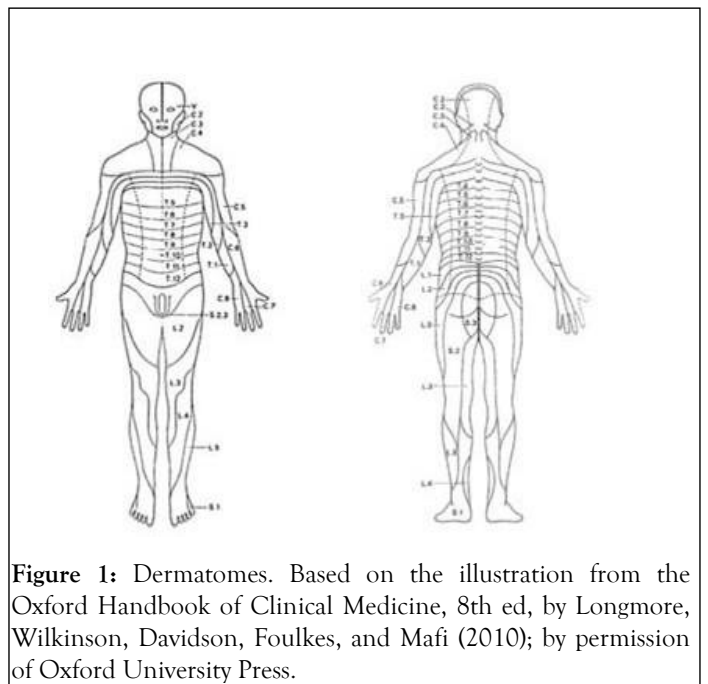
The proposed pathophysiological explanation, as described above, suggests that the primary cause of persistent RPSSO is a functional vicious circle pain - muscle spasm (sore on its own, if prolonged) - increased mechanical pressure on intervertebral discs and thereby nerve roots - more pain [1,8]. All other features are more like the final effects of that vicious circle. It explains why people without any radiologically visible spinal changes, especially the young ones or those after technically correct spinal surgeries, might still suffer from severe chronic back pains and *vice-versa* many, especially elderly people with proven degenerative spinal changes on X-rays/scans, might not have any back pains because they did not trigger that vicious circle. Mental stress can aggravate RPSSO by strengthening muscle tension and in this way accelerating the vicious circle.

## SYMPTOMATOLOGY AND PROPOSED CLASSIFICATION

Depending on the affected spinal levels the RPSSO can demonstrate different symptomatology [1]. Therefore, the following classification is proposed:

### Lower back RPSSO with/without neuralgias

**Sciatica (including so-called piriformis syndrome):** Typical clinical picture of pain originating in the lower spine and radiating down the back of the leg/legs, often with pins-and-needles/tingling sensations, is caused by compression or irritation of one or more of the five sets of L4-S3 nerve roots (Figure 1).



**Figure 1:** Dermatomes. Based on the illustration from the Oxford Handbook of Clinical Medicine, 8th ed, by Longmore, Wilkinson, Davidson, Foulkes, and Mafi (2010); by permission of Oxford University Press.

Reflexive spasm of a narrow piriformis muscle located in the buttock could theoretically add some more irritation to the

sciatic nerve, but that so-called piriformis syndrome should not be regarded as a separate problem.

Prolonged reflexive vasoconstriction of small arteries supplying the sciatic nerves can lead to the nerve degeneration-especially at the distal parts (feet) where the blood supply is most limited: this is probably the most common cause of peripheral neuropathy (along with diabetic neuropathy) with paraesthesia-especially numbness, also severe hyperaesthesia, and typically burning pain in plantar areas. Persistent sciatic pain with prolonged muscle spasms/cramps and limited local blood supply is perhaps the most important factor in the 'restless leg syndrome'.

**L1 neuralgia:** Currently not all doctors/therapists are aware that a pressure applied to the L1 nerve root may result in the persistent pain radiating along the L1 distribution (Figure 1) towards the groin. Therefore, this possibility should always be considered once all other potential causes of inguinal pain are ruled out. Testicular pain, however, is more likely to be caused by S3 neuralgia (Figure 1).

**L2-3 neuralgia:** If the pain radiates from the lower spine – just above the buttocks, towards the hip and the anterolateral aspect of the thigh (Figure 1), then it is typically caused by compression of the L3 and L2 nerve roots.

### Dorsal back RPSSO with/without neuralgias

**T11-12 neuralgia:** Pressure applied to the T11/T12 nerve roots may result in the persistent lateral abdominal pain (Figure 1): this possibility should always be considered once all other potential causes of pain in this region are ruled out.

**Intercostal neuralgias:** Severe intercostal neuralgia can be a source of much stress to patients: because of chest pain it can be initially regarded as a serious cardiac, pulmonary, breast, or even hepatic or gastric problem. The traditionally recommended medication (mainly antiepileptics and antidepressants) is not always very effective and nerve blockades carry a high risk of pneumothorax.

### Upper back RPSSO with/without neuralgias

**Brachialgia:** Typical clinical picture of pain originating in the upper spine and radiating towards shoulder and down the arm and the forearm, with pins-and-needles or even numbness in certain fingers (depending on the spinal level where the nerve roots are pinched), is caused by compression or irritation of one or more of the seven sets of C5-T3 nerve roots (Figure 1). Limitation of pain to the neck and shoulder only (Figure 1) is more indicative for the sole compression of the C4 nerve root (probably the most common cause of the shoulder pain).

**C3 neuralgia:** Pressure applied to the C3 nerve roots may result in persistent pain not only in the posterior neck but also the ear region (especially with concomitant C2 nerve involvement), temporomandibular joint region, and even the frontal part of the neck (Figure 1). Reflexive muscle spasm may involve not only posterior cervical and sternomastoid muscles but also superior constrictor and masticatory muscles, leading to limitation in the range of motion of the mandible and even

swallowing difficulty. Prolonged reflexive vasoconstriction, with limited blood supply to the acoustic nerve, could be a cause of tinnitus. The possibility of the C3 neuralgia should always be considered once all other potential problems in this region, such as otitis media, temporomandibular joint derangement, pharyngitis, etc., are ruled out.

**Occipital neuralgia and cervicogenic migraine:** The C1 nerve carries predominantly motor fibres, but also a small meningeal branch that supplies sensation to parts of the dura around the foramen magnum (via dorsal rami). Being branches of the C2 nerve, the greater and the lesser occipital nerves make their way through muscles at the back of the head and into the scalp. The greater occipital nerve sometimes reaches nearly as far forward as the forehead.

Compression of the C1/C2 nerve roots can result in the occipital neuralgia, typically with sharp, shooting pains arising at back of the head or upper neck, and spreading either to the top of the skull (greater occipital nerve), or to the temple region (greater/lesser occipital nerves). However, the pain automatically triggers muscle spasms (including neck muscles), leading to even more pressure applied to the pinched nerves; during the acute phase this vicious circle can develop into a full clinical picture of the so-called cluster headache, characterized by a recurrent, severe, usually unilateral pain with radiation towards the eye. This kind of headache often occurs at night, perhaps due to the longer-lasting incorrect position of the head and neck. Once the problem becomes chronic, with muscles being continuously over contracted and therefore sore on their own, the so-called tension headache can be created. Mental stress can aggravate such a headache by strengthening muscle tension and in this way accelerating the vicious circle, but it is not a primary cause!

When the problem becomes very serious, it can be called a migraine. Strong pressure on the C1/C2 nerve roots can induce, in the reflexive way, a strong spasm of the respective muscles, including those small muscles in the cerebral arteries' walls. This will lead to vasoconstriction with reduction in the cerebral blood flow; limited oxygen supply will result in the visual aura (blurred vision and flash points), often with dizziness and disorientation. Prolonged cerebral ischaemia may lead to rising intracranial pressure. The reduction in the cerebral blood supply will finally trigger the self-regulatory physiological mechanisms, which will increase the blood volume "pumped" to the brain, usually within the next 15 to 45 minutes. However, this increased cerebral and extracranial blood flow through still-narrowed arteries will raise an intraarterial pressure, producing a characteristic throbbing headache. Severe "bursting" pain together with the reactive mental stress can induce nausea and vomiting. Higher estrogen levels in blood plasma, with subsequent water retention, contribute to a higher risk of migraines during the premenstrual period.

There are currently many theories, mainly biochemical, concerning the pathophysiology of persistent headaches (migraines) but in general they do not clearly distinguish between the causes and the results; many of them concentrate more on technicalities than on clear, general ideas. Therefore, in fact, these theories create more questions than answers. Headache can be a symptom of almost any disease, but the

proposed cervicogenic pathophysiology (as described above) could be the most common cause of persistent headaches [1] and should always be considered after all other potential causes are ruled out.

### So-called fibromyalgia syndrome

It seems that the so-called fibromyalgia syndrome is one of the major misunderstandings in contemporary medicine. According to the American College of Rheumatology, the classification criteria for fibromyalgia syndrome [12] generally consist of:

1. Widespread pain for three months or longer in an axial distribution plus pain on both sides of the body, as well as above and below the waist.
2. The presence of 11 or more (recently, even six is considered enough) out of 18 specified tender points with moderate digital pressure of 4 kg (roughly the force required to blanch the examining nail when pressing against a hard surface).

There are also some associated symptoms that may include chronic pelvic pain, restless leg syndrome, irritable bowel syndrome and neurogenic bladder, noncardiac chest pain, persistent headache, dizziness, so-called chronic fatigue syndrome, and sleep disturbance. All of these symptoms are supposed to be caused by “central sensitization” with disordered sensory processing of pain impulses in the spinal cord. Apparently, it is believed that there is a loss of pain regulation in the central nervous system that causes pain amplification.

However, all of these diagnostic criteria and symptoms are, first of all, typical for a widespread, multilevel, chronic RPSSO. Pinched nerve roots at various spinal levels can be a cause of functional vicious circles pain - muscle spasm (sore on its own, if prolonged) - increased mechanical pressure on intervertebral discs and thereby nerve roots - more pain, which can produce all the previously mentioned symptoms [1,8]. All 18 specified tender points belong to known acupuncture points (aka ‘trigger points’), which always become tender in the case of multilevel spinal problems [1]. Biochemical investigations could perhaps detect in the respective muscles some changes typical for prolonged **over contraction**, but they could not be used as an evidence for the ‘fibromyalgia’ existence as a separate disease; otherwise, there are not any specific laboratory tests available. The main danger of the artificial diagnosis of ‘fibromyalgia’ is that it deprives the RPSSO patients of their best therapeutic options, which could lead to the full and lasting recovery [1].

## DIAGNOSTICS

There are persistent RPSSO sufferers, especially young ones, with perfect-looking spinal X-rays/scans and *vice-versa* especially elderly people with no pains at all, despite severe spinal degenerative changes visible on their X-rays/scans. Therefore, despite the common perception, radiological investigations are not the best tools for an assessment of the RPSSO. Nevertheless, spinal X-rays/scans should always be done to exclude certain serious possibilities, e.g. local tumours, fractures, epidural abscesses, spinal TB, or other infectious/inflammatory problems.

Bone scintigraphy is very useful in identifying vertebral pathologies, e.g. tumours, fractures, inflammation. However, likewise X-rays/scans, it might show no changes in the early uncomplicated RPSSO. The nerve conductivity study can identify damaged nerves and in an objective way confirm the diagnosis.

From the practical point of view, the most suitable for a proper and objective assessment of the RPSSO seems to be these days an organ electrodermal diagnostics (OED; CE Certificate C52113), which must never be mistaken with other unproven so-called electrodermal measurements [1]. This new non-invasive **bioelectronics** method of the regional diagnostics [1,13-19] can get access to precise diagnostic information circulating in the sensory nervous system [1,8] and in this way can physically track the origin of respective afferent nervous signals and even measure their intensity (pain). OED is especially useful in confirmation of the RPSSO presence in radiologically negative cases, including the so-called fibromyalgia syndrome, also in diagnostics of headaches or chest and abdominal pains.

Doctors/therapists who do not have access to OED technology should rely on the clinical picture and can still confirm spinal problems by properly carried out physical examination with moderately strong palpation along the spinal column, in search of very tender areas between spinous processes. The presence of such ‘pressure points’ would indicate affected levels. Tenderness (increased sensitivity to palpation) of the respective dermatomes, with ‘trigger points’ present on top of muscle spasms, would confirm the diagnosis.

Because of the functional nature of RPSSO the laboratory tests are not of diagnostic **value** in severe cases they could perhaps detect in the respective muscles some changes typical for prolonged **over contraction**.

## TREATMENT

RPSSO are caused by vicious circles pain-muscle spasm (sore on its own, if prolonged)-**increased** mechanical pressure on intervertebral discs and thereby nerve roots-**more** pain. It means there are two ways to stop/slow down those vicious **circles** one can either try to directly relax muscle spasms or to block the pain, which triggers muscle spasms. In more severe cases it is good to combine all possible treatments to work together.

### Physiotherapy

The term physiotherapy originates from the Greek “physis”-nature and should be reserved for “physiological” therapies such as exercises (kinesitherapy, biokinetics, water exercises, etc.), also traction. The therapeutic power of proper stretching exercises (including ‘Pilates’, Thai-Chi, Yoga), which can relax muscle spasms, should never be underestimated and because of convenience and low cost of those often prolonged therapeutic courses, they should always be considered as the first step in the prevention and management of RPSSO. To ensure lasting improvement, traction should be done on the hospital bed with weights on both sides continuously over the period of at least 3 **days** because of the size of the respective muscles to be stretched



it helps better in the upper back RPSSO in comparison with the lower back.

### Chiropractic manipulations/manual medicine

Despite claims of reducing “subluxations of spinal joints” [20], it seems that the leading mode of action of the so-called manipulations/mobilizations is forced stretching of the relevant muscle spasms, which can result in relaxation of contractions and in this way reduction of mechanical pressure applied to nerve roots. However, this ‘quick fixation’ should not be applied to people with radiologically confirmed vertebral degenerative changes (‘bone spurs’) because of the risk of compression fractures.

### Pharmacotherapy/neural blocks

This convenient form of the RPSSO management offers various possibilities of stopping/slowing down the vicious circle, which causes the problem. Anti-inflammatories promote healing process by reducing inflammation of compressed nerve roots and therefore should be used as the first line medication on regular basis. Painkillers should be possibly strong but safe and non-addictive. **Antiepileptic’s** (Gabapentin, Pregabalin) slow down functioning of damaged nerves and therefore these days are commonly used for the symptomatic treatment of neuralgias/neuropathies. However, they are not very effective in practice [21,22] and many patients do not tolerate them well. Tranquilizers or antidepressants can help muscle relaxation at least to certain extent, in contrast to the so-called muscle relaxants which are more effective in the real muscle/CNS diseases. Depending on the severity of clinical symptoms medication can be applied orally, IMI, or IVI.

Combination of an anti-inflammatory (steroid) and anaesthetic medication injected in proximity to the affected nerves (nerve root blocks, epidural blocks, and ‘trigger point’ injections) can be very helpful in severe RPSSO. Since the facet arthropathy is usually a secondary effect of the prolonged muscle contraction with narrowing of discs (see: pathophysiology), the facet joint infiltrations or the facet nerve injections should not be the first line treatments.

### Radiofrequency rhizotomy

Radiofrequency rhizotomy or neurotomy/ablation is a therapeutic procedure designed to eliminate/decrease painful sensations by damaging the nerves that carry painful afferent signals, with highly localized heat generated by radiofrequency currents. However, in the case of RPSSO the question remains: why to damage even further the already damaged nerves instead of repairing them with less invasive neural injections (see above) or totally non-invasive reflexive physical therapies (see below)?

### Reflexive physical therapies (including direct spinal cord electro stimulation)

Physical medicine means the medical management of diseases and disorders using various forms of physical energy [1]. Among various physical treatments there is a group of so-called reflexive

therapies, which use various forms of physical energy to stimulate nervous receptors in the specific areas of the skin, in order to control the body’s own self-defense mechanisms and systems [1,8]. Typical reflexive therapies **includes:** **Thermostimulation** (heat, cryotherapy), photostimulation (infrared, ultraviolet, laser), ultrasound stimulation, electrostimulation (direct or via electromagnetic energy), magnetostimulation, and mechanical nerve stimulation (acupuncture and related technics, reflexive massage, cupping, or high-pressure hydrotherapy). Chemical stimulation of the skin’s nervous receptors by the use of various injections (even bee stings), plasters, compresses, and creams also belongs to the same category, because respective chemical substances are utilized in this case as nervous stimuli and not as medications on their own.

According to the neural convergence modulation theory [1,8] reflexive therapies work like ‘natural’ neural blocks at the respective spinal levels and in this way control the pain, relax muscle spasms, and significantly improve local blood supply. Electroacupuncture, extreme local cryotherapy (-70 to -160 degrees Celsius), and to a lesser degree Transcutaneous Electrical Nerve Stimulation (TENS) are clinically most effective because of the highest amplitudes of applied stimuli [1,8].

Reflexive physical therapies can address simultaneously all affected spinal levels and can be used on regular basis, as frequently as required. Because these therapies are applied locally, they are best suited to the effective treatment of peripheral **neuropathies-through** much improved local blood supply [23]. Therefore, for all the good reasons [1], reflexive therapies should be considered as the first line treatment for severe RPSSO.

Electrostimulation of “quick” non-nociceptive nerve fibers, which can result in the blockage of painful signals carried by “slow” nociceptive nerve fibers [1,8], can be performed directly by means of pulse generators with leads implanted in the spinal cord. Relatively weak therapeutic currents will be still able to stimulate the thick non-nociceptive fibers, but not thin nociceptive ones. This direct spinal cord electro stimulation can provide the patient with convenient “on demand” access to electroanalgesia at any time and place. However, it requires a surgical intervention with a potential allergic or immunological response to the implanted materials. Also, the cost of the respective equipment is far higher than modern, portable TENS machines, which in practice seem to be equally effective if used in the scientific way [1].

### Surgical interventions

In the case of RPSSO surgical procedures (laminectomy, laminoplasty, discectomy, artificial discs implantation, fusions) only address the final effects of the functional vicious circle pain - muscle spasm (sore on its own, if prolonged) - increased mechanical pressure on intervertebral discs and thereby nerve roots - more pain, which are permanently flattened discs with all secondary consequences. However, these surgical interventions do not directly address the primary cause of the problem, which is the vicious circle itself. As the result we can see patients still

complaining of severe back pains after technically correct spinal surgeries ('failed back surgery syndrome') [4-7].

This scenario would be similar to that one of young people suffering from back pains despite their spines still looking normal on scans. Surgical procedures are also not suitable for multilevel spinal problems. Therefore, this kind of **expansive** and still risky treatments should be regarded as the last resort and reserved only for selected RPSSO patients.

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## CONFLICT OF INTEREST

None.

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