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TITLE OF CASE

Cold forced open-water swimming: A natural intervention to improve postoperative pain and mobilisation outcomes?

AUTHORS OF CASE ***Please indicate corresponding author by *(after the author's name)***

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SUMMARY ***Up to 150 words summarising the case presentation and outcome***

Postoperative neuropathic pain exacerbated by movement is poorly understood and difficult to treat but a relatively common complication of surgical procedures such as endoscopic thoracic sympathectomy. Here, we describe a case of unexpected, immediate, complete and sustained remission of postoperative intercostal neuralgia after the patient engaged in an open-water swim in markedly cold conditions. Though an incidental chance association is possible, the clear temporal proximity linking the swim with pain remission make a causal relationship possible. We discuss plausible mechanisms that may underlie the relationship and discuss the potential implications for postoperative pain management and patient-centred mobilisation. We recommend further evaluation of cold forced open-water swimming as a mobility-pain provocation challenge to see if the observed unexpectedly positive outcome, can be replicated. With the poor response to traditional management, there is a need for novel, curative interventions for postoperative neuropathic pain and associated impaired mobility.

BACKGROUND ***Why you think this case is important – why you decided to write it up***

Damage to peripheral nerves and chronic pain is a known complication of surgical procedures such as endoscopic thoracic sympathectomy [1]. Intraoperatively, trocars are inserted through the intercostal space, which may damage surrounding intercostal nerves resulting in stabbing neuropathic pain experienced in the overlying chest region postoperatively. This pain is also a significant treatment challenge, as it may not respond well to analgesics and carries significant psychosocial morbidity. Hence there is a need to develop novel interventions for disabling neuropathic pain conditions after surgery.

CASE PRESENTATION ***Presenting features, medical/social/family history***

A 28 year old male presented with ongoing intercostal neuralgia following endoscopic thoracic sympathectomy for severe primary facial blushing refractory to conservative management. There was no other significant past medical history. As per national guidelines [2], endoscopic thoracic sympathectomy was performed uneventfully at a tertiary centre and there were no postoperative complications other than severe bilateral radiating T5 intercostal pain. The patient was discharged with a course of physiotherapy and combination analgesics including paracetamol, non-steroidal and opiate medication. Analgesics provided limited improvement, reducing pain on a visual analogue scale from 6/10 to 4/10. After 10 weeks, the patient was found unresponsive to a standard physiotherapy regime with typical graded activity increases. The patient reported that exercise and movement exacerbated the intercostal neuralgia and prevented full engagement in mobilisation and the physiotherapy rehabilitation program. The patient reported pain was associated with significant distress, prevented return to preoperative levels of recreational sport, and impaired quality of life.

INVESTIGATIONS ***If relevant***

n/a

DIFFERENTIAL DIAGNOSIS ***If relevant***

n/a

TREATMENT ***If relevant***

Ten weeks postoperatively, the patient continued to report a limited benefit from analgesics and graded physiotherapy. With a history of recreational triathlon competition, the patient exposed himself to open-water swimming in an attempt to manage the pain through distraction. This occurred without the knowledge of health professionals. The characteristics of this activity are atypical of traditional postoperative, incremental pain rehabilitation approaches and are characterised in table 1. Because of the rocky, costal geographical layout where swimming took place, the patient stated that water-entry necessitated jumping and plunging into markedly cold water. Once in the water, swimmers were forced to swim for a period of approximately 60 seconds in order to reach somewhere to safely climb back ashore.

OUTCOME AND FOLLOW-UP

Interestingly, contrary to the patient's expectation of severe pain, the patient unexpectedly reported no provocation of pain during swimming. Since the point of water-entry, the patient has reported no further episodes of intercostal neuralgia and reports being able to move and exercise freely without pain. Exposure to cold open-water swimming appeared to provide immediate and lasting analgesia, during which time pain was undetectable. Since exposure to the swimming event, there has been a full return to preoperative levels of mobility, sport and quality of life. Regular opiate and simple non-steroidal analgesics have since been discontinued by the primary care provider.

DISCUSSION ***including very brief review of similar published cases (how many similar cases have been published?)***

Neuropathic pain is a significant disorder which can be difficult to treat and may be associated with structural changes in the brain[3]. Aside from postoperative interventions to avoid neuropathic pain, previous authors have highlighted several intraoperative factors, including the number and size of port incisions and methods used to manipulate tissues surrounding nerves in ways to minimise local nerve damage [1,4,5].

After reviewing the literature, no similar case reports of cold open-water swimming curtailing postoperative pain and associated immobility could be found. Although there is considerable literature on aquatic rehabilitation [6] and cold-water baths in sports medicine [7], cold-water swimming as described in Table 1, to the best of the authors' knowledge, has not been described in the context of postoperative care. A forced swimming task [8], which shares similarities to the exposure seen in this case, has been extensively used in rodents because of its ability to enforce mobilisation and investigate neurochemical systems implicated in depression and pain [9]. No previous reports of forced swimming in cold water could be found with human subjects, presumably because of ethical implications.

Due to the nature of retrospective case reports, it is unclear without further evidence, whether the exposure to forced cold-water swimming is causally and specifically related to pain remission. However, the temporal proximity, the patient's subjective attribution, low patient expectations and the absence of likely alternative explanations (beyond coincidental spontaneous remission) increase the likelihood of a specific causal relationship beyond placebo. In addition, though specific mechanisms remain unclear, plausible mechanisms for short-term relief and sustained longterm remission could underlie the relationship: Biologically, the shock of sudden cold-water immersion combined with the potential threat of drowning may induce a surge of sympathetic activity upon water-entry. The cold shock response has also been linked to reduced cerebral perfusion and altered level of consciousness [10]. These processes may potentially lead to altered pain perception that could explain the reported short-term 'endogenous' analgesia. In addition, forced cold swimming may provide markedly high intensity distractor stimuli. New inputs are received from a range of novel, unhabituated mechanoreceptor, thermoreceptor and proprioceptor afferents that may out-compete nociceptors for attentional capture and conscious awareness and influence the pain gate to prevent perception of pain. There is also the possibility that post-sympathectomy pain has an autonomic nervous system component, and this may have been disrupted by a surge of sympathetic activity during swimming.

It is unclear why the pain remained in remission beyond the acute period of cold activity. One possibility is that the acute endogenous analgesic state challenged reduced mobility which was maintaining the pain, which would otherwise have been intolerable due to movement-related pain. Moreover, the extent of mobilisation may have been increased and enforced through potent primitive escape behaviours associated with forced swimming [8]. As such, the exposure in this report offers overlap with the clinical procedure of 'manipulation under anaesthesia' that is well-established in relieving postoperative pain seen postoperatively in adhesive capsulitis. In contrast to this procedure however, the anesthesia in the case here is endogenous rather than exogenous in origin. Musculoskeletally, if there was a component of pain related to postoperative tissue inflammation and adhesions affecting peripheral intercostal nerves, it is possible that the high range of movement involved in swimming manipulated tissues surrounding peripheral nerves in such a way as to mechanically free adhesions and resolve pain. Psychologically, 'flooding' with intense activity may have abruptly broken maladaptive cycles of movement avoidance and withdrawal from exercise and its associated pain relieving properties.

This case also raises principles of patient-centred postoperative care. Behaviourally, the patient reported a history of recreational athleticism and novelty-seeking traits. These personality factors may have combined to manifest in the behaviour observed. This case reinforces the importance of individualising postoperative care so that it is compatible with and complementary to the individual patient: Suggesting intense swimming exercises to some patients may not be appropriate or safe, and hypothermia brings significant risk [11]. In addition there is the risk associated with the acute cold shock response, which may disproportionately affect the arm muscles whilst swimming and can lead to incapacitation and potential drowning within minutes if unsupervised. It also needs to be highlighted that such a response occurs long before the onset of core hypothermia [12].

Equally however, it is important professionals do not withhold the choice of treatments, should they be proven effective, if benefits outweigh rare theoretical risks [13]. More aggressively paced rehabilitation may suit certain patients more than others, for example those with elevated impulsivity [14] may be predisposed to wanting short-term rewards, and therefore may engage better in single-session rehabilitation approaches if available. Where possible, interventions should be tailored to the person and their temperament [15] and within reasonable limits of patient-centredness [16] so treatment is contextually balanced with the patient's needs [17]. Overall, this case challenges conventional postoperative pain management protocols that emphasise pharmacological analgesics and incremental physical activity. Traditional multisession physiotherapy was experienced negatively as cumbersomely ineffective and was not successful in engaging this patient. As with all interventions, ethical and cultural factors deserve further open and transparent consideration. Specifically in this intervention, the fact that the swimming was "forced" raises ethical challenges over patient autonomy. In order to systematize the intervention ethically in the future, patients need to provide fully informed consent that was entirely voluntary prior to the activity and ideally have a way of stopping swimming in case they changed their mind and wanted to withdraw their consent at any time.

In summary, this case reports describes exposure to a single-session sudden immersion in extreme cold water that was associated with an unexpectedly positive outcome of remission of intercostal neuralgia and associated reduced mobility. Treatment-resistant neuralgia appeared to resolve in a cost-effective and rapid manner that could be acceptable to future patients. Further prospective explorative investigation is needed to assess the replicability and feasibility of forced cold-water swimming as a potentially effective, natural intervention to enhance recovery outcomes from common postoperative compilations.

LEARNING POINTS/TAKE HOME MESSAGES ***3 to 5 bullet points***

- Damage to peripheral nerves after surgery can lead to postoperative neuropathic pain that is difficult to treat and can lead to immobility and worsened quality of life
- Here, we describe the first known immediate remission of intercostal neuralgia following exposure to patient-initiated singe-session open-water swimming in extreme cold conditions
- Forced cold-water swimming may trigger a surge of sympathetic activity and catecholamines that may provide short-term endogenous analgesia and allow aggressive manipulation of the kinetic chain under pain-free conditions
- Forced cold swimming overcame reluctance to engage in pain-provoking postoperative mobilisation and curtailed chronification of pain and reduced mobility
- Future studies are recommended that need to be developed in a rigorously ethical way, in order to attempt replication of positive outcomes after exposure to cold water swimming for postoperative neuropathic pain and immobility

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Table 1. Characteristics of Exposure to Cold Forced Open-Water Swimming Activity

Intervention Variable	
Operative Status	10 weeks post-sympathectomy
Activity conception	Patient-initiated (unsanctioned by health professionals)
Patient-predicted efficacy	Uncertain: "I wasn't sure if it would help the pain – I just wanted to do it – I though at best it was a long-shot, but I was desperate to get some relief."
Approximate Ambient Temperature	8°C
Estimated Sea Temperature	11°C
Wetsuit / thermal clothing	Nil
Anticipated level of pain during activity	9-10: "excruciating"
Actually perceived level of pain during activity	0: "just numb"
Volitional Nature of Activity	Initiation of water-entry: Voluntary Subsequent sustained swimming: Forced
Duration of Swimming	Approximately 1 minute
Accompanying swimmers/observers	Nil – patient was alone
Aerobic intensity / Perceived Exertion	Extremely high (9-10/10)
Exercise Type / Joint Range of Movement	Front Crawl / Compound movements with high ranges of motion across all limb joints
Activity increase relative to baseline function	Non-incremental 'flooding': Extreme – step change
Retrospective self-report during Swimming	"I initially thought – 'damn this is so cold I'm going to die!' I just swam for my life – Once I was in the water, I had tunnel vision – for the first time in months, I completely forgot about the pain or the fear of shootings pains in my chest if I moved. My entire body tingled with the cold. I just knew if I didn't keep swimming, I'd soon freeze. After a few moments I actually enjoyed it - it was just an immersive rush of adrenaline. I bet I couldn't have felt my pain, even if I tried."
Retrospective self-report immediately after Swimming	"When I came out of the water, I realised the neuropathic pain had gone away. I couldn't believe it."
Total duration whilst disrobed and number of sessions 'intervention'	Approximately 10 minutes; single-session