Case Report

Neuromodulation of the Suprascapular Nerve

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Chronic intractable shoulder pain (CISP) is defined as shoulder pain which is present for longer than 6 months and does not respond to standard treatments like medication, physical therapy, rehabilitation, selective nerve blocks and local infiltrations, or orthopedic procedures. The etiology of CISP may be very diverse, varying from many orthopedic conditions to non-orthopedic conditions. The fact that the suprascapular nerve is one of the most important nerves supplying the shoulder region makes this nerve an interesting target in treating patients suffering shoulder pain. Invasive treatment options are peripheral nerve blocks, temporary electrical stimulation, and neurostimulation. To our best knowledge, thus far there are only a few reports describing the technique of permanent neurostimulation of the suprascapular nerve. In this article we present a patient suffering shoulder pain after she underwent surgery for cervical stenosis. After a step by step treatment protocol was done, we finally offered her trial stimulation of the suprascapular nerve. A single quad lead was implanted via a posterior approach under fluoroscopic and ultrasound guidance. Two weeks after successful stimulation, we implanted a permanent neuromodulation system.

Permanent neurostimulation of the suprascapular nerve and its end branches may be a new interesting target in treating patients suffering shoulder pain due to various etiologies. In our patient the follow-up period is 9 months with an excellent result in pain relief, we observed no complications thus far, especially no dislocation or breakage of the lead. In this report, literature on this subject is reviewed, and our technique is well documented with additional anatomical illustrations.

Key words: Suprascapular nerve, shoulder pain, peripheral nerve stimulation, neuromodulation, neurostimulation, chronic pain

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Shoulder pain is an important medical and socio-economic problem in western society with a one-year prevalence of 4.7 – 46.7% (1). Chronic intractable shoulder pain (CISP) is defined as shoulder pain which is present for longer than 6 months and does not respond to standard treatments like medication, physical therapy, rehabilitation, selective nerve blocks and local infiltrations, or orthopedic procedures. The etiology in chronic shoulder pain is very diverse. Orthopedic conditions that can result in CISP include rotator cuff disorders, glenohumeral instability, glenohumeral osteoarthritis, acromioclavicular joint pathology, and adhesive capsulitis. But there are also non-orthopedic causes that lead to shoulder pain, like cervical radiculopathy or persisting pain in the shoulder after treatment for cervical neurological problems. Clinical presentation includes diffuse shoulder pain with restricted range of motion that may lead to inability to work and/or to carry out household and leisure-time activities, burdening both the patient and society. The suprascapular nerve (SSN) is considered to be one of the most important nerves in the shoulder region. The SSN contains motor fibers to the supra- and infraspinatus muscle, and a major part of the sensory fibers from the shoulder joint. The innervation of the shoulder itself is mainly by the SSN and the axillary nerve. These 2 nerves are important targets in treating patients suffering chronic shoulder pain due to various etiology like capsulitis after repetitive orthopedic procedures (2), rotator cuff tear (3), and even for refractory post stroke hemiplegic shoulder pain (4,5). Invasive treatment options are peripheral nerve blocks, and more recently, neuromodulation of these nerves. Peripheral nerve block of the SSN using bupivacaine and methylprednisolone acetate may result in a short-term effect (6), while pulsed radiofrequency to the SSN is associated with a longer-term effect (7). Full surgical access to the suprascapular is possible, but requires extensive surgery, while a percutaneous approach seems to be the ideal approach to ensure blockade of the more proximal branches to the acromion and the subacromial region to maximize coverage. This technique is first described by Dangoisse in 1994, and later modified by other authors as Price, Meier, Checcucci, and Matsumoto (8). All these approaches are from a superior or anterior view into the suprascapular notch where the SSN enters the supraspinosus fossa, just to have access to the main branch of the SSN. It is believed that this is necessary to have a good pain effect, because in approximately 50% of the cases, the sensory branches are already separated from the main stem before the main stem enters the suprascapular notch. The difficulty however is that even with the use of ultrasound, the main stem of the SSN is difficult to visualize. In this report we choose to access the SSN nerve more from a posterior view, paramedial from the spine at level Th2, and we purposely choose end branches of the SSN and not the main branch.

Case Presentation

The patient is a 52-year old Dutch woman, who was referred to our pain clinic for a second opinion of chronic shoulder pain. She experienced pain in her right shoulder already before she underwent decompression surgery at level C3-C7 because of cervical spinal stenosis in 2001. The pain was mainly located in her right shoulder and sometimes in her upper arm. The pain was present continuously day and night, without trigger moments, and impressing as neuropathic pain. Magnetic resonance imaging (MRI) showed signs of myelopathy at the levels C5 and C6, so we formulated the hypothesis that the shoulder pain was on basis of the cervical spondylotic myelopathy. Clinical examination revealed normal sensomotory findings and normal reflexes with a limited range of motion of the shoulder. We offered her a step by step treatment which consisted of therapy that gradually became more invasive, and consisted of physical therapy, treatment by several pain medications (NSAIDs, Tramadol, Lyrica), transcutaneous electrical nerve stimulation (TENS), and suprascapular nerve block. Physical therapy and various pain medications did not show effect. TENS decreased the pain scores but was not feasible for a longer treatment because of an allergy to patches. She underwent a trial of a peripheral suprascapular nerve block with bupivacaine and cryo-blockade, which was successful only for a short time. Due to the positive result of this trial, we proposed performing a trial neurostimulation of the right suprascapular peripheral nerve. Before the procedure, the pain intensity measured during 4 days with Visual Analogue scale (VAS) had a mean of 5.7. The Numeric ration scale (NRS) varied between 5 and 9. The technique was performed in the prone position, with the contralateral arm flexed above her head, and the ipsilateral right arm stretched along her body in order to have a flat level surface over the scapula. The borders of the scapula were marked on the skin, especially the acromion and the mid-median border of the scapula. This corresponded with the Th2 spinous process, which was confirmed after fluoroscopy (Fig. 1). Under local anesthesia, a small incision was made 4 cm lateral to the Th2 spinous process, through which a 6 inch, 14 gauge Touhy introducer needle was guided from the median border of the scapula pointed to the acromion process. The correct needle tip position in relation to the suprascapular notch was confirmed by repetitive fluoroscopic images and intraoperative ultrasound. A single quad lead (Pisces Quad compact, Medtronic) was passed through the introducer needle and was positioned at the target. The introducer needle was withdrawn, after which we performed intraoperative trial stimulation. The patient noticed clear paraesthesia similar to spinal cord stimulation. After achieving good stimulation in the pain area, we fixed the lead to the thoracal posterior fascia using an injet bi-wing anchor (Medtronic), and after connecting with an extension cable, we tunnelled the system outside. For 2 weeks the patient underwent trial stimulation in which she observed complete relief of the preoperative pain with a mean VAS of 0.5 measured during 7 days. After these 2 weeks, we implanted a permanent internal pulse generator (IPG) in the buttock region (Prime Advanced, Medtronic). The follow-up period is 9 months, the patient suffers no pain, she does not need pain medication, and her quality of life is remarkably increased. X-ray shows an unchanged position of the lead when compared with the intraoperative situation (Fig. 2).

Discussion

Peripheral nerve neuromodulation is an established modality in the treatment of chronic pain. It has been applied in order to treat pain in CRPS, plexus avulsion, entrapment neuropathies, injection injuries, and local

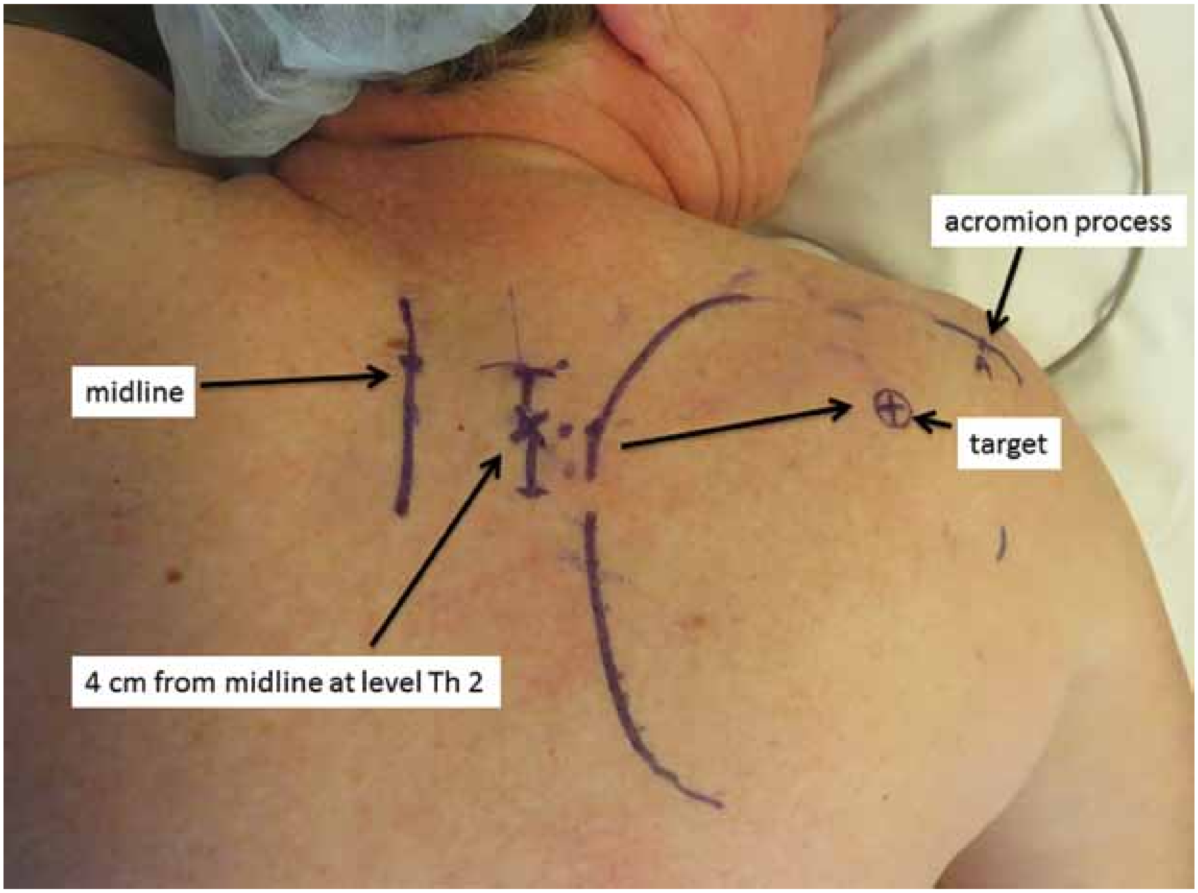

Fig. 1 *Positioning of the patient and anatomical landmarks.*

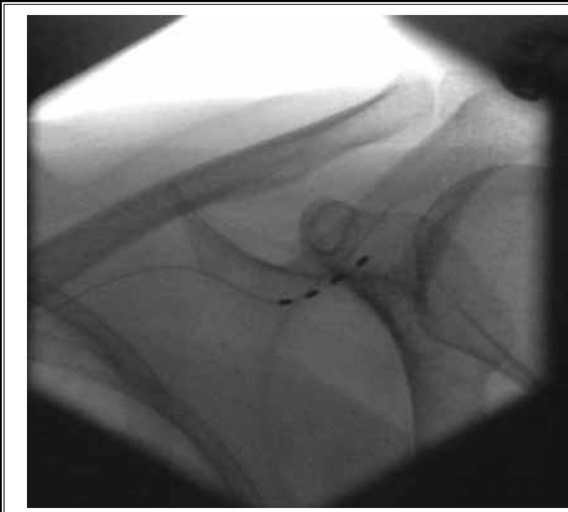

Fig. 2 *Intraoperative X-ray showing the position of the lead.*

operative trauma. To the best of our knowledge, there have been no well-documented publications to date concerning the implantation of a permanent neuromodulation system of the suprascapular nerve in order to treat shoulder pain. Although many blockade techniques and PRF treatments (7) are described, permanent stimulation of this peripheral nerve is very rarely described and the indications are unknown. Short-term stimulation of 3 weeks is described in a randomized controlled trial for treatment of shoulder pain after stroke, but the publication does not clarify the exact targeting of the stimulation, most probably the deltoid muscle itself (9). A case series of 8 patients in a group of patients (hemiplegic shoulder pain) was already published in 2012, with similar results in a 3 weeks stimulation period (5). They describe the targeting of the deltoid muscle. To avoid misunderstanding, some authors use the term intramuscular electrical stimulation and not

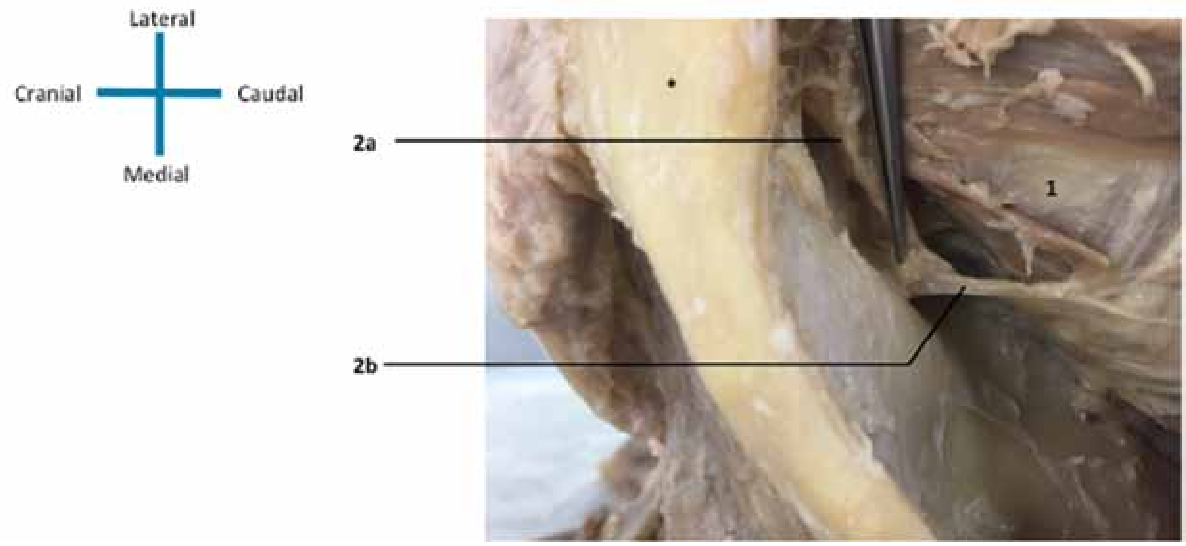

Fig. 3. *Dorsal view on the back . The forceps is pointing at the suprascapular nerve. 1=infraspinatus muscle, ventral part. 2a=suprascapular nerve, lateral branch. 2b=suprascapular nerve, medial branch. *= acromion*

PNS. Unfortunately the term intramuscular suggests direct stimulation of the muscle. However, when low levels of current are used to cause muscle contraction, low-threshold alpha motor neurons innervating the muscle are being stimulated, and not the muscle itself. The threshold for causing muscle contraction via direct muscle stimulation is substantially higher than that is necessary for muscle contraction via motor nerve stimulation. Various theories have been postulated to understand the central mechanisms of peripheral nerve stimulation. Not only is there a direct anatomical link between the peripheral nerve system and the central nervous system (in fact the suprascapular nerve originates from the C5 and C6 nerve roots in most people, while in some people even the C4 root is involved), there are also various mechanisms involved in both the peripheral as well the central system. Segmental pain modulation is a consequence of the stimulation of the peripheral nerve which activates the large myelinated afferents, enhancing the inhibitory actions of local circuit neurons in the dorsal horn on central transmission cells. Since pain states are maintained by continuous firing of unmyelinated and small myelinated afferents, a proportionately greater increase in the activation of large myelinated afferents closes the gate and stops pain transmission via presynaptic inhibition (10,11). Recently in a rat-model of neuropathic pain, it was described that PNS offers inhibition of the short-term neuronal sensitization by activation of afferent $A\alpha/\beta$-fibers which in turn inhibit the C-fiber-mediated windup in the dorsal horn wide-dynamic range neurons (11). In our patient, we choose to stimulate the more distal branches of the suprascapular nerve (Fig. 3) that are located more superficially than the supraspinous fossa where the main branch of the nerve is located. These distal branches are the end branches of the lateral and medial branch of the suprascapular nerve which run into the infraspinate muscle, which is clearly visible in an anatomical study that we performed recently (Fig. 4). This access is easier than the classical route to the SSN, and does have less complication risks than the classical route like damage to the vessels surrounding the main stem of the SSN. Additionally, realizing that the shoulder does have a remarkable range of motion, making it one of the most mobile joints in the human body, we believe that a posterior approach with introduction of the lead will bring a more stable position of the lead with less chance of migration when compared with introduction of the lead from a superior view into to suprascapular notch. We believe that neurostimulation of the SSN offers a unique opportunity to reduce the pain in patients suffering intractable chronic shoulder pain with the emphasis that stimulation of the proximal main branch of the SSN is not necessarily indicated and that stimulation of end branches of this nerve may be sufficient. This hypothesis is already assumed in patients suffering chronic refractory headache syndromes where stimula-

Fig. 4. *Ventral view on the infraspinatus muscle. The forceps is holding the suprascapular vein (1), artery (2) and nerve (3). 4 = suprascapular nerve running on the ventral surface of the infraspinate muscle. 5= perforating branches of the suprascapular nerve which run into the infraspinate muscle.*

tion of the more superficial branches of the occipital nerve gives good results. Further studies are needed to determine efficacy, safety, and clinical indications, and demonstrate long-term effects.

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