Clinical Perspective of Cryoanalgesia-Overview

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ABSTRACT

The technique of Cryoanalgesia can be used as local anaesthetic. Cryoanalgesia is a biotool being used by interventional radiology to treat chronic pain. Within a certain cold temperature range, the peripheral nerve function is interrupted and recovers, without neuroma formation. The technique of Cryoanalgesia has most often been applied to the intercostals nerve. The effect of cryoanalgesic and the neural conduction block is also discussed in this paper.

KEYWORDS: *interventional radiology, Cryoanalgesia, neuroma, peripheral nerve, conduction.*

INTRODUCTION

FEATURES OF CRYOANALGESIA

Available treatments for the postoperative pain relief are limited by varying efficacy and dose-limiting adverse effects, leaving a significant unmet need for the patients. Opioids continue to be the mainstay of the postoperative pain management despite their well-known side effects and risks of abuse, misuse, and the addiction. Known regional anesthetic techniques have been shown to is an effective part of the multimodal analgesia for many surgical procedures but are unfortunately limited by their short duration of actions. Additionally, continuous peripheral nerve blocks are limited by their infection risk, the catheter dislocation, and pump malfunction (Schuster,1982).

A promising alternative postoperative pain treatment option is the cryoanalgesia. Treatment with cryoanalgesia involves cooling specific nerves to reversibly inhibit the peripheral nerve

function, with the subsequent pain relief potentially lasting weeks to months. This typically involves the use of the needle or the cryoprobe at very low temperatures for contact cooling of a selected peripheral nerve (Evans et al.,1981). The Application temperatures vary but must achieve at least −20°C and must not exceed −100°C to be effective and safe. If a nerve is quiet successfully cooled to a temperature in this range, the duration of analgesia is specifically dependent primarily on the length of the lesion. As with the temperature, there is variation in the literature with regard to the preferred number and timing of the freeze-thaw cycles. Relative contraindications to cryoanalgesia include diabetes mellitus, the cold urticaria, the cryoglobulinemia, and Raynaud's disease (Lloyd et al.,1976).

There are distinct advantages with the use of the technique named cryoanalgesia compared to existing modalities, such as the administration of the loco-regional analgesia or peripheral nerve blocks. The most obvious benefit is the prolonged duration of analgesia mainly ranging from weeks to months, although the duration appears to be quiet variable depending on the length of the nerve distally from where the cryoanalgesia was specifically applied. Surprisingly, none of the included studies specifically assessed the durations of relief in their patients over time. Among the available opioid-sparing agents, loco-regional blocks perhaps have the greatest benefits, whenever appropriate. This is because they can be quiet selectively applied to a very precise particular area of the body with no systemic side effects and they also act superiorly on pain with the activity, which is functionally more important. However, they are all limited by their duration of effect. Presently, the strategies to mainly overcome this limitation require the use of either continuous nerve blocks or the use of the liposomal bupivacaine. However, both have inherent limitations, may not be available, and in the case of the continuous blocks-require resources and trained personnel (Brechner,1981).

The potential for the prolonged duration of action with cryoanalgesia may reduce readmissions and the emergency room visits, apart from decreasing the risk of systemic morbidity. Importantly, its opioid-sparing benefit can last after the discharge, minimizing the need for the opioid prescriptions post-discharge, which seems to be quiet contributing to the opioid crisis. Other advantages of the cryoanalgesia encompass its low cost, limited followup requirements, no risk of the local anesthetic toxicity, and no need to carry around an infusion pump as one does with the continuous peripheral nerve blocks (Bellini et al..,2015). However, drawbacks include the increased time required for the administration, unpredictable duration of action, unclear association between the application technique and duration of

blockade, and somewhat limited number of surgical procedures during which it can be mainly utilized.

Percutaneous cryoanalgesia for pain palliation

Percutaneous cryoablation paves a continuously expanding role in interventional radiology therapeutic armamentarium. As the Western society's battle against the established or the upcoming opioid epidemic crisis, interventional radiology techniques for pain reduction constitute the attractive therapeutic alternatives characterized by lack of drug usage. Percutaneous therapies availed for neurolysis include application of chemical agents, such as alcohol or phenol and the thermal techniques, such as radiofrequency, microwaves and cryoablation (Hurst et al.,2004) .

Cryoanalgesia is a term mainly describing application of extremely cold temperatures to peripheral nerves aiming to the pain palliation. Cryoanalgesia (otherwise termed cryoneurolysis) has initially been availed intra operatively under direct visualization of nerves after surgical exposure; the literature evidence of surgical approaches in terms of mainly retrospective and few prospective studies and research reported favorable results over other pain control methods. With the evolution of the imaging and interventional radiology, percutaneous cryoanalgesia can be applied to treat pain rakished to different neoplastic and non-neoplastic diseases without the need of guidance by the palpation landmarks or nerve stimulation, since imaging guidance can be effectively availed for this purpose . By using imaging guidance, even deep nervous system structures can be safely and much effectively reached by means of the percutaneous approaches whilst at the same time, the ablative effect upon target zones can be documented and also monitored (Bihur et al.,2001).History of pharmacology (Dr.S.Sreeremya,2024a)and biotechnology had contributed in major advancements(Dr. S.Sreeremya,2024b).There are several techniques to remdiate the disease (Dr.Sreeremya.S,2024c).

The purpose of this review is to make the reader or researcher more familiar with the most common imaging-guided the percutaneous cryoanalgesia indications, to learn about different technical considerations during performance garnering the current evidence. Controversies concerning products will be addressed (Sepsas et al.,2013).

Pathophysiology

In cryoanaglesia, a cryoprobe is availed to reversibly ablate and provide analgesia in peripheral nerves by the application of extremely cold temperatures. The specific cryoprobe comprises of a hollow tube with a smaller inner and a larger outer tube; gas in high pressure travels from the proximal inner tube to its specific distal part where it passes through a very narrow aperture into the much larger outer tube (which is at a low pressure state) where it rapidly expands within the distal tip (Khanbhai et al.,2014) (Fig-1).

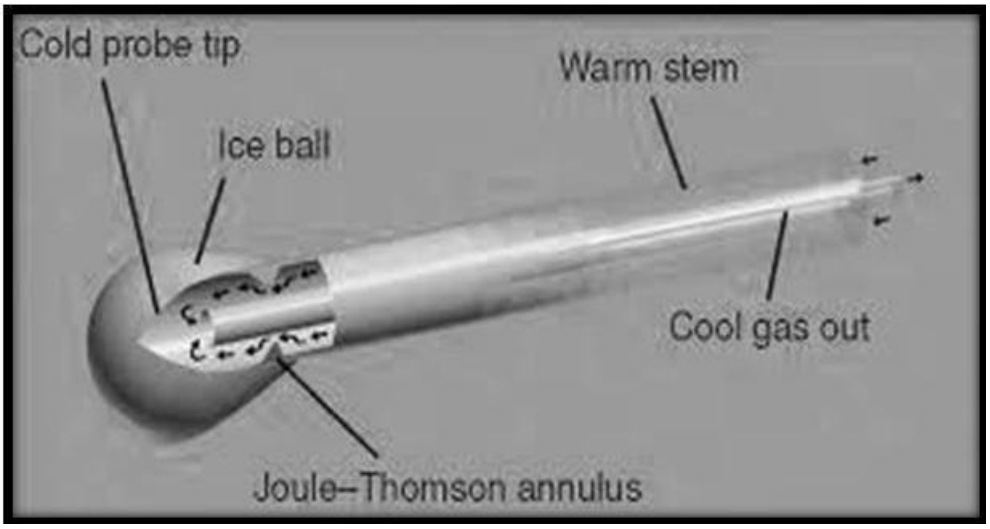

Figure: 1

This leads to the heat extraction from the tip of the probe due to Joule–Thomson effect resulting in drop of the temperature even below −170 °C (if using Argon gas) and formation of an ice ball at the tip of the cryoprobe. The cold gas is clearly vented back through the outer tube to a ventilated outlet so no gas inserts into the patient's tissues. Other gas or the liquid may be availed, such as nitrogen or CO_2 without using the Joule–Thomson effect (Humble et al.,2015).

PHYSICS AND EQUIPMENT

The cryoprobe comprises of a hollow tube with a smaller inner tube. Pressurized gas (usually N2O or CO2) at 600 to800 psi travels down the inner tube and is precisely released into the larger outer tube (which is specifically at a low pressure of 10-15 psi) through a very fine aperture (approx. 0.002mm) which al-lows the gas to rapidly expand into the distal tip . This extracts heat from the tip of the probe resulting in temperatures as cold as around –89 degrees C at the tip itself (The Joule-Thompson effect), forming an ice ball, with temperatures in the

in the range of –70 ℃(Schuster,1982). The gas is then vented back to the machine itself precisely through the outer tube, and is scavenged through a precise ventilated outlet (Trescot et al.,2002). The “closed system” construction of the probe and machine mainly assures that no gas escapes into the patient’s tissues (Calandria,2011). The 2.0 mm probe forms a5.5 mm ice ball while the 1.4 mm probe forms precisely a 3.5 mm ice ball. Precise gas flows are necessary for safe and effective cryo-neuroablation; the inadequate gas flows will not produce an ice ball while excessive flows can cause freezing proximally up the probe which may elevate the risk of skin burns. The probe also includes a nerve stimulator, with sensory and the motor capabilities, which allow precise localization of the target nerve(Kim et al.,1998).The application of cold to tissues creates a typical conduction block, similar tothe effect of local anesthetics. At 10 C”, the larger myelinated fibers stop conducting, but all nerve fibers stop conducting at around -20 C”. The extent and duration of the effect is therefore a function of the degree of the cold obtained and the length of time of exposure .The Long term pain relief from nerve freezing occurs because ice crystals create vascular damage to the vasa nervorum which synthesize severe en-doneuraledema. Endoneural fluid pres-sure aggrandizes about 20 mm within 90minutes of the cryolesioning. Changesin the elastic properties of the perineurium cause a much decrease in extracellular fluid pressure within 24 hours, which elevates again and then reaches a plateau about sixdays post lesion. This disrupts the nerve structure, and specifically creates Wallerian degeneration but leaves the myelin sheath and endoneurium intact. The Schwann cell basal lamina is spared and also ultimately provides the structure for regeneration. Al-though demyelination and degenerationof the axon occurs, when the endoneurium precisely remains intact, neuroma formation does not occur, and the nerveis typically able to regenerate at a rate of approx. 1 – 1.5 mm/week(Trescot,2003).

CONCLUSION

Cryoanalgesia has its applications to peripheral nerve surgery, yet is poorly understood by the reconstructive micro surgeons. This paper also highlights on cryporobe which works with the principle on Joule–Thomson effect.

REFERNCES

1. Trescot AM: Cryoanalgesia in interventional pain management. Pain Physician 2003; 6: 345−360.
2. Kim PS, Ferrante FM: Cryoanalgesia: a novel treatment for hip adductor spasticity

and obturator neuralgia. Anesthesiology 1998; 89: 534−536.

3. Calandria L: Cryoanalgesia for post herpetic neuralgia: a new treatment. Int J Dermatol 2011; 50: 746−50. doi: 10.1111/j.1365-4632.2010.04792.x.
4. Trescot AM, Noback CR. Cryoanalgesia in low back pain. In: Manchikanti L, Slipman C, Fellows B (eds). Low Back Pain, Diagnosis and Treatment. Paducah, KKY, 2002: 473−482.
5. Schuster GD: The use of cryoanalgesia in the painful facet syndrome. J Neurola Orthopaed Surg 1982: 4: 271−274.
6. Humble SR, Dalton AJ, Li L: A systematic review of therapeutic interventions to reduce acute and chronic post-surgical pain after amputation, thoracotomy or mastectomy. Eur J Pain 2015; 19: 451−465. doi: 10.1002/ejp.567.
7. Khanbhai M, Yap KH, Mohamed S, Dunning J: Is cryoanalgesia effective for post-thoracotomy pain? Interact Cardiovasc ThoracSurg 2014; 18: 202−209. doi: 10.1093/icvts/ivt468.
8. Sepsas E, Misthos P, Anagnostopulu M, Toparlaki O, Voyagis G, Kakris S: The role of intercostal cryoanalgesia in post-thoracotomy analgesia. Interact Cardiovasc Thorac Surg 2013; 16: 814−818. doi: 10.1093/icvts/ivs516.
9. Bihur PE, Silver W, Gallagher EJ: Reliability of the visual analog scale for measurement of acute pain. AcadEmerg Med 2001; 8: 1153−1157.
10. Hurst H, Bolton J: Assessing the clinical significance of change scores recorded on subjective outcome measures. J Manipulative Physiol Ther 2004; 27: 26−35.
11. Bellini M, Barbieri M: Cooled readio frequency system relieves chronic knee osteoarthritis pain: the first case series. Anaesthesiol Intensive Ther 2015; 47: 30−33.doi: 10.5603/AIT.2015.0003.
12. Brechner T: percutaneous cryogenic neurolysis of the articular nerve of Luschka. Regional Anesth 1981; 4: 271−274.
13. Lloyd JW, Barnard JDW, Glynn CJ: Cryoanalgesia, a new approach to pain relief. Lancet 1976; 2: 932−934.
14. Dr. S. Sreeremya, Journal of Pharmacology, Toxicology and Therapeutics, History of Pharmacology-Review ,Vol 6(2),pp-40-47.2024a.
15. Dr.S.Sreeremya, Journal of Research in Forensic Medicine and Biotechnology, History of Biotechnology – Overview,.2024b.Vol6(2):48-54.
16. Dr. Sreeremya. S, Book title- Dynamics of Diseases, 2024c, pp-224, paperback ISBN-978-93-6631-712-0, E-Book ISBN- 978-93-6631-712-0.

17. Evans PJ, Lloyd JW, Green CJ: Cryoanalgesia: the response to alternations in freeze cycle and temperature. Br J Anaesth 1981; 53: 1121−1126.
18. Schuster GD: The use of cryoanalgesia in the painful facet syndrome. J Neural Orthopaed Surg 1982; 4: 271−274