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Research Article

Effectiveness of fluoroscopy-guided lytic inhibition of splanchnic nerves with phenol at 2 levels versus 1 level in upper abdominal visceral pain

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Abstract

Objective: To determine the effectiveness of phenol-based lytic inhibition of the splanchnic nerves at two levels versus one level, guided by fluoroscopy, in patients with upper hemi-abdominal visceral cancer pain.

Materials and Methods: A retrospective, observational, descriptive, cross-sectional study was conducted on patients with upper hemi-abdominal visceral cancer pain treated at the Pain Clinic of the National Cancer Institute, Mexico. Statistical analysis was performed using SPSS V25.0.

Results: Pain reduction was evaluated in 85 patients who underwent INE (65 at one level and 20 at two levels). Most patients experienced a short-term reduction in pain intensity (2 hours and 1 week) assessed using the ENA scale, with a decrease of 1 to 3 points in one-level INE and 2 to 3 points in two-level INE. In the long term, some patients maintained analgesia, with an average reduction of 4 points at one month and 3 points at three months in both groups. Opioid consumption (MED) decreased post-procedure in both groups, with an average reduction of 11.02 mg/day in the one-level INE group and 24.7 mg/day in the two-level INE group. Additionally, patients reported high levels of satisfaction (Likert Scale 4/5 or 5/5).

Conclusions: The procedure is equally effective for patients undergoing one-level or two-level lytic INE. Pain control was greater in the group of patients treated with a two-level approach, as reflected in post-procedure MED, which showed a greater reduction in patients undergoing two-level INE. The satisfaction level was classified as satisfied or very satisfied, indicating that performing this procedure at either one or two levels is useful for controlling visceral cancer pain.

Keywords: Cancer pain, lytic inhibition, splanchnic nerves

INTRODUCTION

Cancer is the second leading cause of death worldwide[1]. In 2020, nearly 10 million deaths were attributed to this disease. In Mexico, the states with the highest mortality rates from malignant tumors are Mexico City, Colima, Veracruz, Sonora, Chihuahua, and Morelos[2]. Digestive organ cancer is the leading cause of hospital morbidity due to malignant tumors among men, while it ranks third among women, with gastric and colorectal cancer being the most common[3].

Pain is one of the most frequently reported symptoms in cancer patients, posing a serious and common problem that affects their quality of life and survival. It triggers severe health complications, impacts healthcare costs, increases caregiver fatigue, and reduces patient well-being. Pain caused by tumors in the upper hemiabdomen is intense, and without effective analgesic treatment, it significantly affects the course of the disease, potentially leading to treatment interruption and abandonment, ultimately affecting the patient's quality of life and survival.

Visceral Pain

Visceral pain arises from various body organs, including the heart, large vessels, perivascular structures, airway (pharynx, trachea, bronchi, lungs, pleura), gastrointestinal tract (esophagus, stomach, small intestine, colon, rectum), upper abdominal structures (liver, gallbladder, biliary tree, pancreas, spleen), urological structures (kidneys, ureters, bladder, urethra), reproductive organs (uterus, ovaries, vagina, testicles, vas deferens, prostate), omentum, and peri-omentum[3].

Characteristics of visceral pain include diffuse localization, referral to other body areas, poor localization, lack of clear association with pathology, and the presence of autonomic and motor reflexes[4]. These characteristics are explained by two theories of referred visceral pain distribution. The projection and convergence theory describes that second-order neurons receive visceral afferents from structures such as the skin and muscles, arranged in specific regions, and also receive converging afferents from various visceral organs. Another theory explains the presence of

bifurcated axons originating from a single neuron that innervates two different structures[5].

Managing this type of abdominal pain is a complex challenge, and providing an optimal therapeutic and analgesic approach results in improved patient quality of life. Interventional pain management has developed technological advances and safe techniques for multimodal analgesia. For abdominal pain management, different sites can be targeted to functionally interrupt the sympathetic nervous system via celiac axis blocks, which can inhibit two anatomical structures for the same purpose: the splanchnic nerves (SN) and the celiac plexus.

The selection of the technique depends on individual patient characteristics and the progression of their disease in the abdominal region. The choice between inhibiting the splanchnic nerves or the celiac plexus determines the success of the procedure.

The Sympathetic System and Its Role in Pain

The autonomic nervous system is a largely involuntary sensory and motor system. It has three divisions: sympathetic, parasympathetic, and enteric. The sympathetic and parasympathetic systems innervate cardiac muscle, smooth muscle, and glandular tissues, mediating various visceral reflexes. The enteric division consists of sensory and motor neurons of the digestive tract, mediating digestive reflexes.

Sympathetic pathways transmit thoracolumbar efferents to ganglia along the spinal cord. Preganglionic fibers synapse at prevertebral ganglia, including the celiac ganglion and the superior and inferior mesenteric ganglia. Neurons in these ganglia then innervate the digestive system.

Afferent nerve fibers that innervate the viscera project to the central nervous system through three pathways:

- The vagus nerve and its branches
- Sympathetic efferent fibers (sympathetic chain)
- The pelvic nerve and its branches[3].

The vagus nerve has central terminals in the brainstem and the solitary tract nucleus (NTS), innervating organs in the thoracic and abdominal cavities. Spinal visceral nerves innervate the same thoracic and abdominal organs, as well as the pelvic floor organs, forming pathways dependent on the splanchnic nerve (T10-L2) and the pelvic nerve (L5-S1) at the level of the dorsal root ganglion[6].

Various procedures can intervene in the sympathetic and/or parasympathetic system, with sympathetic chain inhibition being a viable interventional option. This inhibition has two actions:

1. Interrupting preganglionic and postganglionic sympathetic efferents, which influence primary afferent neurons
2. Interrupting visceral afferents from deep structures[7]

There are different levels of the sympathetic chain that can be targeted, each corresponding to specific anatomical structures:

1. Cervicothoracic ganglia (brain, meninges, eye, ear, tongue, pharynx, larynx, salivary glands, neck, upper limbs)[8].
2. Thoracic ganglia (esophagus, trachea, bronchi, pericardium, heart, pleura, lungs)[9].
3. Celiac axis: ganglionic level (celiac plexus) and splanchnic nerves (gastrointestinal tract up to the transverse colon, liver, adrenal glands, abdominal vessels)[9,10].
4. Lumbar ganglia (skin and vessels of lower limbs, kidneys, ureters, transverse colon, testicles)[9].
5. Superior hypogastric plexus (descending and sigmoid colon, rectum, vaginal fundus, bladder, prostate, seminal vesicles, uterus, ovaries)[11].
6. Ganglion impar or Walther's ganglion (perineum, distal rectum, anus, distal urethra, distal third of vagina, vulva)[12].

Splanchnic Nerves

The splanchnic nerves innervate all layers of the intestinal wall, including the serosa and mesentery. These nerves are primarily composed of unmyelinated C fibers but also contain a small number of thin myelinated A fibers. They are distributed in the spinal cord through laminae I, II, V, and X[15].

The abdominal splanchnic nerves originate from the caudal segment of the thoracic sympathetic trunk. Three abdominal splanchnic nerves are described: greater, lesser, and least.

The greater splanchnic nerve is formed by the union of several branches (three or four) originating from the thoracic ganglia T5-T9. It courses anteroinferiorly and medially over the anterolateral portions of the dorsal vertebral bodies, uniting into a single trunk at the level of T10 or T11. The right nerve runs near the azygos vein, while the left approaches the descending thoracic aorta and later the thoracic esophagus. After passing through the diaphragm, the greater splanchnic nerve descends along the lateral part of the main diaphragmatic pillar, covered by the parietal peritoneum. It gives off collateral branches to the adrenal gland and terminates at the lateral horn of the celiac ganglion. Along its thoracic course, near the diaphragm (between T10 and T11), it may present an intermediate ganglionic swelling, called the splanchnic ganglion, which is inconsistent.

The lesser splanchnic nerve is formed by the union of one or two branches from the tenth or eleventh thoracic ganglia. It runs inferiorly and laterally along the vertebral bodies, and after crossing the diaphragm, it divides into branches for the celiac ganglion, the superior mesenteric ganglion, and the renal plexus.

The least splanchnic nerve originates from the last thoracic ganglion. After passing through the diaphragm, it joins the renal plexus. The diaphragmatic points where

the splanchnic nerves and the sympathetic chain pass through are subject to numerous anatomical variations.

Some classical anatomical texts mention a fourth splanchnic nerve, called the accessory splanchnic nerve, which is highly inconsistent. When present, it originates from the last thoracic ganglion and joins the renal plexus[16].

Types of Celiac Plexus and Splanchnic Nerve Blocks

The blocks can be classified based on the approach and techniques used.

Based on Spatial Approach:

- Posterior: The most commonly used approach, performed under fluoroscopic or computed tomography (CT) guidance with the patient in the prone position.
- Anterior: Can be performed via endoscopy, percutaneous needle guided by ultrasound or CT, or intraoperatively via laparotomy, with the patient in a supine position.

Based on Percutaneous Approach:

The diaphragmatic crura anatomically determine whether the block targets the celiac plexus or the splanchnic nerves. If the needle tip remains posterior to the crura, the blocked nerves are the splanchnic nerves. If the needle tip is anterior to the crura, it is considered a celiac plexus block, positioned anterior to the abdominal aorta.

Percutaneous approaches can be further classified as follows:

- Transcrural approach: The most commonly used technique for celiac plexus block. The patient is positioned prone, and at the level of the L1 vertebral body, a needle is advanced on each side 7.5 cm lateral from the midline, passing through the diaphragmatic crura to reach the plexus.
- Retrocrural approach: The patient is positioned prone, and the T11 and T12 vertebral bodies are identified. Needles are advanced to the anterior third of these bodies to block the splanchnic nerves.
- Transaortic approach: A unilateral technique with the patient in the prone position. The needle is inserted from the left side of the L1 vertebral body, passing through the aorta, with the tip positioned anterior to the aorta.
- Transdiscal approach: Performed under CT guidance, traversing the T12-L1 intervertebral disc to reach the splanchnic nerves.
- Abdominal approach: Typically performed under ultrasound guidance via an anterior approach[17].

These blocks can be performed using three different methods: physical, surgical, and chemical.

1. Physical: Cold (cryoanalgesia) and heat (radiofrequency).
2. Surgical: Percutaneous or open surgery.
3. Chemical: Neurolytic agents (alcohol and phenol) [18].

Splanchnic Nerve Inhibition (SNI)

Splanchnic nerve approaches can be guided by fluoroscopy or CT, with two main techniques:

1. Classic posterior approach
2. Transdiscal approach guided by CT

The transdiscal approach, proposed by Plancarte et al. in 2003, is performed under CT guidance with the patient in prone position. A needle is inserted through the intervertebral disc, ideally from the left side, at the T10-T11 or T9-T10 space, reaching the retrocrural space using a loss of resistance technique. A retromediastinoplasty is then performed with 8-10 ml of air and non-ionic contrast medium to assess its distribution, achieving a double-contrast effect. Subsequently, 10-12 ml of 10% aqueous phenol is administered.

This technique produces bilateral inhibition of the splanchnic nerves, targeting retroaortic celiac fibers. The diaphragmatic pillar often prevents the caudal distribution of the solution toward the celiac plexus, while the air injected into the retro mediastinum forces neurolysis of the splanchnic nerves[21].

Fluoroscopy-guided lytic inhibition of the splanchnic nerves using the classic technique has also shown good results. It has been described for performing neurolysis of the celiac plexus and splanchnic nerves (posterior approach only) with the patient in the prone position.

After obtaining an anteroposterior (AP) view, the T11 or T10 level is identified, as well as T12, aligning the inferior endplate of T11 and identifying diaphragmatic movement during inspiration and expiration.

The procedure begins with needle entry at all levels just lateral to the vertebral body and caudal to the rib. The needle is advanced coaxially until it contacts the vertebral body. A lateral view is then taken to confirm the needle depth. The needle is gently slid along the anterior vertebral body and medially until it reaches the junction of the anterior third and posterior two-thirds of the lateral vertebral surface.

Returning to the AP view, the needle tip position is confirmed. For chemical neurolysis, an aspiration test is first performed, which must be negative (no blood or cerebrospinal fluid). Next, 1-3 ml of a non-ionic contrast medium is injected. The optimal contrast dispersion is confirmed in AP and lateral projections, ensuring the contrast medium "hugs" the lateral vertebral body. Finally, 4–8 ml of 6–10% phenol (painless) or 80% alcohol is injected following local anesthesia[22].

Neurolytic Interventional Procedures

Neurolysis is a percutaneous procedure that involves destruction of the plexus through the injection of neurolytic agents at various concentrations within the plexus network, providing prolonged analgesia (23). It causes protein denaturation in nerve fiber membranes and permanent nerve destruction, as well as disruption of neural pathways[13].

The most commonly used neurolytic agents are alcohol, phenol, glycerol, and ammonium compounds. However, phenol and alcohol are the most frequently used in clinical practice due to their availability (18).

Alcohol

Ethanol is a colorless, hypobaric solution relative to plasma, with low water solubility, and remains stable at room temperature[17].

Mechanism of Action:

- Precipitates cell membrane proteins
- Extracts lipids, causing non-selective neural tissue destruction via demyelination and degeneration
- Disrupts the basal membrane, epineurium, endoneurium, and perineurium
- Induces Schwann cell proliferation and axon regeneration[18].

Duration & Effects:

- The theoretical duration of neurolysis is 3-4 months
- The extent of neural damage depends on alcohol concentration
- 6–10% concentration: Sympathetic inhibition
- Below 2%: Anesthetic effect
- 40%: Lesions
- 50–70%: Sympatholytic effect[17]
- Administration volumes: 20 to 50 ml

Phenol

Phenol is a hyperbaric solution relative to plasma and has high vascular endothelial affinity, posing a high risk of systemic absorption at high doses.

Mechanism of Action:

- Coagulates proteins, causing demyelination and degeneration at concentrations above 5%
- At concentrations below 5%, it only denatures proteins
- Administration volumes: 8 to 15 ml[18].

Advantages of Phenol:

- Higher viscosity, preventing spread to adjacent areas
- Greater concentration at the target site
- Painless injection
- Theoretical neurolysis duration: 2-3 months[18].

Although the distribution pattern of neurolytic solutions has been described, phenol's spread depends on air and liquid distribution. It is presumed that if the neurolytic agent is injected within the ganglion, it may diffuse beyond the target area, potentially destroying non-visible ganglia[24].

Considerations for Neurolytic Blocks

Before performing a neurolytic block, several factors must be considered:

1. Volumetric capacity & anatomical site distribution (in relation to adjacent structures)
2. Diffusion capacity of the neurolytic agent
3. Histological changes in nerves and adjacent structures[25].

In the splanchnic nerve region, chemical neurolysis may extend to other relay structures due to the agent's distribution and diffusibility[26].

Complications of Percutaneous Neurolysis

The most common complications include:

- Diarrhea
- Hypotension
- Constipation
- Nausea and vomiting
- Lethargy

Less common complications:

- Weakness & paresthesia
- Pneumothorax
- Hematuria

Rare complications:

- Paraplegia, secondary to:
  - Needle trauma
  - Vasospasm induced by alcohol injection into the Adamkiewicz artery, leading to ischemic spinal cord injury via the anterior spinal artery[27].

MATERIALS AND METHODS

A retrospective, observational, descriptive, cross-sectional study was conducted in patients with visceral oncologic pain in the upper hemiabdomen, treated at the Pain Clinic of the National Cancer Institute in Mexico.

Methodology

The sample size was calculated based on the number of patients treated for visceral pain in the upper hemiabdomen from March 1, 2019, to January 1, 2025, with a total population of 733 patients.

Among these, 85 patients underwent lytic inhibition of the splanchnic nerves using phenol via the transcrural technique described by Plancarte et al. The procedure was performed under sedation and imaging guidance.

Patients were selected based on inclusion and exclusion criteria, and after informed consent, they were randomized (odd/even numbers) and divided into two study groups:

- Arm 1: Single-level percutaneous transdiscal approach (T9/T10 or T10/T11)

- Arm 2: Two-level percutaneous transdiscal approach (T9/T10 and T10/T11)

Variables & Measurements

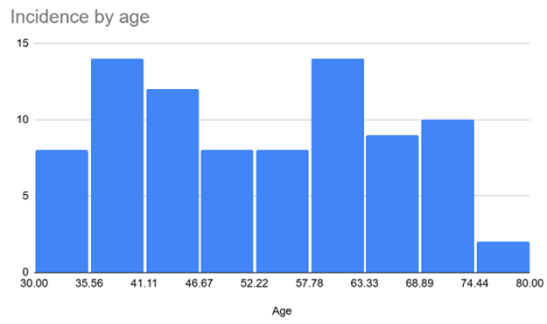
- Pain intensity: Measured using the Numerical Pain Scale (NPS) before and after the procedure (recovery room, 2 hours, 24 hours, 1 week, 1 month, and 3 months).
- Patient satisfaction: Measured using the Likert Scale at day 7 follow-up.
- Opioid consumption: Measured in oral morphine equivalents (mg/day) before and after the procedure (2 hours, day 7, 1 month, and 3 months).

Statistical Analysis

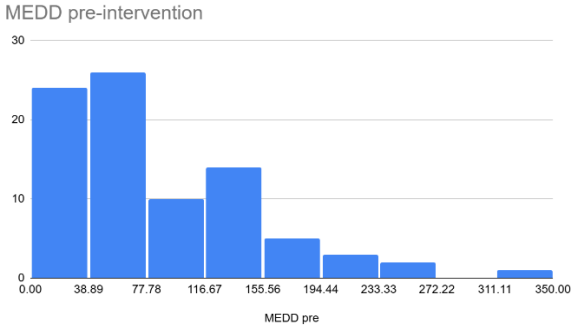
- Frequencies and percentages were used for quantitative variables (central tendency and dispersion).
- Inferential analysis: Student's t-test for paired samples ($p < 0.05$ was considered statistically significant).

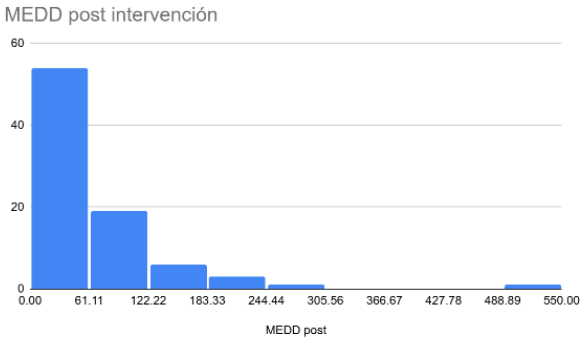
RESULTS

- Fluoroscopy-guided technique was the most frequently used, followed by CT guidance.
- Demographics: Predominantly female (63.5%) with gynecological cancers (cervical, ovarian). Education level: Many patients had primary education or lower, which may impact treatment comprehension & post-procedure care. In 88.1% of procedures were performed in patients aged 40-70 years.



- Pain & Opioid Reduction: Opioid consumption significantly decreased post-procedure in both groups. In 96.6% of patients had a short-term pain reduction (2 hours, 1 week). 75.35% sustained improvement at 1 month, and 88.1% at 3 months.





Opioid consumption, measured as the daily morphine equivalent dose (MEDD) in milligrams per day, decreased after splanchnic nerve inhibition in the total study population. Regarding the two study groups, the comparative analysis showed the following:

Group 1 (Single-Level Approach):

Pre-Procedure MEDD: Dose ranges were between 11 to 315 mg/day, with an average of 74.02 mg/day.

Post-Procedure MEDD: There was a reduction in doses ranging from 1 to 150 mg/day, representing an 11.02% decrease compared to pre-procedure levels.

In three patients, opioid consumption showed a marked reduction, from 180 to 30 mg/day, 126 to 60 mg/day, and 124 to 23 mg/day.

Group 2 (Two-Level Approach):

Pre-Procedure MEDD: Doses ranged between 30 to 246 mg/day, with an average of 103 mg/day.

Post-Procedure MEDD: The average reduction in opioid consumption was 24.7%, with decreases ranging between 10 to 82 mg/day.

Comparative Analysis: Patients in Group 1 had a higher initial minimum MEDD than those in Group 2. Overall, a greater dose reduction was observed in Group 1. Additionally, two patients in Group 1 had significant dose reductions, from 160 to 100 mg/day and 50 to 23 mg/day.

- Satisfaction & Adverse Events: Patient satisfaction, measured using the Likert Scale, showed that 54.4% of patients reported being satisfied or very satisfied (4/5 or 5/5). No serious adverse events were reported in any of the patients included in this study.

DISCUSSION:

Splanchnic nerve inhibition guided by fluoroscopy or tomography showed improvement in pain control for both the group of patients undergoing a single-level approach and those who underwent a two-level approach. These results are similar to those reported in the global literature, such as the publication by Parkinson SK in 1989, as well as by Plancarte et al. in 2003, where the outcomes of splanchnic nerve inhibition for oncologic visceral pain control in the upper hemiabdomen were described.

Regarding the reduction in opioid consumption evaluated through MEDD, the procedure's effectiveness

was evident for both patients who underwent splanchnic nerve inhibition at a single level and those who received the two-level approach. However, we observed that in Group 2 (two-level INE), this reduction was greater, suggesting that addressing the sympathetic chain at two distinct points along its course may enhance the effectiveness of this procedure. Although the effect was not sustained over time (>3 months) in a significant portion of our sample, we still consider this technique to be useful.

The duration of the therapeutic effect was shorter compared to other studies published in classical literature. This could be attributed to the progression of oncological disease at the intra-abdominal level, which may lead to increased compression of visceral structures, thereby intensifying pain in this patient group.

Finally, no severe adverse events were reported in our study, which is consistent with the findings published by Kambadakone A et al. This could be attributed to the strict protocolization applied in the selection of patients and the execution of the procedure by qualified personnel.

CONCLUSIONS:

Splanchnic nerve neurolytic inhibition guided by fluoroscopy or tomography proves effective for controlling visceral pain of oncologic origin, whether using a single-level or two-level approach. It generates a high level of patient satisfaction and demonstrates a good safety profile when performed by experienced hands.

It is important to highlight that existing literature comparing a single-level versus a two-level approach is limited. Therefore, we consider this study to be significant in guiding therapeutic decisions regarding whether to perform the procedure at one or two levels.

We believe that a prospective, randomized trial with long-term follow-up is necessary to confirm the findings obtained in this study.

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Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

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