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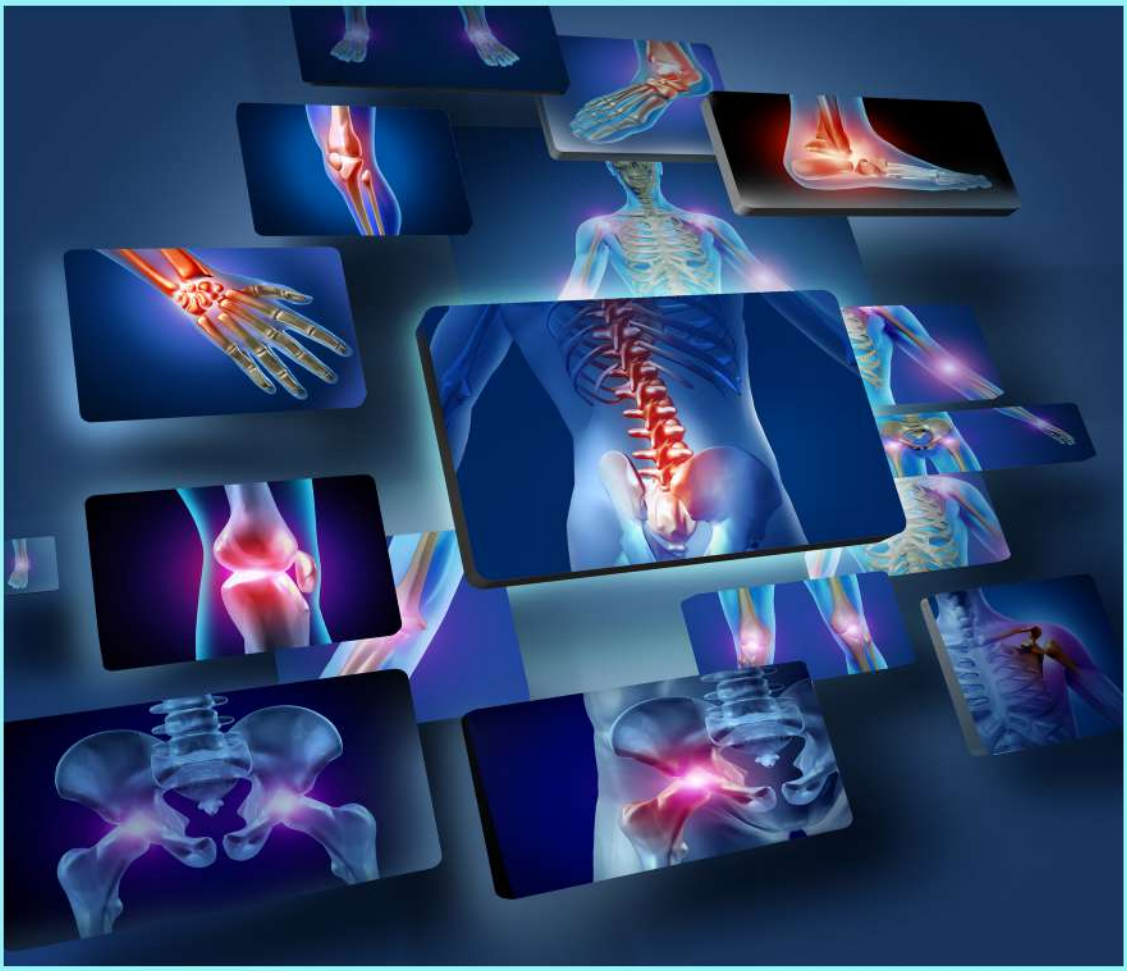

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Systematic Review

The Role of Intravenous Lidocaine in Preventing Chronic Post-Operative Pain

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ABSTRACT

Background and Goal of Study

Chronic post-operative pain (CPOP) is an increasing public health issue considering its impact on the patients quality of life and and the associated costs for the healthcare system. The incidence of CPOP can be as high as 75%, depending on the surgical procedure and other factors. Lidocaine is a local anesthetic with anti-inflammatory, analgesic and antihyperalgesic properties. Several studies have shown its use in controlling acute post-operative pain when used intravenously. The goal of this study was to define the role of intravenous lidocaine in preventing CPOP.

Materials and Methods

The PubMed database was searched from 2006 and 2019 with the keywords: "*Chronic post-operative pain*" or "*Chronic post-surgical pain*" or "*Chronic pain*" and "*Intravenous lidocaine*". Adequate papers for the purpose of this study were selected.

Results and Discussion

Three randomized controlled trials that met criteria were obtained: two on breast surgery and the other on open nephrectomy. All trials used intravenous lidocaine during surgery, suspending the infusion up to the first 24-hours of the post-operative period. All three of them showed a significant decrease on the incidence of CPOP. There was a 20-fold decrease six months after breast surgery.

Conclusion

Intravenous lidocaine seems to decrease the incidence of CPOP however, there is limited evidence. More trials are necessary to define the efficacy and safety of intravenous lidocaine. A generally accepted definition of CPOP is needed.

Keywords

Chronic pain; Chronic post-operative pain; Chronic post-surgical pain; Intravenous lidocaine.

INTRODUCTION

There is no standardized definition of chronic post-operative pain (CPOP) but it is usually described as persistent pain 2 or more months after a surgical procedure, not explainable by any other cause.[1]

The incidence of CPOP can be as high as 75%, depending on the surgical procedure and other factors, which makes it an increasing public health issue considering its impact on patients quality of life and its associated costs for the healthcare system.[2-5] CPOP is a dysfunction of the nociceptive system and the mechanisms that lead to its development are multifactorial and often poorly understood. The wind-up phenomenon seems to be fundamental to the development of central sensitization and chronic pain. Stimulation of C fibers leads to the synaptic release of glutamate that activates α-amino-3-hydroxyl-5-methyl-4-isoxazole-propionate (AMPA) receptors, allowing sodium to leak in the cell and thus propagating the action potential. The intense stimulation of C fibers, for instance after surgery, will result in greater post-synaptic depolarization, which can remove the magnesium ion that normally blocks N-methyl-d-aspartate (NMDA) receptors. Then these also can be activated by glutamate, allowing calcium ions to enter the post-synaptic neuron, increasing the likelihood for this cell to reach threshold for firing an action. This increased status of susceptibility for neuron membrane depolarization is called central sensitization.[2,6,7]

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Several risk factors for the development of CPOP are known. These can be divided into two groups of factors: the ones related to the patient, such as young age, female gender or catastrophization of pain; and those associated with surgery (higher invasive techniques with higher pain scores expected or longer surgery duration). Among the most important risk factors for the development of CPOP is acute post-operative pain. Both thehigher the intensity of pain and the longer the post-operative pain remains uncontrolled, the more predictive is chronification of pain. Therefore, the better the analgesic control in the immediate post-operative period, the lower the incidence of CPOP.[2]

The principal mechanism of action of lidocaine [2-(diethyllamino)-N-(2,6 dimethylphenyl) acetamide] as a local anaesthetic is through blockade of voltage-gated sodium channels, inhibiting the propagation of the action potential. This way, lidocaine prevents the conduction of the stimulus by C and Aδ fibers after tissue damage.[8-10] Several other actions has been associated with this drug, such as the blockade of the NMDA receptors (through inhibition of protein kinase C) and the inhibition of the release of anti-inflammatory cytokines such as thromboxane A2 and neurocinines. This intrinsic multimodal set of action (analgesic, anti-inflammatory and antihyperalgesic properties) aroused interest for its use intravenously in the peri-operative period, mainly focusing on acute post-operative pain.[8,11]

The use of systemic lidocaine have been historically limited by safety concerns. This drug is known to cause central nervous system (CNS) and cardiovascular side effects. This usually occur in a predictive manner developing from mild symptoms as circumoral numbness, tongue paresthesia, dizziness, blurred vision and may progress to agitation, muscle twitches, seizures and even CNS depression (unconsciousness and coma). Major cardiovascular toxicity, expressed as severe hypotension and bradycardia or even as life-threatening arrhythmias (ventricular tachycardia and fibrillation) usually presents later, as it needs higher plasmatic lidocaine concentrations to develop. The peri-operative period raises these concerns as the concomitant techniques used for anesthesia may blunt early clinical signs of lidocaine toxicity.

However, several studies shows that therapeutic plasmatic concentrations of intravenous lidocaine seem to be between 1-5 μg/L. Only minor side-effects such as vertigo, somnolence and perioral paresthesia can develop in these plasmatic concentrations. Classic protocols used for intravenous lidocaine in the peri-operative setting are 1.5 to 3 mg/kg bolus followed by 1.5 to 3 mg/kg/h infusion, which had been shown to reach safe therapeutic plasmatic concentrations. Higher concentrations are needed to occur CNS or cardiovascular toxicity.[9,10]

The utility of intravenous lidocaine in reducing the acute pain and opioid consumption in the early post-operative period is well-documented, mainly in abdominal and thoracic surgery. The efficacy of this drug on more painful surgical procedures may be due to its increased affinity for sodium channels when they are opened rather than deactivated (the so called use-dependent or frequency-dependent blockade).[9-11]

Its multimodal properties aligned with its efficacy on more painful surgeries with higher risk of chronic pain, makes intravenous lidocaine a promising technique for preventing CPOP. Hence, the goal of this study is to review recent literature regarding the use of peri-operative intravenous lidocaine in preventing CPOP.

MATERIALS AND METHODS

A literature search was conducted on the main biomedical database, the PubMed database, with the keywords: "*Chronic post-operative pain*" or "*Chronic post-surgical pain*" or "*Chronic pain*" and "*Intravenous lidocaine*". No methodological filters were added to retrieve articles by study type. The search was also limited to English and Portuguese language documents published between January 1, 2006 and December 31, 2019.

In the first-level of screening, titles and abstracts were reviewed and potentially relevant articles were retrieved and assessed for inclusion. Articles were excluded if they assessed the effect of topical lidocaine, lidocaine injections (including nerve blocks, Bier blocks) and oral lidocaine. Articles were also excluded if they evaluated exclusively acute pain, chronic pain not related to surgery or chronic pain treatment.

RESULTS

A total of forty-two citations were obtained in the literature search. Following screening of titles and abstracts, only nine potentially relevant reports were retrieved for full-text review. Of these potentially relevant articles, three publications were included in this report. All were randomized, double-blind, placebo-controlled clinical trials. Table 1 shows and compares those trials regarding sample, type of surgery, intravenous lidocaine protocol used and results in acute and post-operative pain obtained.

DISCUSSION

There are many literature concerning the use of intravenous lidocaine in acute post-operative pain, however, only three randomized controlled trials, enrolling a total of 158 patients, were found that tried to evaluate the effectiveness of lidocaine in the prevention of CPOP. Two of these trials were on breast surgery and the other one on open nephrectomy. All trials used intravenous lidocaine during surgery, suspending the infusion up to the first 24-hours in the post-operative period.

Our research, as shown in the table, demonstrates that the use of peri-operative intravenous lidocaine a reduces the incidence of CPOP. All three studies found a significant decrease on the incidence of CPOP, besides using different dosage and times of infusion.

Every author accessed CPOP differently which limits the comparison between protocols. A broadly accepted definition of this condition is needed.

Table 1. *Comparison of Trials*

Authors	Surgery	Sample (Lidocaine *vs* Control)	Doses	Duration of Lidocaine Infusion	Post-operative Analgesic Regimen	Acute post-operative pain	CPOP
Grigoras et al[12]	Breast surgery	36 (17 *vs* 19)	Bolus: 1,5 mg/Kg Infusion: 1,5 mg/ Kg/h	Up to 1-h after the end of the surgery	- Morphine sulphate by patient PCA, 1 mg maximally every 5-minutes; no basal infusion; -Diclofenac sodium 50 mg PO/PR, 12 hourly PRN; -Paracetamol 1 g PO/PR, 6 hourly PRN; - Tramadol 100 mg IM/POPRN as rescue medication.	No difference between groups	Assessed 3-months after surgery. CPOP defined as pain related to surgery in the last week Incidence: 5-fold decrease
Terkawi et al[13]	Mastectomy	61 (34 *vs* 27)	Bolus: 1,5 mg/Kg Infusion: 2 mg /Kg/h	Up to 2-h after the end of surgery	Not Standardized	Less pain and analgesic drugs consumption in the lidocaine group	Assessed 6-months after surgery. Incidence: 20-fold decrease
Jendoubi et al[14]	Open Nephrectomy	61:-21 Lidocaine group -20 Ketamine group (Bolus: 0.15mg/Kg/ Infusion: 0.1mg/kg/h) -20 Control group	Bolus: 1.5 mg/Kg Infusion: 1 mg/Kg/h	Up to 24-h after the end of surgery	- Morphine sulphate by PCA, 1 mg maximally every 7-min; no basal infusion. -Paracetamol 1 g, 6 hourly PRN -Nefopam 20 mg IV, 8 hourly PRN.	40% reduction in post-operative acute pain in the lidocaine group	Assessed 3-months after surgery using "neuropathic pain questionnaire" Less incidence of CPOP in the lidocaine group

Both breast surgery and open nephretomy are reported to have a high prevalence of CPOP, 20 to 68% and 4 to 27% respectively.[12-14] There are many other surgical techniques associated with CPOP of which no trial were found. In the studies found, systemic lidocaine was better to reduce incidence of CPOP on breast surgery (up to 20-fold less) rather than on open abdominal surgery. The characteristical dose-dependent or frequency-dependent blockade of lidocaine action may explain this difference.

Interestingly, Grigoras et al[12] found that even when lidocaine fails in reducing acute post-operative pain against placebo, it still considerably decreased the incidence of CPOP. This accounts for the importance anti-hyperlagic properties and NMDA receptor blockade as the lidocaine mechanism in preventing CPOP, and not only by controlling acute pain.

Jendoubi et al[14] has a differently designed study in which it compares lidocaine against placebo and also ketamine (a specific NMDA antagonist drug). In this small sampled trial, lidocaine was superior than ketamine in preventing CPOP after open nephretomy.

Concerning safety, Grigoras et al[12] accessed lidocaine plasmatic concentration at the end of the 1-hour infusion their protocol regarded and it still was on therapeutic range and therefore on safe limit. No side effects or safety concerns were documented in any trial.

Optimal protocol and the usefulness of intravenous lidocaine in other high CPOP incidence surgical procedures such as amputation and thoracic surgery remains to be studied.

CONCLUSION

Lidocaine is a local anesthetic with analgesic, anti-inflammatory and anti-hyperalgesic properties.

Intravenous lidocaine during surgery and up to 24-hours in the post-operative period seems to decrease the incidence of CPOP, even when it fails to reduce the acute post-operative pain.

More trials are necessary to define the efficacy and safety of intravenous lidocaine as well as the optimum dose and duration of infusion.

A generally accepted definition of CPOP is needed.

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Short Communication

Converting Bi-Level Positive Airway Pressure Machines into Ventilators for Hospitalized Coronavirus Disease-2019 Patients: Emergency Use Protocol

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During March 2020 New York State was facing a shortage of tens of thousands of ventilators. City and state officials were rapidly trying to source more of the machines, which were required in the sickest patients who were critically-ill with coronavirus disease-2019 (COVID-19). In the community hospitals, there were 792,417 beds, with 3532 emergency departments (EDs) and 96,500 intensive care unit (ICU) beds, of which 23,000 were neonatal and 5100 pediatric, leaving just under 68,400 ICU beds of all types for the adult population.[1] Other estimates of ICU bed capacity, which try to account for purported undercounting in the American Hospital Association (AHA) data, show a total of 85,000 adult ICU beds of all types.[2] During this time experts warned that the supply of mechanical ventilators could fall far short of the expected demand. At a webinar convened by the AHA, one researcher projected that 960,000 Americans might need a mechanical ventilator before the pandemic is over. There are approximately 62,000 full-featured ventilators (the type needed to adequately treat the most severe complications of COVID-19) available in the United States.[3] Approximately 10,000 to 20,000 more are estimated to be on call in our Strategic National Stockpile[4] and 98,000 ventilators that are not full-featured but can provide basic function in an emergency during crisis standards of care also exist.[3] At the time, many of those were already in use, or were older, more basic models that hospitals have on hand. Across New York during that time, more than 10,000 people were hospitalized with COVID-19, with more than 2,700 people in intensive care units. During that time several avenues of innovation were being pursued, all of which in our opinion were impractical. The two leading focuses at that time were splitting the use of a single ventilator for two or more patients[5] and the second was using anesthesia machines, which were a virtual unknown to most critical care practitioners, as alternatives to invasive mechanical ventilators.[6,7] These measures were being developed and sometimes used in the setting of a crisis and public health disaster where the two choices were either, no ventilator and the patient dies, or use of alternative methods to mechanically ventilate the patient. It is in this setting of crisis and emergency that our team pursued a third, more practical innovation that our health system implemented.

Bi-level positive airway pressure (BiPAP™) is one type of non-invasive, positive airway pressure (PAP) machine that is commonly used to maintain a consistent breathing pattern at night or during symptom flare-ups in individuals with sleep apnea, congestive heart failure or chronic obstructive pulmonary disease (COPD), a chronic inflammatory lung disease. These devices at the time were not being used, they were basically collecting dust in the hospital since at the time our colleagues in Italy and China were reporting that not only were patients not responding to BiPAP™ machines using the usual face mask, that sleep apnea patients use, but they had preliminary concerns that the virus was being aerosolized and infecting healthcare workers. These two concerns, at the time led to the avoidance of using BiPAP™ *via* the facemask interface in this patient population.

In preparation for the continued patient surge and shortage of critical mechanical ventilators for hospitalized COVID-19 patients in March-April 2020, our team successfully designed a protocol to adapt the more common BiPAP™ machine into a functional invasive pressure control mechanical ventilator through a three dimensional (3D) printed adaptor that we designed

to aid in the conversion. This BiPAP™ device is well-known and commonly used by critical care providers and hence it was a clear, practical innovation to implement.

BiPAP™ is one type of non-invasive, PAP machine that is commonly used to maintain a consistent breathing pattern at night or during symptom flare-ups in individuals with sleep apnea, congestive heart failure or COPD, a chronic inflammatory lung disease.

The key component to converting the BiPAP™ machine is a small, plastic T-piece adapter which was designed in a matter of days in collaboration with Northwell Health's 3D design and Innovation Department who had the capacity to 3D print 150 of these adaptors in 24-hours if needed.

Conversion of the BiPAP™ machine using the standard, non-3D printed, and 3D printed adaptor was tested on both COVID-19 and non-COVID-19 patients during our first surge of COVID-19 in March-April 2020. In addition to the T-piece adaptor, modifications to the BiPAP™ machine include the addition of two high-efficiency particulate air (HEPA) filters at both ends of the oxygen hose to alleviate fears of spreading the virus. A blind reservoir connected to the last HEPA filter in the circuit is also recommended (Figure 1).

During the initial COVID-19 patient surge which occurred from March to May 2020, approximately 28 patients a day were being ventilated in this manner across our health system. At the peak of the pandemic which occurred in mid-April 2020, up to 99 patients a day across our health system were being ventilated using our modified BiPAP™ machine method. To put this number in better perspective, during the height of the pandemic, mid-April 2020, approximately 10% of all invasively mechanical ventilated patients across our health system, with and without COVID-19 induced lung disease were supported using this emergency use method we are reporting in this communication.

In conclusion, this emergency use of converting BiPAP™ machines into invasive pressure control ventilators for intubated hospitalized COVID-19 patients proved to be reliable and help alleviate sporadic short-term ventilator shortages, all while using in house 3D printing technology which avoided any product-supply chain issues with the endotracheal tube adaptor required to utilize this method.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

Figure 1. *Add 2 HEPA Filters, One Immediately Connected to the V60 Main Gas Port Outlet and the Second HEPA Gets Connected to the Exhalation Valve Port Closer to the ET/Trach.To Connect to an ETT Tube You Need to Use the Philips Respironics Conventional Exhalation Valve and/or Circuit Kit.We Recommend that the HEPA Filter on the Exhalation Valve Port be Connected to a Blind Reservoir.Turn on Machine and Hit the Menu Tab. Please Ensure the Patient is not Connected to the V60 Machine*

- *Under the menu tab select the option for Mask/port*
- *Select→ET/trach option (extreme left)*
- *Hit Accept*

Then chose type of exhalation port

- *Select→Other*
- *Hit accept*

Select mode- Batch PCV Place patient on the appropriate pressure settings parameters prior to activating mode as follows;The EPAP will be the same as the PEEP; For IPAP use the plateau pressure measured on the conventional ventilator as a baseline;The FiO_2 would be the same;The ramp should be turned off;The rise time can be adjusted based on patient's demand.We recommend a rise time of 3; Now activate the batch change by hitting select (Active Batch Change).

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Case Report

Bipedicular Basi-Vertebral Nerve Ablation: A Case Report

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ABSTRACT

Introduction
Intraosseous ablation of the basivertebral nerve (BVNA) is an emerging minimally invasive treatment to relieve chronic mechanical axial low back pain associated with Modic type 1 or type 2 vertebral end-plate changes. Randomized controlled trials demonstrate improvements in pain and function sustained for up to five-years.

Methods
A 40-year-old woman presented with an eight-year history of central low back with mechanical features. There was minimal response to active physical reconditioning techniques, breast reduction surgery and chronic opioid prescription. Imaging disclosed modic type 1 vertebral end-plate changes at the L5/S1 segment. Following a positive short-term response to bilateral L5/S1 facet joint injections, the L5/S1 facets were treated with radiofrequency ablation of the L4 medial branch and L5 dorsal ramus bilaterally but with minimal benefit. BVNA at L5 and S1 was provided using a bi-pedicular bipolar radiofrequency approach (description attached).

Result
Six-week outcomes data disclosed decreased pain intensity from 8/10 to 3/10 and improved function with a decrease of 22 points on the oswestry disability index (ODI). Measures of depression, anxiety and stress, and quality of life improved significantly. Opioid usage decreased with a weaning plan. Magnetic resonance imaging (MRI) findings demonstrated new sclerosis with surrounding bone marrow oedema of the right and left sides of the L5 and S1 vertebral bodies consistent with the BVNA treatment.

Discussion
This case reports technically successful BVNA using a bipedicular approach. The early result is consistent with the published literature using the uni-pedicular approach. Follow-up plans are in place. A case series will follow.

In Brief
A bi-pedicular bipolar radiofrequency technique for basivertebral nerve ablation to treat vertebrogenic chronic low back pain is described, including early clinical outcomes and MRI findings.

Keywords
Bipedicular; Radiofrequency; Basivertebral nerve; Vertebrogenic; Modic end-plate changes.

INTRODUCTION

Intraosseous ablation of the basivertebral nerve (BVNA) is an emerging minimally invasive treatment to relieve chronic mechanical axial low back pain associated with Modic type 1, or Modic type 2, vertebral end-plate changes.[1-3] The BVNA procedure is supported by a multi-center, prospective, randomized, double-blind sham-controlled trial with results now published out to 5 years[4-6] and by a multi-centre randomized trial.[7]

The results reported include statistically significant decreases in pain, measured with the numerical rating scale (NRS) or the visual analog scale (VAS), and improvements in function, measured with the oswestry disability index (ODI).

Historically, obtaining sustainable and effective treatment outcomes for patients with chronic mechanical axial low back pain associated with Modic type 1 or type 2 vertebral end-plate changes has been challenging.

The inclusion criteria used in the published trials included chronic low back pain of more than six months duration, an inadequate response to six months or more of conservative care, and Modic type 1 or type 2 vertebral end-plate changes at one or more segments from L3 to S1. Additional inclusion criteria included the presence of dysfunction, as measured by an ODI greater than 30, and intrusive pain, as measured by an NRS greater than 4.[4-7]

Wright et al[8] devised and described a novel bi-pedicular technique after appropriate benchwork to demonstrate the potential effectiveness, safety and patient outcomes following bipolar radiofrequency ablation (RFA) of the basivertebral nerve (BVN) by positioning transpedicular radiofrequency electrodes to bracket the intravertebral target tissue.[9] The reported case continues to experience relief of symptoms more than seven years later (personal communication, Dr Wright).

This case report describes the application of a bi-pedicular bipolar radiofrequency technique for BVNA, including the early outcomes and MRI findings.

CASE REPORT

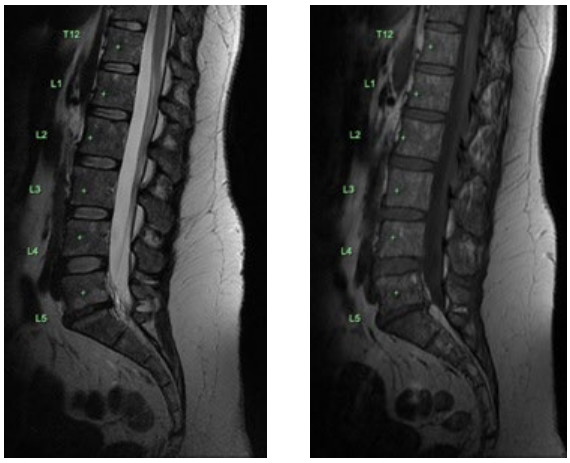
A 40-year-old woman presented with eight years of central low back pain, with mechanical features, occasionally radiating to the buttocks and posterior thighs and with no radiation below the knees. Previous management included pharmacotherapy (oxycodone 50 mg daily), physiotherapy and exercise programme (including Pilates) and breast reduction (which helped cervicothoracic spinal pain symptoms). Background history of treated anxiety and depression and previous lobular breast carcinoma-*in-situ* (incidental finding at surgical excision for breast reduction) with no residual disease at 4-year follow-up.

The pain intensity was worse in the morning, constantly present and aggravated by activity, particularly by coughing and sneezing. There were no red flag symptoms such as unintended weight loss, fevers or recumbency pain. Pain severity was rated as averaging 8/10 over the previous week using the NRS.

Examination disclosed height 165 cm and weight 72 kg. Gait was mildly antalgic. The posture was of increased lumbar lordosis. Lumbar flexion and extension were moderately restricted. There was mild to moderate paravertebral tenderness maximal at the lumbosacral junction. Lower extremity neurological examination was normal.

Imaging findings with lumbar computerized tomography (CT) scan disclosed L5/S1 disk desiccation associated with moderate severity end-plate degenerative changes. Single-photon emission computerized tomography (SPECT) co-registered whole-body bone scan disclosed scintigraphic abnormality localised to the region of the L5-S1 disk, consistent with an active disk degenerative process. Lumbar magnetic resonance imaging (MRI) (Figure 1) disclosed substantial bone and degenerative disk change at L5/S1 with a reduction in disk space height and end-plate signal abnormality (Modic type 1). Mild broad-based disk bulging with relatively minor thecal and nerve root encroachment as well as mild to moderate bilateral foraminal narrowing compressing distal L5 nerve root sheaths. The remaining disks were normal.

Figure 1. *Pre-BVNA Saggital MRI Images, Demonstrating Modic Type 1 Endplate Changes at the L5 Inferior End-plate and S1 Superior End-plate*



a) T2 weighted *b) T1 weighted*

Bilateral L5/S1 facet joint injections with bupivacaine and dexamethasone were provided and gave 50% pain reduction. Therefore, RFA of the L4 medial branch and L5 dorsal ramus was provided bilaterally, but with only mild benefit.

BVNA was then provided with the bipedicular placement of radiofrequency electrodes (a technique described below).

Description of a Technique of Lumbar Vertebrectomy *via* Pediculotomy and Basivertebral Nerve Ablation with Bipolar Radiofrequency Electrodes

The patient is positioned comfortably in the prone position with positioning aids to optimise lumbar lordosis. Sedation anesthesia and monitoring, maintaining responsiveness to voice, and intravenous antibiotic prophylaxis is provided.

Multiplanar fluoroscopy views are obtained as follows.

1. Anatomical anteroposterior (AP) view - identify the juncture of the superior articular process and transverse process at each target.
2. Trajectory view - optimise the pedicle shadow with slight cranial and ipsi-oblique rotation (typically 3-5°).
3. Lateral view - for dorsal to ventral depth.
4. AP view (+/- craniocaudal adjustment) - for a pseudo-axial view of the pedicle and to avoid medial pedicle breach.

In the trajectory view, the skin and deep tissues are infiltrated with preservative-free 0.5% Bupivacaine starting over the 1:00 o'clock (right) or 11 o'clock (left) position of the pedicle *via* a 25-gauge spinal needle advanced to the target. A stab incision is

made to the skin with a number 11 scalpel blade, and then a 101 mm 11-gauge needle (T-handle Jamshidi needle; BD, Vernon Hills, IL, USA) is gently advanced to the pedicle at a point midway between the superior border of the superior articular process (SAP) and the location of the mamillo-accessory notch. Gentle taps with a surgical mallet position the needle firmly into the dorsal pedicle. The needle is then gently driven about halfway (1/2) from dorsal to ventral in the pedicle in the lateral view.

In the AP +/- decline view, the needle in the pedicle is confirmed to avoid the pedicle's medial wall so as to avoid any medial breach. The AP view is re-checked as required. The needle is gently advanced further in the lateral view until a release on exit from the dense pedicle matrix and entry to the intra-vertebral trabecular bone. The needle is then further advanced within the vertebral body to about one-quarter (1/4) of the distance from dorsal to ventral in the lateral view.

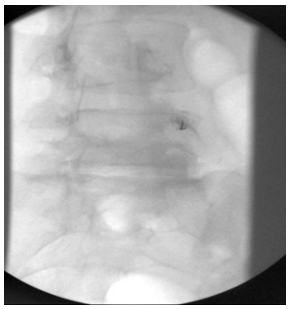
The needle/stylet and trocar thus perform a vertebrectomy of the trabecular bone and create a path for the radiofrequency electrode - bone marrow aspiration aids in cavity creation. The trocar is advanced with multiple passes while remaining in the dorsal two-thirds of the vertebral body for each pass.

In the trajectory view, the lumen of the needle is identified. The needle is gently removed, and the hypolucency in the pedicle shadow left by the needle is identified. The radiofrequency electrode (Nimbus 17-gauge multi-tined expandable electrode; Stratus Medical, Magnolia, TX, USA) is placed through the pedicle hole, and the tip is positioned medially within the vertebral body spanning the mid-portion of the vertebral body in the lateral view.

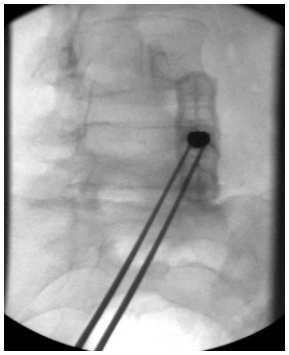
A second radiofrequency electrode is placed using the same technique through the contralateral pedicle, optimally positioned in the vertebral body and precisely superimposed in angle and degree of insertion (Figure 2).

A bipolar lesion is provided at 80° for four minutes fol-

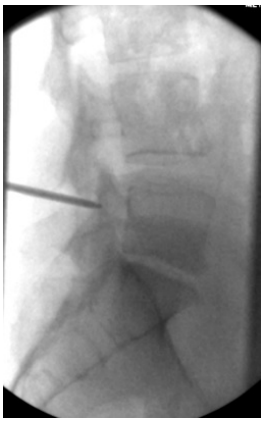
Figure 2. *Flouroscopy Sequence at L5*



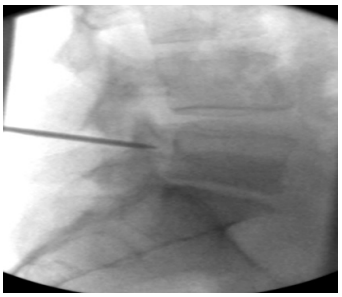
a) Trajectory view, crisp superior end-plate, ipsilateral oblique tilt, 25 G needle on dorsal aspect of right pedicle, approximately 1 o'clock



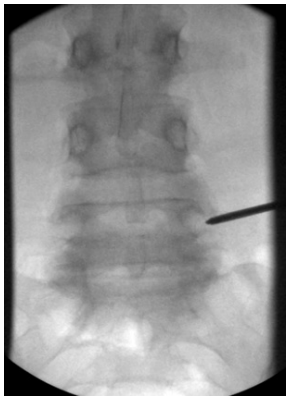
b) Trajectory view, 11G needle on the dorsal aspect of the pedicle



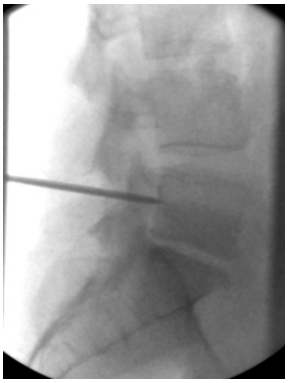
c) Lateral view, 11G needle engaging dorsal aspect of pedicle



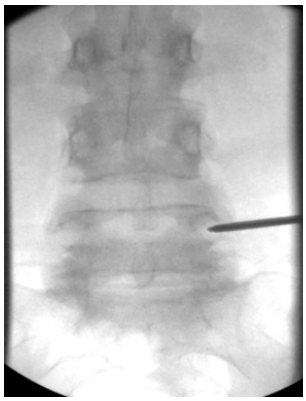
d) Lateral view, 11G needle, mid-pedicle



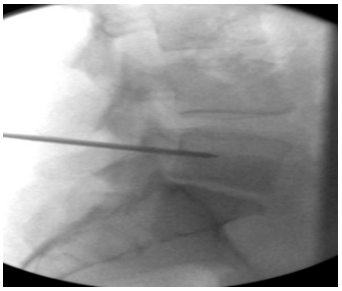
e) AP view, 11 G needle engaged in the mid-pedicle, note clear of medial wall of pedicle



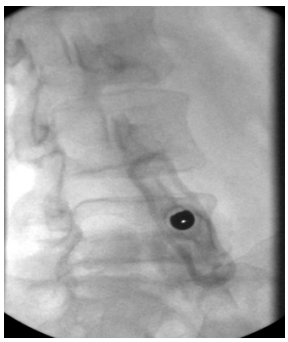
f) Lateral view, 11G needle at ventral aspect of the pedicle



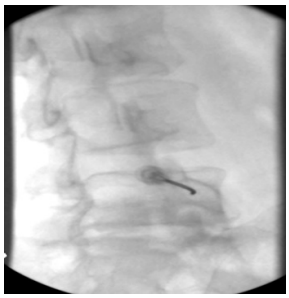
g) AP view, 11G needle at ventral aspect of the pedicle



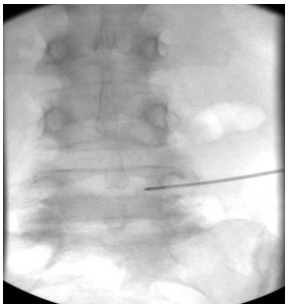
h) Lateral view, 11G needle within the vertebral body



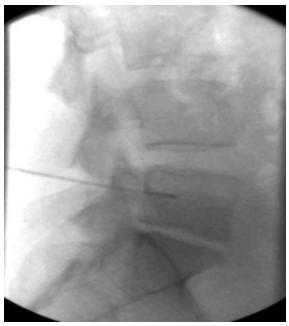
i) Trajectory view, prior to removing 11G needle



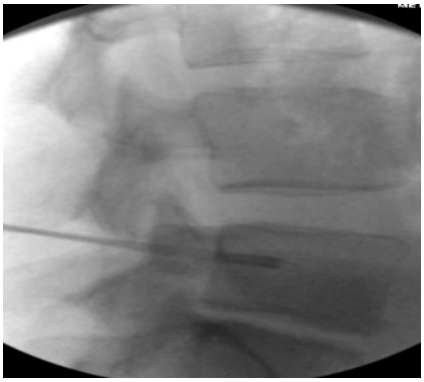
j) Trajectory view, 17G radiofrequency electrode at entry to pedicle hole



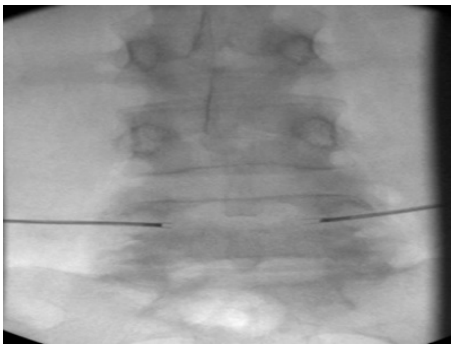
k) AP view, 17G radiofrequency electrode within vertebral body



l) Lateral view, 17G radiofrequency electrode within vertebral body

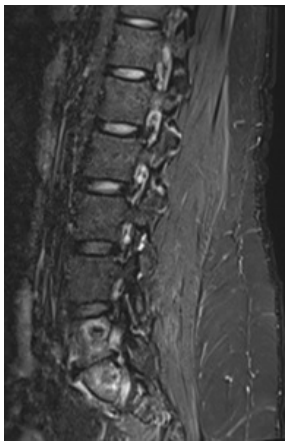


m) AP view, after repeating procedure on the left side to place 17 G radiofrequncy electrodes within vertebral body

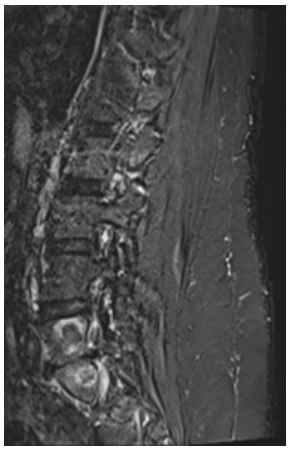


n) Lateral view, 17G radiofrequency electrodes in position for bipolar lesion within the vertebral body, note that the tines are deployed

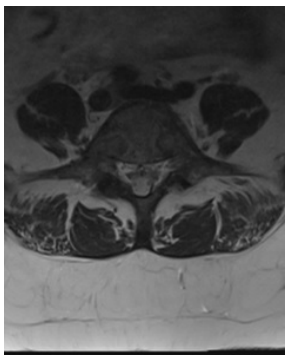
Figure 3. *6-weeks Post-BVNA MRI Images, Demonstrating New Sclerosis Consistent with BVNA Lesions*



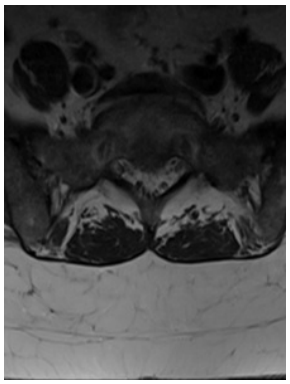
a) Right para-saggital STIR image



b) Left para-saggital STIR image



c) Axial T2 weighted image at L5



d) Axial T2 weighted image at S1

lowing a 60-second ramp from 50 to 80 °C. The anodal temperature reaches 70 to 75 °C, indicating technical success for this aspect of the procedure.

The scalpel incision is closed with a 1-inch Steristrip, and a sterile dressing is applied.

RESULTS

The procedure was well-tolerated. There was moderate post-procedure discomfort reported for a few weeks.

Outcomes data were collected at six weeks using the following psychometric instruments: NRS, brief pain inventory

(BPI), ODI, depression anxiety and stress scale (DASS21) and the EQ-5D-5L.

Lumbar MRI (Figure 3) demonstrated new sclerosis with surrounding bone marrow oedema of the right and left sides of the L5 and S1 vertebral bodies consistent with the BVNA treatment.

Oxycodone dose was decreased (40 mg daily) with a weaning plan.

Pain severity at six weeks post-BVNA was rated as averaging 3/10 over the previous week using the NRS (Table 1).

Table 1. *Psychometric Data Pre-BVNA and 6-Weeks Post-BVNA*

Measure	Pre-BVNA	6-week post-BVNA
NRS	8	3
BPI-Severity	32	15
BPI-Interference	70	23
ODI (%)	57	35
ODI-Category	Severe	Moderate
DASS21-Depression	28 (extremely severe)	16 (moderate)
DASS21-Anxiety	24 (extremely severe)	8 (mild)
DASS21-Stress	24 (moderate)	18 (mild)
EQ-5D-5L (health state)	43444	32332
EQ-5D-5L (VAS)	30	50

DISCUSSION AND CONCLUSION

BVNA is a promising technique to treat vertebrogenic pain. The industry sponsored the published randomized controlled trials[4-7] performed using the Intracept device (Relievant Medsystems, Minneapolis, MN, USA) and this is a potential source of systematic bias.[1] This case reports technically successful BVNA using the bi-pedicular placement of radiofrequency electrodes, including positive early outcomes data. The early result is consistent with the published literature for the uni-pedicular approach using the Intracept device. No industry funding was sought or received.

Precise knowledge of the anatomy and care need to be taken with pedicular access so as to avoid medial pedicle breach, to achieve adequate placement such that the bipolar lesion incorporates the precise location of the basivertebral nerve, and to avoid heating neural structures. Sedation anesthesia maintaining responsiveness to voice is thought to be an important additional safety consideration.

The clinical decision making process in this case was to first exclude the facet joints as a source of significant nociception and although facet intra-articular injections were moderately positive, the radiofrequency ablation of the target facets provided minimal benefit. BVNA was then provided with significant benefit.

Longer-term data collection is required to document sustainability of outcome with the bi-pedicular technique. A case series is envisaged to document outcomes in a community practice setting.

Ideally, independent studies of outcomes will help elucidate the long-term outcomes of BVNA, and refute or validate the technique.

ACKNOWLEDGEMENT

Dr Robert Wright provided the concept of using the bi-pedicular bipolar RFA approach.

CONSENT

The authors have received written informed consent from the patient.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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Case Illustration

Cervical Neurofibroma: Peri-Operative Considerations

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INTRODUCTION

Neurofibromatosis (NF), are a group of hereditary diseases transmitted in an autosomal dominant fashion and characterized by a tendency to formation of ectodermal or mesodermal tissue tumours, possessing *NF1* or *NF2* gene mutation.[1] Neurofibroma, a major feature of *NF1* is a benign mass of peripheral nerve or nerve root consisting of Schwann cells, fibroblasts, mast cells and perineural cells.[2] Literature is sparse regarding anaesthetic considerations for cervical neurofibromas.

CASE DISCUSSION

A 19-year-old female presented with complains of headache, pain in neck and weakness in bilateral upper and lower limbs, for three months. Motor power in upper and lower limbs was 4/5 with an intact bladder and bowel. Magnetic resonance imaging (MRI) cervical spine reported, a 2.2×3.8×4.4 cm lesion at the craniovertebral junction, extending through the left C1-C2 mural foramina into left paravertebral junction (Figure 1. MRI Spine of the patient with cervical neurofibroma). She was posted for tumour decompression *via* left posterolateral approach in prone position with head pin support.

On pre-operative evaluation, all routine blood investigations, electrocardiogram (ECG) and chest X-ray (CXR) were within normal limits. MRI angiography of the brain revealed hypoplastic right vertebral artery. Airway examination appeared normal, except for painful and restricted neck movements. Intra-operatively, patient was premedicated with injection midazolam and

Figure 1. *MRI of Cervical Spine Showing the Neuro-fibromatous Lesion*

injection fentanyl. In view of anticipated difficult airway, modified rapid sequence induction with injection rocuronium (RSI) with manual in line stabilisation (MILS) and adequate preoxygenation was attempted. Video laryngoscopic guided intubation with cuffed endotracheal tubes (CETT) (#7.5 mmID) was smoothly done and bilateral air entry confirmed. Under all aseptic precautions, invasive arterial and central venous pressure lines were inserted and monitored. After completion of the surgery, a 'Philadelphia collar' was applied for cervical stability, followed by the removal of headpin support. Then she was positioned supine and extubated following standard protocol. The entire peri-operative course was uneventful and the patient was transferred to the neurosurgical intensive care unit (ICU) for further monitoring.

Cervical cord compression resulting from cervical nerve root fibroma is a recognized, but infrequently reported complication of *NF1*. Isolated cervical neurofibromas as in our patient can present at any age ranging from the first decade to the seventh decade of life. Cord compression occurs most commonly in the upper cervical spine at C2 and C3.[3]

Patients with symptomatic isolated cervical neurofibromas mostly present with progressive quadriparesis, paraparesis involving lower or upper extremities, incontinence, neck pain, headache, seizures. *NF1* can involve the tongue, larynx, and aryepiglottic folds complicating airway management. Large neurofibromas originating in the mediastinum, retroperitoneal spaces, and cervical paraspinal areas can lead to progressive distal airway compression. Intrapulmonary neurofibromas may present with cough, dyspnea and associated-progressive pulmonary fibrosis. Also, there is an increased incidence of kyphoscoliosis in these patients. These can lead to difficult airway, respiratory complications and spinal cord compression. These patients can also have associated hypertension, cardiomyopathy, vasculopathy, pheochromocytoma and carcinoid tumours. Therefore, a thorough multi-system examination is mandatory pre-operatively.[4]

Surgical excision is associated with multiple challenges like ensuring adequate spinal cord exposure, preservation of involved spinal nerve roots, post-operative kyphosis prevention, stabilization of spine and reducing recurrence rates.[5]

Vertebral artery compression is another important concern in cervical neurofibromas, which is mostly displaced anteromedially by tumours. Hence, bilateral vertebral artery doppler or MRI angiogram of brain was done pre-operatively in the patient. As spinal cord perfusion pressure is the difference between mean arterial pressure and intra-spinal pressure ensuring spinal cord perfusion by maintaining haemodynamic status in the peri-operative period is vital for successful outcome..

CONCLUSION

To conclude, isolated cervical neurofibromas, although rare, can be a part of *NF1*. Multisystem presentation of *NF1* can pose challenges for the anaesthesiologist if unaware of its problems. Also, ensuring cervical spine stability, avoiding spinal cord compression and maintaining cerebral and spinal cord perfusion are the major anaesthetic goals in the perioperative management of cervical neurofibroma. Cautious airway management in the neutral position, application of MILS during any maneuver, use of cervical collar, detailed work-up of neurofibromatosis patient and maintenance of hemodynamic stability are the cornerstones of successful patient outcome.

CONSENT

The authors have received written informed consent from the patient.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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