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Lessons Learned Using Local Anesthesia for Minimally Invasive Endoscopic Spine Surgery

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Abstract

Background/purpose: Operating under local anesthesia allows the patient to respond and provide feedback during surgery that is invaluable for patient safety and for the assessment of the pain generators and ultimately understanding of the source of pain that the surgeon is targeting. Over 10,000 case studies make up the database for information gleaned from patients reporting the pain experienced and relieved during translaminar and transforaminal endoscopic decompression.

Method: The patient is provided mild sedation with versed and fentanyl unless no sedation is requested. Patients requesting no sedation are usually anesthesiologists and other spine surgeons who opt for decompressive surgery, but wanted some measure of surgical participation and control. The anesthesiologist titrates the patient with 1-2 cc of fentanyl and versed pre-op with titration during surgery. The average total amount is 4-5 cc for most procedures. 1% lidocaine is utilized for the local anesthetic. An average of 10-20 cc is used for local anesthesia, titrated as needed during surgery.

Results: The results of decompression can be predicted by a combination of pain relief reported during, immediately after, and augmented by visualization of the targeted patho-anatomy. Such visualized pathology visualized includes annular tears, decompressed spinal nerves, and visualization of the axilla between the traversing and exiting nerve.

Conclusion: Observations provides level 5 EBM (Expert opinion) for surgical intervention. Evidence based medicine usually starts with level 5 “expert” opinions. With the ability to evoke pain in conscious surgical patients, with endoscopic images of the patho-anatomy that correlates evoked pain production with subsequent pain resolution following visualized endoscopic decompression. Along with comparison of pre-and post op images, a new and different and level of EBM may emerge and need to be considered in addition to the traditional Levels 1-5 EBM guidelines.

Keywords: Local anesthesia; Fentanyl; Versed; Neuromonitoring; Patho-anatomy; New evidenced based medicine criteria; Transforaminal endoscopic decompression

Introduction

Endoscopic surgical decompression for painful conditions of the lumbar spine using local anesthesia provided the authors with clinical information that MIS (Minimally Invasive Surgery) surgeons cannot obtain or appreciate when operating under general anesthesia. Local anesthesia allows the patient to respond and provide feedback during surgery that is invaluable for patient safety and for the assessment of the pain generators and ultimately understanding of the source of pain that the surgeon is targeting. Since 1991, lead surgeon Anthony Yeung used only local anesthesia with or without sedation for endoscopic MIS spine surgery mostly for transforaminal, approaches but local anesthesia was also used for translaminar approaches. The translaminar approach was concluded to be safe and easier under general anesthesia because the spinal nerve remains painful even when topical anesthetic is used when retracted. Therefore, general anesthesia is preferred for translaminar micro-lumbar decompression. He and his team at DISC have performed over 10,000 successful transforaminal MIS spine procedures with no need for general anesthesia. The local anesthetic technique is also used for dorsal endoscopic rhizotomy, helpful as an added procedure addressing predominant axial back pain. Surgery can be offered as a hybrid procedure combining selective endoscopic discectomy with foraminoplasty and rhizotomy. Patients over 70 have already undergone natural stabilization from their aging process, therefore foraminoplasty and rhizotomy is especially useful and helpful in elderly patients. When stabilization is needed, MIS fusion procedures such as transforaminal O-lif, performed with foraminalplasty, can be successfully completed under local anesthesia without neuromonitoring [1,2]. The safety of MIS surgical procedures under local anesthesia became evident when the patient can report pain during the procedure, enabling the dedicated endoscopic surgeon to constantly refine his surgical skills. It may also limit the procedure to surgeons who should have the requisite skills to get out of trouble when surgical morbidity and risks are recognized and addressed. In the over 10,000 cases in 25 years, no serious complications resulted in nerve root injury or serious irreversible injury.

Experimental Method

Transforaminal decompression, the standard approach, is described as "surgical pain management" for discogenic pain, herniated nucleus pulposis, foraminal stenosis, and pedunculated synovial cysts [3,4]. It is the least invasive surgical decompressive technique for painful degenerative conditions of the lumbar spine. In selected cases, when spondylolisthesis is identified on imaging studies, the "gold standard" fusion is considered appropriate, backed by the literature. A percutaneous transforaminal decompression procedure, however, can be offered as a less invasive endoscopic option when the instability is mild, and when patients refuse fusion, even when traditionally indicated in selected cases. Endoscopic decompression with or without dorsal rhizotomy as a first procedure can provide pain relief of both back pain and sciatica [5]. As a staged procedure, patients, including spine surgeons, who seek the endoscopic approach over fusion are mostly self-referred after searching the internet, by physician referral, or referred by happy patients or friends. Past surgical successes from the endoscopic procedures drives a steady stream of patients to surgeons with a good surgical track record. In a 2-10-year patient follow-up survey, after 5 years, 75% to 90% were still very satisfied with their choice of endoscopic decompression as a staged procedure, even in the face of spondylolisthesis that may later require fusion, but offered as a staged procedure. In fact, early success on a spine surgeon over 10 years ago, who requested decompression only for their sciatica in the face of isthmic spondylolisthesis provided the inspiration to offer endoscopic decompression first in relatively stable cases, since fusion can always be an option if decompression did not give the desired relief. Foraminal decompression was deemed appropriate for a staged procedure, especially when selection was stratified further by successful diagnostic and therapeutic injections targeting the pain source. These injections are performed without any sedation, and best performed by the endoscopic surgeon. The patient's response to the injection helped with patient selection for endoscopic decompression, ablation, and irrigation inherent in the transforaminal endoscopic approach. If the patient has a very low pain threshold or provides an unpredictable and unanticipated response to diagnostic and therapeutic injections, the response warns the surgeon that the patient might not be a good candidate for the endoscopic and possibly any surgical procedure. In that case, surgery was either not considered appropriate or extra care was considered before offering surgery.

Discussion

There are other pioneers key opinion leaders with different Endoscopic techniques that have their own followers. I will limit this article and discussion to the transforaminal technique that was developed and described by the lead author as the "YESS" technique (Yeung Endoscopic Technique).

The patient is positioned prone on the operating table. This has caused some anesthesiologists to be concerned about not having control of the patient's airway, and caused some less experienced surgeons to agree to use general anesthesia. This scenario makes the surgical complication risk higher than with local anesthesia. While some traditional surgeons may also feel more comfortable performing percutaneous transforaminal spine surgery under general anesthesia, lessons learned by having the patient awake, and only partially sedated provides an increased level of safety as well as information on pain generation [6]. Local anesthesia gives the surgeon valuable clinical information unobtainable by any other means. General anesthesia is not needed, nor desired, unless it is for the convenience of the surgeon and patient. Sometimes the patient requests to have surgery only with general anesthesia. Many surgeons are happy to oblige and even prefers using general anesthesia. Simply providing more local anesthetic, however, is sufficient for patient comfort, and is preferred by accomplished endoscopic surgeons.

Observations described in this publication provide level 5 EBM (Expert opinion) for surgical intervention. Traditionally, all Level 1 and level 2 evidence based medicine starts with level 5 "expert" opinions. With the ability to evoke pain in conscious surgical patients, endoscopic images of the patho-anatomy that correlates evoked pain production with subsequent pain resolution following visualized endoscopic decompression. This evidence can also correlate with pre- and post-operative imaging. A new and different and level of EBM may emerge and need to be considered in addition to the traditional Levels 1-5 EBM guidelines.

Early in the surgical process, some anesthesiologists with traditional training have voiced concern providing anesthesia with the patient in the prone position unless the patient was intubated and they had control of the airway. Some, also concerned about the level of pain control also insisted on using propofol, a general anesthetic that requires close monitoring. Spine Surgery under local anesthesia is demonstrated as safe, and neuromonitoring is not needed. I do not allow my anesthesiologists to use propofol, and my anesthesiology team will discuss their experience with local anesthesia in the prone position from an anesthesiologist's point of view.

Lessons Learned Operating Under Local Anesthesia

Operating on the lumbar spine transforaminally under local anesthesia is safer than using general anesthesia and the use of neuromonitoring is not necessary. Experience from over 10,000 procedures since 1991 provides these observations with information and lessons learned. An awake and conscious patient will react and respond to pain generated during the surgical procedure. The patient can and will report pain or discomfort when the nerve or soft tissue adjacent to nerves are stilmulated or retracted [7]. Local anesthesia applied to the soft tissue will provide anesthesia during the procedure, but to the surrounding soft tissue, but not the large traversing and exiting spinal nerves from each spinal segment. Patients will still respond and report pain with mechanical stimulation of nerves. Large peripheral nerves cannot be sufficiently anesthetized with topical application or injected anesthetic agents in the soft tissue adjacent to the nerves. The nerve will be anesthetized only if the nerve sheath is injected directly with a small gauge needle. A prospective, IRB approved study in 1997 at St Lukes Medical Center was initiated to support this clinical conclusion.

Lesson #1

Neuromonitoring is not needed if the patient is awake and only lightly sedated, using local anesthesia in the foramen and the adjacent soft tissues. Skin incisions and the annulus can be anesthetized with local anesthetics without anesthetizing the spinal nerve where it will not respond with pain when gently stimulated.

In 2001, a prospective study of 18 patients was initiated using Intraoperative Neuromonitoring during Selective Endoscopic Discectomy (SED) with the Yeung Endoscopic Spine System (YESS). EMG monitoring was studied to assess the value of information to the surgeon regarding the position and irritability of the nerves in the operative area [8]. EMG activity can be correlated to the level of the

lumbar spine on X-Ray imaging augmented by physician visualization of the spinal nerve in the operative field. Mechanical elicitation of evoked discharges occurred in 6 cases, (33%). Discharges correlated with the action of tapping past the nerve into the disc space with a cannula. EMG neurotonic irritation response patterns were exhibited by 2 patients (11%). In both cases, the EMG returned to baseline after disc material was removed from the nerve area. No adverse events occurred post-operatively, even when there was activity in the EMG (Figure 1).

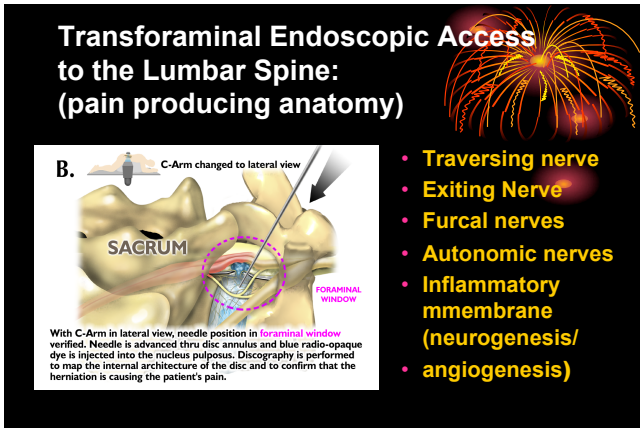

Figure 1: A List of the patho-anatomy of pain generators visualized by transforaminal endoscopic surgery that will respond to decompression and ablation under local anesthesia is provided.

Lesson #2

EMG neuromonitoring will alert the surgeon for any irritation of peripheral nerves that is not anesthetized by local soft tissue injection. EMG activity, even when present, is not indicative of nerve injury or residual nerve symptoms post op. Activity does not correlate with the need to move instrumentation to avoid EMG activity. The spinal nerve is safely retracted and protected by the sides of the cannula.

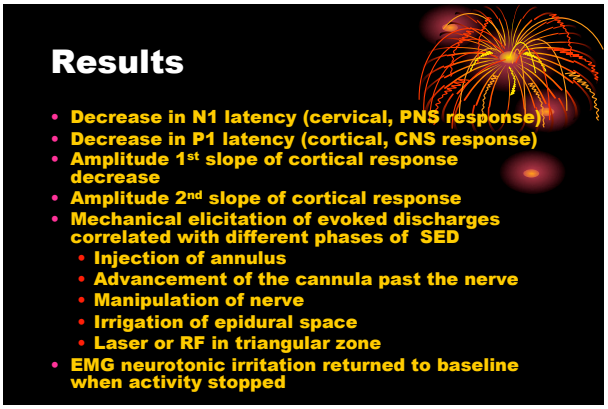

Figure 2a: Results of the neuromonitoring study is summarized in the Results slide.

In 2002, 100 patients undergoing Selective Endoscopic Discectomy (SED) with the Yeung Endoscopic Spine System (Y.E.S.S.) were monitored, also with bilateral SEP tests both pre-and post-operatively. 400 SEP tests were analyzed at the Squaw Peak Surgical Facility under the direction of Anthony Yeung and John Porter Palm OS-based Handspring Visor-TM hardware and HanDBase-TM software were used to acquire data and produce statistics (Figures 2a and 2b).

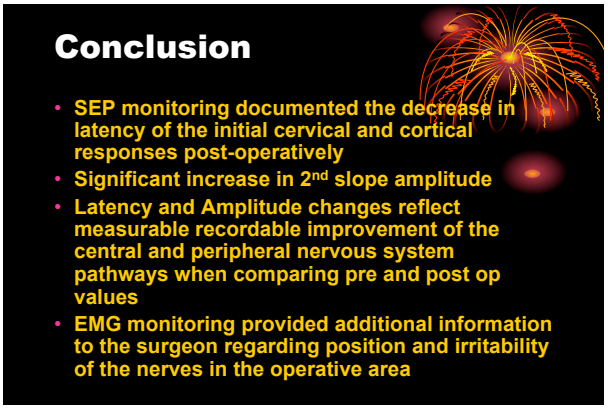

Figure 2b: Conclusions of the neuromonitoring study. The findings served to reinforce the safety and advantages of operating in the foramen using an endoscope with the patient under local anesthesia with or without sedation. SEP monitoring documented latency and amplitude changes consistent with clinical improvement post-operatively.

The 100 consecutive patients using percutaneous monitoring were compared with a group of 100 consecutive patients who had no neuromonitoring. There was no difference in results. Neuromonitoring identified the presence of nerves causing the neuromonitor to send warning alarms, but this only served to warn the surgeon of nerve vicinity and not correlated with neuropathy.

Lesson #3

The presence of "toxic "annular tears causes' pain out of proportion to the imaging study. Annular tears may or may not be visualized on MRI. A perfect cut across the annular tear appears as HIZ (High Intensity Zone) on MRI. Annular tears may be missed that are not apparent on MRI, but identified by "evocative" chromo discography demonstrating grade IV or V tears that are correlated with an inflammatory membrane or granulation tissue. When an inflammatory membrane or neo-neurogenesis is visualized with endoscopic examination of the painful tear, ablation of the site of inflammation will result in pain relief. Interposed nucleus pulposus embedded in the annular layers is a reason why a tear may not heal. If the tear is treated with thermal modulation using a bipolar RF (Radiofrequency) electrode, pain relief will occur. High frequency RF offers the best safety (Figure 3a).

Figure 3a: The patho- physiology of pain can be correlated with patho-anatomy visualized with the patient under local anesthesia.

Selective Endoscopic Discectomy™, thermal discoplasty and annuloplasty has provided expert level 5 EBM clinical data on pain production with stimulation and surgical treatment by endoscopic decompression, ablation, and irrigation [9].

Not all RF is safe and free of neuropathic complications. The extent of pain relief over time is partly dependent on the thickness of the tear and the ability of the tear to heal. Just by removing the inflammatory source, however, will at least give short-term relief by ablating and irrigating the inflammation. Long-term relief is dependent on the extent of the tear, the thickness of the remaining annulus, and the stage and age of the degenerating disc. With the tincture of time and aging, pain may also subside with or without surgery. Endoscopic surgical intervention is dependent on the surgeon's ability to adequately remove the nucleus from the annular tear and adequately modulate the tear intradiscally. Early intervention provides the best results (Figure 3b) [10].

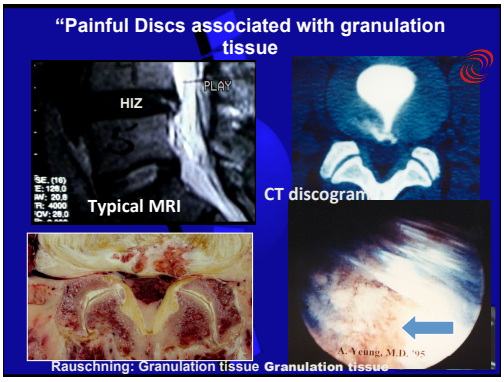

Figure 3b: The imaging and visualization of an annular tear is represented by an HIZ on an MRI, focal tear in a CT discogram, and granulation tissue visualized by the endoscope. This corresponds to granulation tissue in cadaver patho-anatomy as demonstrated by Wolfgang Rauschning.

Lesson # 4

Surgical observations from my own endoscopic decompression surgery by Chris Yeung and Nima Salari, my associates at DISC offer real time correlation of pain production during the surgical procedure. I was comfortable during the procedure with local anesthesia. When an attempt was made to dilate my narrowed scoliotic disc space from degenerative scoliosis, dilating the severely narrowed disc space at L4-L5 produced bilateral S-1 dermatomal radicular pain to the foot. The surgeons used a custom beveled cannula specifically designed for holding and dilating the disc space and to aid foraminoplasty with trephines and endoscopic kerrisons. The articulating burr was not available at the time (Figure 4a).

Figure 4a: I experienced firsthand during my own transforaminal endoscopic surgery without sedation. I was able to feel which parts of the procedure were painful and which were not. My own personal learning curve extended at least 5 or more of the 25 years as the endoscopic transforaminal procedure evolved, aided by constant improvement of results from more effective and quality surgical decompressive instruments and endoscopes.

Bilateral S-1 sciatica was experienced with an attempt to bluntly dilate the collapsed disc space at L4-L5, causing the surgeons to abandon the attempt to dilate of my narrowed disc space when performing foraminoplasty. Instead, while endoscopic foraminoplasty with currently available articulated burrs would have been ideal, I chose to have my associates trained in endoscopic surgery and open surgery stage the decompression with an open translaminar approach on the contralateral side augmented with translaminar decompression and coflex stabilization. The surgery was successful.

In collapsed discs, any attempt to dilate the disc space will cause nerve pain from stretching of spinal nerves from indirect dilation of the disc space. There is a limit to stretching of the spinal nerves that may vary with each individual or degenerative condition. The longer standing a disc space is narrowed; the more vulnerable the nerve is to stretch injury. Patients who undergo indirect decompression are vulnerable to stretch injury of the spinal nerves, or at least temporary worsening that usually improve over time (Figure 4b).

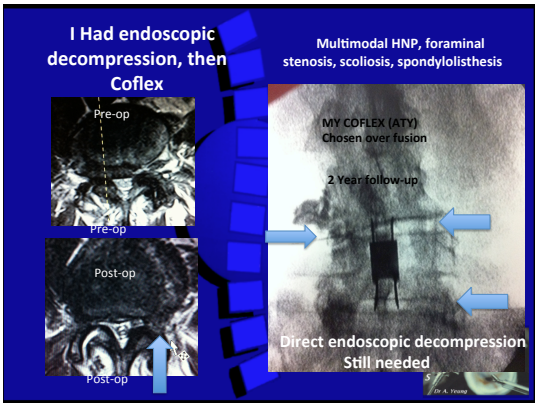

Figure 4b: I had a staged surgical procedure starting with a right endoscopic foraminal decompression where I had severe radiculopathy.

I had a right multimodal HNP, 2 level disc extrusion, and degenerative scoliosis. I also had left lateral recess stenosis and spondylolisthesis. As anticipated, the right transforaminal decompression only relieved the right side symptoms but did not fully relieve my left sciatica, so rather than opt for a left foraminal endoscopic decompression, my associates Chris Yeung and Justin Field followed with an open left translaminar decompression and a Coflex dynamic stabilization over fusion. I chose to have translaminar open decompression at L4-L5 as well, to be supplemented by coflex dynamic stabilization over fusion. The images do not demonstrate the sagittal alignment that is the state of the art in fusion, but my pain is gone! I had a severe progressive degenerative condition that 99% of traditionally trained spine surgeon would have recommended a decompression and MIS or traditional fusion. Today's emphasis on sagittal alignment, the latest hot topic is not always needed, even if desired. Transforaminal decompression was successful for my more debilitating right multimodal HNP and stenosis. The current recommendation on sagittal alignment may be good when fusion is the procedure of choice, but each individual is born without ideal sagittal alignment of their spine, but does not necessarily have debilitating pain. Endoscopic MIS surgery may involve hybrid procedures or staged procedures in lieu of a more extensive traditional procedure offered earlier in the painful degenerative process. The complexities of the spine and the need to deal with instability and deformity require surgical training and experience for the safety of patients. Non-surgeons without surgical training or background may place their patient at risk or adversely affect the successful development and acceptance of endoscopic spine surgery.

Lesson #5

The patient can report relief of pain on the operating table following adequate decompression of the patho-anatomy in the disc and the foramen, providing feedback on the success of decompression (Figure 5) [11].

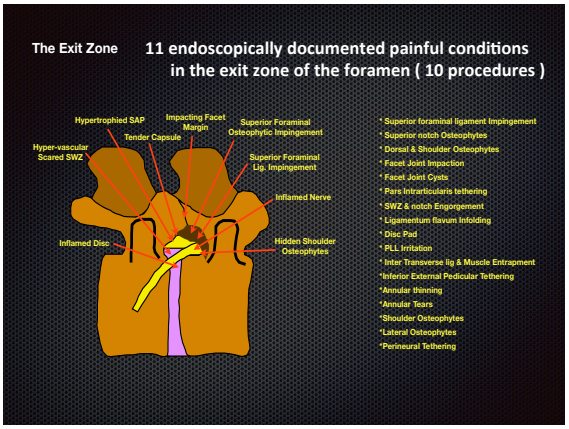

Figure 5: There are multiple pain generators in the foramen accessible and visualized with an endoscope. 11 of the 17 painful conditions have been personally documented and successfully treated multiple times in a 10,000-personal endoscopic case database since 1991.

The exit zone of the foramen is the site of numerous conditions not completely understood and relieved by the translaminar approach; the transforaminal approach affords identification of many causes of "Failed back surgery syndrome".

Lesson #6

Anomalous nerves not visualized during traditional translaminar decompression are found in the "hidden zone" of MacNab. These nerves that look like "thin rice noodles" have ganglia when examined with H and E slides of the biopsied nerves. The existence of ganglia in the specimen is consistent with autonomic or sympathetic nerves. They can cause temporary dysesthesia when irritated, ablated, or when extracted and biopsied. Subsidence of dysesthesia almost always occurs over time, but nothing is 100%. Transforaminal and sympathetic therapeutic blocks will speed recovery (Figure 6a).

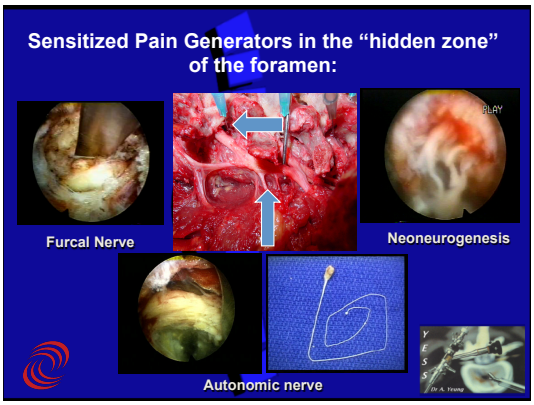

Figure 6a: Anomalous nerves in the foramen, called the "hidden zone" are represented by furcal nerves, autonomic nerves, neuromas, and normal nerves that are in variable anatomic locations.

Other nerves ventral to the intertransverse ligament can be cut if it is part of the medial branch of the dorsal ramus before it exits the foramen to cross the transverse process. Ablation of these nerves will relieve axial back pain [12]. These nerves, however, are difficult to differentiate from furcal nerves that branch from the exiting nerve or are conjoined nerves coming from the cephalad spinal segment (Figure 6b).

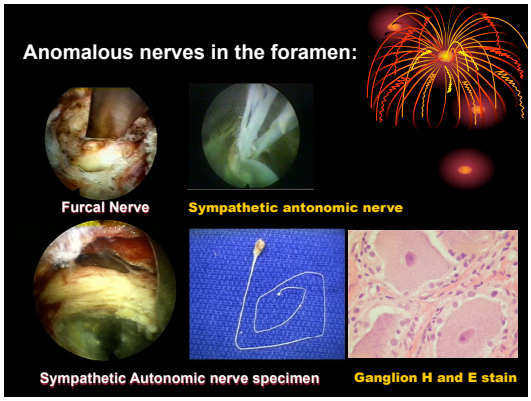

Figure 6b: Specimen of autonomic nerves that look like "rice noodles" when visualized with the endoscope. (Endoscopic view of a sympathetic autonomic nerve) It can also be part of a nerve trunk as seen in the lower left image.

These "anomalous" nerves can produce pain when cauterized with bipolar RF. These findings may be correlated with pain generation previously not described in the literature as a risk of neuropathic pain pre- and post-operatively in the transforaminal approach to the spinal segment [13]. These findings are not as appreciated by surgeons who use general anesthesia because pain generation will alert the surgeon to carefully proceed in the surgical procedure (Figures 6c-6e).

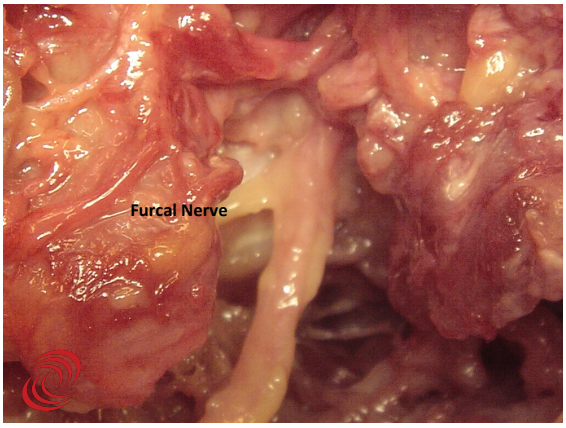

Figure 6c: Cadaver dissection of a furcal nerve branching off the exiting nerve.

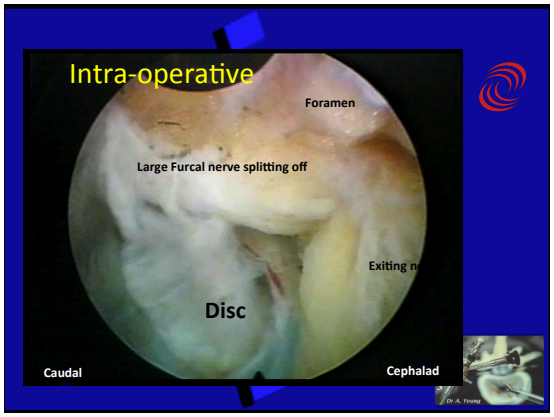

Figure 6d: Endoscopic view of a furcal nerve branching from the exiting nerve.

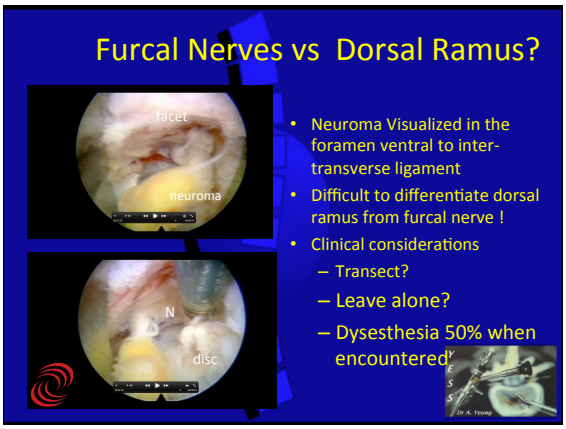

Figure 6e: Dorsal ramus neuromas may cause axial back pain if compressed. Excision or decompression of neuroma will relieve axial back pain. It is speculated the neuroma identified may have been caused by attempts at selective nerve root injections causing severe neuropathic pain and radiculopathy.

Lesson #7

Pedunculated Synovial cysts may be visualized inadvertently or suspected from the MRI demonstrating a Hiz. Cysts usually originate from the inlet of the foramen, but the cyst wall is discovered either in the lateral recess or in the hidden zone between the traversing and exiting nerve because the cyst membrane is pedunculated. It is not always necessary to remove the entire cyst wall, since just puncturing the cyst wall has obtained temporary relief, but removal and thermal or laser ablation of the cyst wall will also provide relief [14,15]. Post-op MRIs may demonstrate resolution of the cyst on MRI. When operating under local anesthesia, decompression to the epidural space and foramen may cause the patient to feel neck pain or transient head ache. The endoscopic procedure may need to be aborted when this happens, but the pain relief post–op is immediate (Figure 7).

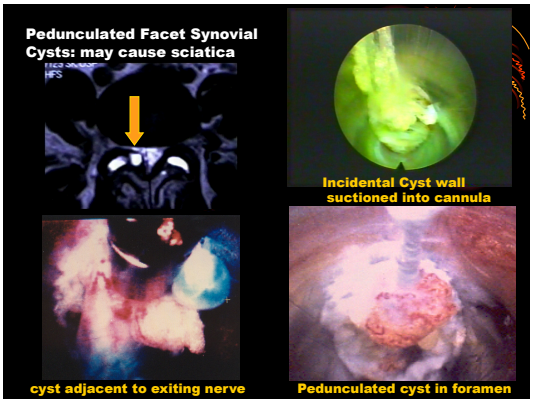

Figure 7: Endoscopic views of synovial cysts found in the foramen and area of the exiting nerve. Although the origin of the cyst is from the medial aspect of facet joint the pedunculated cyst wall can be found in the sub-articular and extra-foraminal lateral recess. Any resection or ablation of the cyst wall will provide pain relief.

Lesson #8

The patient reporting pain or difficulty breathing mitigates the need for continuous blood pressure and vital sign monitoring: In all surgical cases, only a handful (less than 1%) had their surgery aborted due to conditions identified as anxiety, unstable blood pressure, or an uncooperative patient. Any potential surgical morbidity condition reported by the anesthesiologist will allow the surgeon to consider aborting the surgical procedure at any time since the only incision is a 3 mm puncture wound on the skin.

Patients reporting difficulty breathing, chest or neck pain or any complaints for angina have had their procedure aborted or in some cases, abortion of surgery even before surgery commenced because on of an uncooperative or a patient at risk for any reason. In one case report of surgical abortion, there were no findings of a cardiac event and the eventual conclusion was patient anxiety. This has been reported as "broken heart syndrome".

There were no anesthetic complications in over 10,000 procedures.

Our team of anesthesiologists discusses anesthetic considerations making the use of local anesthesiology as safe procedure.

Lesson #9

Monitored Anesthesia Care (MAC): Monitored Anesthesia Care (MAC) sedation used in conjunction with surgeon provided local anesthesia at the surgical incision is the preferred anesthetic technique for Transforaminal Minimally Invasive Endoscopic Spine surgery. This anesthetic technique uses standard ASA monitoring (EKG, BP, Pulse Oximetry, Capnography) along with supplemental oxygen via nasal cannula that doubles as a CO_2 monitor to track patient respiration. The goal of anesthesia is to provide comfort and sedation to a responsive patient with minimal change in their cardiorespiratory function. With our patients positioned prone for the procedure, maintaining airway patency is of the utmost importance. This is achieved by careful titration of a short acting sedative hypnotic (midazolam) with a short acting analgesic opioid (typically fentanyl) to supplement a local anesthetic infiltration of the surgical site. Careful titration and patient monitoring is critical to patient safety and has the added benefit of allowing the patient to communicate with the surgeon throughout the procedure, allowing an extra element of patient safety compared to deep sedation or a general anesthetic technique. Verbal reassurance by the anesthesiologist can be used to reduce patient anxiety, and a responsive patient has the added benefit of being able to provide feedback to the surgeon as the procedure continues. If the patient is experiencing discomfort, the surgeon can use additional local anesthetic within safety limits of the drug being used, and the anesthesiologist can deliver additional analgesic/sedation medications for patient comfort.

Conclusion

Experience shows that conscious sedation is optimal for patient comfort and safety for this procedure, and has an added advantage of minimal post-operative recovery from anesthesia. If the level of sedation is deepened to the extent that verbal communication is lost, most of the advantages of sedation/analgesia are lost and the risk of the technique approximates those of general anesthesia with an unprotected and uncontrolled airway (1). Vigilant monitoring and careful attention of the patient's level of consciousness has shown to be safe for more than 10,000 Minimally Invasive Endoscopic Spine surgeries performed at the center. Dr. Yeung and his associates at Squaw Peak Surgical Facility and Desert Institute do not allow Propofol for Spine Care per surgeon preference. While it may be safe when preferred some cases, the level of sedation can also be mitigated by more generous use of local anesthetic by the surgeon within the safe parameters of the use of local anesthetic agents.

Competing Interests

The lead author is the developer of the YESS endoscopic system by Richard Wolf GMBh. No funding was received for this manuscript. The lead author acknowledges contributions by the coauthors for their contribution to the surgical and anesthesia database.

References

1. Yeung AT, Porter J (2001) Neuromonitoring for the prevention of surgical dysesthesia.
2. Yeung AT, Porter J (2002) Effect of sequential electrical surface stimulation on medication utilization following selective endoscopic discectomy™: Initial evaluation. J Minim Invasive Spine Surg Tech 2: 26-27.
3. Yeung AT, Savitz MH, Chiu JC (2003) Endoscopic removal of three incidental synovial cysts of the lumbar facet joint. J Minim Invasive Spine Surg Tech 2: 42-45.
4. Yeung AT, Yeung CA (2005) Endoscopic surgery and minimally invasive techniques. (7th edn). Pain management: A practical guide for clinicians, Cole. B and Bosworth M. (edS) CRC Press: Taylor and Francis, Boca Raton.
5. Yeung AT, Yeung CA (2003) Advances in Endoscopic Disc and Spine Surgery: Foraminal approach. Surg Technol Int 11: 255-263.
6. Yeung AT, Yeung CA (2016) Percutaneous transforaminal Endoscopic Spine surgery: State- of- the- Art: In Best new technologies in spine and Pain Management from A to Z. SYA Press and Research, Inc. in Spine Universe, Internet article.
7. Yeung AT, Yeung CA (2006) Microtherapy in low back pain Mayer HM (ed): Minimally invasive spine surgery (2nd edn) Berlin Heidelberg, Germany Springer Verlag, pp: 267-277.

8. Yeung AT (2006) Selective Endoscopic Discectomy™ Twelve years' experience" in Kambin P (ed) Atlas of Arthroscopic and Endoscopic Spinal Surgery, Text and Atlas, (2nd edn) Totowa, NJ. Humana Press, Inc.
9. Yeung AT, Yeung CA, Zheng Y (2010) Endoscopic decompression, ablation and irrigation: A minimally invasive surgical technique for painful degenerative conditions of the lumbar spine. Cosar, Khoo (eds). J Spine Neurosurg 5: 3.
10. Yeung AT, Savitz MH, Chiu JA, Rauschning W (2005) Synovial cysts of the lumbar facet joint, in the practice of minimally invasive spinal technique, Savitz MH, Yeung AT, (eds), AAMISS Press, New City, New York, pp: 512-516.
11. Yeung AT, Gore SR (2011) In-vivo endoscopic visualization of patho-anatomy in symptomatic degenerative conditions of the lumbar spine II: Intradiscal, foraminal, and central canal decompression. Surg Technol Int 21: 299-319.
12. Yeung AT, Savitz MH, Chiu JA, Rauschning W (2005) Furcal Nerves. The practice of minimally invasive spinal technique, Savitz MH, Chiu JC, Rauschning W, Yeung AT (eds) AAMISS Press, New York.
13. Gore S, Yeung AT (2014) The "inside out" transforaminal technique to treat lumbar spinal pain in an awake and aware patient under local anesthesia: Results and a review of the literature. Int J Spine Surg 8: 28.
14. Yeung AT (2017) Transforaminal endoscopic decompression for painful degenerative conditions of the lumbar spine: A review of one surgeon's experience with over 10,000 cases since 1991. J Spine Neurosurg 6: 2.
15. Yeung A, Yeung CA (2017) Endoscopic identification and treating the pain generators in the lumbar spine that escape detection by traditional imaging studies. J Spine 6: 369.