

8-9-2014

The Effectiveness of Local Anesthetic Infiltration into a Surgical Wound Prior to Surgical Closure

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THE EFFECTIVENESS OF LOCAL ANESTHETIC INFILTRATION INTO A
SURGICAL WOUND PRIOR TO SURGICAL CLOSURE

by

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For the Degree of Doctor of Philosophy in

Biomedical Science

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2014

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ACKNOWLEDGEMENTS

The knowledge and skills learned with the various stages of this thesis project would not have been possible without the ever present mentoring and unending patience of Dr. Sarah Sweitzer, PhD. Without the patience, support and understanding of my wife and children, Shauna, Jessica and Brandon this educational adventure would never have been possible. I would also like to recognize the cardiovascular anesthesia team (Brian Alexander, Robert Britt, Rebecca DeBoer, and Shawna VanValkenburg) at Palmetto Health Richland, for without them doing extra cases and changing their schedules to accommodate my school schedule this could not have happened.

ABSTRACT

With 73 million surgical procedures annually, acute post-operative pain management is critical to improve patient outcomes and reduce health care costs. Local anesthetic (LA) infiltration prior to surgical incision closure is a frequently used technique in the operating room. This thesis tested the hypothesis that the use of post-incisional infiltration of local anesthetics into surgical incisions will reduce post-operative pain as evidenced by assessing the reduction in post-operative opioids and the Visual Analog Scale (VAS). The first phase of this study was to examine the available literature to determine what evidence existed as to the effectiveness of local anesthetics infiltrated into surgical incisions. A systematic review of the literature revealed that few studies have examined the effectiveness of local anesthetic infiltration into surgical incisions on post-operative pain outcomes and these results varied greatly and did not agree on the effectiveness of the practice. The second phase was to conduct a survey of surgeons, in the state of South Carolina, to better determine what specialties utilized this practice, determine if the beliefs of those who did and did not use this local anesthetic infiltration technique, and to better define a subgroup of patients that would be examined in a retrospective study. A survey of surgeons revealed that approximately 65% of surgeons used local anesthetics injected into the surgical wound at the end of the surgical procedure with 95% of those indicating they believe it reduces surgical pain and 41% indicated that it reduced opioid consumption. In contrast to the high usage of this practice, only 18% of those surveyed believe that this practice is evidenced based. The final, third phase, was a retrospective study of adult

patients that underwent outpatient repair of abdominal hernias done by either an open or laparoscopic surgical techniques. A statistical significant reduction in pain was noted in both the post-operative visual analog scale ($p < 0.001$) and post-operative opioid consumption ($p < 0.001$) in patients who were treated with local anesthetic infiltration prior to wound closure when compared to surgical patients who did not receive local anesthetic. The greatest reduction appeared to be in the first 30 minutes after surgery but an overall pain reduction was noted in the 4 hours post-operatively. These studies identified the need for good quality retrospective and prospective studies examining the efficacy of perisurgical local anesthetic on post-operative pain and opioid consumption.

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LIST OF ABBREVIATIONS

CDC	Center for disease Control
IV	Intravenous
LA	Local Anesthetic
NIH	National Institute of Health
NSAID's	Non-steroidal anti-inflammatory drugs
SEM	Standard error of the mean
SD	Standard deviations
VAS.....	Visual Analog Scale

CHAPTER 1

INTRODUCTION

In the United States, more than 73 million surgical procedures are performed in patients annually. Up to 75% of these patients experience pain after surgery, which can have a significant effect on recovery time (Kessler, Shah, Gruschkus, & Raju, 2013). Post-operative acute pain management is a major health issue (Allegri, Clark, De Andres, & Jensen, 2012). Acute post-operative pain management is critical to patient satisfaction and a timely discharge, for improved outcomes and to reduce health care costs. Post-operative pain management is a large contributor to the overall cost of health care and long term hospital viability (Allegri et al., 2012).

1.1 Treatment of acute operative pain:

Currently, the standard treatment for acute post-operative pain is the use of systemic opioids. Opioids bind to specific receptors located throughout the central nervous system and other tissues. Four major opioid receptor types have been identified; mu (μ), kappa (κ), delta (δ), and sigma (σ). All opioid receptors couple to G proteins, resulting in membrane hyperpolarization in neurons and inhibiting neuronal activation. Opioids inhibit voltage-gated calcium channels and activate inwardly rectifying potassium channels. Opioid receptor activation inhibits the presynaptic release and postsynaptic response to excitatory neurotransmitters (acetylcholine, substance P) from nociceptive neurons. Opioid receptors respond to systemically administered exogenous opioids. Modulation through a

descending inhibitory pathway from the periaqueductal gray matter to the dorsal horn of the spinal cord also plays a role in opioid analgesia. Although opioids exert their greatest effect within the central nervous system, opioid receptors have also been identified on somatic and sympathetic peripheral nerves (Mikhail, 2013). Unfortunately, opioids are not without complications. Drowsiness, nausea, vomiting, ileus, urinary retention and pruritus, are all side effects of opioids (Brennan, 1999; Sherwinter et al., 2008). These side effects can lead to longer lengths of stays and poor patient outcomes (Brennan, 1999; Sherwinter et al., 2008).

Alternatively, there is growing use of IV acetaminophen post-operatively (Arslan, Celep, Cicek, Kalender, & Yilmaz, 2013; Pasero & Stannard, 2012). This practice limits the post-operative use of opioids and decreases opioid-induced adverse events (Macario & Royal, 2011). However, the use of IV acetaminophen is to be used with caution in certain patient populations like those with hypovolemia related to dehydration or blood loss, those suffering from chronic alcoholism, chronic malnutrition and severe kidney impairment. Furthermore, IV acetaminophen is contraindicated in individuals with severe hepatic impairment (Arslan et al., 2013; Pasero & Stannard, 2012).

Thus to adequately manage post-operative pain and reduce side effects of current therapies other courses of treatment must be considered. Peripheral nerve blocks are one of those approaches but these are technically much more difficult, must be performed by trained individuals and are not without potential lifelong complications. Complications of peripheral nerve blocks (paralysis and neurological deficits), both single injection and continuous infusions, are rare but do exist which can result in permanent and chronic issues (Allegri et al., 2012).

1.2 Local Anesthetic Wound Infiltration:

Another approach to control post-operative pain and limit post-operative opioid usage is local anesthetic wound infiltration prior to wound closure. In theory this approach should lessen peripheral and central hyperalgesia and minimize wound inflammation producing less post-operative pain without impairing wound healing (Scott, 2010; Sweitzer, Fann, Borg, Baynes, & Yost, 2006). The technique of injecting local anesthetics into the various layers of the surgical incision (wound) is a commonly used practice in general anesthesia surgical cases (Scott, 2010). Surgical wound infiltration with local anesthetics has continued to increase in popularity since the mid 1990's (Johnson, Hedges, Morris, & Stamatakis, 1999). It is relatively inexpensive, technically not difficult, and may potentially reduce the post-operative discomfort (Brower & Johnson, 2003). There are two main approaches to local anesthetic wound infiltration. The first is a preemptive model which applies the anesthetic prior to surgical incision. The second model applies the anesthetic immediately prior to surgical closure at the end of the surgical case. Several studies have applied both models and administered local anesthetic both prior to and at closure.

1.3 Preemptive Model:

Injecting local anesthetics prior to surgical incision into the surgical wound has been more extensively studied (Hilvering et al., 2011; Lohsiriwat, Lert-akyamanee, & Rushatamukayanunt, 2004; Lowenstein et al., 2008; Metaxotos, Asplund, & Hayes, 1999; Sihoe, Manlulu, Lee, Thung, & Yim, 2007; Venmans, Klazen, Lohle, & van Rooij, 2010; Walsh et al., 2007). The results in this area are mixed with several studies showing significant pain reduction (Lohsiriwat et al., 2004; Lowenstein et al., 2008; Sihoe et al.,

2007) while other studies did not find a reduction in pain or had mixed results (Fayman, Beeton, Potgieter, & Becker, 2003; Hilvering et al., 2011; Metaxotos et al., 1999; Venmans et al., 2010; Walsh et al., 2007).

1.4 Pre-closure model:

The technique of injecting local anesthetics, as a onetime dose (non-continuous infusion) is a relatively common practice. This technique involves the surgeon injecting local anesthetic into the various layers of the surgical incision (Figure 1.1). Although the technique may vary slightly from practitioner to practitioner it involves determining the dose of local anesthetic, based upon type of local anesthetic used and weight of the patient, as to not exceed the maximum dose, then injecting the LA with a syringe and needle into the various layers of the incision, which include the muscle, subcutaneous fat, dermal and epidermal tissues (Figure 1.2). While local anesthetic infiltration is relatively inexpensive, technically not difficult, and may potentially reduce the post-operative discomfort (Brower & Johnson, 2003) there is currently limited evidence base for pre-closure local anesthetic infiltration and a reduction in post-operative pain or opioid consumption. The technique of injecting local anesthetics after the surgical incision has been made (prior to ending the surgical procedure) and its reduction in post-operative pain remains in debate as to the effectiveness in both animal and human studies (Fitzpatrick, Weir, & Monnet, 2010).

1.5 Local Anesthetics:

Local anesthetics interrupt conduction of the neuronal pathway by inhibiting the sodium channel thus not allowing sodium to enter the cell. Action potential threshold is not reached and the electrical impulse is inhibited, so the “pain” impulse never reaches the

central nervous system. Local anesthetics work differently on different nerve fibers, based partially upon size of the fibers and varying characteristics of the local anesthetics themselves. Larger fibers are harder to block as it takes more local to block enough segments to prevent an impulse from being initiated and propagating toward the central nervous system.

All local anesthetics have the same basic structure that consists of 3 components, a lipophilic aromatic ring, an ester or amide linkage, and a tertiary amine (Figure 1.3). Although these are well known and predictable structures they are not without risk, although that risk is relatively small. Local anesthetics reach toxicity if injected or absorbed too quickly into the bloodstream and have varying degrees of consequences, from an antiarrhythmic effect and increasing to convulsions, coma and even cardiovascular collapse and respiratory arrest as serum concentrations increase. Allergic reactions to local anesthetics are rare and often caused by preservatives (methylparaben) and antioxidants like sulfites and not to the local anesthetic agent itself (Becker & Reed, 2012).

1.6 Hypothesis:

Thus in theory the use of local anesthetics injected into surgical incisions should reduce pain post-operatively and by doing so reduce the need for analgesics like opioids and non-steroidal anti-inflammatory drugs (NSAID'S) and their side effects. Unfortunately the body of evidence does not strongly suggest this when clinical trials are performed. As medicine has evolved over the past few decades, evidence based practice has become a corner stone of good practice. The evidence is not compelling that the use of local anesthetics injected into surgical incisions, at the time of surgical closure, is reducing post-

operative pain and other analgesic usage. My hypothesis is that “the use of post-incisional infiltration of local anesthetics into surgical incisions will reduce post-operative pain” as evidenced by assessing the reduction in post-operative opioids and the Visual Analog Scale (VAS).

To confirm this hypothesis, the area of study was divided into 3 phases. The first phase of this study was to examine the available literature to determine what evidence existed as to the effectiveness of local anesthetics infiltrated into surgical incisions. The second phase was to conduct a survey of surgeons, in the state of South Carolina, to better determine what specialties utilized this practice, determine the beliefs of those who did and did not use this local anesthetic infiltration technique, and to better define a subgroup of patients that would be examined in a retrospective study. The final, third phase, was a retrospective study of adult patients that underwent outpatient repair of abdominal hernias done by either open or laparoscopic surgical techniques.

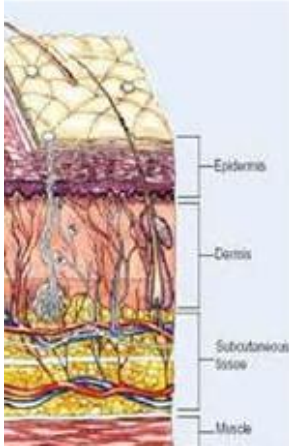


Figure 1.1: Layers of Injection

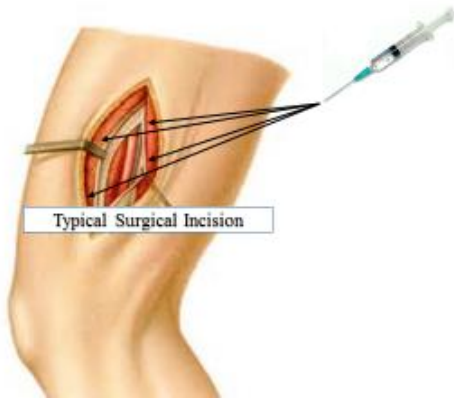


Figure 1.2: Surgical Incision with example of onetime (non-continuous) local anesthetic infiltration

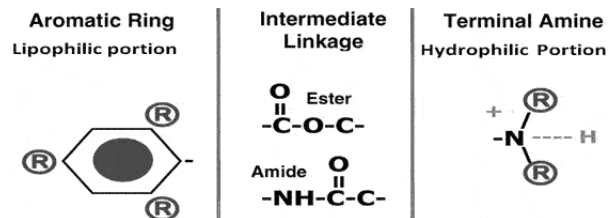


Figure 1.3: Structure of local anesthetics. Local anesthetics are composed of a lipophilic aromatic ring, an intermediate ester or amide linkage and a hydrophilic terminal amine.

CHAPTER 2

SYSTEMATIC REVIEW OF CLINICAL EVIDENCE FOR LOCAL ANESTHETIC WOUND INFILTRATION IN REDUCTION OF POST-SURGICAL PAIN

2.1 Introduction:

The focus of this systematic review was to determine the available literature addressing the use of one time local anesthetic infiltration after the surgical incision (wound) has been made and prior to wound closure. The outcomes examined were the reduction in post-operative pain using either a Visual Analog Scale or reduction in opioid usage. A review of the literature finds inconclusive evidence on the effectiveness of local infiltration prior to surgical closure in reducing post-operative pain (Fitzpatrick et al., 2010; Grainger & Saravanappa, 2008; Kuan, Smith, Miles, & Grigg, 2002; Venmans et al., 2010).

2.2 Methods:

Search Strategy:

Using the search engine PubMed and the search parameters of “local anesthetic infiltration and pain reduction” as well as “local anesthetic infiltration and wound healing” resulted in 137 documents. Both criteria were used to ensure that the search captured any aspects of local anesthetic infiltration and a broad area of local anesthetics and surgical incisional usage. The PubMed search done November 2012 identified 117 papers. This was

based on the criteria of “local”, “anesthetic”, “infiltration”, and “pain reduction”. Another search was run on the same date using the criteria of “local”, “anesthetic”, “infiltration”, and “wound healing” resulting in 47 papers. Some of the papers in the two searches repeated thus an overall total of 137 results were obtained. As this search did include several review articles, the specific articles that were reviewed were pulled and if additional to what was found in the original PubMed searches they were then included in the overall total of 150.

Inclusion of articles:

The majority of the articles (n=122) were excluded (Figure 2.1) if they stated perioperative without differentiating pre versus post incisional injection of the local anesthetic, used combinations of another medication like opioids, magnesium sulfate or topical anesthetics, continuous local anesthetic infusions, tumescent instillations (high volume), local anesthetic versus topical anesthetics, peripheral nerve blocks, local anesthetic versus general anesthesia or were not available in English, as these are not the focus of this review. The remaining 28 publications were sorted into two categories: pre-incisional administration, prior to surgical incision, and post-incisional administration at the time of wound closure. One of the post-incisional administration articles was a review article (Vasan, Stevenson, & Ward, 2002) and the original studies from the review were included in this analysis but the review article was excluded.

The inclusion criteria included all surgical sites, retrospective and prospective studies, as well as any meta-analysis/systematic reviews. Any studies that used a single infiltration of local anesthetic, both pre and post-incision with pain reduction

measurements, were included as the number of studies found for post incision only was very limited.

Assessment of Article Quality:

Articles were assessed for quality (Table 2.1) by assessing study design (approach, inclusion/exclusion criteria, randomization, methods), subjects (inclusion criteria, demographics, control matching), outcomes, and implementation (blinding, follow-up). Article quality was assessed independently by the two authors and any discrepancy in scoring was discussed and a consensus was reached between the two authors of this study, Kevin LeBlanc and Sarah Sweitzer.

Normalization of VAS scores for comparison across studies:

To compare the effectiveness of the local anesthetics in reducing pain in the post-operative period, a normalized change in VAS was calculated for all studies that presented VAS scores with Standard Error of Mean (SEM) or standard deviations (SD). The choice was made, by both the authors, to use standard deviations. If the study listed a standard error of the mean, this was converted using a standard statistical formula ($SD = SEM \times \text{square root of } n$). Several studies did not present either group averages or SEM or SD and could not be included in this comparison. Several different visual analog scales were used (as some used a 0-100 or 0-5 scale) across studies. A standard 0-10 scale was chosen to normalize data. All studies examined were converted into this 0-10 VAS scoring standard.

2.3 Results:

The objective of this study was to determine the evidence base for the use of local anesthetic infiltration at the end of surgery prior to wound closure and its effectiveness in pain reduction using a VAS score and a reduction in post-operative opioid consumption. The included articles ranged in quality from poor to good and examined local anesthetic infiltration with a variety of local anesthetics (n=10 bupivacaine, n=4 ropivacaine, n=3 lidocaine articles), various surgical sites (n=9 tonsillectomy, n=4 iliac crest harvesting procedures, and n=1 saphenous vein stripping studies), a number of different pain outcomes (n=14 VAS, n=5 additional analgesic consumption), and large variations in clinical sample sizes (18-100 patients in a study). The lack of consistency between studies prevents a meta-analysis of the findings and so we present the results as a systematic review and grouped by surgical site (Table 2.2). The largest groups of studies were examining the effectiveness of local anesthetic infiltration on post-tonsillectomy pain. Nine studies were found that included a total of 623 patients and focused on the efficacy of local anesthetics infusion on post-tonsillectomy pain (Grainger & Saravanappa, 2008). All of these studies were prospective randomized designs, with ages ranging from 2 to 65 years of age. Five of the studies looked at children (2 to 17 years of age), 3 studies addressed a mix of children and adults (ages 8-65) and one study only had adults (no ages listed) (Grainger & Saravanappa, 2008). Studies examined used bupivacaine compared to saline (placebo), bupivacaine compared to ropivacaine or a three group comparison of bupivacaine, ropivacaine and saline. The doses of bupivacaine ranged from 3-6 ml of 0.25% to 0.5%, the doses of ropivacaine ranged from 0.2% to 2% and lidocaine of 1.5-5 ml of 1%-2%. All studies but one used the pre-incisional injection of the tonsillar bed, with six of the studies

(out of nine total) finding a reduction in post-operative pain via a pain scale similar to the visual analog scale. (Akoglu, Akkurt, Inanoglu, Okuyucu, & Dagli, 2006; Arikan, Ozcan, Kazkayasi, Akpinar, & Koc, 2006; Jebeles, Reilly, Gutierrez, Bradley, & Kissin, 1993; Naja, El-Rajab, Kabalan, Ziade, & Al-Tannir, 2005; Sorensen, Wagner, Aarup, & Bonding, 2003) Two studies did find that post-operative pain was not reduced (Unal et al., 2007; Vasan et al., 2002), one stating that after consideration of the usage of other analgesics they saw no reduction in the amount of the other analgesics required for patient comfort. (Johansen, Harbo, & Illum, 1996)

One of the highest quality tonsillectomy studies examined pre-incisional versus post-incisional injection of bupivacaine (0.25% with 6 ml used in children and 9 ml used in adults), using saline injection as a control. This was a randomized, double blinded, placebo-controlled study, of 68 patients ranging from 8 to 65 years of age. Pain was assessed by the visual analog scale at varying time intervals from 1 to 21 hours. It was noted that there was not a significant difference between the bupivacaine pre-and post-incisional groups in pain reduction, but there was a significant difference in these groups compared to the saline groups. This study did address the use of other analgesics (acetaminophen) when assessing the VAS score, but the researchers did not note doses or frequency of those analgesics, as they were looking at the pre versus post-incisional infiltration and if differences in post-operative pain was more effective in the pre- versus the post-incisional groups (Molliex et al., 1996). This study suggests that in tonsillectomy either pre- or- post-incisional infiltration of bupivacaine may produce a reduction in post-surgical pain when compared to the saline (control) group.

The next largest group of studies included four studies that examined Ropivacaine (7.5% 10mls) or Bupivacaine (0.5% from 4-20mls) versus a control site of saline or no injection in Iliac Crest bone harvesting surgery. In all studies the local anesthetic was injected post-procedure and looked at visual analog scale. None of the studies noted whether other analgesics were used by the patients. The total number of patients from the four studies was 187, and all studies concluded that pain was reduced at the local anesthetic site compared to the control site. (Chern, McCarthy, Hutchins, & Durrant, 1999; Hoard, Bill, & Campbell, 1998; Schaan, Schmitt, Boszczyk, & Jaksche, 2004; Todd & Reed, 1991)

One additional study examined the use of Bupivacaine 2mg/kg in saphenous vein stripping. The study examined 18 female patients undergoing bilateral saphenous vein stripping, injecting either the right or left surgical site and using the other side as a control. Ten of the 18 were injected prior to closure and the remaining 8 were injected prior to surgical incision, but in all cases the subjects were unaware which the bupivacaine injected site was and which was the control (not injected site). Neither pre- or post-incisional administration of bupivacaine showed a reduction in pain, as assessed by a visual analog scale (Kuan et al., 2002).

To compare the efficacy of local anesthetic infiltration in the reduction of post-surgical pain, the pain scores were extracted from the studies included in this review and normalized to a 10 point VAS scale (Figure 2.2). A majority of the studies used local anesthetic (pre- or post-incision) in tonsillectomies and demonstrated highly variable reductions in postoperative pain. Several studies stated a significant reduction ($p < 0.05$) in postoperative pain but in many cases the overall change in the VAS from the control to the local anesthetic groups was small or the error bars were large.

2.4 Discussion:

The use of a multimodal approach to pain relief is not new and the use of local anesthetics in surgical wound, both prior to and post incision is a common practice in the surgical suite (Johnson et al., 1999). Surgeons want to reduce post-operative pain in their patients, while reducing the potential side effects associated with opioids and other analgesics. In spite of the widespread use of this practice, the evidence base for local anesthetic infiltration prior to surgical closure has not been assessed in the literature. This review demonstrates that despite the widespread use of this practice across a variety of surgical sites there is a paucity of high quality evidence to support this practice. In addition, the variability in study designs and patient populations make it difficult to draw global conclusions about the effectiveness of this approach in reducing post-operative pain and opioid consumption. The limited number of studies that show a positive effect of this preemptive approach to control post-surgical pain highlight the need for further well designed randomized controlled trials across a variety of surgical sites.

The varied type of local anesthetics used from study to study further complicates the issue of whether using local anesthetics reduces pain post-operatively as efficacy might be dependent upon the duration of action of the different local anesthetics employed. With studies looking at different local anesthetics, often comparing if one type is more effective than another, the true effectiveness of local anesthetics in reducing post-operative pain is still unclear. An ideal local anesthetic would have a short onset of action, minimal side effects, would not affect wound healing and would last 12- 24 hours thus reducing the need for other analgesics in the post-operative period while still reducing post-operative pain. As to the question of whether injecting the local anesthetic prior to or post incision is also

in debate, and when you consider that studies on the same site (i.e. tonsillectomies) do not agree as to the effectiveness of pre-incisional injection, the effectiveness of the less studied topic of post-incisional injection begs for further research.

A clear limitation in any clinical study looking at post-operative pain and pain control is the use of the VAS scale as a sole outcome. The VAS scale is a proven standard of measure for patient pain but is based on patient subjectiveness. There is not a current guideline as to how large a change in VAS should be to be considered not just statistically significant but also physiologically and clinically significant. In the current review, several studies claimed a change in VAS of 20% was significant while others did not. With this in mind the need for further good quality retrospective and prospective studies remains paramount, as the technique of injecting local anesthetics to reduce surgical pain is a commonly used practice. Alternatively, future study designs could be strengthened by including other “non-subjective” measures of pain control such as overall analgesic consumption, discharge time, and perhaps patient satisfaction. The majority of studies found, in this literature search, did not address the amount or frequency of opioid or other analgesics. Further studies need to be conducted addressing not only the reduction in VAS but the overall dosing and frequency of other pain reducing medications.

Although the use of local anesthetic infiltrated into the surgical wound prior to incision has been studied more extensively, the results are still not conclusive as to the effectiveness in reducing post-operative pain. Only a few studies address the use of additional analgesics to help control pain in the post-operative period. Studies that examine the technique of post-incisional injection of local anesthetics and their effectiveness are lacking. One study looked at Levobupivacaine injected prior to trocar insertion on 101

patients undergoing a laparoscopic cholecystectomy did not find a significant reduction in post-operative pain as measured by a VAS scale (Hilvering et al., 2011). As noted above, six of the nine studies found the use of local anesthetic infiltrated pre-incision, while examining post-operative pain in tonsillectomies, reduced pain post-operatively but only one addressed the use of other analgesics to reduce pain. In that study, local anesthetic injection was without effect (Johansen et al., 1996).

The use of continuous infusion of local anesthetics, that is to say a continuous infusion into the surgical site, has been shown to be effective, in the studies examined (Gottschalk et al., 2003; LeBlanc, Bellanger, Rhynes, & Hausmann, 2005), but often requires inpatient hospitalization and special infusion devices and thus is more costly. The other methods previously discussed, pre and post-incisional one time tissue infiltration, are often done for both inpatient and outpatient procedures thus not significantly altering procedural costs. In today's health care atmosphere this must and is an important consideration.

In conclusion further investigation needs to be done on the use of local anesthetics, as an augment to general anesthesia, in reducing post-operative pain while potentially reducing other analgesic usage, thus reducing the potential adverse side effects of medications like opioids. The use of post-incisional infiltration of local anesthetic into the surgical incision was not found to be significantly studied, and the studies that do exist do not agree as to the effectiveness.

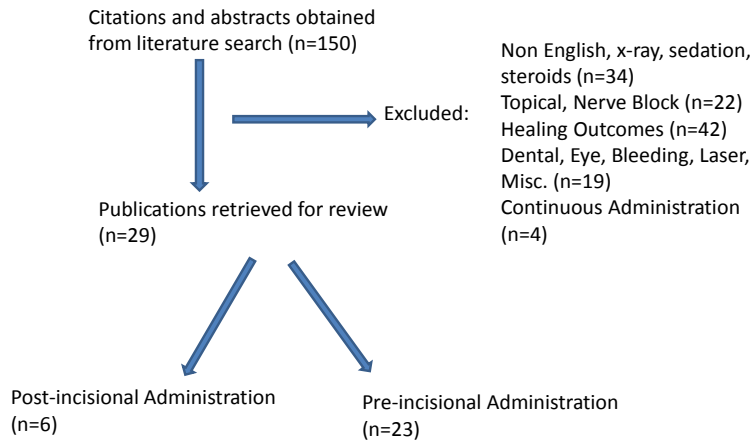


Figure 2.1: Literature Search Results

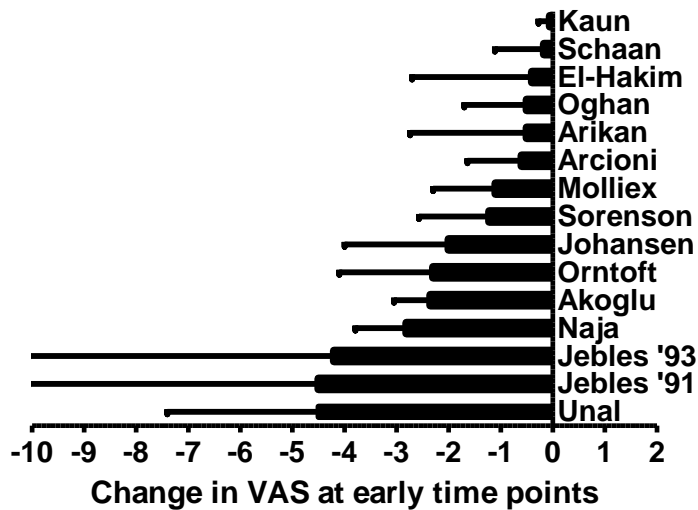


Figure 2.2: Study results showing change in VAS from control groups with error bars

Table 2.1: Criterion for determining the quality of papers included in the systematic analysis.

Score	Study Design	Subjects	Outcome	Implementation
Good – 2	<p>Clear description of design</p> <p>Design appropriate for study question</p> <p>Clear inclusion/exclusion criteria</p> <p>Procedures for randomization clearly described (if applicable)</p> <p>Experimental methods (doses/treatment schedule) clearly defined</p>	<p>Subjects meet inclusion criteria</p> <p>Demographics for all subject groups are included</p> <p>Controls adequately match study subjects</p>	<p>Clearly defined including methods of measurement</p> <p>Outcome measures answer the study question</p>	<p>Groups comparable at baseline</p> <p>Blinding is maintained across study</p> <p>All patients accounted for at end of study</p> <p>Valid methods</p> <p>Appropriate and well described statistics</p> <p>Summary statistics needed for a meta-analysis included in the paper</p>
Fair – 1	Missing 1 of the criteria listed above	Missing 1 of the criteria listed above	Missing 1 of the criteria listed above	Missing 1 of the criteria listed above
Poor - 0	Missing greater than 1 of the criteria listed above	Missing greater than 1 of the criteria listed above	Missing greater than 1 of the criteria listed above	Missing greater than 1 of the criteria listed above

Table 2.2: Summary of the study design, number of patients, surgical site, outcomes and quality of the study for each of the trials included in this systematic analysis.

Study Design	# of Patients	Surgery Type	Intervention	Outcome	Quality Score of paper	Reference
Randomized Control	46	Tonsillectomy	Ropivacaine versus Bupivacaine	Post-operative pain reduced, no difference in comparison groups	7	Akoglu
Prospective Randomized DBL BL	52	Tonsillectomy	Lidocaine	Effective in pain reduction	5	Sorensen
Prospective Randomized DBL BL	70	Tonsillectomy	Bupivacaine	Pre-incisional injection not effective	7	Vanan
Prospective Randomized DBL BL	20	Tonsillectomy	Bupivacaine	Pre-incisional injection effective	5	Arikan
Prospective Randomized DBL BL	60	Tonsillectomy	Bupivacaine versus ropivacaine	Pre-incisional injection neither effective in pain control	8	Unal
Randomized Control	20	Tonsillectomy	Lidocaine 1% and 0.125% bupivacaine vs. control	Pre-incisional injection but no reduction in pain	1	Arcioni
Prospective randomized DBL BL	41	Tonsillectomy	Ropivacaine 1% vs. saline	Pre-incisional soaked swabs (topical)	6	Oghan
Randomized Prospective DBL BL	19	Tonsillectomy	Lidocaine 2% vs. saline	Pre-incisional injection had more rapid return to normal function	8	Naja
Prospective DBL BL	68	Tonsillectomy	Bupivacaine	Pre and post effective	8	Molliex
Prospective DBL BL	19	Tonsillectomy	Bupivacaine vs. Saline	Pre-incisional injection no difference in first 24 hrs	5	Johansen
Prospective DBL BL	14	Tonsillectomy	Bupivacaine vs. Saline	Pre-incisional injection effective	6	Jebeles '91

Prospective DBL BL	22	Tonsillectomy	Bupivacaine vs. Saline	Pre-incisional injection effective	3	Jebeles '93
Prospective Randomized blinded	92	Tonsillectomy	Bupivacaine vs. saline	Pre-incisional injection, Not effective	8	El-Hakim
Prospective DBL BL	42	Tonsillectomy	Bupivacaine vs. saline	Pre-incisional injection, Not effective	7	Stuart
Prospective randomized	50	Tonsillectomy	Bupivacaine vs. saline	Pre-incisional injection, Not effective	5	Schoem pedes
Prospective randomized	51	Tonsillectomy	Bupivacaine vs. saline	Pre-incisional injection, Not effective	5	Schoem Adult
Prospective DBL BL	18	Vein Stripping	Bupivacaine	Not effective	3	Kuan
Prospective DBL BL	100	Iliac Crest	Ropivacaine	Effective	4	Schaan
Prospective Single BL	24	Iliac Crest	Bupivacaine	Effective	5	Chern
Prospective	34	Iliac Crest	Bupivacaine	Effective	0	Hoard
Random Prospective	29	Iliac Crest	Bupivacaine	Effective for first 4 hours	2	Todd

CHAPTER 3

HOW COMMON IS LOCAL INFILTRATION PRIOR TO WOUND CLOSURE IN THE OPERATING ROOM. A SURGEON SURVEY

3.1 Introduction:

Acute post-operative pain management is critical to patient satisfaction and a timely discharge. Post-operative pain management is a large contributor to the overall cost of health care and long term hospital viability (Allegri et al., 2012). Currently, systemic opioids remain the gold standard treatment for acute post-operative pain. Side effects of opioids, especially the sometimes high doses required to adequately alleviate post-operative pain, include drowsiness, nausea, vomiting, ileus, urinary retention and pruritus. These side effects can lead to longer lengths of stays and poor patient outcomes (Brennan, 1999; Sherwinter et al., 2008). In response to the limitations associated with post-surgical opioid use there has been a growing use of IV acetaminophen in the first 24 hours post-operative (Arslan et al., 2013; Pasero & Stannard, 2012). It is suggested that iv acetaminophen will reduce post-operative opioid usage and opioid-associated adverse events (Macario & Royal, 2011). However, post-operative intravenous acetaminophen is not appropriate for all patients and has only recently gained popularity in the United States (Arslan et al., 2013; Pasero & Stannard, 2012). Another approach to reduce post-operative pain and opioid usage has been local anesthetic wound infiltration prior to wound closure.

This is a popular technique as it does not distort the surgical area and given at the end of surgery can still be effective in the post-operative period. In theory, local anesthetic infiltration at the time of wound closure should decrease action potential generation in somatic and muscle afferent fibers in the incisional area. This should result in post-operative pain reduction. The technique of injecting local anesthetics into the various layers of the surgical incision is often quoted as a commonly used practice in general anesthesia surgical cases but a survey of its incorporation into clinical practice has never been published (Scott, 2010). With the rise in laparoscopic surgical techniques, the literature suggests there has been a rise in local anesthetic wound infiltration prior to closure (Johnson et al., 1999) but it is unclear if a parallel rise of this technique has occurred in other surgical arenas.

While local anesthetic infiltration is relatively inexpensive, technically not difficult, and may potentially reduce the post-operative discomfort (Brower & Johnson, 2003) there is little evidence pre-closure local anesthetic infiltration reduces post-operative pain and/or opioid consumption. A previous systematic review of the available literature showed mixed reviews as to the effectiveness of this technique and highlighted the need for additional studies in the field. As a first step in the design of future studies, examining the efficacy of local anesthetic infiltration of post-surgical pain management, requires an understanding of when and where this technique is currently being applied. The focus of the current survey study was to determine the prevalence of this technique of local anesthetic surgical wound infiltration in a cohort of surgeons and the beliefs that surgeons have for using or not using this technique.

3.2 Methods:

Survey design:

This survey study was granted exempt status from the Palmetto Richland Institutional Review Board. The 18 question anonymous survey determined the prevalence of local wound infiltration prior to surgical closure across surgical specialties, as well as the reason and beliefs of why this practice occurs. All questions were designed with the time constraints of the surgeons in mind, and thus utilized a method where the surgeon selected a multiple choice prepared response, although the surgeon still had an area to choose “other” and fill in a response if they felt the prepared responses did not fit their practice. In addition, after development of the survey a focus group of 5 surgeons, specialized in general, neurosurgery, orthopedics and trauma, went through the survey and provided their suggestions for refinement of the survey. These surgeons addressed several areas of the survey, specifically as it pertained to surgical site, including more specific body areas as well as questions on the beliefs of why local anesthetics are used or not used.

The survey consisted of in three parts: demographic data, prevalence of technique, and reasons for using or not using the technique. The first 7 questions collected demographic data that included where in the USA their practice was located, years of practice, region of training (residency), specialty, size, and location (rural/inner city) of their major hospital of practice. The next 8 questions determined the usage of local anesthetic surgical wound infiltration prior to surgical incision or at the time of closure, which surgical sites were commonly used, which surgical sites were never used, if surgeons who use local infiltration include epinephrine with the local anesthetic, what was the

preferred local anesthetic agent, and how many layers of the incision are infused with anesthetic. With the questions that asked about use, a 4 tiered response was provided: Yes, Always; Yes, Sometimes; Yes, Rarely; and No, Never. For sometimes and rarely, surgeons were given the option to write in a percentage and approximately 95% provided actual percentage estimates in the survey administration. The last three questions assessed attitudes/beliefs about local anesthetic infiltration and why they choose to administer local anesthetic at closure. These final questions were designed to determine the reasons why the surgeon used the local technique and their beliefs as to the effects on patient care (pain reduction, opioid reduction, etc.) and the reasons why they use this technique (evidence based, taught, personal experience...). If a surgeon stated they did not use local or used it prior to surgical incision, they were then directed to answer questions as to why they did not use the technique of infiltration just prior to incision, with their beliefs and patient care reasons.

Survey Administration:

The survey was administered at 15 hospitals in South Carolina; these included both inner city and rural facilities ranging in size from 50 to >600 bed facilities. The surveys were distributed with the assistance of the anesthesia departments in all hospitals. Surgeons were asked to fill out the survey by nurse anesthetists or via email from administrators of the anesthesia departments. The surgeons returned the surveys either electronically, or as most preferred as a hard copy survey. In all, 300 surveys were distributed to surgeons in South Carolina. The survey was not sent out nationally as the logistics/time constraints did not permit this. The data were kept confidential and only generalized data were used. No

surgeon or patient identifiers were used in this survey. No specialties of surgery were excluded and most specialties responded and thus were represented in the final results.

Data Analysis:

All data were then entered into an electronic spread sheet and analyzed by the primary author and verified by the secondary author.

3.3 Results:

Demographics of Participating Surgeons:

Three hundred surveys were distributed and 92 (31%) were completed and returned. All surgeons stated that their primary practice was located in the South Carolina. The survey regarding the percentages of payer mixes was not included in the final analysis as 75% of surgeons stated that these percentages were very uncertain and that with changes in practices and health care these were a guess at best. The majority (94.5%) of surgeons practiced at primary practice hospitals with >200 beds. Half of the surgeons practiced at inner city hospitals and 43% classified their hospital practice as suburban. The surgeons that completed the survey completed their residency training in the South (74%), Northeast (14%), Midwest (12%), and West (0%). There was a good mix of how many years the surgeons had been in practice ranging from 1 to greater than 30 years (Figure 3.1). The specialties that were identified represented all areas and were in ratios typical of most full service hospitals in America (Table 3.1).

Prevalence of Local Anesthetic Infiltration:

Over 90% of surgeons surveyed use local anesthetic infiltration at least occasionally. Of those, 45% use local anesthetic both pre- and post-incision, 26% use it only pre-incision, and 20% use it only post-incision (pre-closure) (Figure 3.2). Only 9% of surgeons surveyed reported having never used local anesthetic infiltration. Approximately 39% of surgeons who use local before incision use it less than 20 percent of the time while 49% of surgeons used local anesthetic greater than 50 percent of the time (Figure 3.3). Over half (51%) of surgeons that utilized the post incisional infiltration technique (at surgical closure), use this technique less than 20 percent of the time and only 35% use local infiltration in more than half of their surgical cases (Figure 3.4).

Local Anesthetic Choice:

Bupivacaine was the most common local anesthetic used (49% of surgeons who used local infiltration). Lidocaine was the next most common, followed by ropivacaine (Figure 3.5). The remaining percentage of surgeons did not specify the type of local they used. The use of epinephrine in the local anesthetic was used by a wide variety of surgical specialties and utilized with all types of anesthetics. Of those surgeons who use local anesthetics, pre- or post-incisional, only 30% use epinephrine added to the infiltrated local anesthetic.

Attitudes and Beliefs:

Of the surgeons that use local anesthetic either before incision or prior to closure, 100% believe that this practice alleviates postoperative pain (Figure 3.6). In contrast, only 45% of surgeons felt that it reduced post-operative opioid usage and very few (1%)

indicated local anesthetic infiltration into the surgical wound reduced complications or inflammation or increased early ambulation. Interestingly, while 100% of surgeons believe that the practice will reduce post-operative pain, only 18% of surgeons stated that the use was evidence based medicine. In general 50% of surgeons report using this technique based on personal experience and 33% indicated their use is based on what they were taught in residency (Figure 3.7).

In contrast, the surgeons that did not use local anesthetic infiltration post incision (n=41) reported that they did not feel the practice reduced post-surgical pain (25% of respondents) and they were not taught this practice in residency (27%). In addition, “personal experience” was chosen 27% of the time as a reason for why they did not use local anesthetics. Two out of the 41 surgeons indicated that this practice was not applicable to their patients or that it may injure the patient (Figure 3.8).

3.4 Discussion:

This study demonstrates that the use of pre- and post-incisional local anesthetic infiltration is a common practice in the operating room with less than 10% of surgeons never using these techniques. The remaining surgeons use local anesthetic infiltration at least on occasion with a smaller group using it very frequently. The most commonly cited reason for using these techniques is a surgeon belief in the reduction of post-operative pain. Interestingly, the majority of surgeons recognize the limited evidence base for this practice and instead use it based on personal experience or having been taught the technique in

residency. As would be expected as years of experience increased, the number indicating they use or do not use local anesthetics based upon personal experience increased.

The use of a multimodal approach to pain relief is not new and the use of local anesthetics in surgical wound, both prior to and post incision, is a common practice in the surgical suite (Johnson et al., 1999). Surgeons want to reduce post-operative pain in their patients, while reducing the potential adverse side effects associated with opioids and other analgesics. In spite of the widespread use of this practice, the evidence base for local anesthetic infiltration prior to surgical closure is limited in the literature.

The largest group of studies in this area investigate the use of either pre- or post-incisional local anesthetic infiltration in tonsillectomy (Akoglu et al., 2006; Arikan et al., 2006; Grainger & Saravanappa, 2008; Jebeles, Reilly, Gutierrez, Bradley, & Kissin, 1991; Jebeles et al., 1993; Molliex et al., 1996; Naja et al., 2005; Sorensen et al., 2003; Vasan et al., 2002). The results from these studies range from no effect to showing some efficacy. The ability to extrapolate these studies to a wider surgical population is limited by the wide variation in study designs (controls, blinding), methods for applying the local anesthetic, local anesthetic used, the varied pain scales, the use of the contralateral tonsil as the control, and the use of different local anesthetics in the different studies. In addition, the anatomical differences inherent between surgically resecting a tonsil and abdominal surgery adds another layer of complexity in extrapolating these limited findings to the larger surgical practice. A group of similar studies examining local anesthetic infiltration during iliac crest bone surgery demonstrate pain reduction with anesthetic compared to placebo (Chern et al., 1999; Hoard et al., 1998; Schaan et al., 2004; Todd & Reed, 1991). In contrast, a placebo controlled blinded study did not demonstrate a reduction in post-surgical pain with

local anesthetic infiltration at the time of closure in bilateral saphenous vein stripping surgery (Kuan et al., 2002). Thus, a review of the literature supports the general surgeon belief that this practice is not based on evidence from the clinical literature but rather on their personal experience and training.

In contrast to local anesthetics prior to closure, administering local anesthetics prior to surgical incision into the surgical wound has been more extensively studied (Hilvering et al., 2011; Lohsiriwat et al., 2004; Lowenstein et al., 2008; Metaxotos et al., 1999; Sihoe et al., 2007; Venmans et al., 2010; Walsh et al., 2007). The results in this area are mixed with several studies showing significant pain reduction (Lohsiriwat et al., 2004; Lowenstein et al., 2008; Sihoe et al., 2007) while other studies did not find a reduction in pain or had mixed results (Fayman et al., 2003; Hilvering et al., 2011; Metaxotos et al., 1999; Venmans et al., 2010; Walsh et al., 2007). The technique of injecting local anesthetics after the surgical incision has been made (prior to ending the surgical procedure) and its reduction in post-operative pain remains in debate as to the effectiveness in both animal and human studies (Fitzpatrick et al., 2010). The use of continuous infusion of local anesthetics into the surgical site may have some demonstrated efficacy (Gottschalk et al., 2003; LeBlanc et al., 2005).

This survey study has its limitations, being done in only one state and with 92 surgeons responding. However, in the state of South Carolina the number of surgeons listed by the 2013 Bureau of Labor and Statistics was 440 and thus, this survey represents 21% of surgeons within the state. In addition, while the survey was conducted at 15 hospitals, many of the surgeons surveyed have privileges to perform surgery at several hospitals and thus, the reported data are applicable to a greater number of hospitals in the region. To

ensure that the survey was not duplicated by the same surgeon, each surgeon was instructed they could only fill out the survey once regardless of the number of hospitals they practice at. Thus, these 92 responses are a fair representative sample of surgeons practicing in South Carolina, which may or may not be representative of other southeastern states, or states in other regions of the country. Additional surveys across the region and the United States are needed to determine how widespread and common these techniques are being applied on a daily basis in operating rooms.

Surgeons are utilizing and admit that they use this technique to reduce post-operative pain, but only less than 20% feel that the technique of infiltrating local anesthetics is evidence based. Of those that use the technique less than 40% feel local anesthetics reduces post-operative opioids. This survey further verifies the need for good quality retrospective and prospective studies.

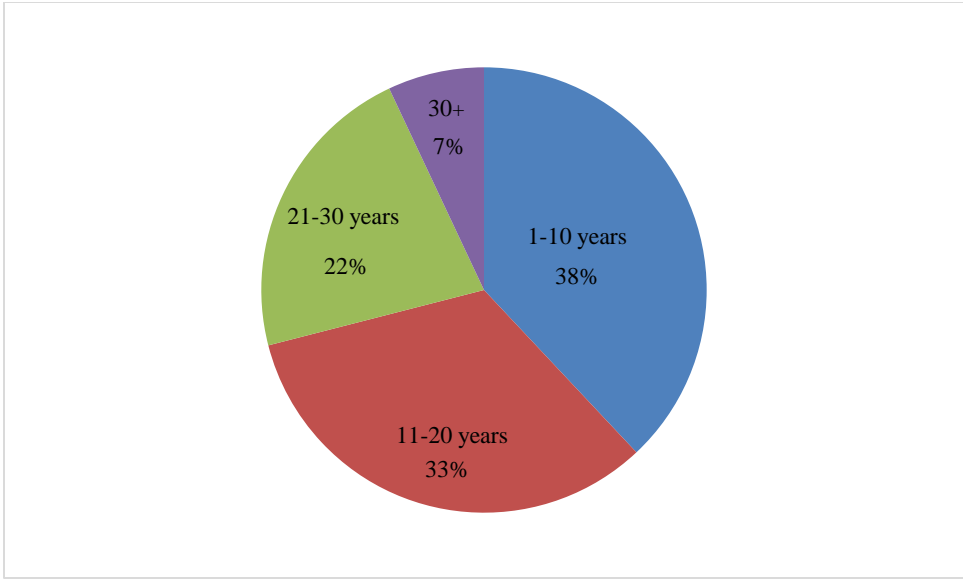


Figure 3.1: Survey results examining the use, attitudes, and beliefs regarding local anesthetic infiltration pre-closure. Participating surgeons had 1-30 years of experience

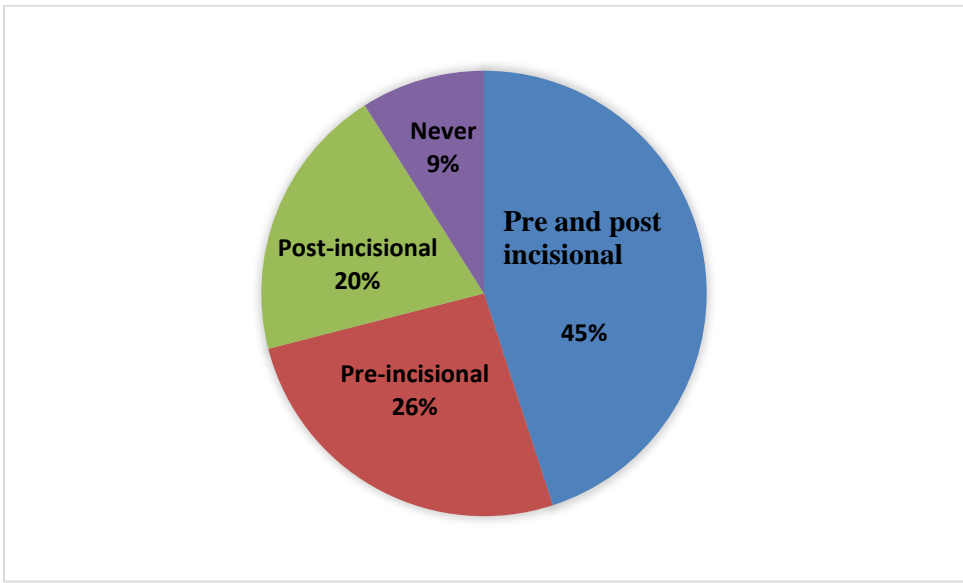


Figure 3.2: Survey results examining the use, attitudes, and beliefs regarding local anesthetic infiltration pre-closure. The majority of surgeons use local anesthetic infiltration either before surgical incision or at the time of surgical closure

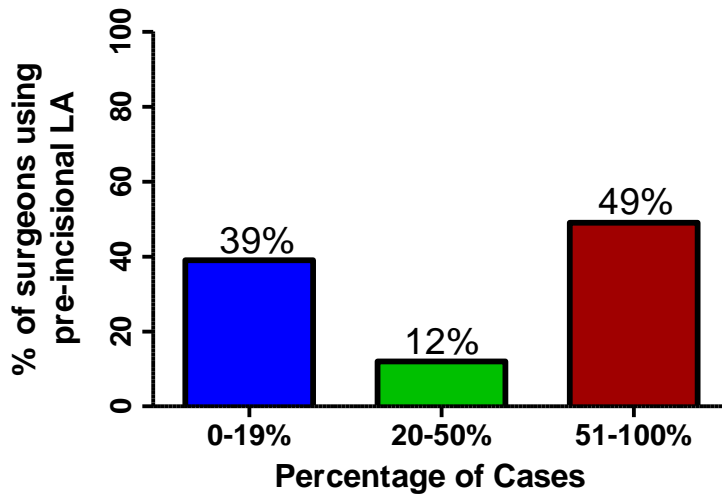


Figure 3.3: Approximately half of surgeons use pre incisional local anesthetic infiltration 50% or more of the time.

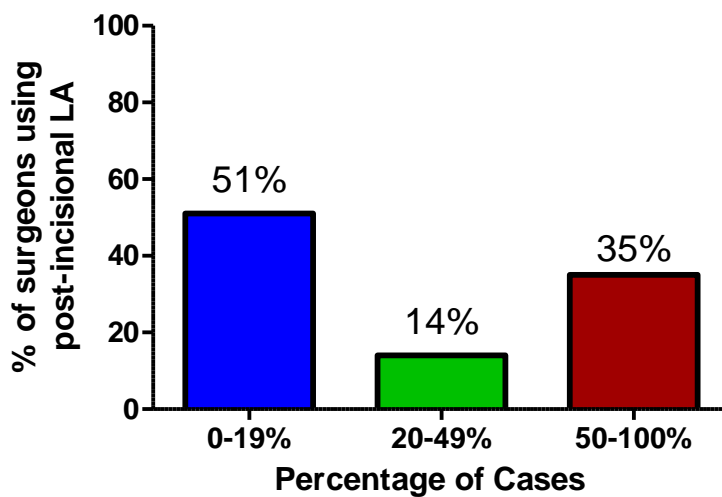


Figure 3.4: Local anesthetic infiltration at time of closure is used in less than 20% of cases by half of the surgeons.

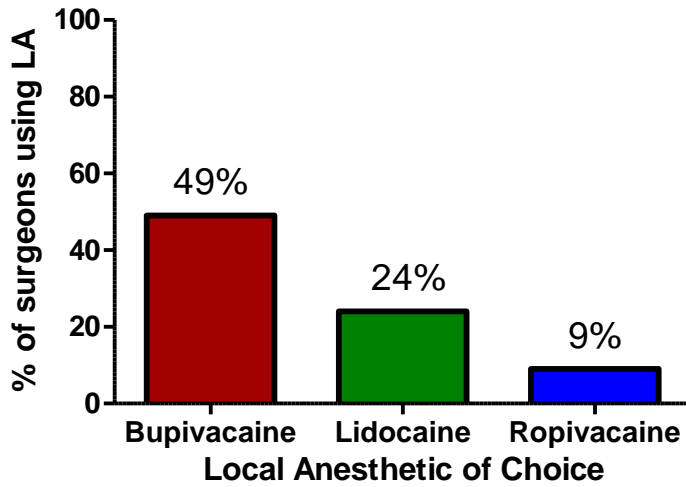


Figure 3.5: Bupivacaine is the local anesthetic of choice for approximately half of surgeons

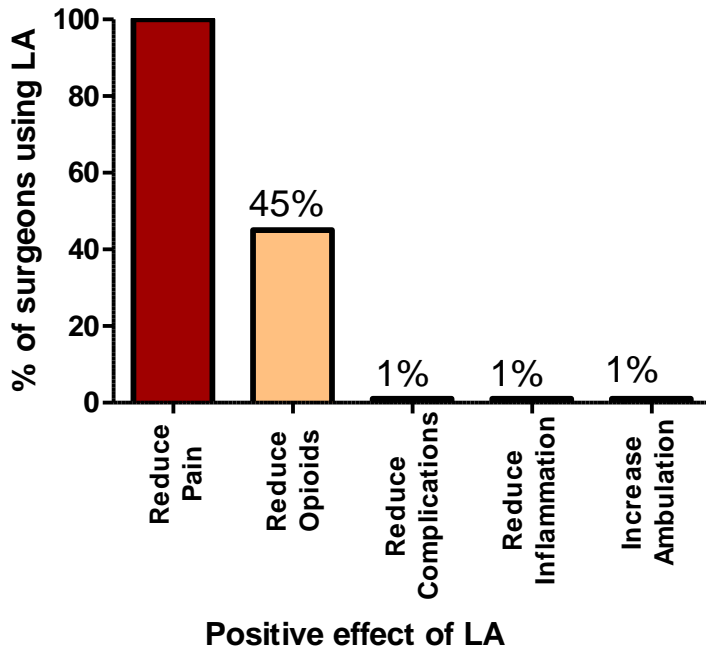


Figure 3.6: Of the surgeons that use local anesthetic infiltration, 100% believe it reduces pain and almost half believe it reduces post-surgical opioids

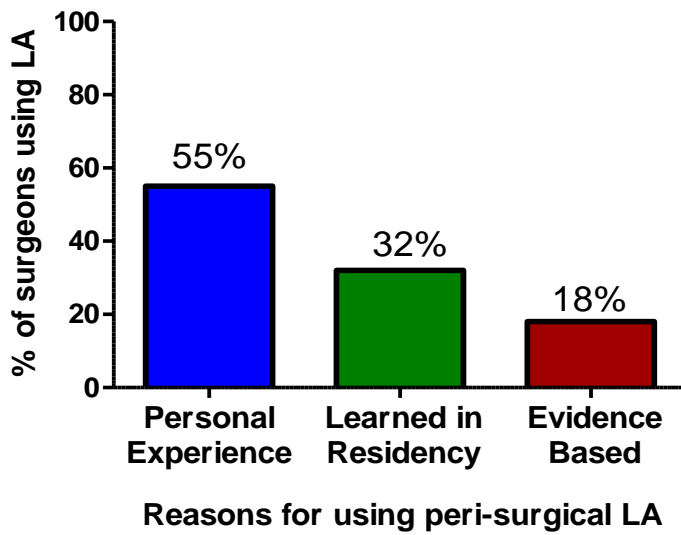


Figure 3.7: Of the surgeons that use local anesthetic, the majority use this practice based on personal experience.

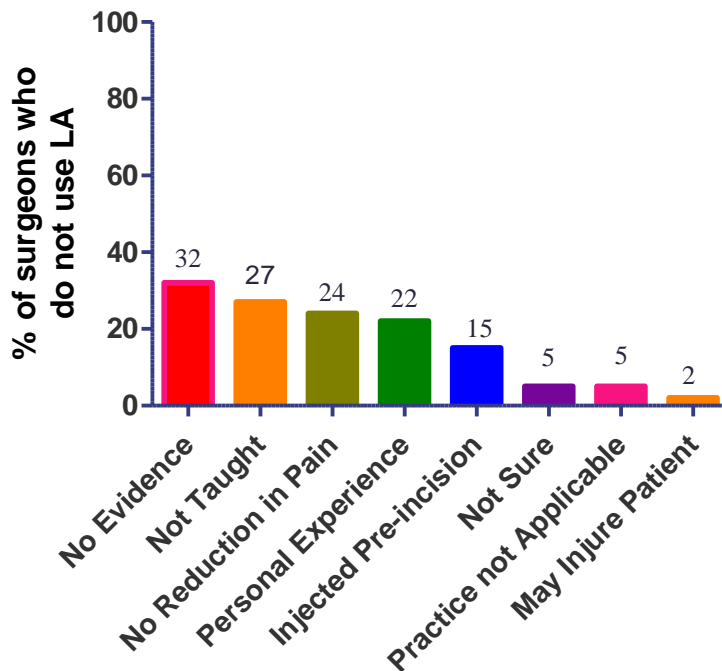


Figure 3.8: A number of reasons underlie why a surgeon chooses not to use local anesthetic infiltration.

Table 3.1: Surgical Specialty of surgeons who completed the survey.

Surgical Specialty
General/Trauma – 27%
Neurosurgery – 1%
Orthopedics – 19%
ENT – 3%
OB/GYN – 13%
Pediatrics – 2%
Cardiac – 3%
Vascular – 3%
Urology – 11%
Other – 18%

CHAPTER 4

REDUCTION OF POST-OPERATIVE PAIN AND OPIOID CONSUMPTION WITH LOCAL ANESTHETIC INFILTRATION PRIOR TO WOUND CLOSURE IN ABDOMINAL HERNIA REPAIRS: A RETROSPECTIVE STUDY

4.1 Introduction:

Acute post-operative pain management is critical to patient satisfaction and the time to discharge. This is one contributor to the overall cost of health care and long term hospital viability (Allegri et al., 2012). It is estimated by the NIH, that 53 million Americans undergo surgery every year and that 31 million are outpatient ambulatory surgeries. The NIH also estimates that 50-70% of patients reported that they experienced inadequate pain control in the post-operative period with a cost of \$100 billion (Weiss, Elixhauser, & Andrews, 2006). Of the surgeries done in the United States every year, it is conservatively estimated that more than 1 million are hernia surgeries.

Currently, systemic opioids are the gold standard treatment approach for acute post-operative pain. Side effects of opioids, especially the sometimes high doses required to adequately alleviate post-operative pain include drowsiness, nausea, vomiting, ileus, urinary retention, and pruritus. These side effects can lead to longer lengths of stays and poor patient outcomes (Brennan, 1999; Sherwinter et al., 2008). In response to the limitations associated with post-surgical opioid use, there has been a growing use of alternative approaches to either prevent (preempt) the post-surgical pain or to manage the

post-surgical pain without opioids. In the latter category, intravenous (IV) acetaminophen use in the first 24 hours post-operative has been growing in popularity (Arslan et al., 2013; Pasero & Stannard, 2012). However, post-operative IV acetaminophen is not appropriate for all patients and has only recently gained popularity in the United States (Arslan et al., 2013; Pasero & Stannard, 2012).

Another approach to reduce post-operative pain and opioid usage has been local anesthetic wound infiltration prior to surgical wound closure. In theory, local anesthetic infiltration at the time of wound closure should decrease action potential generation in somatic and muscle afferent fibers in the incisional area. This should reduce post-operative pain. The technique of injecting local anesthetics into the various layers of the surgical incision is often quoted as a commonly used practice in general anesthesia surgical cases but a survey of its incorporation into clinical practice has never been published (Scott, 2010). With the rise in laparoscopic surgical techniques there has been a rise in local anesthetic wound infiltration prior to closure (Johnson et al., 1999) but it is unclear if a parallel rise of this technique has occurred in other surgical arenas.

While local anesthetic infiltration is relatively inexpensive, technically not difficult, and may potentially reduce the post-operative discomfort (Brower & Johnson, 2003) there is currently little evidence base for pre-closure local anesthetic infiltration and a reduction in post-operative pain or opioid consumption (LeBlanc and Sweitzer, 2014). This retrospective study examined the impact of pre-closure local anesthetic infiltration on post-operative pain (VAS scale) and opioid usage in patients undergoing either open or laparoscopic abdominal hernia repairs at a large (>600 bed) hospital in South Carolina.

4.2 Methods:

Retrospective chart review design:

This study was approved by the Institutional Review Board at Palmetto Health Richland Hospital. The study included all patients (males and females) between the ages of 19 and 80 years that had undergone abdominal hernia repairs, either laparoscopic or open between January 1, 2012-December 31, 2012. A list of 2103 abdominal procedures was obtained from the Medical records department. Inclusion of only abdominal hernia repairs narrowed the study down to 553 cases. A power analysis was applied based upon a 90% confidence and utilizing 2 groups, those that received local anesthetic infiltration (prior to closure) and those that did not receive any local anesthetic prior to surgical closure, and determined that a total of 112 (56 in each group) was required, but all charts meeting criteria were assessed for the year of 2012 as to further increase the power of the study results (Figure 4.1). The next step was to exclude all patients that were outside the age ranges, had recent trauma, chronic drug abuse, patients with documented chronic pain prior to laparoscopic surgery (those taking long term pain medications, >3 months), patients that received epidural/spinal anesthesia for the current procedure, patients who received IV acetaminophen for the current procedure, patients hospitalized for >72 hours prior to current surgery, patients hospitalized for multiple system injuries, patients receiving or diagnosed with chemotherapeutic agents, alcohol or drug use, Alzheimer's or dementia, epilepsy, psychiatric diagnosis of schizophrenia or psychoses, antipsychotic or mood stabilizing drug prescriptions, any patient that the hernia involved bowel resections, and all patients that were admitted to the hospital post-surgery.

The data were collected by the author and placed in an electronic spread sheet. The data collected from each record were surgeon (in a coded and blinded format), type of surgery, age of patient, sex (male/female), dose and frequency of pain medications pre-operatively, dose and frequency of pain medications intra-operatively, dose and frequency of pain medications post operatively, local anesthetic type (for pre or post incision), amount of local anesthetic used, visual analog scale numbers documented at preset times (10, 20, 30 min; 2, 4, 6 hours), time in post anesthesia recovery unit, and time of discharge. The reliability of all data extracted was verified by Dr. Sweitzer, reviewing 10% of the 156 charts, which included 59 fields per chart. This reliability was found to be 98.6% accurate. 156 patient charts were included as a final number as the entire year of 2012 was included, following the above inclusion and exclusion criteria, and to ensure the original minimum power of 90% was obtained and exceeded. The primary measure that was identified and collected was the total amount of pain medication received (to be listed in morphine equivalents), then averaged over the first 6 hours or at time of discharge. This applied to patients that received local anesthetic injection at surgical closure and those who did not receive injected local anesthetic as a control group. Secondary measures addressed the Visual Analog Scale score (VAS) and the time to first rescue medication. Both these measures were collected using all of the above criteria. The surgeon was identified by an assigned number only (link of name and number to be kept in separate file).

Statistical Methods:

SPSS Statistics (version 22, IBM Corporation) was used to conduct the statistical analyses. The data were analyzed for differences in VAS average, VAS 0-30 minutes, VAS 1-2 hours, and post-operative opioid dose between the treatment and control groups via Multivariate Analysis of Covariance (MANCOVA). The analysis incorporated the influence of age, gender, and body surface area as covariates. Significant differences between groups were determined using Pillai's trace; p-values < 0.5 were considered significant. The multivariate analysis results were confirmed via separate univariate analysis of covariance (ANOVA) on the outcome variables.

The relationship between post-operative opioid dose and patient perception of pain was determined using Pearson Product Moment Correlation. The Pearson Product Moment correlation coefficients were converted to z-scores. Differences in the relationship of dose and VAS between the treatment and control groups were determined by calculating the difference in z-scores (p-values < 0.05 were considered significant).

4.3 Results:

An independent t-test confirmed that the covariates, body surface area ($t(154) = 0.33, p = 0.57$) and age ($t(154) = -0.47, p = 0.64$), did not significantly differ by group; however, gender was not included in subsequent analysis since an independent t-test revealed there were a higher proportion of males in the pre-closure anesthetic group, $t(154) = -2.905, p < 0.01$ (Table 4.1). The data were analyzed via Multivariate Analysis of Covariance (MANCOVA). Using Pillai's trace, the covariate, BSA, was not significantly

related to patient post-operative opioid consumption and average VAS, $V = 0.02$, $F(4, 146) = 0.70$, $p = 0.59$. Conversely, the covariate, age, was significantly related to patient post-operative opioid consumption and VAS (Figure 4.2), $V = 0.09$, $F(4, 146) = 3.45$, $p < 0.05$. This correlation was driven by the early post-surgical 0-30 minute time point. There was also a significant effect of administration of LA at closure on patient post-operative opioid consumption and VAS after controlling for the effect of age, $V = 0.12$, $F(4, 146) = 5.12$, $p < 0.01$.

Separate univariate ANCOVAs on the outcome variables revealed significant treatment effects on opioid dose, $F(1, 152) = 9.09$, $p < 0.01$, and VAS, $F(1, 152) = 21.98$, $p < 0.001$, after controlling for the effect of age. A statistically significant reduction in mean VAS over the 0-30 minutes post-surgery (Figure 4.3) was found in patients in which local anesthetic infiltration (LA) was used at the time of closure ($N = 74$, $M = 6.44$, $SD = 2.78$) compared to those who did not receive LA at the time of closure ($N = 75$, $M = 4.66$, $SD = 2.35$). Mean VAS were similar during the 1-2 hour time period ($M_{yes} = 5$, $SD_{yes} = 0$, $M_{no} = 5.28$, $SD_{no} = 1.99$) as well as during the 2-4 hour time period ($M_{yes} = 1.5$, $SD_{yes} = 0$, $M_{no} = 2.39$, $SD_{no} = 1.02$). Data for patient perception of pain scores at 4+ hours was available for only 9 patients in the control group; therefore the 4+ hours' time interval data were excluded from further analysis.

For patients who did not receive local anesthetic at closure, age was significantly related to post-operative opioid consumption, $r = -0.30$, to the average VAS, $r = -0.31$, and to VAS from 0 – 30 minutes, $r = -0.32$, $p < 0.01$, but was not significantly related to VAS from 1 – 2 hours, $p = 0.144$. For patients who received pre-closure local anesthetic, age was not significantly related to the post-operative opioid consumption nor to VAS.

Controlling for the effect of age, Pearson Product Moment Correlation revealed that the post-operative opioid consumption was significantly related to the average VAS as well as VAS at 0 -30 minutes and 1 – 2 hours, regardless of whether patients received local anesthetic at closure (Figure 4.4). Pearson correlation coefficient between VAS and post-operative opioid consumption demonstrated statistically significant differences in the correlations across the entire time course and during the 0-30 minute time points ($p < 0.05$) but not at the 1-2 hour time point (Table 4.2). No correlations were found between age or opioid consumption and time to discharge in patients who received LA at closure or did not receive LA (Figure 4.5).

An independent t-test revealed that there were a higher proportion of males in the local anesthetic infiltrated group, $t(154) = -2.91, p < 0.01$ which indicates that sex as a covariate was not independent of the treatment, and therefore was excluded from the above statistical analysis. A separate analysis examined the potential impact of sex on VAS (0-30 minutes) and opioid consumption using independent t-test with Bonferroni correction (Figure 4.6). VAS and opioid consumption were not significantly different between male and females, although there was a trend for females to have both higher VAS and opioid consumption compared to males. Both VAS and opioid consumption was significantly decreased in males, but not females, who were administered local anesthetic infiltration compared to control.

In recognition of the difference in proportion of surgeries completed, laparoscopic versus open, a secondary analysis was completed comparing VAS and opioid consumption in laparoscopic versus open conditions. Surprisingly, VAS and opioid consumption was significantly higher in patients with laparoscopic ($n=51, 23$ females, 28 males) compared

to open hernia repair (n=104, 20 females, 84 males) in the 1-4 hour post-surgical period examined in this study (Figure 4.7).

4.4 Discussion:

The use of local anesthetics in surgical wound, both prior to and post incision is a common practice in the surgical suite and is often employed as a multimodal approach to reduce post-surgical pain (Johnson et al., 1999). Surgeons want to reduce post-operative pain in their patients, while reducing the potential side effects associated with opioids and other analgesics. In spite of the widespread use of this practice, the evidence base for local anesthetic infiltration prior to surgical closure is minimal with highly variable efficacy. This study attempted to provide an evidence base for the practice in abdominal hernia repairs using a retrospective study design. Interestingly, the use of local anesthetic infiltration at the time of closure was correlated with a statistically significant reduction in post-operative pain scores within 30 minutes post-surgery and reduced opioid consumption in the immediate recovery period compared to patients that were not given local anesthetic at closure. However, closer examination of the surgical and patient specifics illustrate the difficulty in interpreting these results and extrapolating them to other patient populations.

The current finding that an acute bolus local anesthetic infiltration at the time of closure can reduce post-operative pain and opioid consumption is in line with previous studies that showed a reduction in post-operative pain via a pain scale similar to the visual analog scale (Akoglu et al., 2006; Arikan et al., 2006; Jebeles et al., 1993; Naja et al., 2005; Sorensen et al., 2003). One study on post-operative pain after tonsillectomy surgery

examined pre-incisional versus post-incisional injection of bupivacaine, using a saline injection as a control. It was noted that there was not a significant difference between the bupivacaine pre-and post-incisional groups in pain reduction, but there was a significant difference in these groups compared to the saline groups. This study did address the use of other analgesics (acetaminophen) when assessing the VAS score, but the researchers did not note doses or frequency of those analgesics and did not systematically assess whether post-surgical analgesic use was decreased by local anesthetic infiltration (Molliex et al., 1996). This study suggests that in tonsillectomy either pre- or- post-incisional infiltration of bupivacaine may produce a reduction in post-surgical pain when compared to the saline (control) group. In a study of local anesthetic infiltration in Iliac Crest bone harvesting surgery it was also reported that this technique reduced post-procedural pain compared to a control group but there was no examination of the effect of local anesthetics on post-procedural analgesic consumption (Chern et al., 1999). The majority of studies that examine local anesthetic infiltration report variable changes in post-surgical visual analog scale pain score but few note whether other analgesics were used and the doses used (Chern et al., 1999; Hoard et al., 1998; Schaan et al., 2004; Todd & Reed, 1991). To our knowledge, the current study is the first in the literature to examine surgical hernia repair and demonstrate a reduction in both VAS and post-surgical opioid consumption with local anesthetic infiltration at the time of wound closure.

However, the generalization of the current findings must be made with caution as one of the inherent limitations of a retrospective study design can be an inequality in comparison groups. While the two groups were comparable with regard to patient age and body surface area, there were several differences between the groups that may confound

interpretation of the results. The first important difference in the groups is that sex is not equally distributed between the two groups. There are over twice as many females in the control group (38% of patients are female) as compared to the anesthetic intervention group (18% of patients are female). It is possible that the sex differences observed in the current study may have been a result of the limited sample number of females compared to males. With increased numbers of females a similar reduction of post-surgical VAS and opioid consumption may also be occurring in females administered local anesthetic at surgical closure. Given the power analysis numbers, this study is underpowered to detect differences in female patients. Future studies, should be designed to capture equal representation of both sexes to determine whether sex is predictive covariate in these models.

Alternatively, there is a growing literature on the difference in pain thresholds and pain tolerance in females compared to males. Sex and gender differences in pain may be due to biological factors such as blood pressure, gonadal hormones, cortisol levels and overall body size (Berkley, 1997; Dixon, Thorn, & Ward, 2004). In addition, psychosocial factors have been shown to differ between the sexes in regards to pain perception especially as it pertains to fear of pain, the impact of depression and anxiety on pain, and utilization of coping strategies. Psychosocially, culturally and socially constructed meanings that describe how women and men should behave in certain situations according to gender roles are learned throughout life and have been shown to impact pain perception and expression. Traditionally, in several cultures, high levels of stoicism are related to men and high levels of sensitivity are related to women (Alabas, Tashani, Tabasam, & Johnson, 2012; Berkley, 1997; Riley, Robinson, Wise, Myers, & Fillingim, 1998). Thus, with the recognition of

biological and psychosocial impacts on pain perception, the current findings of higher pain reports and opioid usage in the control group, may be partially attributed to some or all of these factors.

Another important difference between the groups lies in the specific surgical procedure using open or laparoscopic approaches. In an open procedure a single incision is made and repair of the hernia defect performed. This type of surgical incision allows direct visualization of the herniated tissue and surrounding area and then repair of said defect (hernia). In comparison, laparoscopic surgical repair involves several smaller incisions, one for the laparoscopic camera (allows for indirect visualization) and then 1-3 (on average) other incisions for the instruments used to repair the defect to be introduced into the surgical area. Based on the literature of laparoscopic surgery (Jaffray, 2005; Misiakos, Machairas, Patapis, & Liakakos, 2008; Novitsky, Litwin, & Callery, 2004) it would have been predicted that laparoscopic techniques would have lower post-surgical pain and thus opioid usage. According to the literature, patients undergoing laparoscopic surgery have lower mortality, shorter lengths of hospital stay, and less patient discomfort compared with open procedures (Zhang et al., 2014). In addition, laparoscopic procedures may have less impact on immune function than the open technique. Decreased postoperative pain and speedy functional recovery of laparoscopic patients may be attributable to the reduced inflammatory response, as well as avoidance of larger wounds as is often necessary in open procedures (Jaffray, 2005; Kahokehr, 2013; Zhang et al., 2014). In the current study, it was surprising and unexpected that the control group had a larger portion of patients that had undergone laparoscopic surgery (63% laparoscopic vs. 4% open) to repair their hernias and had higher post-surgical pain scores and opioid usage

compared to the group treated with local anesthetic infiltration that were largely open surgeries.

Some of this difference in laparoscopic versus open surgery may result from the differences in surgical procedures in the control versus local anesthetic intervention groups. In the control group, 33% of surgeries were inguinal and 45% were ventral with the majority being done laparoscopically. In contrast, in the local anesthetic intervention group, 72% of surgeries were inguinal and 11% were ventral with the majority being done open. Open inguinal hernia repair is generally accomplished with one small surgical incision that generally takes the surgeon approximately 15 minutes (Eklund et al., 2010). Laparoscopic approaches for inguinal hernia repair require two small incisions (one for the visualization camera and one for repair instruments) and takes the surgeon around 30 minutes (Eklund et al., 2010). In the current study, only 20% of inguinal hernia repairs were completed laparoscopically and 99% of those cases were in the control group. In contrast, open ventral hernia repair is a more complicated procedure that requires one larger surgical incision and generally takes 1-2 hours. Laparoscopic approaches for ventral hernia repair require an average of three small incisions (one for the visualization camera and two for repair instruments) and the duration of surgery is highly variable depending upon the complexity of the hernia. In the current study, 66% of ventral hernia repairs were completed laparoscopically and 94% of those cases were in the control group. Thus, a larger percentage of patients in the control group underwent a more complicated ventral hernia repair compared to the local anesthetic intervention group which was largely inguinal hernias. This disparity in surgical procedures between groups may contribute to the differences in post-surgical VAS and opioid consumption.

A secondary analysis of pain scores and opioid consumption as a function of surgical approach (laparoscopic versus open) demonstrated lower average pain scores and opioid consumption in the open surgeries (n=104, 20 females, 84 males) compared to laparoscopic (n=51, 23 females, 28 males) surgeries. Interpretation of these findings though must take into account that the proportion of males and females is different between the groups with 18% of the patients being female in open cases vs 45% of patients being female in laparoscopic cases. As mentioned above there are likely to be biological and psychosocial differences in pain perception and expression across the sexes that may account for the results observed in this study. Another potential confound in interpreting these data is the difference in surgical procedures between the groups. As discussed above, a larger percentage of the more complicated ventral hernia repair were completed laparoscopically, while the majority of less complicated inguinal hernia repairs were completed with open techniques. Both differences in sex and surgical procedures may contribute to the difference in post-surgical VAS and opioid consumption between the two surgical approaches.

There are reports in the literature that suggest early post-surgical pain following laparoscopic surgery may not be significantly reduced compared to equivalent open procedures (Ponsky, Nalugo, & Ostlie, 2014). Our study would support this more recent literature. A difference between the older and more recent literature that compares laparoscopic outcomes to open surgical outcomes is the timing of measurement of those outcomes. The early studies mainly focused on recovery of function, pain at hours to days after surgery, and wound infection rates (Alexander, 1997). In contrast, our study examines early time points (0-4 hrs.) after surgery. During this time point, there may not be an

immediate benefit of laparoscopic versus open or that benefit may be more dependent upon the surgical site and the difference in surgical complexity between open and laparoscopic techniques.

This study found that post-incisional infiltration with local anesthetics significantly reduced post-surgical VAS and opioid consumption in the first 4 hours post-abdominal hernia repair surgery. This study further contributes to the overall body of evidence that remains divided as to the overall effectiveness of this technique, while clearly identifying a need for good quality prospective studies. Although retrospective studies can address many criteria it cannot easily control for factors such as age, gender, more specific type of surgery and surgeon that may be confounds to interpreting results and extrapolating those results across patient populations. While post-operative pain management is critical to improving patient satisfaction and health care cost savings, the efficacy of using local anesthetic infiltration at the time of closure in hernia repairs requires further investigation. In conclusion, all of the potential confounds identified in this study highlight the need for further well designed and very specific retrospective and prospective studies to determine the efficacy of local anesthetic infiltration, as an augment to general anesthesia, in reducing post-operative pain, opioid consumption, and health care costs.

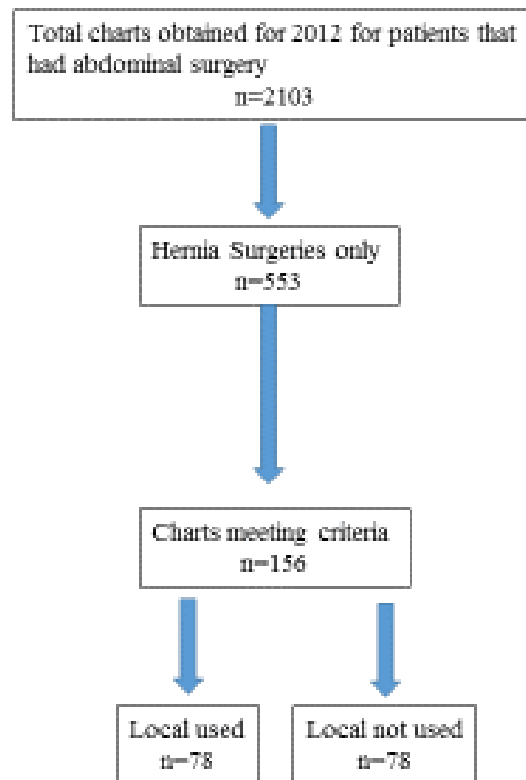


Figure 4.1: Chart Review Summary showing the total charts received for abdominal surgery in 2012 at Palmetto Health Richland, then showing the final numbers as inclusion and exclusion criteria were applied.

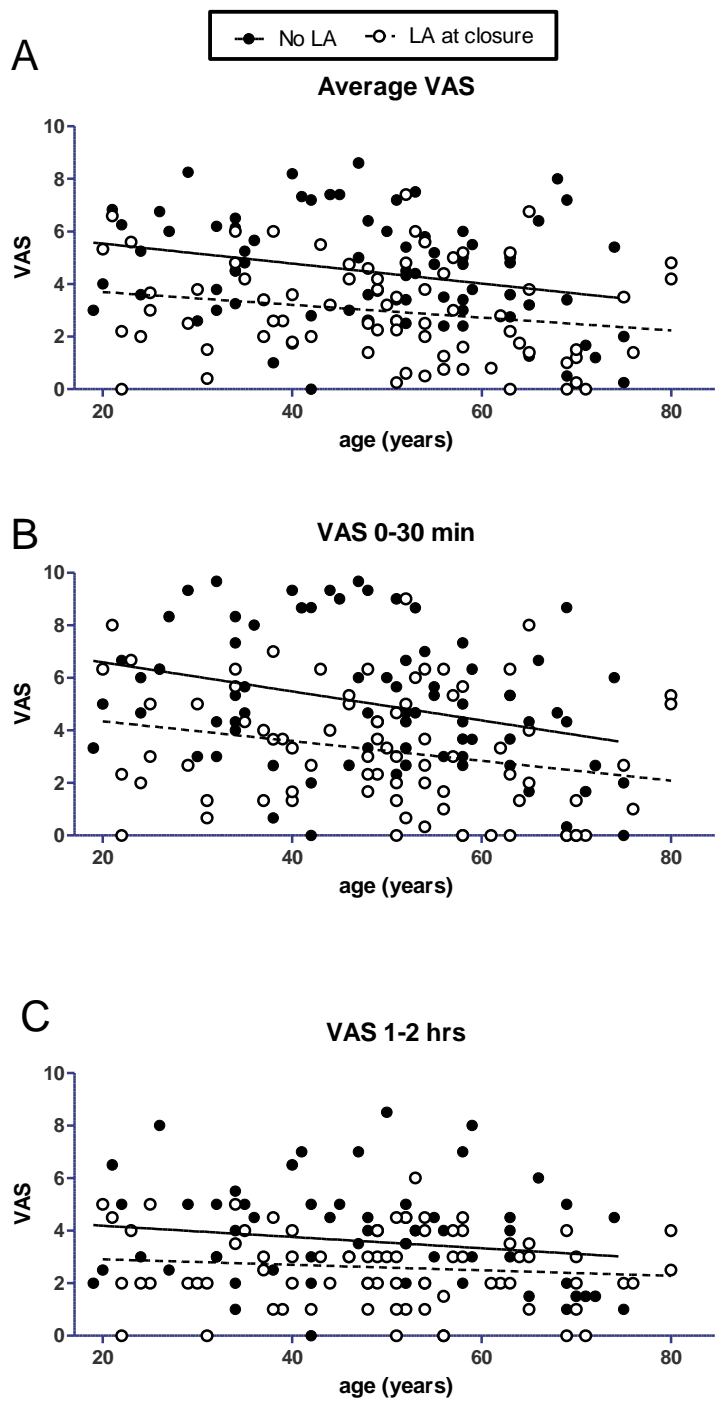


Figure 4.2: Visual Analog Scales correlated with age across different post-surgical times. A. Average VAS scores for the entire 0-4+ hours post-surgery in control or intervention groups. B. VAS scores from 0-30 minutes post-surgery in control or intervention groups. C. VAS scores from 1-2 hours post-surgery in control or LA intervention groups.

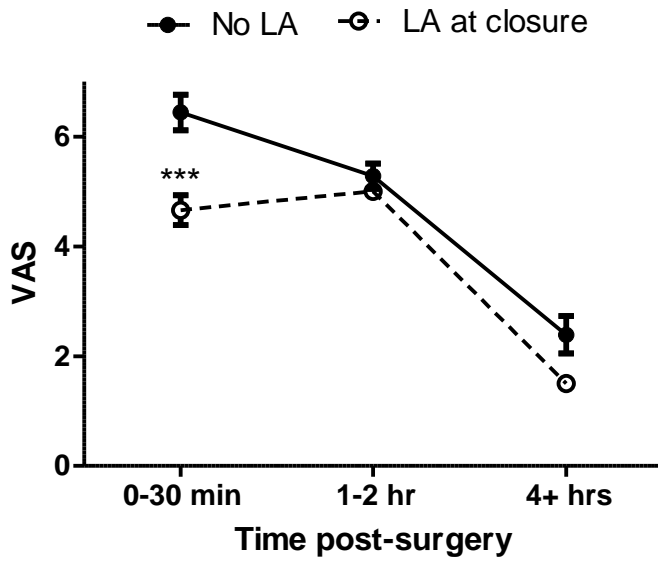


Figure 4.3: Average VAS scores in control patients and patients that received local anesthetic at closure as a function of post-surgical time. $p < 0.001$ versus control no local anesthetic.

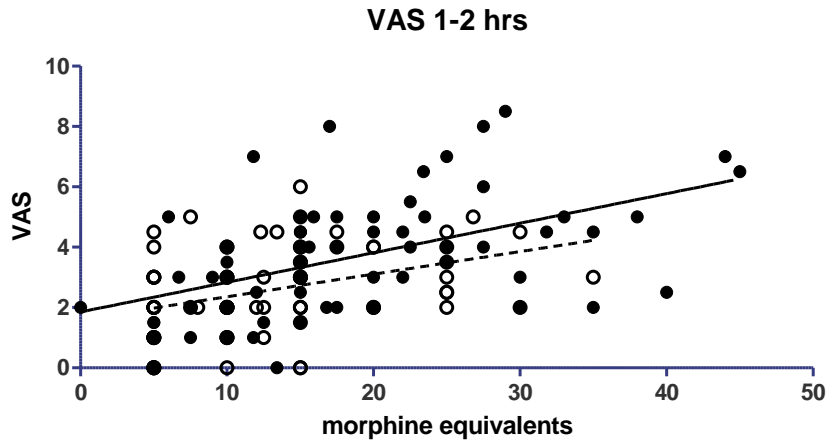


Figure 4.4: Visual Analog Scales correlated with morphine equivalents across different post-surgical times. A. Average VAS scores for the entire 0-4+ hours post-surgery in control or intervention groups. B. VAS scores from 0-30 minutes post-surgery in control or intervention groups. C. VAS scores from 1-2 hours post-surgery in control or intervention groups.

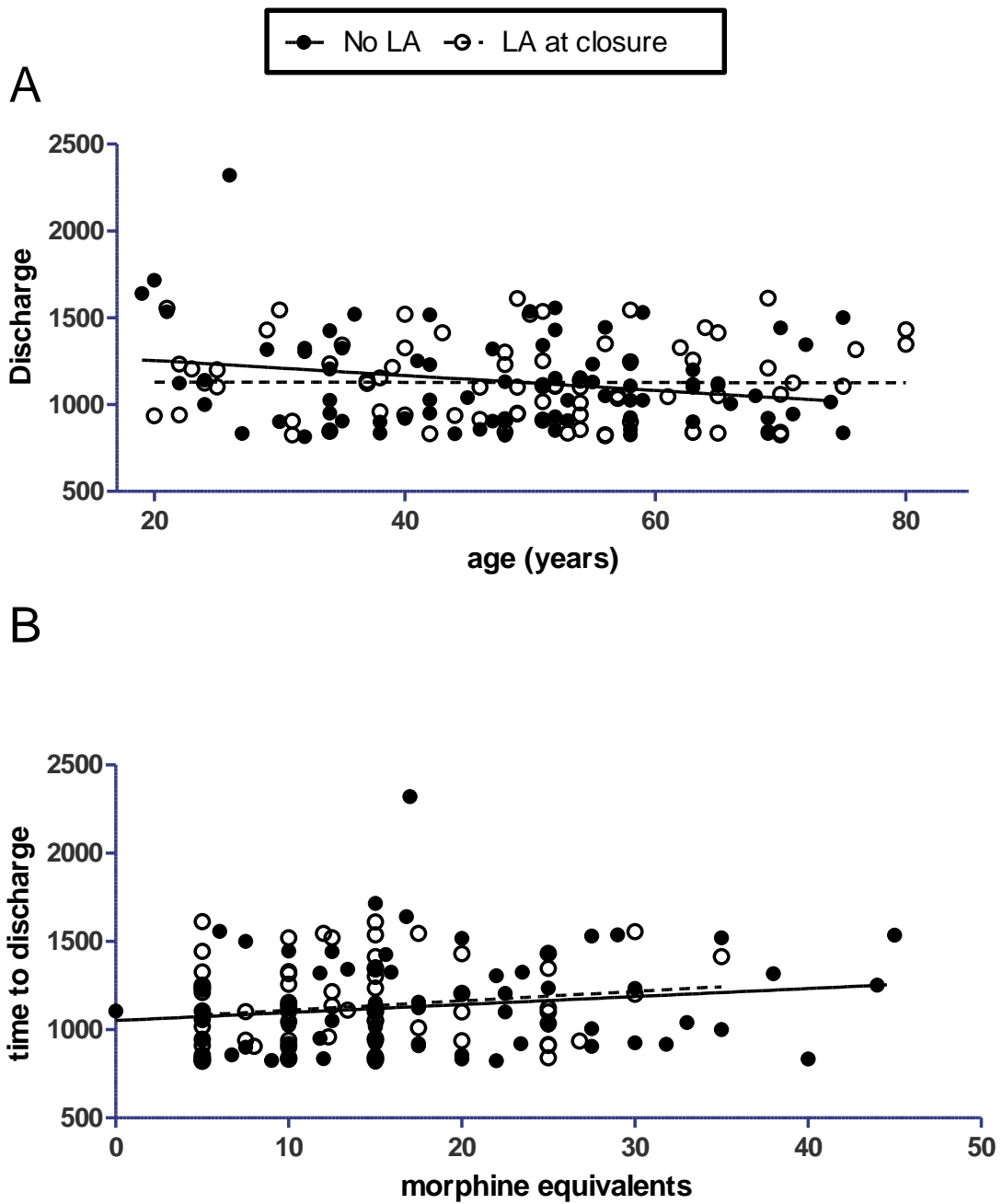


Figure 4.5: Times to discharge after surgery correlated with A. age across different post-surgical times. B. Morphine equivalents across different post-surgical times.

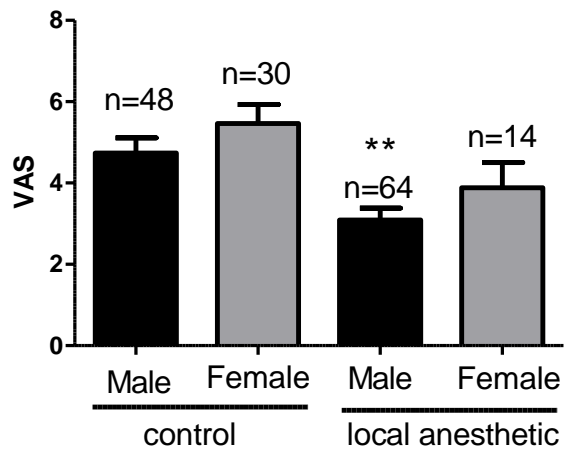


Figure 4.6: Sex differences in average VAS and opioid consumption in abdominal hernia repair surgery with or without local anesthetic infiltration at closure. *** $p < 0.05$, 0.01 males with versus without local anesthetic infiltration.

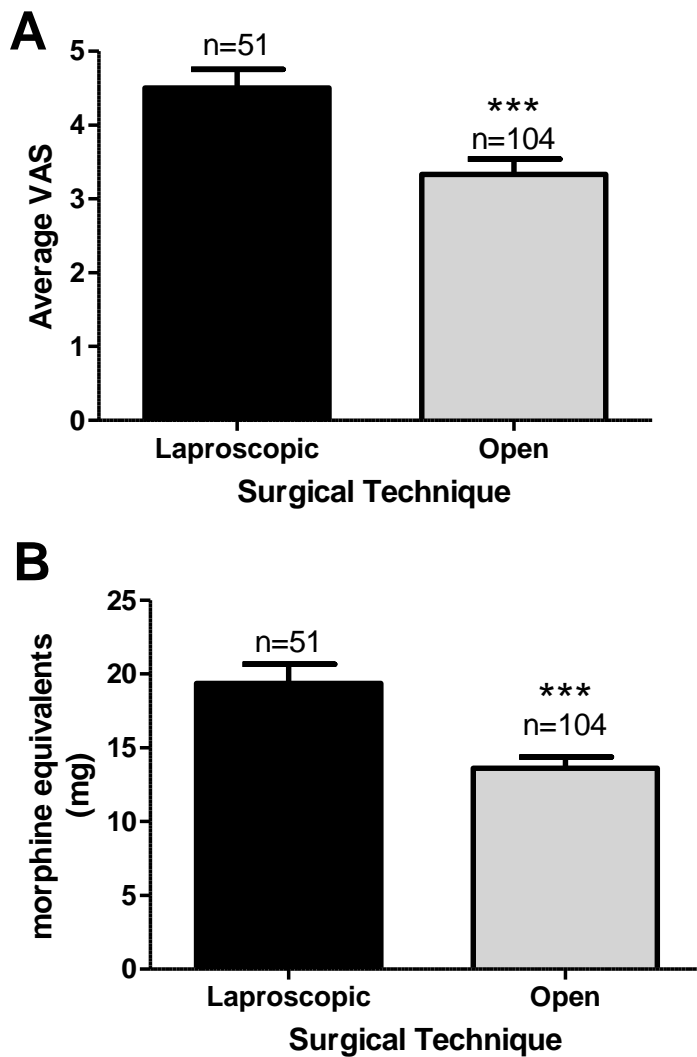


Figure 4.7: Difference in average VAS and opioid consumption in laparoscopic versus open abdominal hernia repair surgeries. *** $p < 0.001$ compared to laparoscopic surgical technique.

Table 4.1: Patient demographics of the control group that did not receive local anesthetic at closure and patients who did receive local anesthetic at closure.

	Without Local Anesthetic	With Local Anesthetic
Total Cases	78	78
Procedure		
Inguinal (lap)	10 (16)	55(1)
Umbilical (lap)	13 (4)	13 (0)
Ventral (lap)	6 (29)	7 (2)
% Laparoscopic	62.8%	3.8%
Average Age (SD)	49.6 (1.707) years	48.5 (1.683) years
Sex (F/M)	30/48	14/64
BSA Average (SD)	2.07(0.026)	2.12 (0.035)
Females (SD)	2.03 (0.051)	1.99 (0.061)
Males(SD)	2.09 (0.028)	2.15 (0.039)
Average time to discharge (SD)	137 (7.17) minutes	113 (5.12) minutes
Females	149 (9.46)	132 (13.92)
Males	129 (9.96)	108 (5.36)

lap = laparoscopic

Table 4.2: Pearson correlation coefficient between VAS and post-operative opioid consumption in patients treated with LA at closure compared to patients that did not receive LA. *p < 0.01. †p < 0.05.

	LA Infiltration	No Local Anesthetic	p-value
	df = 74	df = 73	
VAS average	0.68*	0.50*	0.082
VAS 0 – 30 minutes†	0.72*†	0.51*†	0.034†
VAS 1 - 2 hours	0.37*	0.48*	0.424

CHAPTER 5

SUMMARY AND FUTURE DIRECTIONS

5.1 Summary of Findings:

This thesis was completed in three phases with the goal of determining whether the use of infiltration of local anesthetic into surgical incisions at the time of closure reduces post-operative pain and opioid consumption (Figure 5.1). Phase one was a review of the current available literature that identified little evidence base for this practice. Phase two determined how commonly local anesthetic infiltration is used in clinical practice. A surgeon survey was designed and conducted in 15 hospitals in South Carolina and over 90% of surgeons surveyed use local anesthetic infiltration at least occasionally. Interestingly, 82% of surveyed surgeons recognized that although they are using the practice of injecting local anesthetic it may not be an evidence based practice. The third phase was a retrospective study of surgical patients who underwent abdominal hernia repairs. Decreases in the visual analog scale pain scores, and opioid consumption in the early post-operative period (0-4 hours) was found in patients who had received local anesthetic infiltration at the time of closure compared to controls. However there were several limitations to the analysis of the retrospective study that highlight the need for future retrospective and prospective studies in this clinical area of research. This chapter focuses on the major findings from each of the three studies, how these findings add to the current literature, the limitations of the studies, and the potential future directions.

Phase I: Systematic Review

Local anesthetic infiltration prior to surgical incision closure is a frequently used technique in the operating room. Debate continues, with clinicians, as to the effectiveness of this technique in pain reduction. A literature review using PubMed with the criteria of “local anesthetic infiltration and pain reduction” was conducted for the use of local anesthetic infiltration prior to surgical closure. The search provided 137 results that were then categorized and reviewed. The studies that reviewed the effectiveness (pain reduction) of single dose infiltration of local anesthetics into the surgical wound was small, only numbering 23 studies. The use of local anesthetics before surgical incision or a continuous infusion of the local anesthetics into the surgical wound in the immediate post-operative period has been more widely studied, but the effectiveness of this practice varies greatly between studies. The efficacy of using a single pre-closure local anesthetic infiltration ranged from producing a modest reduction in post-surgical pain to no change in post-surgical pain. This systematic review revealed that few studies have examined the effectiveness of local anesthetic infiltration into surgical incisions on post-operative pain outcomes and these results vary greatly as to the effectiveness of this surgical practice. Further investigation needs to be done on the use of local anesthetics, as an augment to general anesthesia, in reducing post-operative pain while potentially reducing other analgesic usage thus reducing the potential adverse side effects of medications like opioids. The use of post-incisional infiltration of the surgical incision with local anesthetics was not found to be significantly studied, and the studies that do exist are not always of the highest quality and do not agree on the effectiveness of the practice.

Phase II: Surgeon Survey

Even in the face of limited evidence bases in the literature, local anesthetic infiltration prior to surgical incision closure remains a frequently used technique in the operating room. The prevalence of this practice across surgical specialties and surgery types is unknown. Furthermore, the debate among clinicians as to the effectiveness of this technique in pain reduction continues. A survey of surgeons was completed, in both inner city and rural hospitals of South Carolina, to assess the actual implementation of this practice and the common reasons given for using or not using this technique. The data collected from the survey showed that approximately 65% of surgeons used local anesthetics injected into the surgical wound at the end of the surgical procedure. Of those that use local anesthetic infiltration, after incision (at surgical closure), 95% of those indicated they believe it reduces surgical pain and 41% indicated that it reduced opioid consumption. In contrast to the high usage of this practice, only 12% of those surveyed believe that this practice is evidenced based. The surgeons that did not use local anesthetics at surgical closure responded that the major reasons they do not use this technique were that they were not taught the technique in residency, their personal experience and the absence of evidence of pain reduction. The current study demonstrated that although surgeons are using the technique of injecting local anesthetics prior to surgical closure, greater than 80% believe there is limited evidence base for this practice. This survey further identified the need for good quality retrospective and prospective studies examining the efficacy of perisurgical local anesthetic on post-operative pain and opioid consumption.

Phase III: Retrospective Study

Clinical evidence for the practice of local anesthetic infiltration into surgical incisions is limited with around half of the studies showing minimal to no effect on reducing pain and post-operative opioid consumption rarely examined. This retrospective study addressed the outpatient surgical procedure of abdominal hernia repairs (open and laparoscopic) and the effectiveness (measured as pain reduction and opioid consumption) of a one-time infiltration of local anesthetic injected at the time of surgical closure. Over a one year period (2012), 553 charts were reviewed in one large inner city hospital. The study included 156 abdominal hernia repairs on adults' ages 19-80 years of age. Statistical significant reduction in pain was noted in both the post-operative visual analog scale ($p < 0.001$) and post-operative opioid ($p < 0.001$) usage in this outpatient population. The greatest reduction appeared to be in the first 30 minutes after surgery but an overall reduction pain was noted in the 4 hours post-surgery this study addressed. A secondary analysis noted a statistical significance ($p < 0.001$) of greater pain, in the first 4 hours, in laparoscopic hernia procedures compared to the open hernia procedures. Limitations of the study include differences in sex, surgical procedures, and surgical approaches between the groups. This study demonstrates the need for well controlled prospective studies on this topic.

5.2 Significance of Research to the Field

With over 73 million surgical procedures annually, post-surgical acute pain management has significant health and economic impact (Allegrì et al., 2012; Kessler et al., 2013). Acute post-operative pain management is critical to improve patient outcomes and reduce health care costs (Allegrì et al., 2012). The current standard treatment for post-operative pain is the use of systemic opioids, acetaminophen, and NSAIDs (Arslan et al., 2013; Macario & Royal, 2011; Pasero & Stannard, 2012). Unfortunately, these therapies are not without complications and patient limitations (Arslan et al., 2013; Pasero & Stannard, 2012). These complications can lead to longer lengths of stays and poor patient outcomes (Brennan, 1999; Sherwinter et al., 2008). In response to this, surgeons have turned to other techniques to adequately manage post-operative pain and reduce side effects of current therapies, one of which is the infiltration of local anesthetics in the surgical wound.

In theory, local anesthetic infiltration is thought to reduce post-surgical peripheral and central sensitization resulting in decreased post-operative pain and analgesic use (Scott, 2010; Sweitzer et al., 2006). This technique has continued to increase in popularity since the mid 1990's (Johnson et al., 1999). The benefits are that it is inexpensive, technically straightforward, and limited potential for complications (Brower & Johnson, 2003). Two main approaches have been used: a preemptive model anesthetic application prior to surgical incision, and a model of anesthetic application immediately prior to surgical closure. Injecting local anesthetics prior to surgical incision into the surgical wound has been more extensively studied with variable reports of efficacy (Hilvering et al., 2011; Lohsiriwat et al., 2004; Lowenstein et al., 2008; Metaxotos et al., 1999; Sihoe et

al., 2007; Venmans et al., 2010; Walsh et al., 2007). In contrast, this thesis found that the literature on injecting local anesthetics, as a onetime dose (non-continuous infusion) prior to closure is limited and the outcomes are mixed. Furthermore, the quality of the studies are highly variable, thus making the generalizability of the findings limited. This also illustrates the need for additional retrospective and prospective studies in the field.

While the evidence base for this practice is limited, the surgeon survey identified widespread use of this technique across surgical specialties and years surgeons have been in practice. These survey results are supported by other literature that identifies the common use of multimodal approaches to pain relief using local anesthetic infiltration in the surgical wound, both prior to and post incision (Johnson et al., 1999). As far as we know, this is the first study to identify surgeon attitudes and beliefs about the practice. The most commonly cited reason for using these techniques was how they were trained in residency or on personal experience in pain reduction (for more experienced surgeons). All surgeons surveyed stated they use local anesthetics in surgical wounds with the belief it reduces post-operative pain, of those that use the techniques only approximately 40% feel that the local anesthetic actually reduces post-operative opioid consumption. Interestingly, and given the systemic review of the literature that was phase I of this thesis, only 18% of surveyed surgeons suggested that this practice was evidence based. Although the techniques of injecting local anesthetics, both pre and post-incisional infiltration are being used, it is not with a high confidence of the surgeons that the literature supports this or that it actually reduces pain or the medications to help control pain. There is a need for additional studies in this area given the propensity with which the practice is being used.

In response, to the common use of the practice and the highly variable literature, a retrospective analysis was undertaken. Hernia repair surgeries are one of the most commonly performed surgeries by general surgeons (Peker et al., 2014). To help exclude factors related to pain that may be related to deep abdominal organ manipulation outpatient abdominal hernia repairs were chosen. This study showed a significant reduction ($p < 0.001$) in both VAS scores and opioid requirements in the first 4 hour post-surgery, in patients with local anesthetic infiltration as compared to the control group. Of interest to note, this study found that less pain was experienced by the open group as compared to the laparoscopic group. This is contrary to what one would expect to see, based upon the current literature and trend towards laparoscopic surgeries, but may be related to the early time frame of post-operative pain measurement. This study lends to the body of evidence that for abdominal hernia repairs (both laparoscopic and open), the use of post-incisional infiltration of local anesthetic is effective in reducing post-operative pain while addressing opioid usage, which was not considered in a lot of other similar studies.

5.3 Limitations and Future Directions:

The data discovered in this thesis project opens a Pandora's Box of questions. To our knowledge, our retrospective study is the first in the literature to examine surgical hernia repair and demonstrate a reduction in both VAS and post-surgical opioid consumption with local anesthetic infiltration at the time of wound closure. Unfortunately, with any retrospective study there is the potential for multiple confounds. The generalization of the current findings must be made with caution as one of the inherent limitations of a retrospective study design can be an inequality in comparison groups.

There were several differences between the groups that may confound interpretation of the results. The first important difference in the groups was twice as many females in the control group as compared to the anesthetic intervention group (18% of patients are female). There is a vast literature exploring the differences in pain and analgesia in males and females (Berkley, 1997; Dixon et al., 2004). Thus one future direction is to complete similar retrospective studies that either have equal representation of males and females in each group or complete studies that examine only males or females.

Two other important differences that we identified were the specific surgical procedure (e.g. ventral or inguinal) and open or laparoscopic approaches. This disparity in surgical procedures and approaches between groups may contribute to the differences in post-surgical VAS and opioid consumption. Thus, one future direction would be to look at laparoscopic and open in separate studies and to limit the surgical procedures to just one type (eg. ventral or inguinal), and this would need to be controlled for sex and age. Similarly, future studies may want to examine post-surgical pain and opioid function as a factor of age since our study showed age dependence in both outcomes.

Post-surgical time is probably also very important to both data collection and data analysis in these studies. In future studies, the time frame of data collected to include the early post-operative period, as this study did, but also the later periods to extend out several more hours to several days. These proposed future directions would further contribute to the overall body of evidence that remains divided as to the overall effectiveness of this technique.

Although retrospective studies can address many criteria it cannot easily control for factors such as age, gender, more specific type of surgery and surgeon that may be confounds to interpreting results and extrapolating those results across patient populations. The need for good quality prospective studies is even more evident after the analysis of the data collected here, as it continues to lend to the idea that local anesthetic infiltration into surgical wounds reduces post-operative pain, but the overall body of the literature is still mixed. The prospective studies that need to be done must be double blinded, placebo controlled studies that are very specific to the type of surgery, limit the number of surgeons, control for age, sex and the type of local anesthetics used.

5.4 Overall Conclusions:

While post-operative pain management is critical to improving patient satisfaction and health care cost savings the efficacy of using local anesthetic infiltration at the time of closure in hernia repairs requires further investigation. In conclusion, all of the potential confounds identified in this study highlight the need for further well designed and very specific retrospective and prospective studies to determine the efficacy of local anesthetic infiltration, as an augment to general anesthesia, in reducing post-operative pain and opioid consumption.

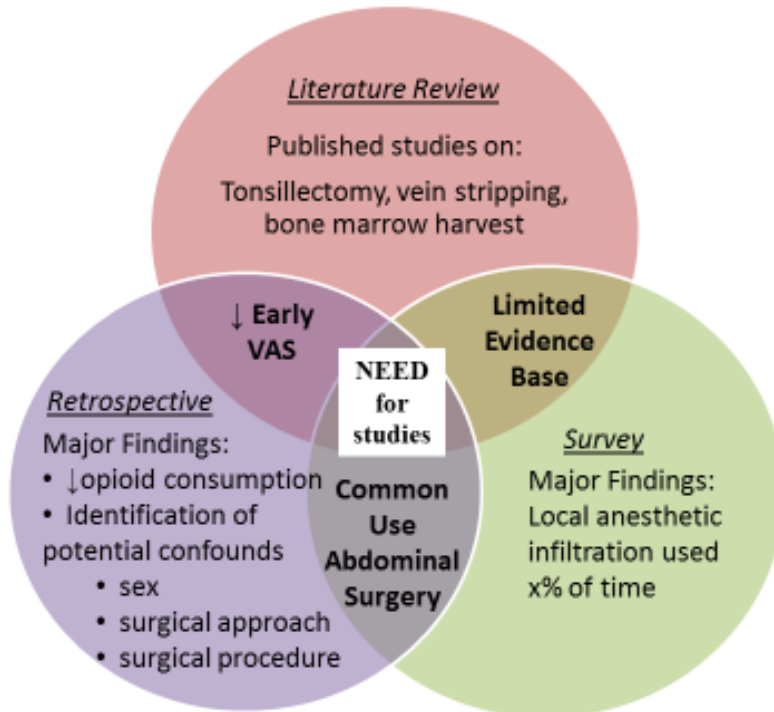


Figure 5.1 Visual representation of the phases of research and interlinking aspects

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