INTRA-OPERATIVE LOCAL ANESTHESIA AND ANESTHESIOLOGIST INTERVENTION DURING PEDIATRIC OUTPATIENT DENTAL SURGERY

A Thesis Presented in Partial Fulfillment

Of the Requirements for

The Degree Master of Science in the

Graduate School of The Ohio State University

By

Amy Kamille Watts, BS, DDS

*****

The Ohio State University

2008

Master's Examination Committee:

Sarat Thikkurissy, DDS, MS, Advisor
Megann Smiley, DMD, MS
Dennis McTigue, DDS, MS

Approved by

Advisor
Graduate Program in Dentistry

ABSTRACT

Purpose: To evaluate the use of intra-operative local anesthetic (LA) in pediatric outpatient dental surgery using general anesthesia (GA), vital sign fluctuation (end-tidal CO_2, heart rate, and respiratory rate) and subsequent anesthesiologist intervention (AI).

Methods: Forty-eight children (mean age of 3.87 years (SD 1.06)) were included in this randomized parallel-design study. Following collection of baseline vital signs, patients were either given local anesthesia before comprehensive dental treatment or not. Vital sign change was noted 30 seconds after each procedure.

Results: In the 'no' local anesthetic group, the two areas found to be statistically significant included the end-tidal CO_2 and the heart rate, both post-extraction. There was a statistically significant relationship between local anesthetic use and anesthesiologist intervention when assessing the pooled data ($p=0.0013$).

Conclusion: Patients who were not given intra-operative local anesthesia were more likely to experience vital sign fluctuation that required anesthesiologist intervention.

ACKNOWLEDGMENTS

I would like to start by saying thank you to Dr. Sarat Thikkurissy for his guidance, patience, wisdom, and support. Thank you for your many statistics lessons and consistent positive attitude throughout this journey. I feel very fortunate to have had an advisor that teaches, cares, and encourages.

Dr. Megann Smiley and Dr. Dennis McTigue were amazing committee members who helped to shape and guide this project. Dr. Smiley - a huge thank you to you not only for your anesthesia wisdom but also for helping so much with data collection. Rod Stewart – I greatly appreciate your help throughout my project with data collection.

Thank you to the College of Biostatistics and specifically Dr. Soledad Fernandez for using her amazing statistical knowledge to help guide our project and produce accurate parameters and statistical results.

Thank you to the staff dentists at Nationwide Children's Hospital for participating in my study. I was able to meet my goals and deadlines with the help of your time and involvement.

Last but certainly not least, I want to acknowledge and thank the two guys in my life who have had to endure my stress, struggles, and long hours – my husband, Dane, and my son, Evan. You both are the lights of my life and your endless support and love helped me to persevere and complete this Masters journey.

VITA

December 7, 1979.....	Born – Bryan, Texas
2001.....	B.S. Biomedical Science Texas A&M University
2006.....	D.D.S. The University of Texas Health Science Center at San Antonio Dental School
2006-present.....	Resident and Graduate Student, The Ohio State University and Nationwide Children's Hospital

FIELDS OF STUDY

Major Field: Dentistry

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figures Page

INTRODUCTION

Pain stems from a variety of events and is a conscious, emotional, and private experience. In addition to a distinct psychological response to tissue damage, there is also a physiologic component. It is the physiologic component that serves as the point of interest to the anesthesia community. All activity resulting from tissue damage is referred to as *nociception.* The balance between nociception and anti-nociception is commonly based on non-specific autonomic reactions such as hypertension, tachycardia, sweating or tearing as well as the ultimate indicator of inadequate analgesia, patient movement in response to surgery[1]. Studies are continually performed to investigate medications, monitoring, and effects of analgesia (or lack thereof) during general anesthesia.

In the anesthetized patient, pain can be referred to as nociception, which encompasses all activity resulting from tissue damage, from peripheral sensory afferent input to the brainstem level. At the level of the brainstem, the nociception may manifest as hormonal or cardiovascular responses[1]. This nociception may be modified through systemic and local manipulation of pain pathways.

The medical literature has found that the use of regional anesthesia can help reduce the amount of inhalational general anesthetic used in the overall procedure[2]. Regional anesthesia (i.e. major nerve block) has been found to

provide profound sensory and motor blockade without influencing the patient's consciousness. It also allows for a more rapid exit from the operating suite, produces little nausea[3], and controls pain in the immediate postoperative period[4]. Sevoflurane is a popular and frequently used inhaled anesthetic. According to Eger et al, anesthetic induction is often achieved with sevolfurane in children. It is a desirable choice over halothane and desflurane because it has a low pungency and non-irritating odor. It also has a low blood-gas partition coefficient which is significant, especially for children, in allowing precise control over the depth of anesthesia as well as a smooth, rapid induction of and emergence from general anesthesia[5]. Patients who are given sevoflurane exhibit fewer ventricular extrasystoles and rarely experience the severe hepatic injury seen with halothane[6]. However, it has been observed that the use of sevoflurane coincides with a high incidence of emergence agitation in the pediatric population[7]. Cravero et al found that sevoflurane caused emergence agitation (EA) in 57% of patients undergoing bilateral pressure equalization tube insertion compared to only 27% with halothane and in a separate study, found 33% of patients exhibited EA when a high threshold for agitation was defined and 80% when a low threshold was defined[8]. The mechanism to explain why this agitation occurs is unclear but it could possibly be due to the rapid recovery of consciousness seen with sevoflurane because of its low solubility[7]. If one could use regional or local anesthetic intra-operatively and allow for a reduction in the amount of sevoflurane used, emergence agitation could potentially be minimized.

The ideal anesthetic agent provides; immobility, amnesia, sedation, analgesia/nociception, and arousal blockade with a pharmacodynamic profile that includes a wide margin of safety. Anesthesia produced by inhalation anesthetics leads to amnesia and immobility[9]. Certain drugs poorly accomplish amnesia and anesthesiologists must consider this when choosing their drug regimen. Potent inhaled vapors, as well as midazolam and propofol, are better able to suppress awareness than nitrous oxide and opioids[10]. Alkire and Gorski studied the relative amnestic potency of different inhalational anesthetics and found that nitrous oxide was the most potent amenstic followed by desflurane, sevoflurane, isoflurane, and halothane being the least amenstic. Interestingly, this is the exact opposite for minimum alveolar concentration potency (i.e. nitrous oxide is the least potent but most amenstic). During the study, halothane, at its lowest dose, was found to actually increase retention performance (i.e. enhance memory). This finding lead Alkire and Gorski to hypothesize that as patients recover from halothane, and possibly sevolfurane, they likely pass through a dose stage were there is not only an increased sensitivity to pain but also an increased propensity toward remembering experiences.

Thus, the low-dose related memory enhancing effect might contribute to intra-operative awareness in cases where lighter levels of anesthesia are desired[11].

Another definition of anesthesia states there are 3 major components: amnesia, immobilization, and analgesia[12]. The latter component is a rationale some practitioners provide against using local anesthetic. The relationship between amnesia and analgesia as found by Alkire and Gorski, is not consistent

between the different inhalational agents. The doses which caused amnesia were higher (sevoflurane), approximately equal to(halothane, isoflurane, nitrous oxide), or lower (desflurane) than the doses that caused analgesia[11]. Thus, one cannot assume that a patient will have equal levels of amnesia and analgesia at all times under general anesthesia. Knowing that local anesthetic is safe for our patients[13], all resources should ensure procedures are as physiologically kind to our patients as possible.

The interaction between local and general anesthesia is a new concept in the realm of pain control that could prove very relevant to preventing "pain" or "painful memories/experiences" during dental general anesthesia cases. The process of interpreting pain physiologically is likely more complex yet than we understand. The idea of 'plasticity' related to pain has been recently introduced and involves the thought that injury can produce alterations in CNS function affecting subsequent pain sensitivity[14]. In regards to the perception of pain, it appears to be a dynamic process influenced by the effects of past experiences[14]. Studies by Kenshalo *et al* and Woolf and Wall indicate that injury or noxious stimuli can actually lead to dramatic alterations in spinal cord function[14]. According to Crile, those patients who receive inhalational anesthesia should also receive the protection of regional anesthesia in order to prevent the occurrence of persistent CNS changes and enhanced postoperative pain[14].

Full mouth dental rehabilitation under general anesthesia (GA) has become a more popular and accepted modality of treatment for comprehensive pediatric dental treatment. In a study in 2005 by Eaton JJ et al of parental

attitudes toward current behavior management techniques, GA ranked third highest in acceptability out of 8 techniques behind only tell-show-do and nitrous oxide sedation[15]. When the same behavior management techniques were examined previously in 1992, GA ranked as one of the least acceptable behavior management techniques[16]. This shift in acceptability of GA has contributed to a focus on clinical guidelines and recommendations.

Ambulatory surgery patients are expected to have shorter recovery times as well as relatively rapid discharge and restoration of normal activities[6]. The United States has had a dramatic increase in outpatient surgery in the past two decades from 16% in 1980 to 63% in 2000[17]. Regardless of the location of an operating suite, anesthesia requires the depression of the central nervous system sufficient to suppress untoward perception of, and responses to, surgical stimulation and needs to be achieved without prolonging postoperative recovery time[6]. There are, however, still aspects of outpatient dental treatment under GA that have not received specific recommendations in terms of their efficacy, purpose and safety.

One facet of full mouth dental rehabilitation under general anesthesia for which there is a paucity of literature is the use of intra-operative local anesthesia as intra-operative analgesia, or more accurately, nociception control. The American Society of Anesthesiologists and American Dental Association currently have no prescriptive guidelines as to the use of local anesthetic during general anesthetic dental rehabilitation[18,19]. The American Academy of Pediatric Dentistry does recommend that local anesthesia "may be used" to reduce pain in

the postoperative recovery period after general anesthesia and to reduce the maintenance dosage of the anesthetic drugs[20]. However, there is no recommendation in the AAPD guidelines with regards to using local anesthesia under general anesthesia for intra-operative pain and physiologic stability. The American Pain Society has a joint statement with the American Academy of Pediatrics to highlight the leadership and advocacy role of the pediatrician to ensure treatment of pain in infants, children, and adolescents, but does not make any remark as to pediatric dentists and their role in alleviating discomfort for their patients.[21] There is no clinical standard of care for the use of local anesthetic during GA dental cases. Practitioners may choose to use or not use local anesthetic during GA cases based on anecdotal experiences or pre-doctoral/post-graduate training. In the era of evidence-based dentistry, evaluation of the impact of local and general anesthetics on pediatric pain control is a useful outcome measure.

There are two primary objectives of this study. The first objective is to examine the physiologic effects of representative dental procedures (rubber dam clamp placement, pulpotomy, cementation of a stainless steel crown, and extraction) on children undergoing general anesthesia (GA). Attention will be directed to whether the use of intra-operative local anesthetic has any effect on the child's physiologic response as measured by heart rate, respiration and end-tidal carbon dioxide levels. The second objective of this study will be to determine how often therapeutic intervention is required by the anesthesia team, if and when vital signs deviate from clinically acceptable levels.

METHODS

All patients included in this IRB-approved study were seen on an outpatient basis in the Dental Surgery Center at Nationwide Children's Hospital. As there is limited literature examining this interaction, a pilot study was conducted with the first 23 subjects. The College of Biostatistics at The Ohio State University ran the initial statistics for our pilot study and was able to derive the minimum number of patients needed per group in our post-pilot study. Specifically, the focus was on AI and it was found that, when using a sample size of 23, the percent of AI in the 'no local' group (62%) and the percent of AI in the 'yes local' group (10%) gave a difference of >50% and power of 95%. Therefore, the minimum required sample for the post-pilot study was a total of 46 patients (23 per group). All patients were previously identified as requiring general anesthesia for their dental care due to pre-cooperative/uncooperative behavior and extent of need. The Nationwide Children's Hospital Institutional Review Board (IRB) approved all methods and consent forms. The inclusion criteria for this study was as follows: (1) ages 12-84 months, (2) at least one extraction of a primary maxillary tooth, (3) the use of a rubber dam clamp in the maxilla, (4) at least one maxillary primary tooth requiring pulp therapy and a crown. Operators used maxillary local infiltration and palatal infiltration. By using teeth in the maxillae, the intent was to avoid the possibility of confounded results due to

ineffective mandibular anesthesia (i.e. missed alveolar nerve blocks). According to Costa et al, the onset and duration of pulpal anesthesia by maxillary infiltration using 2% lidocaine with 1:100,000 epinephrine was found to be 2.8 minutes for onset and 39.2 minutes for duration[22]. In another study by Ram and Amir, onset of anesthesia with maxillary infiltration was noted by 100% of pediatric patients studied within two minutes[23]. All children included were classified, according to the American Society of Anesthesiologists Physical Status Classification System, as ASA Class I or II. Patients with significant cardiovascular or respiratory conditions were excluded so as to rule out any confounding variables due to a patient's current medical regimen[24].

The study consistently used one dental anesthesiologist (MS) to allow for standardization of anesthetic regimen. Rapid mask induction was used with sevoflurane 8 L/min in 100% oxygen. Then, shortly after the patient loses consciousness, sevoflurane was changed to 4 L/min in 100% oxygen. After the patient was intubated, maintenance was achieved with 50% nitrous oxide in oxygen and isoflurane titrated to desired effect, typically close to 2%. Boluses of intravenous propofol were given throughout the case, as indicated.

Standardization was also achieved by titrating the patients to a depth of anesthesia gauged by end-tidal CO_2 between 45 and 55mmHg in the spontaneously breathing patient. The dentists involved were chosen because their current practice fit into the design of our study and they were not asked to change their style of dentistry. Patients were randomly assigned to either the control group or the treatment group prior to the study[25]. Numbered envelopes

held a slip of paper inside that stated "local anesthetic" or "no local anesthetic." Charts were reviewed on a weekly basis by the study coordinator (AW) to assess who met the inclusion criteria of the study. For those patients who appeared to meet the requirements, the appropriate envelope in chronological order was placed in the patients chart prior to the day of surgery, along with the consent form. The study coordinator, operator, or the anesthesiologist was responsible for obtaining consent. Following induction, a throat pack was placed and the initial vital signs including heart rate (beats per minute), respiratory rate (breaths per minute) and end-tidal CO2 (mmHg), as well as the corresponding time, were recorded. The local anesthetic, if given, was administered next. 2% xylocaine with 1:100,000 epinephrine (AstraZeneca), at a level of 7mg/kg maximum, was the standard local anesthetic used for the anesthesia. The total amount of local anesthetic given was noted. The literature for xylocaine with epinephrine states full anesthesia will be achieved after 2-3 minutes and is maintained for 60 minutes[26]. As a result, necessary radiographs and a prophylaxis were performed next while full local anesthesia was being achieved.

After approximately five minutes, the first procedure began. The dentist stated when each procedure to be evaluated was being performed (i.e. "rubber dam clamp placed"). The data recorder would write the time of the procedure and record the vital signs after a 30 second interval following the stimulating event. General anesthetic intervention was noted simply as yes or no for each procedure. When intervention was needed, the patient received propofol in 10mg boluses. The anesthesiologist intervened when any of the following criteria

were met: patient movement, breath holding, vital sign increase 20% above baseline or end-tidal CO2 less than 40mmHG. All patients received intravenous pain control 30 minutes before the end of the case, according to the Dental Surgery Center's standard pain management protocol of 1mg/kg of Ketorolac (Toradol/Roche) to a maximum dose of 30 mg.

A pilot group with a convenience sample of 23 was utilized to assess the validity of the inclusion criteria and establish the proper sample size for a power or 90% and an alpha of 0.05. Based on the findings of the pilot group, the minimum required sample was 46 total, 23 per group. As a result of the pilot study's findings, the documentation of the reason for anesthetic intervention, additional information deemed important for evaluation, was added to the data collection form and included vital sign increase 20% above baseline for respiratory rate and heart rate, ETCO2 less than 40mmHg, patient movement, and breath holding.

For statistical analysis of the pilot study, mixed models were used rather than ANOVA because multiple measurements were taken within each subject and these measurements should be correlated. It cannot be assumed that they are independent, as is assumed in ANOVA. Tukey-Kramer adjustment was done to maintain an overall alpha level to 0.05. For the study portion of the statistical analysis, GraphPad online statistical software and JMP 6.1 software was utilized. The categorical data evaluation was completed using the Fishers exact test, and continuous data analysis was completed using the two-tailed T-test.

The statistical tests performed were chosen based on the type of data and the sample size for each test. The data that was categorical, primarily anesthetic intervention with the answer of yes or no, was evaluated using the Fisher's Exact test. This test was appropriate because often there was one or more cells with a value less than ten. Chi-square tends to overestimate significance when small numbers are used. The two-tailed, paired T-test was used for the continuous data, which included all vital sign means (end-tidal CO2, respiratory rate, and heart rate).

RESULTS

A total of 48 patients, 25 boys and 23 girls, were included in this study with a mean age of 3.87 years (standard deviation 1.06) and data was collected over a 12-month period. Demographic information is presented in Table 1. Intervention variables and the research design were validated in a pilot study of 23 patients.

I. Pilot data: Within the 'No LA' group, the mean heart rate is 15.15 bpm higher after extraction as compared to that at baseline ($p = 0.0112$). Within the 'No LA' group, the mean heart rate is 14.7 bpm higher after extraction as compared to that at crown placement ($p = 0.0048$). After extraction, the mean heart rate is 25.3 bpm higher in the 'NO LA' group compared to that in the 'YES LA' group ($p = 0.0279$). The mean heart rate in females is 10.9 bpm higher than that in males, after adjusting for LA and status variables ($p = 0.0392$). TABLE 1 gives the statistical values for heart rate and FIGURE 1 shows an illustration of the trend seen with heart rate.

Contrast	Mean Difference	Tukey Adjusted P-value
'No LA Baseline' – 'No LA extraction'	-15.1538	0.0112
'No LA Crown P' – 'No LA extraction'	-14.6923	0.0048
''No LA Extraction' – 'Yes LA extraction'	25.2980	0.0279
'Females' – 'Males'	10.9172	0.0392

Table 1: Heart Rate

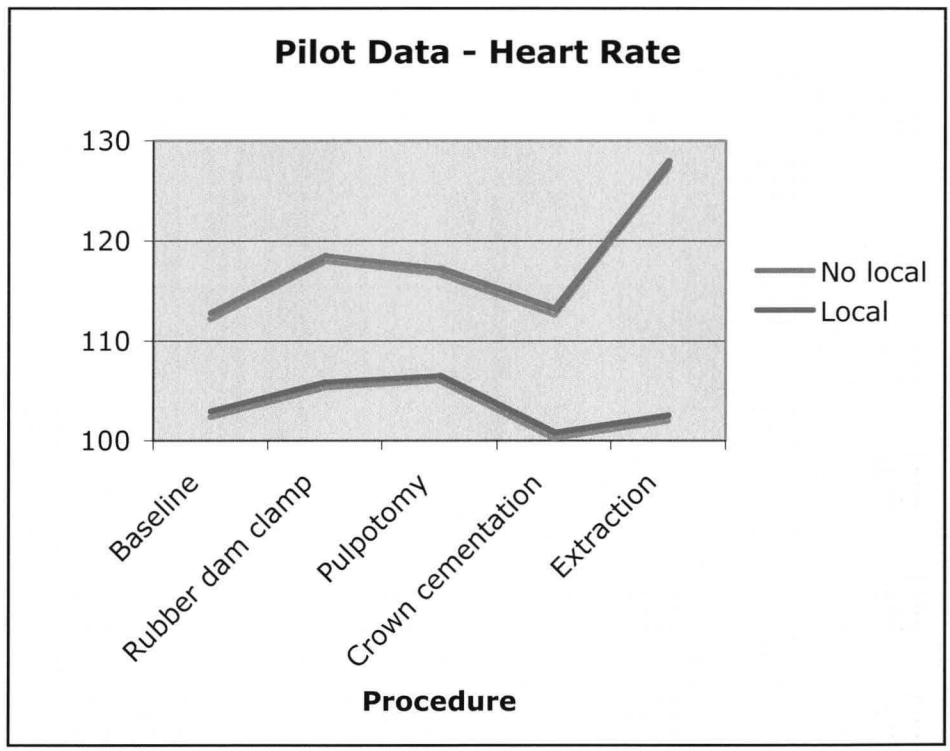

Figure 1: At each time point, 'No LA' has a higher mean than 'YES LA.' 'No LA' group has a much higher mean change as we move from 'crown cementation' to 'extraction' compared to 'Yes LA' group.

The mean respiratory rate after extraction was 2.39 breaths per minute higher than the mean respiratory rate after crown placement (P = 0.0419). The mean respiratory rate following rubber dam clamp placement was 1.74 breaths per minute higher than was found following crown placement (P = 0.0550). See Table 2 for respiratory rate statistical values. FIGURE 2 exhibits the changes noted with respiratory rate.

Contrast	Mean Difference	Tukey Adjusted P-value
'Crown placement' – 'extraction'	-2.3913	0.0419
'Crown placement' – 'Rubber dam'	-1.7391	0.0550

Table 2: Respiratory Rate

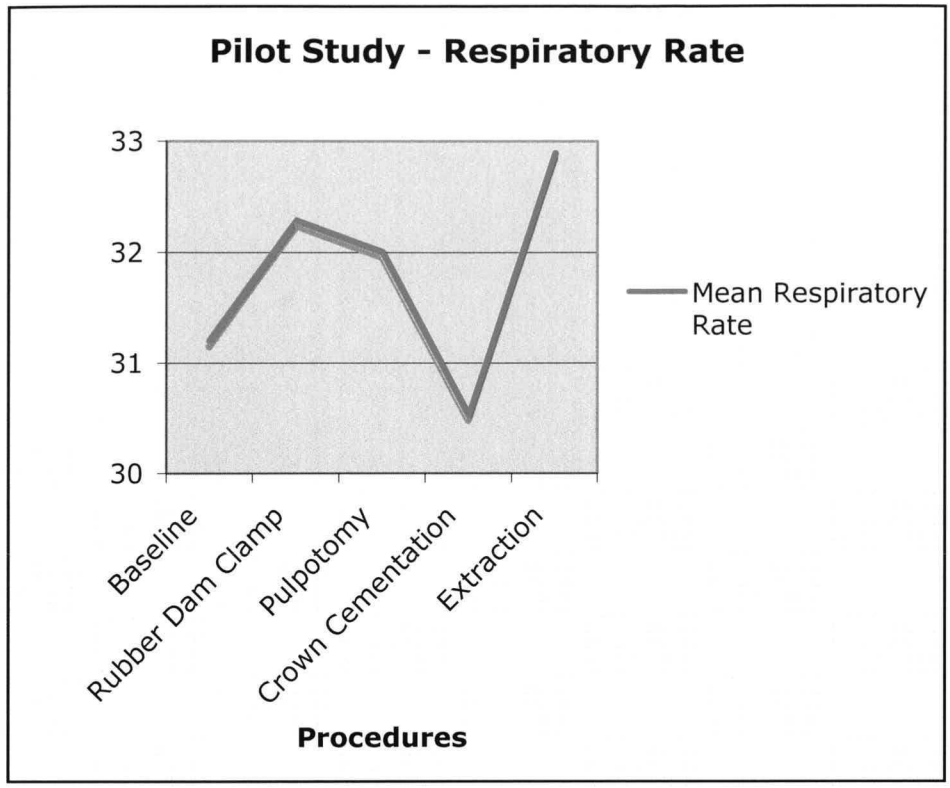

Figure 2: Mean respiratory rate is lowest during crown cementation and highest during extraction

The mean end-tidal CO_2 during baseline was 3.78 mmHg higher than that post-extraction' (P = 0.0045), 2.26 mmHg higher than that following rubber dam' clamp placement (P = 0.0187), and 3.13 mmHg higher than that after pulpotomy (P = 0.0046). The mean end-tidal CO_2 among males was 3.38 mmHg higher than that among females (p-value 0.0058). TABLE 3 shows the statistical results for end-tidal CO2, and Figures 3 illustrates the variation found with end-tidal CO2.

Contrast	Mean Difference	Tukey Adjusted P-value
'Baseline' – 'extraction'	3.7826	0.0045
'Baseline' – 'Rubber dam'	2.2609	0.0187
'Baseline' – 'Pulpotomy'	3.1304	0.0046
'Female' – 'Male'	-3.3763	0.0058

Table 3: End-Tidal CO2

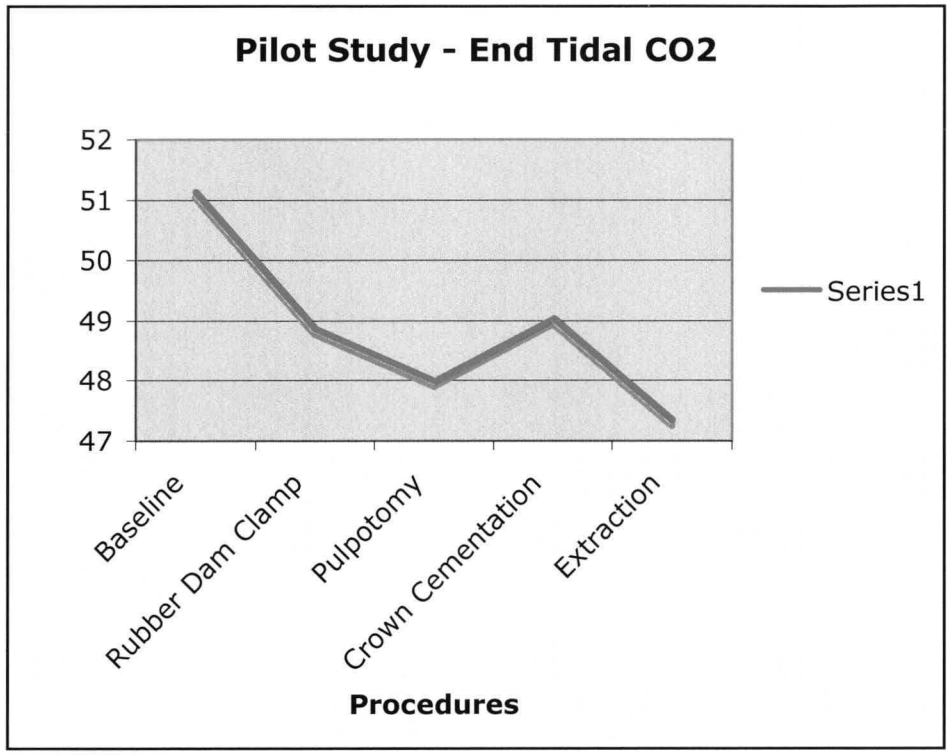

Figure 3: Mean End-tidal CO2 rate is lowest during 'Extraction' stage and highest during 'baseline' stage.

For our pilot data, when intra-operative local anesthesia was not used, a mean increase in heart rate of 25.3 bpm was noted with extractions, which was statistically significant from the local anesthesia group (p=0.0279). The

change in respiratory rate (p=0.0419) and end-tidal volume (p=0.0045) were also statistically significant with all procedures, although clinical significance was minimal.

II. Post-pilot Data Collection: In the 'yes' local anesthetic group, no statistically significant differences were found. However, in the 'no' local anesthetic group, two areas were statistically significant. These two areas included the end-tidal CO_2 post-extraction and the heart rate post-extraction. The data for both groups is presented in tables 4, 5, and 6.

	Local Anesthesia			No Local Anesthesia		
	Mean	Std Dev	p-value (vs*)	Mean	Std Dev	p-value (*)
Baseline (*)	50.54	3.55		51.42	3.08	
Rubber Dam Clamp	50.88	3.39	0.736	49.82	3.49	0.114
Pulpotomy	50.26	3.46	0.807	50.24	4.15	0.354
Crown	50.96	3.97	0.707	51.25	3.61	0.862
Extraction	50.2	3.55	0.795	47.46	4.16	***0.011***

Table 4: End-Tidal CO_2

	Local Anesthesia			No Local Anesthesia		
	Mean	Std Dev	p-value (vs*)	Mean	Std Dev	p-value (*)
Baseline (*)	30.58	5.69		29.92	5.12	
Rubber Dam Clamp	30.96	5.82	0.820	30.41	5.47	0.761
Pulpotomy	32.63	7.17	0.336	33.88	6.85	*0.065*
Crown	30.30	6.09	0.873	30.00	6.26	0.962
Extraction	30.33	5.08	0.899	32.08	5.50	0.310

Table 5: Respiratory Rate

	Local Anesthesia			No Local Anesthesia		
	Mean	Std Dev	p-value (vs*)	Mean	Std Dev	p-value (*)
Baseline (*)	118.54	15.80		111.58	14.05	
Rubber Dam Clamp	120.38	15.49	0.686	117.82	14.67	0.157
Pulpotomy	119.11	18.03	0.918	117.41	16.87	0.282
Crown	121.13	16.06	0.584	112.96	14.35	0.738
Extraction	119.53	16.50	0.868	124.38	16.45	***0.043***

Table 6: Heart Rate

III. Anesthesiologist Intervention (AI): The fisher exact test indicates there is an association between LA and AI. In the pilot data, there was a statistically significant relationship between local anesthetic use and anesthesiologist intervention (p=0.001). 38% of the time, when the vital was unacceptable, it was due to heart rate, and 60% of the time it was extraction that caused the

vital sign fluctuation. The study data revealed that 44% of the time, when the vital was unacceptable and required AI, it was due to heart rate, and 35% of the time it was extraction that caused the vital sign fluctuation. The relationship between LA and AI was only moderately significant at p=0.0599. Overall, for the entire data pool (71 patients), heart rate was the primary cause of anesthetic intervention at 42% of the time and extraction was the main cause of the vital sign fluctuation (43%). The relative risk was 3.48, which indicates there is a very significant increased risk for a patient without local anesthetic to require AI due to unacceptable vital sign change. The data for AI is presented in table 8.

Anesthesiologist Intervention	P-value
Pilot	***0.029***
Study	*0.059*
Pilot + Study	***0.001***

Table 7: Anesthesiologist Intervention

DISCUSSION

In assessing the patient profile and completeness of the data collection pool, it can be observed that the pilot study had 100% complete data collection as compared to only 46% of the study data being complete collections per patient. The pooled data resulted in 63% of the 71 subjects being complete collections. Therefore, data distribution is not equivalent and should not be assessed comparatively. There is, however, value in evaluating the pooled data, which resulted from both populations.

Another point to discuss is the impact that the incomplete data had on the results. The goal of the study was not to have one patient doing all procedures every time, but rather to always have a baseline point and then a procedure point, where vitals signs could be compared. Therefore, because there was always a standardization in the beginning (i.e. baseline), the study becomes more of an assessment of individual responses per procedure. From the pilot study, it was determined that 'per procedure' changes were more significant than 'per patient' changes.

It is the supposition of the study that once a baseline level of vital sign fluctuation/anesthetic intervention is established for healthy children, it can be further refined to examine children with compromised cardiovascular or respiratory status. Statistically and/or clinically significant values in healthy

children have implications for treatment of sick children. Cardiac patients who cannot tolerate an increase in heart rate or those patients with chronic asthma or cystic fibrosis who need to have a very stable value for their end-tidal CO2 and respiratory rate. If the mean drop in end-tidal CO2 is nearly 4 mmHg which is statistically significant but is viewed to only have mild clinical significance in a healthy child, would it be more significant in a patient with chronic asthma? If information is taken from a healthy patient and applied to a child with cardiac complications who is in need of an extraction, will the rise in heart rate, which is probable when no local anesthetic is used, be clinically unacceptable?

Although there was found to be statistical significance in several areas of the pilot and post-pilot data, it should be assessed if the degree of change has any clinical significance. As illustrated in tables 2 and 3 for the pilot data, the actual mean change for respiratory rate and end-tidal CO2 were small. The clinical impact this has on healthy children under general anesthesia is minor and would not necessarily be cause for alarm. The values for mean difference in heart rate in table 1 shows much larger changes. Again, in a healthy child, an anesthesiologist may or may not be concerned about this change assuming it was transient/temporary. Turning to the post-pilot data, the values found to be statistically significant were both found to be associated with extractions. The mean change for end-tidal CO2 was -2.74mmHg and for heart rate, 4.85 bpm. These changes are mild and the impact of these values for an anesthesiologist and their intervention would be minimal. It is important, as stated before, that

these values be examined for clinical significance in reference to children with cardiac and respiratory illness where small changes have a much larger impact.

This study was based on an ambulatory dental surgery center, which averages a room-in to room-out approximately 90 minutes for each case and has its own PACU and recovery nurse. While patient turnover is important in the specific setting studied, it does differ from a private dental office with a visiting anesthesiologist or an ambulatory surgery center which schedules far more patients each day. Each surgery center has its own anesthesia/anesthetic regimen and this variation can greatly affect depth of anesthesia as well as the type of nociception control and post-operative pain control used. The challenge with ambulatory dental surgery is to provide a quick turnaround and rapid recovery for patients while also trying to keep material expenses down. The older anesthetic agents that are less expensive impose longer recovery times and therefore can increase cost associated with the post-operative period[27]. The ideal scenario is to use a newer drug, often more expensive, in such a way that can minimize the cost without compromising the rate or quality of recovery[27]. This can be achieved by using the least anesthetic needed and possibly in combination with other forms of anesthesia such as local infiltration[28].

One weakness of our study is the lack of precise control over the amount of local anesthetic given. Each patient who did receive LA, received 1.8 ml distributed over the maxillary arch, buccal and palatal. However the exact amount each tooth received was not controlled. In the study by Ram and Amir, which evaluated the time of onset, efficacy, duration of numbness of the soft

tissues, and other aspects associated with local anesthetic, the amount of local anesthetic used was not precisely controlled, and simply stated that the study used 'up to one cartridge of lidocaine'[24]. Another aspect that arose, in one rare instance, was that local anesthetic was given and then, due to the complexity of the case, some procedures to be evaluated were not completed until 60 plus minutes after local was administered. Judging by the literature and the duration of pulpal anesthesia, this could explain why the patient, who was given local anesthetic, reacted in a way similar to those who were not locally anesthetized (i.e. minor drop in ETCO2).

The agent used for AI in this study was propofol, generally in 10mg boluses, and not an inhalational anesthetic. Using propofol is an accepted anesthetic intervention regimen/technique in pediatric dental outpatient surgery. Choosing propofol is appropriate because it has a shorter half-life than isoflurane. It is rapidly distributed to the peripheral tissues and often wears off very quickly[28]. Therefore, propofol can be used to bring the patient's vital sign(s) back to baseline without lingering in the patient's bloodstream for an extended period of time while still ensuring that the child still has a quick wake-up/recovery.

Finally, the topic of timing, or order, of procedures should be addressed. In this study, the order of procedures performed was up to the dentist completing the case, and all procedures to be examined were usually completed first or at the very least, in the first half of the case. In a future study, the impact of completing an extraction, or any procedure, at the beginning of the case as compared to the end of the case, when often the anesthetic gases are reduced,

would be a valid point to examine. The times for each procedure were recorded on all of the study patients and could be evaluated in terms of the order and the vitals to evaluate any relationship or significance.

CONCLUSION

Patients who were not given intra-operative local anesthesia were more likely to experience vital sign fluctuation that required anesthesiologist intervention. The anesthesiologist intervention that resulted was found to be of extreme significance. This study on healthy children can be used as a reference and recommendation as to the use of local anesthetic during general anesthesia for children with cardiac and respiratory complications.

BIBLIOGRAPHY

1. Rantanen M et al. Novel multiparameter approach for measurement of nociception at skin incision during general anesthesia. British Journal of Anaesthesia. 2006; 96(3): 367-76.

2. Shandling B, Steward D. Regional analgesia for postoperative pain in pediatric outpatient surgery. J Pediatr Surg 1980;15(4):477-80.

3. Patel N, Smith C, Pinchak AC, et al. Desflurane is not associated with faster operating room exit times in outpatients. J Clin Anesth1996; 8: 130-5.

4. Dahl V, Gierloff C, Omland E, et al. Spinal, epidural, or propofol anaesthesia for out-patient knee arthroscopy? Acta Anaesthesiol Scand 197; 41: 1341-5.

5. Goa KL, Noble S, Spencer CM. Sevoflurane in Paediatric anaesthesia: A Review. Paediatr Drugs. 1999 Apr-Jun;1(2):127-53.

6. Eger E, White P, Bogetz M. Clinical and Economic Factors Important to Anaesthetic Choice for Day-Case Surgery. Pharmacoeconomics 2000 Mar; 17 (3); 245-262.

7. Ko YP, Huang CJ, Hung YC, Su, NY, Tsai PS, Chen CC, Cheng CR. Premedication with Low-Dose Oral Midazolam Reducse the Incidence and Severity of Emergence Agitation in Pediatric Patients Following Sevoflurane Anesthesia. Acta Anaesthesiol Sin. 2001 Dec; 39(4): 169-77.

8. Cravero JP, Beach M, Dodge CP, Whalen K. Emergence characteristics of sevoflurane compared to halothane in pediatric patients undergoing bilateral pressure equalization tube insertion. J Clin Anesth 2000 Aug;12(5):397-401.

9. Eger EI 2nd, Sonner JM. Anaesthesia defined (gentlemen, this is no humbug). Best Pract Res Clin Anaesthesiol. 2006 Mar; 20(1):23-9.

10. Dwyer R, Bennett HL, Eger II EL. Effects of Sevoflurane and nitrous oxide in aubanesthetic concentrations on memory and responsiveness in volunteers. Anesthesiology 1992; 77:888-98.

11. Alkire MT, Gorski LA. Relative Amnesic Potency of Five Inhalational Anesthetics Follows the Meyer-Overton Rule. Anesthesiology 2004 Aug;101:417-29.

12. Guignard B. Monitoring Analgesia. Best Pract Res Clin Anaesthesiol. 2006 Mar; 20(1): 161-80.

13. Davis MJ, Vogel LD. Local anesthetic safety in pediatric patients. NY State Dent J. 1996 Feb;62(2):32-5.

14. Melzack R, Coderre TJ, Katz J, Vaccarino AL. Central Neuroplasticity and Pathological Pain. Ann N Y Acad Sci. 2001 Mar; 933:157-74.

15. Eaton, JJ, McTigue, DJ, Fields HW Jr, Beck, M. Attitudes of contemporary parents toward behavior management techniques used in pediatric dentistry. Pediatric Dentistry, 2005;27(2):107-13.

16. Havelka C, McTigue D, Wilson S, Odom J. The influence of social status and prior explanation on parental attitudes toward behavior management techniques. Pediatr Dent. 1992 Nov-Dec;14(6):376-81.

17. Fleisher LA, Pasternak LR, Lyles A. A Novel Index of Elevated Risk of Inpatient Hospital Admission Immediately Following Outpatient Surgery. Arch Surg. 2007;142:263-268.

18. Guidelines for Ambulatory Anesthesia and Surgery from American Society of Anesthesiologists. Oct. 2003. Accessed 2/16/07. http://www.asahq.org/publicationsAndServices/standards/04.pdf

19. American Dental Association – Current Policies. 2005, pgs 39-55. http://www.ada.org/prof/resources/positions/doc_policies.pdf

20. American Academy of Pediatric Dentistry - Clinical Guidelines. 2006-2007 Reference Manual, Vol 28, no. 7, pgs 106-110.

21. The Assessment and Management of Acute Pain in Infants, Children, and Adolescents. AMERICAN PAIN SOCIETY. Accessed 3/5/08. http://www.ampainsoc.org/advocacy/pediatric2.htm

22. Costa CG, Tortamano IP, Rocha RG, Francischone CE, Tortamano N. Onset and duration periods of articaine and lidocaine on maxillary infiltration. Quintessence Int. 2005 Mar;36(3):197-201.

23. Ram D and Amir E. Comparison of articaine 4% and lidocaine 2% in paediatric dental patients. International Journal of Paediatric Dentistry. 2006;16:252–256.

24. Malamed, Stanley F.. Sedation: A Guide to Patient Management, 4th Edition. Elsevier, 2002. 11.5). <vbk:0-323-01226-4#outline(11.5)>

25. http://www.randomizer.org/

26. Malamed, Stanley F. Handbook of Local Anesthesia, 5th Edition. St. Louis, MO; 2004:63

27. Eger EI, White PF, Bogetz MS. Clinical and Economic Factors Important to Anaesthetic Choice for Day-Case Surgery. Pharmacoeconomics. 2000 Mar;17(3):245-62.

28. http://en.wikipedia.org/wiki/Propofol. Last modified 16 February 2008 at 08:33.