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# General anesthesia versus deep sedation for children undergoing invasive procedures in oncologic clinic

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Keypoints

What is already known:

- Several studies promote specific general anesthesia or deep sedation techniques in managing children undergoing invasive oncologic procedures, but few compare them.

What this study adds:

- This pilot study showed that when compared to deep sedation, general anesthesia improved operative conditions and reduced procedure time without increasing side effects.
- When patient families are allowed to choose technique, general anesthesia did not lessen patient anxiety, improve comfort, or reduce discharge readiness time over sedation.

## Abstract

### Introduction

Several successful general anesthetic and deep sedation techniques have been established for children undergoing invasive oncologic procedures. This pilot prospective cohort study examined whether general anesthesia facilitated lumbar puncture and bone marrow aspiration and improved patient conditions better than sedation in patients with acute lymphocytic leukemia.

### Materials

Nineteen children with newly diagnosed leukemia who required day seven lumbar puncture/bone marrow aspirates at the Children's Hospital of Philadelphia were enrolled. Subjects were initially randomized, but due to falling recruitment, the final nine subjects were allowed to choose treatment arm. Ten patients received sedation and nine received general anesthesia. Intravenous midazolam and fentanyl were administered for sedation. General anesthesia subjects were induced with intravenous lidocaine and propofol, and maintained by mask with isoflurane or sevoflurane and $N_2O$ in $O_2$. Procedure room entry, procedure start and finish, and discharge readiness times were recorded. Serum cortisol, epinephrine, and norepinephrine levels were determined. Procedural difficulty and parent/child comfort levels were measured using 10 cm visual analog scales. Validated instruments were used to assess anxiety, quality of life, and satisfaction.

Results

Average preparation time (34.0±21.8 min vs. 11.6±10.2 min, p=0.01) and procedure time (19.4±8.8 min vs. 8.1±5.9 min, p=0.005) were longer for sedation. Oncologists rated sedation procedures more difficult than general anesthesia (4.3±4.4 vs. 0.8±0.8, p=0.03). General anesthesia decreased neither recovery time nor time to discharge readiness (25.0±21.1 min vs. 34.1±9.2 min, p=not significant). Neither parental perception of child comfort nor overall satisfaction differed significantly between groups. One failed sedation required conversion to general anesthesia.

Conclusions

General anesthesia improved operative conditions, reduced procedure time, and decreased variability in recovery time without increasing side effects. General anesthesia did not appear to alleviate patient anxiety, improve comfort, or reduce discharge readiness time over sedation.

**Keywords:** general anesthesia; deep sedation; child; bone marrow examination; lumbar puncture; patient satisfaction

## Introduction

Children diagnosed with acute lymphocytic leukemia undergo repeated lumbar puncture (LP) and bone marrow aspiration (BMA) for intrathecal chemotherapy and disease surveillance. Patients are most often sedated for these painful procedures [1-3]. However, general anesthesia (GA) may be required either primarily or after unsuccessful sedation attempts. Few studies have comprehensively compared sedation and GA in this setting. We sought to explore differences in distress and satisfaction of patients and their families, quality of operative conditions for the oncologist, time required for the procedures and recovery and incidence of adverse events. We hypothesized that without increasing the incidence of adverse events, GA would offer better operative conditions and shorter procedure times, decrease recovery time and time to disposition, reduce patient distress and pain, and improve parental satisfaction.

## Materials and Methods

After Institutional Review Board approval, 19 children between the ages of 2 and 15 y were enrolled in this prospective cohort study. All patients had been newly diagnosed with acute lymphoblastic leukemia and participation was permitted based on written parental informed consent and documentation of child assent for those of sufficient age and comprehension. Initially patients were randomized to sedation or GA for Day 7 LP/BMA using an age-stratified computer generated randomization scheme, with group assignment handed to parents in a sealed envelope. Due to progressive slowing of enrollment over a 2 year period, however, randomization opt-out was implemented after the tenth evaluable subject thereby allowing families to choose the treatment arm.

Administration of sedation and GA followed The Children's Hospital of Philadelphia's institutional standards. The sedation protocol included incremental intravenous midazolam 25-50 mcg/kg (max 2.5 mg/dose; 10 mg total) and intravenous fentanyl 1 mcg/kg (max 100 mcg total) administered by a sedation nurse under the direction of the procedurist. This nurse was dedicated exclusively to the care of the sedated patient and was responsible for monitoring and recording the of level of consciousness, respiratory rate, heart rate, arterial oxyhemoglobin saturation ($SpO_2$), and blood pressure. Measurements were recorded every 5 min in the procedure room and every 15 min during recovery. Blow-by supplemental oxygen was used to maintain $SpO_2 \geq 95\%$. Patients in the GA group underwent intravenous induction with lidocaine 1 mg/kg and propofol 3-5 mg/kg by an anesthesiologist, and were then maintained with isoflurane or sevoflurane and $N_2O$ in $O_2$ by mask.

Parents were allowed to stay at their children's bedside until they were asleep and then were escorted to the recovery area by a nurse. GA patients were monitored for end-tidal $CO_2$, temperature, respiratory rate, heart rate, $SpO_2$, and blood pressure. Vital signs were recorded

every 5 min while the children were anesthetized and every 15 min in the recovery room.

Research personnel recorded times for room entry, procedure start and finish, and recovery to Children's Hospital of Philadelphia standard discharge criteria. Baseline, pre-procedure patient anxiety was measured using the modified Yale Preoperative Anxiety Scale [4]. Blood samples were drawn from patients immediately before their procedure and again 30 minutes later in order to quantify changes in neuroendocrine stress markers. Cortisol levels were analyzed at Children's Hospital of Philadelphia using the Vitros ECi competitive immunoassay (Ortho-Clinical Diagnostics, Rochester, NY) and epinephrine and norepinephrine levels were measured by high-pressure liquid chromatography with electrochemical detection at the CORE Laboratories of The Hospital of the University of Pennsylvania. University of Michigan Sedation Scores (UMSS: 0 = awake and alert, 1 = lightly sedated/sleepy, 2 = sedated/sleeping, 3 = deeply sedated/deep sleep, 4 = unarousable) were determined for all subjects starting with procedure room entry and continued every 5 min until discharge [5].

Following LP/BMA completion, oncologists were asked to rate procedural difficulty using a 10 cm visual analog scale (VAS: 0 = no difficulty to 10 = maximum difficulty). A Steward Score was also recorded every 5 min during recovery [6]. Postoperative pain was measured using the Children's Hospital Eastern Ontario Pain Scale (CHEOPS) or the Wong-Baker Faces (FACES) scales [7, 8]. Incidences of in-hospital nausea, vomiting, delirium, headache, and sore throat were recorded. Patients meeting discharge criteria were awake, maintained normal respiratory function, had room air $SpO_2$ >92% asleep or >95% awake, had pain under control without intravenous opioids administered within the previous 20 min, were without vomiting or delirium, and had no procedure site drainage.

Parents answered questionnaires to assess stress, quality of life and satisfaction. The Parenting Stress Index – Short Form, completed at the time of the procedure, was used as a measure of baseline parent-child stress prior to the procedure [9]. Using a standardized log, parents recorded their child's health 24 hours after the procedure to identify persistent nausea, vomiting, delirium, headache, sore throat, or other new symptoms. In addition, parents rated their overall satisfaction with the procedure day and their impressions of their child's discomfort using 10 cm visual analog scale following the sedation or anesthetic technique (10 indicating complete satisfaction or no discomfort). Two validated pediatric oncology survey tools were completed 1 to 4 weeks following the procedure to explore patient and parent experiences: the Perception of Procedures Questionnaire, a measure of parent and child distress throughout the procedural process, and, the Pediatric Oncology Quality of Life Scale, evaluating quality of life [10-12].

Descriptive statistics including medians, means and standard deviations were determined. Gender associations were evaluated using the Fisher's Exact Test. Pearson Correlations and Spearman's rho Correlation Coefficients were used to examine the associations of age with all outcomes. Student t-tests were used to query equality of the means and Mann-Whitney analyses were used to discern differences by group (GA versus sedation) for non-parametric outcome data. All data analysis was conducted using SPSS for Windows, Release 15.0, 2006 (SPSS, Chicago, IL).

## Results

Forty-seven patients with newly diagnosed acute lymphoblastic leukemia were identified by the Division of Oncology staff for research personnel to consent, 38 prior to randomization opt-out. Of these potentially eligible 38 patients/families, 11 (29%) declined participation, insisting on either sedation (n= 6) or GA (n= 5); 4 (11%) declined, being too overwhelmed by the new diagnosis and treatment; 2 (5%) had complicating medical conditions excluding them from study; and one had a language barrier making it impossible to use of the survey tools. Nine subjects were enrolled following ran-

domization opt-out: 6 subjects in the sedation group and 3 in GA. In total, 19 children aged 2 to 15 y were enrolled, 10 under the sedation protocol, and 9 under GA (Table 1). Despite lack of complete randomization, age was comparable between sedation and GA subjects and there were no differences in preoperative anxiety and baseline stress as indicated by modified Yale Preoperative Anxiety Scale and Parenting Stress Index – Short Form scores.

**Table 1**
Demographics, baseline anxiety, and stress indices

| | **SD** (n=10) | **GA** (n=9) | **p-value** |
|---|---|---|---|
| **Age** (y) mean (StDev) | 7.0 (±3.8) | 5.5 (±3.6) | 0.38 |
| **Gender** male / female | 4 / 6 | 7 / 2 | 0.17 |
| **Weight** (kg) mean (StDev) | 37.7 (±26.8) | 23.5(±14.0) | 0.18 |
| **mYPAS** mean (StDev) | 9.8 (±4.2) | 11.4 (±5.8) | 0.34 |
| **PSI-SF** mean (StDev) | | | |
| PD | 19.3 (±4.8) | 20.9 (±8.3) | 0.66 |
| P-CDI | 17.7 (±6.2) | 16.8 (±5.3) | 0.75 |
| DC | 22.0 (±7.8) | 21.9 (±6.7) | 0.98 |
| Total | 59.0 (±16.6) | 59.6 (±15.4) | 0.95 |

*SD = sedation;GA = general anesthesia; StDev = standard deviation; mYPAS = modified Yale Preoperative Anxiety Scale; PSI-SF = Parenting Stress Index œShort Form; PD = Parental Distress; P-CDI = Parent-Child Dysfunctional Interaction; DC = Difficult Child. P-values for Chi-square testing.*

Composite time (from procedure room entry until recovery to discharge criteria) trended 24 min longer in the sedation group than in the GA group (79.0 ± 35.0 min for sedation versus 54.9 ± 14.1 min for GA, p=0.09) (Figure 1).

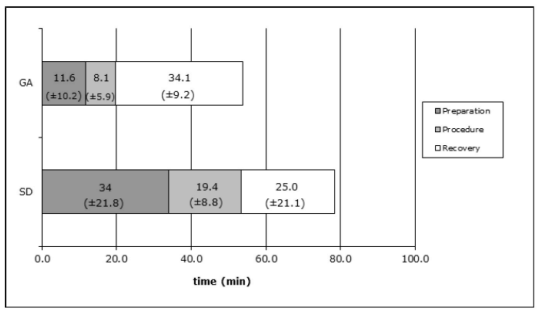


Figure 1
Composite time for procedure preparation time, procedure time, and recovery time.
SD = sedation; GA = general anesthesia

Preparation time (time from room entry to procedure start) averaged 22 min longer for the sedation group than for GA subjects (34 ± 21.8 min for sedation versus 11.6 ± 10.2 min for GA, p=0.012) and procedure time itself was similarly 11 min longer (19.4 ± 8.8 min for sedation versus 8.1 ± 5.9 min for GA, p=0.005). With regard to procedural readiness and depth of sedation, 8 of 9 (89%) GA subjects reached a University of Michigan Sedation Scale of 4 within 10 min, whereas only 2/8 (25%) sedation patients reached a University of Michigan Sedation Scale level of 2 within 30 min of room entry. Procedural and post-operative University of Michigan Sedation Scale values were consistently lower for sedation patients than GA. Half of the sedation subjects were either awake or lightly sedated immediately following the procedure, while all GA patients were sedated or unconscious. Two of 8 (25%) sedation patients remained significantly sedated (University of Michigan Sedation Scale ≥ 2) for 35-40 min. All GA patients recovered from an average University of Michigan Sedation Scale of 3.9 (Range 2-4) upon post-anesthesia admission to a score of ≤ 1 within 5-25 min. On a 10 point Visual Analog Scale where 10 is maximally difficult, operators rated procedure difficulty at 4.3 (± 4.4) for sedation and 0.8 (± 0.8) for GA (Table 2). Operator notes indicate an easier and more reliable procedure under GA than with sedation.

**Table 2**
Procedural Difficulty.

| | **SD** (n=7) | **GA** (n=9) | **p-value**, Chi-square |
|---|---|---|---|
| **Procedure Difficulty: Operator Report** mean (StDev) | 4.3 (±4.4) | 0.8 (±0.8) | 0.03 |

Changes in heart rate, blood pressure, and respiratory rate were comparable between the two groups, except for lower mean systolic blood pressure (122 ± 15 mm Hg for sedation versus 97.1 ± 6 mm Hg for GA, $p < 0.05$), lower mean diastolic blood pressure (70 ± 12 mm Hg for sedation versus 42 ± 5 mm Hg for GA, $p < 0.05$), and more significant decreases in minimum heart rate (-5.2 ± 8.3 for sedation versus -16.8 ± 11.0 for GA, $p < 0.05$) in the GA group (Table 3).

**Table 3**
Procedural hemodynamic and respiratory changes. Mean and average minimum and maximum changes from preprocedure baseline (StDev).

| | | SD (n=10) | GA (n=9) | p-value |
|---|---|---|---|---|
| **HR**, bpm | mean | 103.8 (±34.9) | 91.2 (±15.3) | 0.32 |
| | min | -5.2 (±8.3) | -16.8 (±11.0) | 0.02 |
| | max | 26.0 (±29.5) | 12.3 (±12.5) | 0.27 |
| **SBP**, mmHg | mean | 122.1 (±15.3) | 97.1 (±6.4) | 0.004 |
| | min | -19.8 (±16.7) | -16.3 (±13.4) | 0.46 |
| | max | 41.2 (±26.4) | 22.3 (±13.4) | 0.09 |
| **DBP**, mmHg | mean | 70.4 (±11.5) | 42.1 (±5.3) | 0.000009 |
| | min | -6.0 (±9.2) | -19.1 (±9.6) | 0.01 |
| | max | 13.0 (±19.7) | 15.1 (±6.9) | 0.20 |
| **RR**, breaths/min | mean | 20.4 (±4.2) | 23.5 (±3.1) | 0.09 |
| | min | -4.6 (±4.5) | -6.0 (±6.6) | 0.80 |
| | max | -0.8 (±5.5) | 2.2 (±4.7) | 0.19 |

*HR = heart rate; bpm = beats per minute; SBP = systolic blood pressure; DBP = diastolic blood pressure; RR = respiratory rate*

For the few subjects with neuroendocrine markers sampled, the levels observed were similar for the pre-procedure and post procedure mean, and the average change, except the post-procedure mean epinephrine levels which were lower for the GA group (Table 4).

**Table 4**
Serum neuroendocrine markers. Pre-procedure and post-procedural mean, and average change between preoperative and minutes postoperative levels (Range).

| | | SD (n=6) | GA (n=2) | p-value |
|---|---|---|---|---|
| **Cortisol**, mcg/dL* | Mean pre | 1.02 (± 0.75) | 0.75 (± 0.64) | 0.67 |
| | Mean post | 1.08 (± 0.54) | 0.45 (± 0.21) | 0.08 |
| | Average change | +0.06 (± 0.34) | -0.30 (± 0.42) | 0.28 |
| **Epinephrine**, pg/mL | Mean pre | 78.86 (± 31.19) | 52.19 (± 5.53) | 0.09 |
| | Mean post | 74.96 (± 30.68) | 34.51 (± 3.13) | 0.02 |
| | Average change | -3.90 (± 38.65) | -17.68 (± 8.65) | 0.45 |
| **Norepinephrine**, pg/mL | Mean pre | 247.60 (± 107.86) | 185.5 (± 17.96) | 0.23 |
| | Mean post | 269.29 (± 98.93) | 177.70 (± 196.86) | 0.63 |
| | Average change | +21.7 (± 133.02) | -7.8 (± 214.82) | 0.88 |

** n=5 for this value*

No intraoperative adverse effects were noted and there were no cases of nausea, vomiting, delirium, headache, or sore throat in the postoperative period for any subject. In the first 30 min following LP/BMA, most children, regardless of group assignment, were without pain (as measured by Children's Hospital Eastern Ontario Pain Scale or the Wong-Baker Faces scales) or were asleep. Moderate pain in 4 patients (2 sedation, 2 GA) resolved within 30 min without additional medication.

Narrative comments in the parent log and Perception of Procedures Questionnaire indicated negative experiences with the prior procedures under initial sedation (n=9) or general anesthesia (n=2) with one subject in each group having had procedure failure. With regard to the day 7 LP/BMA, one patient was moved to the GA group after failed sedation. Seeing their children scared/distressed upset 6 parents and 3 wanted to be present for the whole of the procedure. The Perception of Procedures Questionnaire indicated that parental perceptions of child distress before procedures were greater in the GA group. Similarly, the Pediatric Oncology Quality of Life Scale demonstrated that the GA group had increased reaction to therapy and a trend toward increased emotional distress (Table 5).

**Table 5**
Experience perspectives.

| | SD (n=7) | GA (n=9) | p-value, Chi-square |
|---|---|---|---|
| **PPQ** mean (StDev) | | | |
| Parent satisfaction | 6.9 (±1.2) | 11.3 (±7.3) | 0.13 |
| Child distress during | 16.9 (±8.6) | 21.6 (±9.9) | 0.33 |
| Child distress before | 6.3 (±1.8) | 17.2 (±9.6) | 0.01 |
| Parent involvement | 4.7 (±4.6) | 4.3 (±2.3) | 0.84 |
| Parent distress | 8.1 (±4.8) | 10.3 (±4.1) | 0.34 |
| Total | 44.0 (±16.4) | 68.3 (±22.8) | 0.03 |
| **POQOLS** mean (StDev) | | | |
| Physical function | 30.8 (±5.6) | 34.5 (±6.0) | 0.24 |
| Emotional Distress | 17.8 (±4.7) | 23.5 (±5.9) | 0.06 |
| Reaction to therapy | 13.8 (±2.0) | 21.7 (±4.0) | 0.001 |
| Total | 67.0 (±5.7) | 82.7 (±11.7) | 0.01 |
| **24h VAS** mean (StDev) | | | |
| Child Discomfort | | | |
| Child report | 5.8 (±3.8) | 8.3 (±1.4) | 0.15 |
| Parent report | 6.9 (±3.6) | 7.6 (±2.7) | 0.67 |
| Satisfaction | | | |
| Child | 8.5 (±1.9) | 8.6 (±2.1) | 0.98 |
| Parent | 9.0 (±1.6) | 8.9 (±1.0) | 0.87 |

*PPQ = Perception of Procedures Questionnaire; POQOLS = Pediatric Oncology Quality of Life Scale; VAS = Visual Analog Scales*

## Discussion

This small, non-randomized prospective pilot study showed that, compared to sedation, GA reduced LP/BMA preparatory and procedure times (Fig 1). In addition to differences in mean scores, standard deviations were also smaller for GA than for sedation, suggesting that GA more reliably facilitated these procedures. Indeed, the procedurists rated GA as offering unequivocally improved operative conditions. Although from patient and parental perspectives, patient anxiety, child discomfort, and overall satisfaction were generally com-

parable between the groups, GA may be advantageous overall.

The standard of care in offering GA versus sedation for pediatric LP/BMA is institution dependent [13-17]. With more limited availability of anesthesia services and historically successful sedation experiences, many institutions favor sedation [14]. Clearly, coordinating anesthesia provider and procedurist schedules can be challenging and, when sedation will suffice, logistics are kept simpler with sedation. However, due to potentially insufficient sedation, sedation may have a higher probability of failure than does GA, especially in older children [18-19]. Current practice at Children's Hospital of Philadelphia, one common to many centers, is to attempt sedation primarily unless there are abnormal airway findings or other contraindications to sedation and then move immediately to GA in the event of sedation failure. While procedurists favor GA over sedation because of improved operative conditions and a concomitant ability to focus on procedure performance, parents appear to favor the choice itself. During a time of intense stress and uncertainty with a new oncologic diagnosis in their child, parents often want to minimize the unknown, choosing familiar protocols that have been successful already. A single negative experience with a particular protocol, medication, or personnel can polarize a family away from one technique or the other.

Preparatory and procedure times were definitively reduced with GA compared to sedation for several likely reasons. Reliable anesthetic depths that decrease patient movement can be achieved more quickly and adjusted more rapidly with GA, especially with the use of propofol and sevoflurane administered by a pediatric anesthesiologist [13]. In addition to the differences in medication potencies, protocol-driven sedation titration guidelines do not allow nurses administering sedation to dose in excess of population-based norms, and further require ≥ 5 minutes between doses for adequate observation of effect. Fully 92% (22/24 min) of the sedation composite time increase over GA is related to preparatory time. Finally, in the sedation group, procedurists must both perform the LP/BMA and supervise the sedation process, potentially diverting attention from and thereby lengthening the procedures themselves in order to assure sedation safety.

From a physiologic standpoint, GA may more effectively mitigate the stress response associated with LP/BMA. Subjects in the GA group had lower mean systolic blood pressure, mean diastolic blood pressure, and significant decreases in minimum heart rate and diastolic blood pressure (Table 3). These hemodynamic differences may be consequences of the deeper plane of anesthesia and/or the properties of drugs themselves causing vasodilation and decreased cardiac output [20, 21]. Higher procedural systolic blood pressure and diastolic blood pressure are consistent with sedation being less effective in blunting stress response to invasive procedures. Too few samples were obtained for measurement of neuroendocrine marker levels and the 30 minute comparison interval may not have been optimal to capture stress-related change, but the limited data are at least consistent with GA more effectively minimizing stress response: post-procedure epinephrine levels were lower for GA subjects than for sedation subjects. No other studies have explored pre- and post-operative differences in neuroendocrine markers in this setting. The correlations between patient anxiety, response, and physiological and biochemical changes may, in fact, be independent of each other [22].

Patient anxiety, parental perception of child discomfort, and overall satisfaction were generally comparable between the groups, but potential associations undoubtedly were influenced by selection biases. Kazak and colleagues had demonstrated an inverse relationship between patient age and level of distress [23]. Although the GA cohort trended younger and was predominantly male in this small non-randomized study, modified Yale Preoperative Anxiety Scale measurements of baseline patient anxiety and Parenting Stress Index – Short Form surveys of parent-child stress were comparable in both

groups. The Perception of Procedures Questionnaire measure for child distress before the procedure indicated that parents perceived greater distress for those receiving GA before the procedure (6.3 ± 1.8 for sedation versus 19.1 ± 8.3 for GA, p=0.01). While we cannot be certain as to the reason for the apparent discordance in preprocedural anxiety/distress for the GA group between the modified Yale Preoperative Anxiety Scale and the Perception of Procedures Questionnaire subdomain, it is most likely related to parental perspective as reported in the Perception of Procedures Questionnaire. Narrative comments of negative experiences with prior sedation for earlier diagnostic procedures make it clear that the Perception of Procedures Questionnaire scores do not reflect the study technique only; most GA subjects with high Perception of Procedures Questionnaire scores had negative experiences with prior sedation, comments from these parents strongly favor GA. Furthermore, Kazak et al previously found that the Perception of Procedures Questionnaire Factor 3 (child distress before) discriminates between anticipatory stress and stress during the procedures and also includes parental perceptions of how long before the procedure the child showed distress. For patients and parents with prior negative sedation experiences, it would reason that this population would have earlier and higher anticipatory stress and would prefer GA.

Despite parent-selection of anesthetic technique, patient anxiety and parent-child stress did not seem to improve. This suggests that the impact of the illness and procedural experience, and not the chosen procedural management or baseline anxiety, were the basis of preoperative discomfort. As measured 1 - 4 weeks following the study procedure, emotional distress and reaction to therapy appeared to be worse in subjects having GA. Although this could be a consequence of GA itself, it is more likely a result of parental selection and reporting biases. Indeed, the Pediatric Oncology Quality of Life Scale emotional distress and report of symptoms reflects the parents' perception and shows low correlation with the child's and health care professional report [12]. Kazak et al has shown that parents' perception of their child's stress is more influenced by the affective experience for their children rather than more concrete treatment side effects [10]. Furthermore, for parents with higher procedure anticipatory stress as demonstrated in the Perception of Procedures Questionnaire, some of that anxiety could carry over into the acute post-procedural period.

The most significant limitations of this study are its small sample size and its non-randomized cohort design. The lack of randomization and blinding mitigate differences in outcomes such as perceived comfort and satisfaction. Parents were generally happy that expectations were met in the study protocol of their choice. Further research in this area would benefit from a larger sample size with randomization, but in the current environment we feel that it is unlikely that parents would consent to randomization. A repeat Perception of Procedures Questionnaire and a Pediatric Oncology Quality of Life Scale conducted at 6 to 12 months following the procedures should also be implemented to determine whether there are long term consequences of choosing sedation or GA, such as whether emotional distress and worsened reaction to therapy persist and even eclipse any early time savings benefits. Pilot study results for neuroendocrine markers levels will provide sample data for power analysis in preparation for future studies.

In this interdisciplinary study we found that GA improved operative conditions and reduced preoperative and procedure times for patients undergoing LP/BMA, but neither alleviated patient anxiety nor improved comfort. GA decreased variability in recovery time but did not reduce discharge readiness time. Without an increase of side effects and with greater control of medications administered, GA can be characterized as a superior option and alternative to sedation for these routine painful oncological procedures.

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**Disclosures**

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3. There are no conflicts of interests.

**References**

1. Evans D, Turnham L, Barbour K et al. Intravenous ketamine sedation for painful oncology procedures. Pediatr Anesth 2005; 15: 131-138.
2. Pellier I, Monrigal JP, LeMoine P et al. Use of intravenous ketamine-midazolam association for pain procedures in children with cancer. A prospective study. Pediatr Anesth 1999; 9: 61-68.
3. Zeltzer LK, Altman A, Cohen D et al. American Academy of Pediatrics Report of the Subcommittee on the Management of Pain Associated with Procedures in Children with Cancer. Pediatrics 1990; 86: 826-831.
4. Kain ZN, Mayes D, Cicchetti DV et al. The Yale Preoperative Anxiety Scale: how does it compare with a "gold standard"?. Anesth Analg 1997. 85: 783–788
5. Malviya S, Voepel-Lewis T, Tait AR et al. Depth of sedation in children undergoing computed tomography: validity and reliability of the University of Michigan Sedation Scale (UMSS). Br J Anaesth 2002; 88: 241–245.
6. Steward DJ. A simplified scoring system for the postoperative recovery room. Can Anaesth Soc J 1975; 22: 111-113.
7. McGrath PJ, Johnson G, Goodman JT et al. CHEOPS: A behavioral scale for rating postoperative pain in children. In: Fields HL, ed. Advances in Pain Research and Therapy. New York, NY: Raven Press, 1985: 395-402.
8. Wong DL, Hockenberry-Eaton M, Wilson D et al. Wong's Essentials of Pediatric Nursing, 6th edn. St. Louis, MO: Mosby, 2001.
9. Abidin RR. Parenting Stress Index Short Form: Test Manual. Charlottesville, VA: Pediatric Psychology Press, 1990.
10. Kazak AE, Penati B, Waibel MK et al. The Perception of Procedures Questionnaire: psychometric properties of a brief parent report measure of procedural distress. J Pediatr Psychol 1996; 21: 195 - 207
11. Goodwin DAJ, Boggs SR, Graham-Pole J. Development and validation of the pediatric oncology quality of life scale. J Psychol Assess 1994; 6: 321-328
12. Boggs SR, Durning P. The Pediatric Oncology Quality of Life Scale: development and validation of a disease-specific quality of life measure. In: Drotar D, ed. Measuring Health Related Quality of Life in Children and Adolescents: Implication for Research and Practice. Mahwah, NJ: Lawrence Edlbaum and Associates, 1998.
13. Crock C, Olsson C, Phillips R et al. General anaesthesia or conscious sedation for painful procedures in childhood cancer: the family's perspective. Arch Dis Child 2003; 88: 253-257.
14. Ljungman G, Gordh T, Sorensen S et al. Lumbar puncture in pediatric oncology: conscious sedation vs. general anesthesia. Med Pediatr Oncol 2001; 36: 372-379.
15. Iannalfi A, Bernini G, Caprilli S et al. Painful procedures in children with cancer: comparison of moderate sedation and general anesthesia for lumbar puncture and bone marrow aspiration. Pediatr Blood Cancer 2005; 45: 933-938.
16. Barnes, C, Downie, P, and Chalkiadis, et al. Sedation practices for Australian and New Zealand paediatric oncology patients. Journal of Paediatric and Child Health 2002; 38: 170-172.

17. Hain, RDW, and Campbell, C. Invasive procedures carried out in conscious children: contrast between North American and European paediatric oncology centres. Arch Dis Child 2001; 85: 12-15.
18. Malviya S, Voepel-Lewis T, Tait AR. Adverse events and risk factors associated with the sedation of children by non-anesthesiologists. Anesth Analg 1997; 85: 1207-1213.
19. Ronchera-Oms CL, Casillas C, Marti-Bonmati L et al. Oral chloral hydrate provides safe and effective sedation in pediatric resonance imaging. J Clin Pharmacol Ther 1994; 19: 239-243.
20. Oh, JE, Lee, HJ, and Lee, YH. Propofol versus midazolam for sedation during esophagogastroduodenoscopy in children. Clinical Endoscopy 2013; 46:368-372.
21. Davis, PJ, Cladis, FP, and Motoyama. A Practice of Anesthesia for Infants and Children, 8th edition. Chapter 7. Elsevier, Philadelphia PA, USA
22. Walco GA, Conte PA, Labay LE et al. Procedural distress in children with cancer: self-report, behavioral observations, and physiological parameters. Clin J Pain 2005; 21: 484-490.
23. Kazak AE, Penati B, Boyer BA et al. A randomized controlled prospective outcome study of a psychological and pharmacological intervention protocol for procedural distress in pediatric leukemia. J Pediatr Psychol 1996; 21: 615-631.