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Acupuncture as an Anesthetic Adjuvant for Pediatric Orthopedic Patients: A Pilot Study and Protocol Description

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ABSTRACT

Introduction: Postoperative pain and nausea are common sequelae of surgical interventions and general anesthesia. Acupuncture has shown promise for managing postoperative pain and nausea in adults, but studies have been limited in children.
Objective: This was a pilot study exploring the potential efficacy of perioperative acupuncture in 5 pediatric patients undergoing orthopedic surgery.
Materials and Methods: Five children undergoing routine orthopedic procedures were enrolled in an open-label pilot trial as part of an ongoing study of acupuncture in pediatric orthopedic patients. Perioperative acupuncture was performed following induction of general anesthesia. Postoperative courses are described and compared to previous surgeries performed without acupuncture in several cases.
Results: Acupuncture was associated with smooth postoperative courses, including low levels of pain and nausea, and relatively rapid recovery from anesthesia and surgery. In patients who underwent other procedures without acupuncture intervention, the addition of acupuncture was associated with improved recovery profiles and decreased pain. Patients' and parents' satisfaction was high. There were no side-effects of the perioperative acupuncture.
Conclusions: Acupuncture was well-tolerated in this pilot study of 5 pediatric orthopedic patients. Additional studies are to be conducted to evaluate clinical and statistical significance using a randomized, blinded study protocol.

Key Words: Perioperative Acupuncture, Pediatric Acupuncture, Pain Management

INTRODUCTION

Postoperative pain and nausea are common sequelae of surgical trauma and general anesthesia. Pain directly related to surgery may result from direct tissue damage, hematoma formation, or local inflammation. There can be associated pain, including nociceptive pain from the surgical incision, muscle spasm caused by prolonged immobilization, or abdominal pain or nausea caused by postoperative ileus.

From a Chinese medicine perspective, surgery and anesthesia can lead to loss or Stagnation of Qi or Blood, as the channels themselves may be cut, and an imbalance of Yin and Yang in the *Zang Fu* organs.[1] Patients may also experience a disturbance of *Shen*, manifesting as insomnia, anxiety, decreased energy, nausea, or loss of appetite. Perioperative acupuncture dates back to ancient times of 2000 years ago, when the legendary doctor Hua Tuo anesthetized the arm of General Guan Yu to remove an arrowhead from his upper arm.[2]

In recent times, perioperative acupuncture reemerged in 1958, when Zhuang performed acupuncture anesthesia on a patient undergoing a tonsillectomy.[3] Acupuncture anesthesia

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textbooks were published in the 1970s, outlining specific protocols for various surgical interventions.[4] As experience accumulated, it became clear that acupuncture alone was not sufficient to induce optimal anesthesia. However, acupuncture may be an effective anesthetic adjuvant as part of a multimodal technique, potentially decreasing anesthetic requirements, and facilitating postoperative recovery.[5]

As the field of perioperative medicine and anesthesia expands to include the entire process of surgical and anesthetic recovery, perioperative acupuncture has become a promising area for investigation.[6,7]

Studies with adult subjects have shown that acupuncture can be useful in the perioperative arena to reduce postoperative nausea, analgesic requirements, and pain scores.[8,9] Lin at al., in a study on adult patients undergoing lower abdominal surgery, showed that perioperative high-frequency electroacupuncture (EA) reduced morphine requirements by up to 61%, compared to a control condition without the EA.[10]

Few studies have explored the use of perioperative acupuncture in pediatric surgery. Lin et al., in a study on pediatric patients undergoing tympanostomy procedures, showed that acupuncture at LI 4 and HT 7 after induction of anesthesia resulted in decreased pain and agitation postoperatively.[11] Rusy et al.[12] and Wang et al.[13] showed that acupuncture at PC 6 resulted in significantly reduced nausea following tonsillectomy.[12,13] Gilbey et al. found that perioperative acupuncture at LI 4, LI 11, and ST 44, performed in three separate sessions over 2 days, resulted in decreased pain and analgesic consumption, with higher patients' and parents' satisfaction following tonsillectomy.[14] Tsao et al. found that use of a single preoperative treatment following induction of anesthesia, utilizing a multimodal technique involving *Shen Men*, Cingulate, Master Cerebral and tonsil ear points; and ST 36 and LI 4, PC 6, TE 5, and KI 6 led to decreased postoperative pain and increased oral intake in patients following tonsillectomy.[15]

In this article, the current authors report the use of perioperative acupuncture as an adjunct to improve the outcomes of children undergoing orthopedic surgery. Specifically, this article describes a case series of 5 children who underwent orthopedic surgery with general anesthesia and received preincisional acupuncture immediately following anesthesia in the operating room. This series represents a subset of a larger ongoing study to determine if acupuncture will reduce hydromorphone use via patient-controlled analgesia (PCA) by children after orthopedic surgery. Some of these children had undergone previous surgery for ongoing orthopedic concerns; the children's previous perioperative courses are reviewed briefly.

MATERIALS AND METHODS

Following approval by the institutional review board, informed consent and assent, as appropriate, were obtained from a parent and each patient prior to surgery. Surgical and nursing staff received in-service on the research protocol and were informed prior to each child's participation in the study. Children were prospectively enrolled according to the following:

- *Inclusion criteria*—1–16 years old, American Society of Anesthesiology (ASA) health status I–III, and scheduled for orthopedic surgery under general anesthesia
- *Exclusion criteria*—ASA IV status, patients unable to use a PCA device, inability to keep track of outpatient medications, body mass index (BMI) >35, or undergoing surgery for metastatic malignancy.

A standard premedication of midazolam (0.5 mg/kg PO or 0.025 mg/kg intravenous [I.V.]) was given to each study patient in the preoperative holding area. Following anesthetic induction, all study patients underwent a 15-minute acupuncture session prior to surgical incision. The perioperative protocol consisted of 4 separate protocols described in detail below. The rationale for this multimodal acupuncture protocol is similar to the ''compound point prescription'' described in textbooks of acupuncture anesthesia practiced in the People's Republic of China.[4]

Perioperative Protocol

Protocol 1. Bladder meridian points, located 2.5 cm from the spinal vertebrae, were used to decrease sympathetic stimulation. Kotani et al. have previously shown that stimulation of these points via placement of intradermal needles reduced sympathetic stimulation following abdominal surgery.[8] Painless sterile disposable press tacks (SEIRIN® Pyonex Jr.) were placed on the back on Inner Bladder or *Back Shu* meridian points corresponding to the anatomical area of surgery—C5–T8 for upper-extremity surgery, and L3–S2 for lower-extremity surgery. These press tacks were left in place during the surgery, and then removed in the morning of postoperative day (POD) 1.

This acupuncture protocol on the Bladder meridian was omitted for spine surgery, as this would interfere with the surgical procedure.

Protocol 2. Percutaneous electrical acupuncture using an 8C.Pro Pantheon Electrostimulator electrical stimulation alternating 2 Hz and 100 Hz was applied for 15 minutes bilaterally from acupuncture points LI 4 to ST 36, contralaterally, GB 34 to GB 39, and PC 6 bilaterally. Han showed that alternating low and high electrical frequencies stimulated both the endogenous endorphins and dynorphin systems.[16]

LI 4 and ST 36 are principal meridian points. LI 4 is one of 4 strongest energy and analgesic points on the body, and is part of the Four Gates System. As a strong energy point, LI 4 strengthens the body against illness and fatigue, and helps dispel disrupted Qi flow. ST 36 in combination with LI 4

tonifies Yang energy and, by itself, has strong analgesic properties. The contralateral administration was performed to adhere to classical meridian organization principles. GB 34 was chosen as a *Hui* point for tendons and muscles. GB 39 was used as the *Hui* point for marrow and bone, as well as being an intersection point for the 3 Yang channels of the leg. PC 6 stimulation was performed at high frequency as this has been shown in many previous studies to be superior in management of postoperative nausea and vomiting (PONV).

These acupuncture needles were removed just prior to the start of surgery.

Protocol 3. Percutaneous neuromuscular stimulation along principal meridians proximal to the incision site for segmental inhibition of nociceptive input from the surgical intervention was performed by identifying the two meridians most closely affected by the surgical incision. Electrical stimulation was then performed at bilateral points most closely accessible to the practitioner along the direction of the meridian. This rationale was derived from the technique of ''stimulating the nerve trunk that controls the location of the surgery''—also described in the People's Republic of China *Acupuncture Anesthesia* textbook—and varied with the surgical site.[4] Acupuncture needles used during this protocol were removed prior to the start of surgery.

Protocol 4. Auricular microsystem stimulation was performed with a Pointer Plus electrotherapy device for 60 seconds at each of the following points bilaterally: *Shen Men*; Master Cerebral; Cingulate; Lung; and the anatomical site of the surgery (e.g., leg or arm, as appropriate). This was followed by placement of SEIRIN Pyonex Jr. press tacks in those points after surgical draping and skin incision. These ear points enabled an easily accessible microsystem that reinforced the benefits of body acupuncture (anatomical surgical-site designate on the ear), helped alleviate anxiety (Master Cerebral, *Shen Men*),[17] and decreased pain from the skin incision (Lung) and stress of the surgical intervention (Cingulate, *Shen Men*). The last two points are routinely utilized in Battlefield Acupuncture protocols.[18] The ear tacks were left in place until emergence from general anesthesia at the completion of surgery.

Streitberger (Asia Med) verum acupuncture needles, Special No. 16 (Gauge 8, 0.3×30 mm) were utilized for all acupuncture treatments. Needles were inserted perpendicular to the meridian, until a manual De Qi sensation was obtained. Acupuncture was performed by Drs. Seybold and Golianu, both certified physician acupuncturists with more than 5 years of experience in medical acupuncture.

Hydromorphone boluses were given to maintain each patient's mean arterial pressure and heart rate within 20% of the patient's baseline, and a respiratory rate under 30 breaths per minute (when the patient was breathing spontaneously with a laryngeal mask airway [LMA] in place). All of the patients received 0.1 mg/kg of ondansetron 20 minutes prior to extubation. All of the patients were placed on a hydromorphone PCA (1 mcg/kg/hour basal rate and 2 mcg/kg every 8 minutes for breakthrough pain) for postoperative pain control. These amounts were adjusted as necessary by the pediatric pain-service personnel.

Postanesthesia adverse events, such as PONV, sedation, pain scores, and postoperative opioid use, were recorded.

RESULTS

Case 1

A 10-year-old boy with a history of familial exostoses, anxiety, and attention deficit hyperactivity disorder (ADHD), was taking Concerta,® Lexapro, and melatonin. He presented for his fifth surgery to excise a recurrent tumor on the head of his fibula. In all of his previous surgeries, this patient experienced severe PONV, emergence delirium, and severe pain that was difficult to control despite having hydromorphone PCA. In addition, he reported having chronic pain that lasted several weeks after his last osteochondroma excision.

Per this study protocol, preincisional acupuncture was performed after tracheal intubation. During the surgery, he received 20 mcg/kg of hydromorphone. The patient awoke without emergence delirium, PONV, or pain. He remained comfortable on a basal rate of 1 mcg/kg/hour of hydromorphone overnight. He did not require any additional I.V. pain medication, and was discharged to go home with as-needed oral hydrocodone 5/500 the following morning. All pain scores postoperatively until the time of discharge were 0 on a 10-point scale.

Four months later, this patient returned to have an osteochondroma removed from his humerus. The family specifically requested preoperative acupuncture. He received the same anesthetic technique and was administered 20 mcg/kg of hydromorphone intraoperatively. Postoperatively, the patient received only acetaminophen orally for a pain score of 2 and was discharged to go home after 59 minutes in the postanesthesia care unit (PACU). On this occasion, he also had no PONV or emergence delirium, and subsequently, his parents reported that this child had no issues with severe pain at home.

Case 2

A healthy 5-year-old girl, who was not taking any previous medications, was scheduled for surgery. Three months prior, she had undergone an incisional open biopsy of a tumor under general anesthesia for which she received 3 mcg/kg of fentanyl and 25 mcg/kg of hydromorphone, intraoperatively. During her postoperative course, she had severe postoperative pain requiring unanticipated hospital admission.

She returned for a complete excision of a benign tumor and open reduction with plating of her distal femur. The same anesthetic technique was used as with her first surgery, with equipotent opioid dosing given intraoperatively. In addition, acupuncture was performed after induction of anesthesia per the study protocol. This time, in the postoperative area, this patient reported being comfortable after the tumor excision and plating of her femur. She required no additional analgesic medications in the PACU and was discharged to go home 1 hour after her surgery. Her pain at home was well-controlled with oral pain medications on an as-needed basis.

Case 3

A 9-year-old boy, with a history of bilateral hypoplastic lateral femoral condyles and corrected cataracts, presented for a wedge osteotomy of his right femur with acupuncture. The same procedure was subsequently repeated on his left femur 4 months later without perioperative acupuncture. An identical anesthesia technique was used for both procedures. During the first surgery, he had a right femoral osteotomy with acupuncture and received 40 mcg/kg of hydromorphone intraoperatively. On arrival to the PACU, this patient's pain score was 5 on a 10-point scale. He later received 40 mcg/kg of morphine for a pain score of 8 in the PACU. He fell asleep and awoke 3 hours later to report no pain. Overnight, he had good pain control with PCA hydromorphone (1 mcg/kg basal and 2 mcg/kg demand dose) with self-reported pain scores between 0 and 7 and an acceptable pain level of 8. This patient was transitioned to oral pain medications by the next morning, 18 hours after his surgery, and was discharged to go home on POD 1 with good pain control.

For his second osteotomy, the patient refused additional regional block because he ''did not have much pain'' when he had his first osteotomy. This second surgery was performed with the same anesthetic technique and medications used in the first osteotomy, but without acupuncture. This time the patient experienced severe postoperative pain with an initial pain score of 8. His pain increased up to 10 in the PACU, where he received a bolus of 2 mcg/kg of hydromorphone, which reduced his pain level to 2–3. On his first postoperative night, during 21 hours of PCA use, his pain scores ranged from 2 to 7, with an acceptable pain score of 4. He was finally transitioned to 5/325 mg of oxycodone/acetaminophen 35 hours after surgery. The patient could not be discharged until POD 2 because his pain was inadequately controlled with oral medications.

Case 4

A 9-year-old healthy boy underwent a right femoral osteotomy and leg lengthening with instrumentation to correct a leg length discrepancy resulting from growth arrest of unknown etiology. The patient had no previous surgeries and did not take any medications. Per the study protocol, preoperative acupuncture was performed after induction of anesthesia and the placement of an LMA. The patient received the equivalent of 20 mcg/kg of hydromorphone during the surgery. He then received an additional 3.7 mcg/kg of hydromorphone in the PACU and reported a pain score of 2 when he was transferred to the floor. He did not have nausea. This patient used the standard dose PCA for 23 hours, after which his pain was adequately controlled with hydrocodone. He was cleared for discharge on POD 1.

Case 5

A 13-year-old girl, with spina bifida, a ventriculoperitoneal shunt, severe scoliosis, and anxiety, presented for spinal fusion. She had undergone many surgeries in the past and had experienced severe postoperative pain that was difficult to control despite I.V. PCA use. After this spine surgery, with the study preoperative acupuncture protocol, this patient slept well and had adequate postoperative pain relief with minimal usage of PCA during the first 24 hours. She advanced to oral pain medications on POD 4, and was discharged to go home on POD day 7. This patient reported that her postoperative pain was well-controlled during this admission.

Additional Feedback

Comments from parents and patients who took part in the study included the following: ''I want acupuncture again.'' ''I have never felt this good after surgery!'' ''This is the first time he's woken up calm. Could be he's matured, but probably not.'' ''This is the best post-op experience. I need acupuncture next time I have surgery.'' ''We want acupuncture for him next summer.'' ''I feel great! Can you teach the people at the other hospital I went to before how to do acupuncture?''

DISCUSSION

This case series describes an interesting subset of patients, some of who underwent repeated surgeries, in a sense, functioning as their own historical controls. It is notable that none of the patients, even those with histories of severe PONV, experienced any nausea or emergence delirium after their surgeries and most had reductions in their pain scores when they received acupuncture as an adjuvant to anesthesia. This small pilot of 5 pediatric orthopedic patients suggests a range of beneficial effects of perioperative acupuncture, including improved pain control, decreased nausea, decreased agitation, and earlier discharge from the hospital. The finding of decreased symptoms of emergence delirium was consistent with those reported by Kundu et al.[19] and Lin et al.[20]

Limitations of this study were the case-series format and the heterogeneity of the patient populations. Strengths included use of a consistent acupuncture technique by 2 experienced anesthesiologist acupuncturists, as well as a

comprehensive protocol addressing many of the common sequelae of anesthesia and surgery, namely, analgesia, agitation, nausea and vomiting, and sympathetic activation. An additional strength is that this protocol could be administered in one session, under general anesthesia, making the protocol relatively easy to accept from the perspective of the pediatric patients and their families. Furthermore, the study acupuncture protocol did not appear to interfere in any way with the surgical procedure.

In this study, no effort was made to determine the relative contributions of the various points to the analgesic outcomes of postoperative improvements. Instead, the aim was to maximize the analgesic and therapeutic signal, much as one would in designing a treatment aimed at optimizing clinical care. If such a signal is detectable—as appears might be the case from this limited prospective case series—further studies can determine the contribution of various components of this treatment protocol, as well as the potential synergy that may exist between components of the protocol.

There is increasing interest in the use of acupuncture as an adjunctive technique in the perioperative setting.[21,3] Although acupuncture has been shown to decrease anesthetic requirements, clinically significant benefit likely lies more in the immediate perioperative period of recovery from anesthesia and surgery.[22,23] Wang et al. showed that the use of auricular acupuncture reduced perioperative anxiety in pediatric patients.[23] Lee et al.[24] found a decreased incidence of laryngospasm in patients who received acupuncture, while Kotani et al. showed that preoperative intradermal needles reduced postoperative pain, nausea and vomiting, and sympathoadrenal responses.[8] Li et al. demonstrated that EA attenuated immune suppression associated with the surgical stress response in patients undergoing supratentorial craniotomy.[25] It is unclear how these responses may be mediated; however, studies suggest that some effects of acupuncture may be attributed to changes in cerebral blood flow, as evidenced by functional magnetic resonance imaging studies.[26]

An interesting point of discussion is that most recent pediatric perioperative studies use acupuncture protocols after the children have received general anesthesia. Although it is possible that acupuncture effects may be attenuated by the process of general anesthesia,[27] the clinical effects from this prospective case series as well as many other studies[11–15] suggest that acupuncture administered under general anesthesia can nevertheless yield clinically significant outcomes. Further research is needed in this area.

Acupuncture may benefit a patient in the perioperative period by decreasing pain/nausea and by enhancing recovery. At a time when some evidence suggests potential neurotoxicity of anesthetics in the early developmental periods, the addition of acupuncture may decrease side-effects and could potentially offer protective effects.[3] To evaluate acupuncture's clinical effects further, more-rigorous studies are needed to determine if these observations can be replicated and if they are clinically significant.

CONCLUSIONS

This was a qualitative pilot study that demonstrated the feasibility and safety of a perioperative acupuncture technique in pediatric patients undergoing orthopedic surgery.

Additional studies are necessary to investigate the specific individual contribution of the multimodal acupuncture protocol's effect on analgesia and the postoperative recovery process. Perioperative acupuncture may be a useful adjunctive therapy to decrease PONV, delirium and pain, in addition to facilitating earlier hospital discharge.

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AUTHOR DISCLOSURE STATEMENT

No competing financial interests exist.

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