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Acute Postoperative Pain Management After Major Limb Amputation in a Pediatric Patient: A Case Report

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Purpose: *Although total prevention of phantom pain is difficult, pediatric patients requiring amputation benefit from an individualized combination of analgesic techniques for phantom pain reduction using a multimodal and interprofessional approach. This is especially useful in the event a single therapy is ineffective for total pain reduction, and may ultimately lead to a reduction in chronic pain development.*

Design: *Case report with multimodal and interprofessional approach.*

Methods: *A 16-year-old patient with synovial sarcoma underwent a right hemipelvectomy and hip disarticulation. The patient had significant preoperative cancer pain requiring high-dose opioid analgesics prior to surgery. An interprofessional multimodal pain management strategy was used for acute and long-term reduction of postoperative phantom pain.*

Findings: *Although our patient developed acute phantom pain, multimodal therapy reduced immediate pain with resolution by 2 years follow-up.*

Conclusions: *An individualized plan using interprofessional teamwork before surgery may provide optimal results in alleviating phantom pain after amputation for pediatric patients.*

Keywords: *phantom limb pain, children, nerve block, neuraxial anesthesia, gabapentin, ketamine.*

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DESPITE ANALGESIC MEDICATION THERAPY, most pediatric patients undergoing surgical amputation, including joint disarticulation, still develop postoperative phantom pain.[1-4] Although prevention of phantom pain is difficult, a multimodal treatment plan is necessary for

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Conflict of interest: None to report.

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Published by Elsevier, Inc. on behalf of American Society of PeriAnesthesia Nurses

1089-9472/$36.00

https://doi.org/10.1016/j.jopan.2018.11.004

reduction of phantom pain in the acute period and long-term resolution.[3] A multimodal pain management strategy involves a purposeful combination of different pharmacologic analgesics, at optimal doses, with nonpharmacologic therapies, including psychological interventions, to provide improved efficacy and safety for the treatment of pain.[5-7] Although multimodal therapy is continually evolving in search of the ideal combination of analgesics, this type of strategy has been shown to decrease opioid consumption and morbidity from opioid side effects while improving pain control.[8]

We present a case involving an adolescent with synovial sarcoma requiring hip disarticulation, in which multimodal strategies were used for pain reduction. Patient consent was obtained via a standardized institutional written consent form that was signed by the patient at age 18 years. This case highlights how a multimodal plan must be individualized for each patient to effectively reduce postoperative pain after major amputation and joint disarticulation. We suggest interprofessional teamwork, including the importance of nursing care for the ongoing assessment of pain while understanding and delivering multimodal treatment methods. These multimodal methods include oral and intravenous analgesic medications, neuraxial and peripheral nerve catheters, and psychological support.

Case Description

A 16-year-old, 51 kg, patient presented for right hemipelvectomy with hip disarticulation for a 9 × 8 cm right adductor synovial sarcoma with 7 × 5 cm intrapelvic extension. Before surgery, she required multiple platelet transfusions for chemotherapy-induced thrombocytopenia. She became wheelchair bound from severe right thigh, groin, and pelvic pain despite escalating opioid doses. Subcutaneous enoxaparin provided deep vein thrombosis prophylaxis. She developed anxiety requiring lorazepam (1 mg orally every 6 hours as needed) with psychological intervention for both depression and anxiety, including daily bedside cognitive behavior therapy (CBT) with her psychologist. Table 1 lists a timeline of her care.

On the day of surgery, she reported 5/10 pain using the Numerical Rating Scale-11, which is standard at our institution for most older children, adolescents, and adults. Although an exact minimum age for use of the Numerical Rating Scale-11 is yet to be determined, the reliability and validity have been confirmed for pain assessment in pediatric and adolescent patients.[9] Her home medications at the time of arrival for surgery included oral morphine sulfate controlled release (30 mg twice daily) and morphine sulfate immediate release (15 mg every 6 hours as needed). A multimodal pain management strategy was developed preoperatively through collaboration between the anesthesiology and surgical teams. This was discussed with the patient and family members in the preoperative surgical clinic, and confirmed again on the morning of surgery. The multimodal pain management plan included analgesic medications, intraoperative surgical placement of epineural infusion catheters, continued psychological support with CBT, and long-term chronic pain care. Neuraxial catheters were avoided because of concerns of thrombocytopenia and anticoagulation. Once in the operating room, general anesthesia was induced with intravenous propofol 160 mg, fentanyl 150 mcg, and rocuronium 50 mg. As needed intravenous fentanyl and hydromorphone boluses provided analgesia with a total of fentanyl 650 mcg and hydromorphone 1.4 mg administered for the duration of the 9-hour surgical procedure. An intravenous ketamine 0.2 mg/kg bolus was given after induction, followed by continuous intravenous low-dose ketamine infusion at 0.2 mg/kg/h until emergence.

After hip disarticulation, right femoral and sciatic intrapelvic epineural catheters were inserted into the epineural sheath, by the surgeon, under direct nerve stump visualization and tunneled percutaneously through the skin. Figure 1 illustrates the surgical approach with structures involved in the disarticulation, and also includes the location of the sciatic and femoral epineural catheters. The surgical technique for inserting the epineural catheters directly into the nerve epineurium with percutaneous tunneling is shown in Figure 2. This is in contrast to nonsurgical peripheral nerve catheters, which are inserted percutaneously using ultrasound to place the catheter in a perineural position without penetration into the epineurium.

After surgical placement of the femoral and sciatic epineural catheters in the operating room, a 10 mL

Table 1. Case Timeline for a 16-Year-Old Female Requiring Hemipelvectomy for Synovial Sarcoma

Date	Summaries From Initial and Follow-Up Visits	Diagnostic Testing (Including Dates)	Interventions
December 2013	• Slip injury at work with subsequent fall from standing resulting in right hip pain • Visit to primary care physician for continued right hip pain		• NSAIDs prescribed by primary care physician for continued pain
January 2014	• Evaluation by orthopedist for increased right hip pain • CT and MRI scans revealed a large mass within the right adductor compartment with femoral canal extension into the right hemipelvis	CT scan: January 27 MRI scan: January 28 Core needle biopsy: January 28	• Corticosteroid injection by orthopedist • Oral opioids initiated by oncology team for continued hip and pelvic pain
February 2014	• Biopsy results confirm synovial sarcoma • Continued pain preventing ambulation requires patient to become wheelchair bound • Referral to psychologist for symptoms of depression		• Chemotherapy cycles begun • Anticoagulation initiated for DVT prophylaxis • Cognitive behavioral therapy and psychological intervention
March 2014	• Continued treatment by pediatric oncology team with referral to radiation oncologist		• Radiation therapy for tumor reduction initiated
April 2014	• Evaluation by orthopaedic surgery for potential resection after chemotherapy and radiation completion • Reduction in tumor size on MRI and PET scan negative for metastasis	MRI scan: April 25 PET scan: April 30	• Hemipelvectomy surgical procedure planned
June 2014	• Surgery performed with multimodal pain management plan including surgically placed epineural catheters, oral and intravenous medications, and psychological support in conjunction with the surgical, anesthesiology, oncology, and psychology teams • Patient experiences phantom limb pain and anxiety in the acute postoperative period that diminished over time during her hospitalization • Complex pain management after surgery because of compounding factors of pre-existing pain requiring opioids and potential for neuropathic pain after chemotherapy and radiation	Surgical hemipelvectomy: June 11	• Anxiolysis, analgesics, and epineural catheters provided in the perioperative period • Opioid PCA, epineural catheters, gabapentin, and psychological support with cognitive behavioral therapy used postoperatively • Intravenous opioids and PCA converted to oral methadone after 8 d • Epineural catheters discontinued on postoperative day 12 • Patient was discharged on postoperative day 15

(Continued)

Table 1. Continued

Date	Summaries From Initial and Follow-Up Visits	Diagnostic Testing (Including Dates)	Interventions
July 2014	• The patient suffers a syncopal episode during a hospital admission for postoperative chemotherapy • She is able to complete chemotherapy with discharge to a rehabilitation hospital	EKG: July 19	• QT Prolongation found on EKG • Oral methadone was converted to oral oxycodone • Gabapentin continued
August 2015	• After 1 year follow-up, the patient continued with outpatient rehabilitation therapy with plans for prosthesis • The only analgesic medication required at this point was gabapentin with intermittent and tolerable phantom limb pain		

CT, Computed tomography; DVT, deep venous thrombosis; EKG, electrocardiogram; MRI, magnetic resonance imaging; NSAIDs, nonsteroidal anti-inflammatory drugs; PCA, patient-controlled analgesia; PET, positron emission tomography.

Before her cancer diagnosis in December 2013, the patient was a healthy 16-year-old female. She had a history of childhood asthma that had resolved without any exacerbation or requirement for treatment for several years.

bolus mixture of 0.25% bupivacaine 6 mL and 2% lidocaine 4 mL was subsequently administered through each catheter. An infusion of 0.2% ropivacaine at 6 mL/h via each catheter was initiated before emergence and continued for 12 days postoperatively.

Within the first 30 minutes of arrival to the postanesthesia care unit, the patient awoke with severe anxiety that was treated with intravenous midazolam 2 mg. Within the first hour after awakening, she experienced 10/10 phantom pain. Intravenous hydromorphone patient-controlled analgesia (PCA) was titrated to the following settings: basal rate 0.5 mg/h, bolus 0.4 mg, 6 minute interval lockout, and hourly maximum 4.5 mg. She required lorazepam 0.5 mg every 8 hours for anxiety with psychological and palliative care team consultations performed within the first postoperative day. Her pain score decreased to 5/10 within the first 24 hours.

On postoperative day 1, adjuvants were added, including oral gabapentin, 300 mg three times daily titrated to 800 mg three times daily over 5 days, and clonidine 100 mcg/d patch applied through discharge. Psychological interventions were used regularly throughout her hospitalization, including the continued use of CBT and the initiation of mirror visualization on the first postoperative day. The technique of mirror visualization involved the bedside use of mirror reflection for the patient to visualize her intact limb while attempting to cognitively move the disarticulated limb.

After 8 days, breakthrough PCA requirements were converted to oral hydromorphone 4 mg every 6 hours as needed. The PCA basal rate was discontinued and oral methadone titrated to 15 mg three times daily. The epineural catheters were removed on day 12, and she was discharged home 3 days later with pain scores 2-4/10.

Two weeks later, she suffered syncope with a new prolonged QT interval on electrocardiogram. Oral methadone was replaced with oral oxycodone extended release 80 mg twice daily. At 1 year follow-up, she had tolerable intermittent phantom pain ranging 0-2/10 with gabapentin and as needed oxycodone. By 2 years after surgery, she no longer required opioids and continued only on gabapentin.

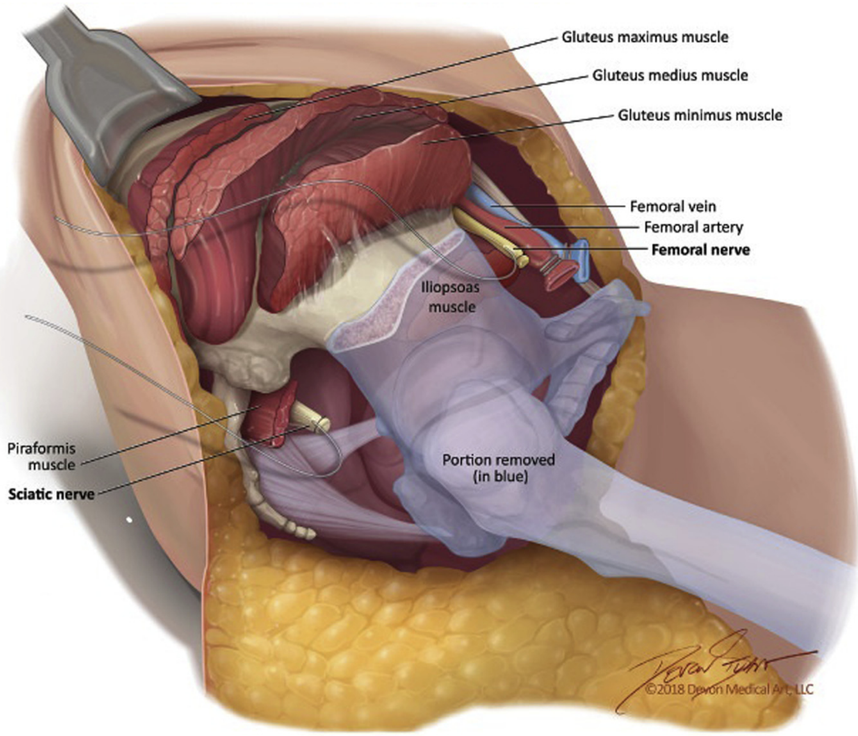

Figure 1. The retracted anatomy of the right hemipelvis showing surgical joint disarticulation, with structures removed in transparent blue shading. The surgically placed epineural catheters are shown in both the femoral and sciatic ligated nerve stumps, with percutaneous exit through the skin. (Provided by Devon Medical Art, LLC.)

Discussion

Development of phantom pain typically occurs within the first postoperative week,[1] and up to 92% of pediatric patients undergoing amputation experience phantom pain within the first year.[1-3] Although our patient developed early phantom pain that was compounded by substantial preoperative pain, escalating opioid requirements, and anxiety, the use of multimodal combination therapy reduced this within 24 hours after surgery. The treatment of postoperative pain after amputation and joint disarticulation is extremely difficult. These patients may suffer from a myriad of pain symptoms, including preoperative somatic pain related to tumor invasion and bone pain, as well as postoperative phantom limb and stump pain.[10] Also compounding postoperative amputation and disarticulation pain is the potential for residual neuropathic pain in the form of peripheral neuropathy from preoperative chemotherapy.[11] Fortunately, our patient did not suffer from postchemotherapy-induced peripheral neuropathy.

In addition, interprofessional teamwork and perioperative nursing care were imperative for the reduction of acute pain for this patient after hip disarticulation. Nursing care was instrumental in obtaining adequate and frequent pain assessments as the combination therapy analgesics and adjuvants were added to help alleviate pain. As described by Pasero and McCaffery,[12] nurses are essential for the assessment and reassessment of pain, including descriptors such as location, quality, duration, and intensity. Nursing care is also required for the direct implementation of the treatment plan and application of recommendations from interdisciplinary and interprofessional team members. A successful team approach for the reduction of pain includes clear and frequent communication with the sharing of common goals, language, and knowledge.[12] The successful

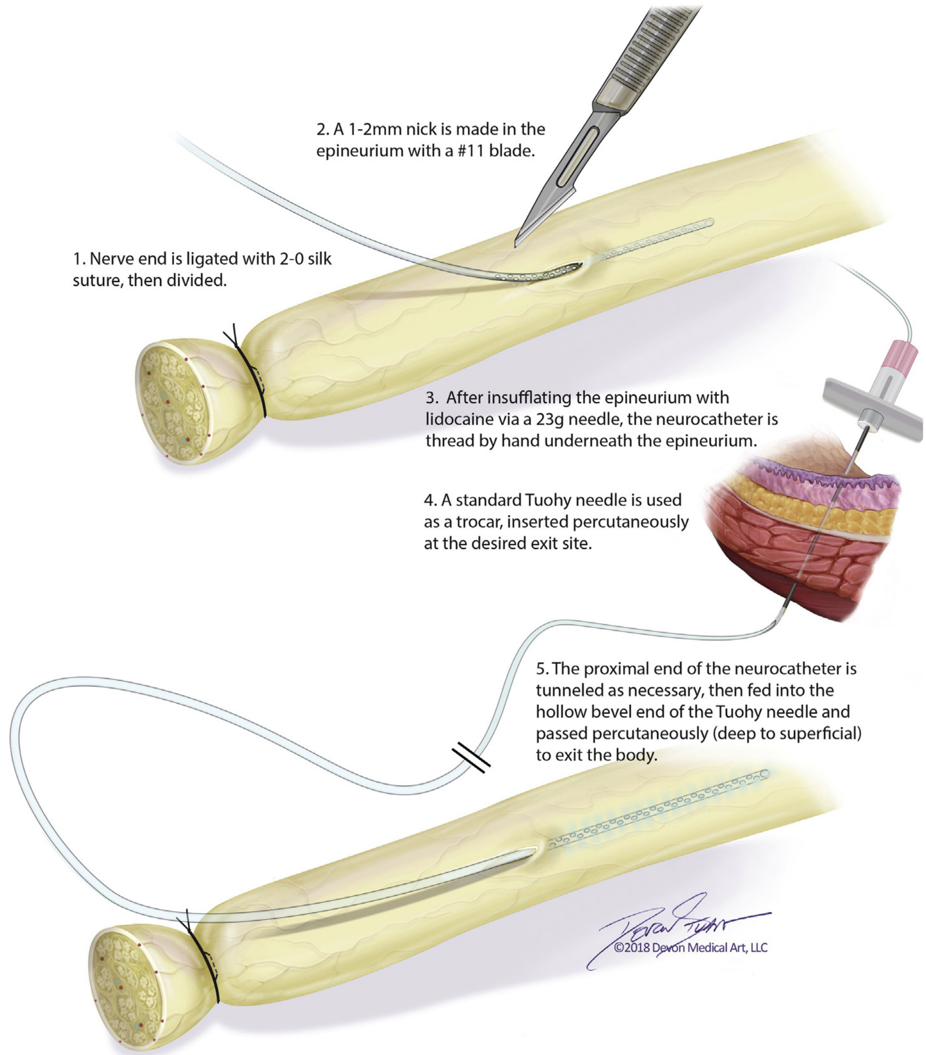

Figure 2. The stepwise surgical insertion technique for the epineural catheters into the epineurium of the ligated nerve stump. Once inserted into the nerve, the catheter is percutaneously tunneled out through the skin as shown using a standard spinal needle as a trocar. (Provided by Devon Medical Art, LLC.)

reduction of acute pain for our patient and decrease in long-term opioid requirements are attributed not only to the combination therapy of the multimodal pain management plan, but also to the interprofessional teamwork and nursing care provided for continual reassessment, understanding and application of analgesics and therapies, and partnership in treatment goals.

Similarly, neuraxial and regional anesthesia techniques have successfully reduced phantom pain in adults.[4,13-15] Although pediatric data are limited, there is no difference in comparison between epidural and peripheral nerve catheters in the development of phantom pain in adults,[13] and both are associated with less phantom pain than spinal or general anesthesia alone.[14] Because of preoperative thrombocytopenia and anticoagulation, epineural catheters were chosen for our patient rather than neuraxial anesthesia. Epineural catheters are inserted directly by the surgeon into the epineurium of the nerve (Figure 2) in contrast to perineural catheters that are inserted percutaneously using location techniques

Table 2. Perioperative Multimodal Management Strategies for Pediatric Amputation and Disarticulation Procedures

	Timing of Use			
	Preoperative			
	Weeks to Months Before Amputation	Within 24-48 h of Amputation	Intraoperative	Postoperative
Therapeutic tools				
Oral analgesic and adjuvant medications	+	+		+
Opioids, gabapentin				
Intravenous analgesic and adjuvant medications		+	+	+
Opioids, ketamine				
Continuous local anesthetic catheters		+	+	+
Epidural, peripheral nerve				
Psychological and cognitive behavioral therapy	+	+		+

(+), Recommendation as therapeutic tool.

including nerve stimulation and ultrasound to place the catheter in close proximity to the nerve outside the nerve sheath. Because of a large area of resection and surgical exposure, we preferred intrapelvic epineural catheters over a potentially challenging percutaneous insertion.

Along with this, successful peripheral nerve catheters rely on optimal positioning relative to the desired nerve.[15] Malawer et al found that the use of continuous local anesthetic infusion catheters, placed within the nerve sheath after amputation and limb salvage surgery, for 23 patients resulted in an 80% reduction in morphine equivalent requirements within the first postoperative 72 hours in comparison to historical control subjects without infusion catheters. In addition, 11 of these patients with continuous epineural local anesthetic infusion catheters did not require any supplemental opioid medications within the first 72 hours of the postoperative period. The epineural catheters for all 23 patients were placed in the operating room by the surgeon, under direct visualization of the nerve stump, into the nerve sheath after amputation and before surgical closure.[16] We used the same surgical insertion technique for the epineural catheters in our patient (Figure 2). Although epineural catheters can provide optimal analgesia,[16] insertion into the epineurium does increase the risk for nerve damage.[17] Hence, epineural catheters are reserved for those patients for whom the benefit of analgesia outweighs the risk of nerve damage, such as those patients having amputation and joint disarticulation procedures in which the nerves are surgically transected.

In addition to the epineural catheters, the early use of gabapentin was beneficial for our patient, and it was continued through 2 years follow-up. Gabapentin administration within 24 hours of amputation may alleviate long-term phantom pain, especially in combination with neuraxial or regional anesthesia.[2] Moreover, intraoperative ketamine may be advantageous in treating postamputation phantom pain in pediatric patients. Ketamine is an antagonist of the *N*-methyl-D-aspartic acid (NMDA) receptor, and its benefit to providing analgesia and decreasing opioid consumption is likely because of decreasing opioid-induced hyperalgesia for those patients requiring chronic high-dose opioids. Opioid-induced hyperalgesia occurs because of modulation of the NMDA receptor, causing aberrant nerve signaling, which can be attenuated or reduced by the NMDA antagonism of ketamine.[18,19] Although data regarding ketamine use for pediatric patients in the perioperative period are limited, low-dose ketamine infusions between 0.1 and 0.5 mg/kg/h provide opioid reduction for children suffering from cancer pain.[20] An intraoperative low-dose ketamine infusion was beneficial for our patient; therefore, perioperative low-dose ketamine infusion may decrease opioid consumption for children undergoing amputation and joint disarticulation.

Along with this, psychological interventions provided reduction in pain through management of anxiety and depression using CBT. CBT is an effective treatment for the reduction of anxiety, depression, and chronic pain in adults and children.[21] Mirror therapy was also initiated in the acute postoperative period to help alleviate her phantom limb pain. The use of mirror therapy has been successful for phantom pain reduction, although an exact scientific mechanism for its success is still unclear.[22] Although some studies show little improvement in phantom pain with mirror therapy, the side effects are extremely minimal making it a low risk intervention.[23] We recommend the use of CBT and mirror therapy in addition to analgesic therapy for the potential reduction of long-term chronic pain and phantom limb pain for pediatric patients after amputation, including joint disarticulation.

Conclusions

An interprofessional multimodal approach, including collaborative planning and nursing care to provide frequent pain assessments and therapeutic applications of analgesics in the postoperative period, successfully provided phantom pain reduction for our patient. The addition of the epineural catheters and psychological support with CBT and mirror therapy were also beneficial for our patient and contributed to pain control. Although an exact combination of analgesic therapy for multimodal pain management specifically for phantom limb pain prevention is not known, combination therapy is advantageous in the event a single therapy is ineffective. This is evident as our patient required multiple adjuvants in addition to the planned epineural catheters. Psychological interventions, including CBT and mirror visualization, may also provide additional benefit with little risk. Although multimodal analgesia reduced phantom pain for our patient, perhaps preoperative initiation of nonopioid adjuvants may have been more successful for phantom pain prevention. We suggest a multimodal approach for pediatric patients undergoing amputation, including joint disarticulation as given in Table 2. An individualized and interprofessional multimodal plan before surgery may provide optimal results in alleviating pediatric phantom pain after amputation and joint disarticulation.

Acknowledgments

The authors would like to thank Sonia Vaida, MD, and Diane McCloskey, PhD, from the Department of Anesthesiology and Perioperative Medicine and Deana Deeter, CRNP, from the Pediatric Palliative Care Hummingbird Program, at the Penn State Health Milton S. Hershey Medical Center and Children's Hospital, Hershey, Pennsylvania, for their contributions in reviewing and editing this work. In addition, the authors would like to thank David Riley, MD, of the Integrative Medicine Institute, Portland, Oregon, and CARE group member for consultation and editing of the manuscript and timeline table. The authors did not receive any external funding or grants for this work.

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