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Original Research

Characteristics of and Factors Contributing to Immediate Postoperative Pain After Ankle Fracture Surgery

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ABSTRACT

To build an appropriate strategy of pain management after ankle fracture surgery, surgeons need to know the characteristics of postoperative ankle pain and its contributing factors. The aim of the present study was to investigate the maximum pain period after ankle fracture surgery and the factors affecting postoperative pain using a linear mixed model when patient-controlled analgesia (PCA) was used as a basic modality. A total of 219 adult patients (108 males and 111 females; mean age 51.2 ± 15.9 years) who had undergone operative treatment for ankle fractures were included. Data on fracture severity, causes of injury, interval between injury and surgery, anesthesia method, American Society of Anesthesiologists classification, and operative time were collected. Pain intensity was measured using an 11-point pain intensity numerical rating scale preoperatively and postoperatively every 8 hours. Intravenous PCA was prescribed to all patients. The chronologic pattern of postoperative pain and factors affecting it were statistically analyzed using a linear mixed model. Maximum postoperative pain was observed at 8 hours postoperatively, and the maximum pain numerical rating scale score was 3.92, measured at 8-hour intervals. The severity of fracture ($p = .01$) was the only significant factor contributing to postoperative pain after ankle fracture surgery on multivariate analysis. Clinicians should consider the chronologic pattern of postoperative pain after ankle fracture surgery during postoperative pain management. Interventions for pain control, in addition to PCA, might be needed at ~8 hours postoperatively, especially for those with severe ankle fractures.

Postoperative pain management is an important problem because postoperative morbidity, rehabilitation, and patient satisfaction can be affected by the extent of postoperative pain (1–5). To build a strategy of proper postoperative pain management, we need to acknowledge the pain characteristics of various surgical procedures and their respective contributing factors.

Ankle fractures are 1 of the common orthopedic injuries (6–8), and a considerable portion of ankle fractures will be treated operatively (i.e., open reduction and internal fixation). Previous studies have reported that spinal anesthesia, low American Society of Anesthesiologists (ASA) classification, the nonuse of a tourniquet during surgery, and applying a local block were factors that improved pain relief and function after ankle fracture surgery (9–12). However, the chronologic pain characteristics immediately after ankle fracture surgery have been insufficiently examined.

A linear mixed model (LMM) is a parametric model for longitudinal data that quantifies the relationships between a continuous dependent variable and various predictor variables, providing a simple and effective method to incorporate within-subject and between-subject variations and the correlation structure of longitudinal data. A LMM can include both fixed and random effects. Fixed effects are nonrandom covariates assumed to be at the same level in the specific sample group and the population. Random effects are variables from which we examine only a subset of possible values within the model, and for which our interest lies, not in specific coefficient

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estimates, but, rather, in the variability in outcomes associated with those variables (13). Therefore, investigating the factors that influence postoperative ankle pain using a mixed mode application can provide more practical and refined information to clinicians (14). The aim of the present study was to investigate the chronologic pattern of the immediate postoperative pain period after ankle fracture surgery using a LMM and patient-controlled analgesia (PCA) as the baseline pain management.

Materials and Methods

The institutional review board at our hospital approved the present retrospective study.

Subjects

Consecutive patients with ankle fractures who had undergone operative management from January 2008 to December 2012 were included in the present study. All patients underwent ankle trauma radiographs (anteroposterior, lateral, and mortise views) and were asked about the cause of their injury, which was recorded in the electronic medical records. Pain using a numerical rating scale (NRS) was recorded every 8 hours during hospitalization. Demographic data, including age and gender, were collected. The inclusion criteria were as follows: (1) adult patients aged >20 years, and (2) operative treatment for ankle fractures, including medial malleolar, lateral malleolar, bimalleolar (medial and lateral malleoli), and trimalleolar (medial, lateral, and posterior malleoli) fractures. The exclusion criteria were as follows: (1) extra-articular distal tibial fractures and pilon fractures, (2) other concomitant fracture at other body parts such as the foot, contralateral ankle, and spine, (3) open fractures, (4) neurovascular injury, (5) neuropathic disorders, and (6) a history of substance or narcotic abuse.

Surgery was performed by 2 orthopedic surgeons (M.S.P., K.M.L.) with 14 and 12 years of experience, respectively, using the same protocol. The surgical procedure consisted of open reduction and internal fixation using a plate and screws for the lateral malleolus and a cannulated screw or tension band wiring for the medial malleolus. Fixation of the posterior malleolus was performed percutaneously using a cannulated screw anteroposteriorly if displaced >2 mm or if constituting more than one third of the joint surface on the lateral radiograph. Syndesmotic fixation was performed in cases of obvious widening of tibiofibular clear space on stress-testing after fixation of the medial and lateral malleoli. No attempts were made to repair the deltoid ligament. All surgical procedures were performed with a pneumatic tourniquet inflated, followed by a compressive dressing, with short leg splint immobilization after layer-by-layer wound closure.

All patients were treated with a standardized postoperative protocol for physical therapy and weightbearing ambulation. All patients used an applied splint and were immobilized for about 2 weeks, at which time the sutures were removed. Subsequently, the patients wore a functional brace during the beginning of passive ankle motion. All patients were kept non-weightbearing for 4 weeks and then advanced to weightbearing, as tolerated, until full weightbearing began at 6 weeks postoperatively. Sports activity was allowed after 3 months postoperatively, as tolerated.

Predictors for Immediate Postoperative Pain After Ankle Fracture Surgery

According to previous data and discussion among ourselves, the candidate contributing factors to postoperative pain collected from medical records were the severity of fracture, cause of injury, interval between injury and surgery, concomitant medical diseases (hypertension and diabetes mellitus), method of anesthesia (spinal or general), ASA classification, and operative time (infiltration time of pneumatic tourniquet) (9,11,15).

The severity of fracture was divided into 2 groups: mild and severe. The mild group included medial malleolar fractures and lateral malleolar fractures, and the severe group included bimalleolar and trimalleolar fractures. The cause of injury was categorized into high-energy trauma and low-energy trauma. Traffic accidents and a fall from a height >1 m were considered high-energy trauma, and slips and falls from a height <1 m were considered low-energy trauma.

Spinal anesthesia was performed using bupivacaine/glucose 4 mL (bupivacaine HCl 20 mg plus dextrose monohydrate 320 mg). General anesthesia was induced with propofol 2 mg/kg, remifentanil 0.1 μg/kg, and vecuronium 0.1 mg/kg and maintained with propofol 0.06 mg/kg/hr and remifentanil, as needed. Additional local anesthesia was not administered, and postoperative cryotherapy was not used.

Evaluation of Pain Intensity

Pain intensity was measured using an 11-point pain intensity NRS (0, no pain to 10, the worst possible pain). During the preoperative period, patients were asked about their pain every 8 hours until surgery, as required by the protocol at our hospital. Surgery was delayed until soft tissue swelling and blistering, if present, had resolved to minimize the risk of postoperative wound complications. During the postoperative period, pain was assessed immediately on the patient's return to the general ward, which was at ~1 hour postoperatively, and then every 8 hours until discharge. Intravenous PCA with fentanyl was prescribed to all patients. The standard PCA regimen consisted of a PCA bolus of 1 to 3 mg, a lockout time of 15 minutes, and a background infusion of 0 to 50 μg/hr adjusted by patient weight and renal and hepatic function. Tramadol 37.5-mg/acetaminophen 325-mg combination tablets were prescribed as postoperative oral pain medication from the day after the operation.

Building a LMM

The pattern of postoperative pain was assessed using a LMM, adjusted for multiple factors, with gender and the severity of fracture as the fixed effects and patient age and each subject as the random effects. The estimates were fitted using the restricted maximum likelihood estimation method to produce unbiased estimators. A LMM was developed to estimate the changes by incorporating the linear follow-up duration effect, gender, age at surgery, severity of fracture, and operative time as covariates. By examining the individual pattern of the immediate postoperative pain and the follow-up time, we fitted a random slope and random intercept. To build an appropriate model that accounted for the possible additional effects on the peak postoperative pain period, multiple analysis was performed after bivariate analysis. In the bivariate analysis, a LMM was used to assess the relationship between the immediate postoperative pattern of pain and each covariate.

Statistical Analysis

Data normality was tested using the Kolmogorov-Smirnov test. A descriptive analysis was performed. Categorical variables are presented as percentages and continuous variables as mean ± standard deviation.

On univariate analysis, a LMM was used to model the immediate postoperative pattern of pain and to assess the covariate effects. Multivariate analysis was performed for the final model to examine the factors significantly contributing to the pattern of immediate postoperative pain after ankle fracture surgery. It was assumed that the covariance structure would be compound symmetric in the present study.

Statistical analyses were conducted with R, version 2.15.2 (R Foundation for Statistical Computing, Vienna, Austria) using the NLME package. All statistics were 2-tailed, and $p < .05$ was considered significant.

Results

A total of 395 patients who had undergone surgery for ankle fracture were enrolled in the database. Of the 395 patients, 176 were excluded, 91 for distal tibia or pilon fracture and 85 because of the presence of other concomitant fractures. After implementation of the inclusion and exclusion criteria, 219 patients were included in the final analysis.

The average age of the patients was 51.2 ± 15.9 years, and 108 patients were male and 111 were female. Of the 219 patients, 120 (54.8%) were assigned to the mild fracture group and 99 (45.2%) to the severe group. Also, 25 (11.4%) patients had diabetes mellitus and 46 (21%) had hypertension. Of the 219 patients, 201 (91.8%) were injured by low-energy trauma and 18 (8.2%) by high-energy trauma. Most patients (n = 202; 92.2%) received spinal anesthesia, and 17 (7.8%) received general anesthesia. The average interval between injury and surgery was 5.0 ± 4.4 days. The average operation time was 61.1 ± 26.7 minutes. The overall average length of hospital stay was 6.6 ± 2.7 days (Table 1).

The maximum postoperative pain was observed at 8 hours after surgery, at which time the average NRS score was 3.92 ± 2.2. Thereafter, the NRS score tended to decrease over time and had reached <3.0 by 32 hours postoperatively and <2.5 by 48 hours postoperatively (Fig.).

In the bivariate analysis, the fracture severity ($p < .01$) and operative time ($p = .02$) were shown to significantly affect the pattern of postoperative pain after ankle fracture surgery (Table 2).

After univariate analysis, age, gender, fracture severity, and operative time were included in the multivariate analysis. However, of all the variables we evaluated, the fracture severity ($p = .01$) was the only significant contributing factor that maximized immediate postoperative pain after ankle fracture surgery (Table 3).