CLINICAL ARTICLE

Effect of Intraoperative Dexamethasone on Pain Scores and Narcotic Consumption in Patients Undergoing Total Knee Arthroplasty

Jason Samona, DO[1,2], Carrie Cook, RN, BSN[1,2], Kyle Krupa, RN, BSN[1,2], Krystle Swatsell, RN, BSN[1,2], Andrew Jackson, MD[1,2], Chase Dukes, MD[1,2], Sidney Martin, MD[1,2]

[1]Hurley Medical Center Master of Anesthesia Program, University of Michigan-Flint, and [2]Department of Orthopaedic Surgery, Hurley Medical Center, Flint, Michigan, USA

Objective: To examine whether the addition of intravenous dexamethasone during total knee arthroplasty (TKA) would be effective at reducing postoperative pain scores and postoperative opioid consumption.

Methods: A total of 102 patients undergoing TKA were placed into two groups: 55 subjects received intraoperative dexamethasone 8 mg intravenously (treatment group) and 47 did not receive dexamethasone at any time during the perioperative period. Comparison was made using the 0–10 numeric pain rating scale and the amount of opioids used in each group.

Results: Patients who received dexamethasone required significantly less oral opioids compared to the control group. Pain scores at 24 h post-surgery were significantly less for the dexamethasone group compared to the control group. There was no difference between groups in regards to patient-controlled analgesic dose or pain scores in the post-anesthesia care unit, at 12 or 48 h post-surgery.

Conclusion: A single dose of dexamethasone given intraoperatively significantly decreased oral narcotic consumption and decreased pain scores 24 h postoperatively. Dexamethasone appears to be a safe modality to use to control pain in patients undergoing TKA.

Key words: Dexamethasone; Pain; Total knee arthroplasty

Introduction

Total knee arthroplasty (TKA) is a procedure for the treatment of degenerative joint disease of the knee. Despite advances in surgical and anesthetic techniques, many patients still suffer from acute pain in the postoperative period. Many anesthesia modalities and medications have been used in various combinations to reduce the amount of pain experienced by patients postoperatively. Standard treatment for pain relief after TKA involves the use of opioids. Other strategies employ a multi-modal approach.

Single opioid analgesics may not provide effective pain relief for moderate to severe pain, and are associated with side effects such as nausea, vomiting, sedation, constipation, and/or bleeding. These adverse side effects alter the patient's perceived surgical outcomes, and may increase the hospital stay and financial burden on the patient and the medical system. Dexamethasone is a long-acting glucocorticoid that functions as an anti-inflammatory, commonly used in the field of orthopedics. Dexamethasone has been shown to inhibit peripheral phospholipase, which decreases the pain-aggravating products from the cyclooxygenase and lipoxygenase pathways. In addition, corticosteroids inhibit cytokine gene expression and the release of pro-inflammatory enzymes, bradykinin, and neuropeptides from injured nerve terminals, all of which play a role in precipitating pain. Pro-inflammatory mediators such as interleukin 1, 6, and 8, as well as tumor necrosis factor, C-reactive protein, and leukocyte adhesion molecules also decreased with the use of corticosteroids[1].

Address for correspondence Jason Samona, DO, Department of Orthopaedic Surgery, Hurley Medical Center, 1 Hurley Plaza, Flint, Michigan, USA 48503 Tel: 248-9396263; Email: jasonsamona@yahoo.com
Disclosure: The authors have no disclosures.
Received 27 March 2016; accepted 4 April 2016

The biologic half-life of dexamethasone is 36–55 h, and its effects are most apparent in the first 24–48 h. The medication continues to maintain therapeutic levels throughout the postoperative period, when inflammation and postoperative pain are at their peak levels. Transmission of pain signals evoked by tissue damage leads to sensitization of the peripheral and central pain pathways. Administering dexamethasone before the start of the surgical procedure is a concept known as preemptive analgesia. Preemptive analgesia is a treatment that is initiated before the surgical procedure to reduce this sensitization, with the ultimate goal of decreased inflammation and pain. The current literature shows that preemptive analgesia must include a way of modulating the prolonged neuronal input into the spinal cord in the postoperative period that is produced by the inflammatory process at the site of tissue damage. Inflammatory, metabolic, hormonal, and immune responses to surgery are activated immediately after the surgical incision and, thus, early administration of corticosteroids may be important to obtain the full postoperative benefit[1].

The optimal time to administer dexamethasone is debatable; however, some studies have found that administration of dexamethasone preoperatively was more effective at reducing 24-h pain scores than intraoperative administration[2]. It is theorized that because the onset of dexamethasone is 1–2 h, sufficient time is needed to allow for the drug to diffuse across the cell membrane to alter gene transcription and protein production[2].

Several studies have shown the use of dexamethasone to be a beneficial adjunct in decreasing postoperative pain. A large systematic review of 5796 patients evaluated the impact of a single preoperative dose of dexamethasone on postoperative pain. Patients who received dexamethasone reported significantly less pain at 24 h after laparoscopic procedures, tonsillectomies, and hysterectomies, but not after abdominal surgery or middle ear surgery when compared to those who did not receive dexamethasone[2]. A 10% reduction in opioid consumption was also found at 2 h postoperatively and a 13% reduction in opioid consumption was seen at 24 h postoperatively[2]. Several other studies have found similar results in the effectiveness of dexamethasone at decreasing postoperative pain in a variety of surgical procedures, including TKA[1,3–7].

A retrospective chart review determined the effectiveness of 10 mg intraoperative intravenous dexamethasone followed by 3 days of 4 mg oral dexamethasone in patients who underwent TKA[6]. These patients demonstrated significantly lower pain scores in the recovery room and decreased opioid dose equivalence throughout the hospital stay than those not on the regimen. That study showed the effectiveness of a multi-dose dexamethasone regimen in producing postoperative analgesia in patients undergoing TKA; however, the current authors are interested in the efficacy of a single dose of dexamethasone given intraoperatively.

The purpose of the present study is to examine whether the administration of a single dose of dexamethasone intravenously early in the perioperative period to patients undergoing TKA is effective at reducing postoperative pain scores and reducing total opioid requirement during the postoperative period. We hypothesize that patients who received a single dose of dexamethasone, 8 mg, intraoperatively will have lower pain scores and a decrease in opioid consumption during the first 3 postoperative days.

Methods

Study Type and Population

Following Institutional Review Board approval, a retrospective chart review was conducted comparing postoperative pain scores and opioid consumption following a total knee arthroplasty at a center with a high volume of total joint arthroplasty procedures. American Society of Anesthesiologists (ASA) physical status I, II, and III patients who underwent total knee arthroplasty from July 2013 to December 2013 were placed into two groups. The treatment group included patients who had received intraoperative dexamethasone 8 mg intravenously and the control group included patients who did not receive dexamethasone during the TKA.

The study population was comprised of a convenience sample of all patients undergoing TKA at the institution during this time interval. A total of 102 patients underwent TKA, 55 subjects received dexamethasone (treatment group) and 47 did not (control group). The dose of dexamethasone used in this study was based on the standard dose given to patients at this institution. All patients in this study received a single dose of 8 mg of dexamethasone intraoperatively, and did not receive any more during the remainder of their hospital stay.

Study Criteria

Other inclusion criteria were age greater than 18 years, and either spinal or general anesthesia. Patients with type 1 diabetes or a history of substance abuse were excluded. Three patients were excluded from the study during the data collection process. The first patient was excluded because he had undergone bilateral knee arthroplasty. This patient received a much greater quantity of opioids when compared to the patients who had a single knee arthroplasty. The second patient was excluded because he received a dose of Ketamine, which has analgesic properties. The last patient excluded received multiple doses of dexamethasone immediately postoperatively and through his/her hospital stay for the treatment of nausea.

Data Collection

Data collected from the electronic medical record (EMR) included patient's age, sex, ASA score, height, weight, anesthesia technique (spinal versus general), dexamethasone dose, and postoperative analgesia. Where patient controlled analgesia (PCA) was used, the drug, the basal rate, the demand dose, the total dose, and any supplemental narcotics

received (intravenous and oral) were recorded. The total dose of narcotics received was converted to morphine dose equivalents (DE, 1 DE = 10 mg morphine, using the McPhearson opioid conversion calculations chart). Pain scores were recorded (using the 0–10 Numerical Rating Scale [NRS]) at the following intervals: preoperatively, immediately postoperatively, 12 h postoperatively, 24 h postoperatively, and 48 h postoperatively (which is standard protocol in our institution).

Postoperative pain scores were compared between the groups along with the total amount of opioid use for pain relief. Opioid intake during the intraoperative period and all administered analgesics were accounted throughout the patient's hospital experience, up to time of discharge. This included review of analgesia type and doses needed postoperatively in the recovery area, as well as medications administered on subsequent postoperative days.

Statistical Analysis

The primary outcome variable was reported pain scores throughout the standard postoperative hospital stay following total knee arthroplasty. A secondary outcome variable was total morphine dose equivalents. These variables were compared using independent *t*-tests. Demographic and baseline data were analyzed using two sample *t*-test for continuous data and χ^2 for categorical data to determine whether there were any differences between groups. All statistical tests were two-tailed and the alpha level was set at 0.05.

Results

No significant difference was noted between the groups with regards to age, gender, weight, and height. Administration of either general and spinal anesthesia were evenly distributed between the groups; therefore, differences in methods of anesthesia was not a statistically significant factor (Tables 1–2). Immediate postoperative pain scores were compared according to the specific anesthetic received. However, at the 12-h mark the spinal and general anesthesia groups were combined, due to the negligible analgesic effect of spinal anesthesia 12-h post administration. Both the therapeutic and control groups of the study received standard intravenous patient-controlled analgesia, which was discontinued 24 h after surgery. There was no statistical difference noted in the prescribed dosing regimen between the groups for the standardized PCA dosing ($P = 0.68$).

TABLE 1 Baseline characteristics of the patients in the treatment and control groups

Characteristics	Control group (47 cases)	Dexamethasone group (55 cases)
Age (years)*	62.6 ± 5.2	64.8 ± 4.4
Weight (kg)*	85.2 ± 9.9	92.4 ± 10.5
Height (cm)*	165.1 ± 10.2	158.9 ± 9.8
Gender (M/F)	19/28	25/30
ASA physical status (I/II/III)	0/35/12	0/41/14

*Values are expressed as the mean ± standard deviation.

TABLE 2 Anesthetic techniques between the treatment and control groups

Anesthetic	Control group (47 cases)	Dexamethasone group (55 cases)
Spinal	24	28
General	23	27

Narcotic Consumption

Patients who received dexamethasone required a significant smaller quantity of oral opioids (oral morphine equivalence 37.1 mg) compared to the control group (73.1 mg, $P = 0.020$) throughout the standard 3-day hospital stay (Fig. 1).

Pain Scores

No statistically significant difference was noted in immediate postoperative NRS pain scores upon arrival to the post-anesthesia care unit, at 12 and 48 h. However, at 24 h the NRS pain scores were lower for the dexamethasone group (4.57) than for the control group (6.077) ($P = 0.003$, Fig. 2).

Discussion

This study evaluated dexamethasone as a modality to decrease pain immediately postoperatively, at 12, 24, and 48 h following a TKA. In our retrospective study, we found a significant difference in the amount of oral narcotics used by the treatment group ($P = 0.020$) throughout the standard 3-day hospital stay, and pain scores at 24 h postoperatively were significantly lower in the treatment group ($P = 0.003$). However, immediately after surgery, at 12 h, and at 48 h, there was no difference noted in NRS pain scores, indicating

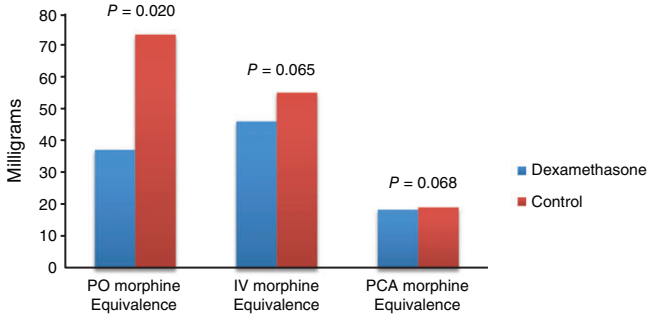

Fig. 1 Opioids taken by patients in the control and treatment groups in morphine dose equivalence. IV, intravenous; PCA, patient controlled analgesia; PO, oral.

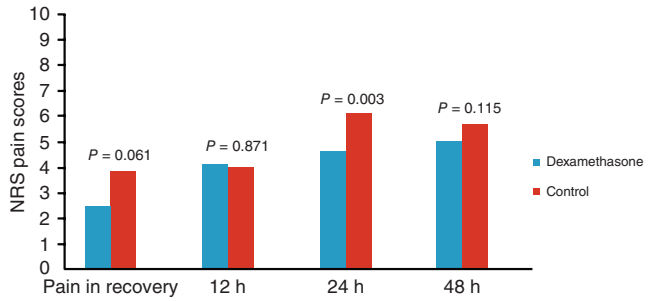

Fig. 2 Pain Numerical Rating Scale score of patients in the control and treatment group.

the greatest analgesic effect of intraoperative dexamethasone dosing in this study was noted within the initial 24 h time period. This may have contributed to the nature of the dosing and/or the mechanism of action of the medication, resulting in a delayed clinical response. Alterations in the dosing regimen, different glucocorticoids, or varying chemical properties may alter the clinically effective analgesic window. This is the only study in the medical literature known to use this standard dosing regimen of dexamethasone. A similar study was completed with dosing of 10 mg of intravenous dexamethasone prior to incision, with standard administration of ondansetron in all patients[8]. The effect of ondansetron has been known to have a clinically significant effect on the efficacy of pain medications in the perioperative period; therefore, standard administration of this medication likely skewed the perception of pain[9–11]. This study did not include the administration of ondansetron as standard protocol; therefore, the true analgesic effects of dexamethasone may have been better demonstrated in this study.

The authors call for increased research in this field, to enhance to clinical effects as demonstrated in this paper. Decreasing pain with intraoperative dexamethasone administration will reduce opioid consumption and reduce pain scores postoperatively as proven by this paper. This correlates to increased patient satisfaction, decreased strain on hospital staff in treating pain, and decreased medical costs.

This study is limited by its retrospective nature. We depended on available documentation and could not control for confounding variables. The proposed sample size was 125 subjects in each group to reach a power of 80% to detect a 0.35 difference in pain between groups; however, due to changes in the medical record system we were unable to obtain the number of subjects needed to reach this level of power. The small number of patients in this study is a limitation. The groups were not matched, although there were no significant differences between the group demographics. Due to the short half-life of fentanyl, we did not take into account the intraoperative doses. This may have skewed the immediate postoperative pain scores, but is unlikely due to the nature in which the medication was administered, the half-life of the drug, and the timeframe in which data was collected. Other medications that were not accounted for in the morphine equivalents were preoperative Ultrium, Celebrex, and Neurontin. All spinals in this study consisted of plain Marcaine, no epinephrine wash or added opioids. To highlight the true efficacy of the dexamethasone, different doses could have also been analyzed to determine the ideal dose for an ideal response. This study was limited in that this analysis was not completed, and further studies should investigate this factor. Preoperative pain scores nor designated "knee scores" were analyzed preoperatively and compared postoperatively, which could be compared to postoperative scores to provide further details regarding the final data points. Although this is a drawback for the study, the analysis of pain scores postoperatively and the random nature of patient group selection was felt to give clinically useful data regarding the use of dexamethasone in treating postoperative pain.

Conclusion

The published literature suggests that the administration of dexamethasone decreases postoperative pain scores, reduces opioid consumption, and minimizes postoperative nausea and vomiting. All of these factors impact patient satisfaction, and, most importantly, produce an overall positive postoperative outcome. In this study, we examined pain scores and opioid consumption in patients who received intraoperative dexamethasone. We found that a single dose of dexamethasone given intraoperatively significantly decreased oral narcotic consumption and decreased pain scores 24 h postoperatively. Dexamethasone appears to be a safe modality to use to control pain in patients undergoing TKA. Although many studies are proving the efficacy of dexamethasone in decreasing pain in many different surgeries, the ideal dose is yet to be found. More studies are needed in the future to focus on an ideal regime, dosage, and timing to optimize the clinical effects of this medication.

References

1. Salerno A, Hermann R. Efficacy and safety of steroid use for postoperative pain relief. Update and review of the medical literature. J Bone Joint Surg Am, 2006, 88: 1361–1372.
2. Waldron NH, Jones CA, Gan TJ, Allen TK, Habib AS. Impact of perioperative dexamethasone on postoperative analgesia and side-effects: systematic review and meta-analysis. Br J Anaesth, 2013, 110: 191–201.
3. Elhakim M, Ali NM, Rashed I, Riad MK, Refat M. Dexamethasone reduces postoperative vomiting and pain after pediatric tonsillectomy. Can J Anaesth, 2003, 50: 392–397.
4. Murphy GS, Szokol JW, Greenberg SB, *et al.* Preoperative dexamethasone enhances quality of recovery after laparoscopic cholecystectomy: effect on in hospital and postdischarge recovery outcomes. Anesthesiology, 2011, 114: 882–890.

5. Gómez-Hernández J, Orozco-Alatorre AL, Domínguez-Contreras M, *et al.* Preoperative dexamethasone reduces postoperative pain, nausea and vomiting following mastectomy for breast cancer. BMC Cancer, 2010, 10: 692.
6. Rosen AS, Pulido P, Munro M, *et al. Peri-operative dexamethasone for control of pain after total knee arthroplasty.* 2013. Available from: http://www2.aoao.org/members/news/2013spring/rosen%20abstract.html (accessed 01 June 2013).
7. Turan A, Sessler DI. Steroids to ameliorate postoperative pain. Anesthesiology, 2011, 115: 457–459.
8. Backes JR, Bentley JC, Politi JR, Chambers BT. Dexamethasone reduces length of hospitalization and improves postoperative pain and nausea after total joint arthroplasty: a prospective, randomized controlled trial. J Arthroplasty, 2013, 28: 11–17.
9. Pain Medicine News. *Pennsylvania: personalized pain medicine: pharmacogenetic testing for pain and opioid addiction*. 2015. Available from: http://www.painmedicinenews.com/ViewArticle.aspx?d=Clinical+Pain + Medicine &d_id = 82&i = October 2013&i_id = 1004&a_id = 24217 (accessed 31 January 2015).
10. IARS. *Ancona: ondansetron inhibits the analgesic effects of tramadol: a possible 5-HT3 spinal receptor involvement in acute pain in humans*. 2002. Available from: http://journals.lww.com/anesthesia-analgesia/Fulltext/2002/06000/Ondansetron_Inhibits_the_Analgesic_Effects_of.33.aspx (accessed 31 January 2015).
11. Peterson C, Hursti TJ, Börjeson S, *et al.* Single high-dose dexamethasone improves the effect of ondansetron on acute chemotherapy-induced nausea and vomiting but impairs the control of delayed symptoms. Support Care Cancer, 1996, 4: 440–446.