

11-20-2013

## Comparing the cumulative pain patients experience waiting for knee arthroplasty to their postoperative pain

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### Recommended Citation

Schwenk ES, Epstein RH, Dexter F (2013) Comparing the Cumulative Pain Patients Experience Waiting for Knee Arthroplasty to their Postoperative Pain. J Anesth Clin Res 4: 364.

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**As submitted to:**

***Journal of Anesthesia and Clinical Research***

**And later published as:**

**Comparing the Cumulative Pain Patients Experience  
Waiting for Knee Arthroplasty to their Postoperative  
Pain**

**Published: November 20, 2013**

**doi: 10.4172/2155-6148.1000364**

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**Funding:** Departmental funds

**Conflicts of Interest:** No conflicts to report

**Approval:** All authors approved the final manuscript

1   **Abstract**

2  
3   **Introduction:** Reduction of pain is a major goal of anesthesiologists treating patients  
4   undergoing knee arthroplasty. This has been achieved traditionally through the use of  
5   regional analgesia. Although these techniques decrease postoperative pain, they  
6   inherently do not affect the longstanding pain patients experience as they wait for  
7   surgery. Our objectives were to quantify 1) the decrease in pain achieved by surgical  
8   joint replacement and 2) the decrease in postoperative pain achievable through femoral  
9   nerve blocks versus opioids. From a systems-based perspective, we wanted to determine  
10   how much reduction in waiting time before surgery would be necessary to achieve an  
11   equal cumulative pain decrease (i.e., pain x duration of pain) as that afforded by regional  
12   techniques in the immediate postoperative period.

13  
14   **Materials and Methods:** A systematic review using PubMed was performed to obtain:  
15   1) articles reporting preoperative pain scores for patients awaiting joint arthroplasty; 2)  
16   articles with knee arthroplasty patients who received femoral nerve blocks; and 3) articles  
17   providing duration on joint arthroplasty waiting lists. Cumulative pain was assessed by  
18   the area under the response curve of pain scores vs. time, a methodology that is simple  
19   and valid. This was calculated by multiplying mean pain scores by the duration of pain.

20  
21   **Results:** The decrease in knee pain subsequent to arthroplasty (6.4/10 vs. 2.9/10) is  
22   similar to the decrease in pain afforded by femoral nerve blocks for knee arthroplasty  
23   (4.7/10 vs. 2.0/10). Waiting times in many countries exceed 3 months. A decrease in

1 waiting time by about 2 days results in a decrease in the area under the curve of pain  
2 comparable to that afforded by femoral nerve blocks.

3

4 **Conclusion:** Reducing waiting time for knee arthroplasty decreases total pain  
5 experienced by patients and is one systems-based approach that anesthesiologists could  
6 take to relieve pain. Further studies are needed to evaluate how best to accomplish this  
7 goal.

8

## 1    **Introduction**

2        Patients experience significant pain while waiting for knee replacement. Although  
3    multiple studies have assessed pain at one or more times for patients awaiting surgery,<sup>1-3</sup>  
4    less is known about the cumulative amount of pain they experience. Quantifying this  
5    cumulative pain over a period of time can be accomplished by applying the concept of  
6    area under the response curve (AUC).<sup>4</sup> The AUC for pain scores may be described as the  
7    product of the average pain score over a period of time and the duration of the pain. This  
8    has been studied in parturients and found to be a reasonable estimation of the cumulative  
9    labor pain.<sup>5</sup> A patient's single recall rating of his or her average pain over a period of  
10   time has been shown to be just as sensitive to the effects of a pain treatment as a  
11   composite score made up of multiple measurements.<sup>6</sup> Therefore, AUC can accurately  
12   describe pain while waiting for knee arthroplasty, despite the waxing and waning nature  
13   of osteoarthritis pain.

14       Regional analgesia has proven benefit for knee arthroplasty patients. Femoral nerve  
15   blocks provide superior analgesia compared to patient-controlled analgesia (PCA) for  
16   knee arthroplasty.<sup>7</sup> Given the importance of regional anesthesia and analgesia, expected  
17   competencies for anesthesiology residents include technical skills in regional anesthesia.<sup>a</sup>

18       In the U.S., milestones for anesthesiologists also include “[using] system resources  
19   to facilitate and optimize cost-effective and safe longitudinal perioperative care” and  
20   “[participating] in performance improvement efforts within health care systems to  
21   improve patient outcomes.”<sup>a</sup> It is within this context that improvement in patients’

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<sup>a</sup> Stony Brook Medicine, Department of Anesthesiology. Available at  
[http://anesthesia.stonybrook.edu/anesfiles/AnesthesiologyMilestones\\_Version2012.11.11](http://anesthesia.stonybrook.edu/anesfiles/AnesthesiologyMilestones_Version2012.11.11.pdf)  
.pdf. Last accessed September 27, 2013.

1 cumulative pain waiting for surgery could potentially be accomplished. Regional  
2 techniques, despite their proven benefit, are inherently limited to the intra- and  
3 postoperative periods. As anesthesiologists continue to emphasize their role as  
4 perioperative physicians, systems-based efforts that begin preoperatively are important.

5 The purposes of this study were: 1) to quantify the AUC for pain scores rated by all  
6 patients on joint arthroplasty waiting lists; and 2) to determine how much of a decrease in  
7 waiting time would be necessary to achieve the same decrease in AUC that femoral nerve  
8 blocks provide after knee arthroplasty. To accomplish this, we first performed a review  
9 that involved three separate search queries designed to identify all published studies that:  
10 1) provided a preoperative visual analog scale (VAS) pain score for patients awaiting  
11 joint arthroplasty; 2) provided postoperative VAS pain scores for patients given a femoral  
12 nerve block and VAS pain scores for those given opioids alone; and 3) provided a mean  
13 duration of waiting list time for patients scheduled for joint arthroplasty.

## 15 **Methods**

16 We performed three separate search queries (see Table 1) that were designed to  
17 identify three distinct groups of articles. Query 1 was performed to identify articles that  
18 included patients on a waiting list for joint replacement that provided a preoperative  
19 mean VAS pain score (Table 1). Both hip and knee arthroplasty studies were included to  
20 maximize the number of possible studies for analysis. Data extracted included: author,  
21 number of patients, preoperative VAS pain score with standard deviation, and  
22 postoperative VAS pain score with standard deviation. To be included, the manuscript  
23 needed to report standard deviations and sample sizes. Although not an inclusion

1 criterion, postoperative mean VAS scores and standard deviations also were recorded, if  
2 available.

3 Query 2 was designed to find studies that determined the analgesic benefit of the  
4 femoral nerve block compared to opioids, which has been shown to improve analgesia  
5 outcomes following knee arthroplasty<sup>7</sup> (Table 1). Data extracted include: author, time of  
6 assessment, number of patients in each group, VAS pain score in the opioid group with  
7 standard deviation, and VAS pain score in the femoral nerve block group with standard  
8 deviation. To be included, the study had to have a control group that was given opioids.  
9 Mean VAS scores, standard deviations, and sample sizes had to be provided for both  
10 groups.

11 Query 3 was designed with the goal of identifying studies that would allow  
12 calculation of a mean waiting duration for arthroplasty (Table 1). Both knee and hip  
13 arthroplasty were included to maximize search results. Data extracted included author,  
14 country in which author conducted the study, joint (hip or knee) studied, number of  
15 patients, and length of time on waiting list. To be included, the study had to provide the  
16 mean duration of time on the waiting list along with the standard deviation and sample  
17 size.

18 All published articles in PubMed in all languages were included with no limitations  
19 on date of publication, number of participants, or study type (prospective or  
20 retrospective). Search protocols were last accessed September 25, 2013. Studies meeting  
21 initial criteria and published in a language other than English were translated using  
22 Google Translate. Abstracts of articles that were identified from the initial query were  
23 manually checked for additional inclusion criteria, with translation into English, as



necessary. All articles using VAS scores measured pain at rest. Abstracts for articles found after the initial PubMed query were screened for eligibility based on the criteria in Table 2 and if eligibility was unclear after reading the abstract, the full article was read. Figure 1 shows a flow diagram of the article selection process. The numbers of screened articles and those excluded with each criterion are shown in Table 2 with corresponding references.<sup>3,8-28</sup> Biases of individual studies and as a whole were assessed by consensus of the study authors.

Weighted means were calculated for the preoperative waiting list VAS scores, postoperative waiting list VAS scores, and knee arthroplasty treatment and control group VAS scores (Tables 3-5). Means were weighted using the inverse of the squared standard errors of the mean pain score from each study. The AUC for pain scores was calculated as the product of the mean preoperative VAS score and number of days spent waiting for surgery.

## Results

For Query 1, six articles<sup>3,8-12</sup> were returned initially and, after application of inclusion criteria, three articles<sup>3,8,9</sup> were included in the analysis. Arthroplasty reduced the weighted mean preoperative VAS pain score from 6.4 cm (on a 10-cm scale) for all patients awaiting joint arthroplasty (both hips and knees) to 2.9 cm at 3 months after surgery (Table 3).

For Query 2, nine articles<sup>13-21</sup> were returned initially and, after application of inclusion criteria, two articles<sup>13,20</sup> were included in the analysis. Femoral nerve blocks

1 decreased the weighted mean knee arthroplasty pain from 4.7 (opioid group) to 2.0 cm  
2 (femoral nerve group) in the recovery room and on postoperative day #1 (Tables 3 and 4).

3 For Query 3, eight articles<sup>8,22-28</sup> were returned initially and, after application of  
4 inclusion criteria, three articles<sup>8,22,26</sup> were included in the analysis. Mean waiting times  
5 ranged from 16.1 weeks in Nunez et al<sup>26</sup> to 43.4 weeks in Vuorenmaa et al.<sup>8</sup>

6 The AUC for the benefit of femoral nerve block after knee arthroplasty, using a  
7 typical duration of femoral nerve catheters of 2 days, would be 5.4 cm•days. To  
8 determine the decrease in waiting list time needed to provide the same AUC as femoral  
9 nerve blocks provide, the AUC for knee arthroplasty (5.4 cm•days) was divided by the  
10 mean pain reduction that surgery itself provided (3.5 cm). A decrease in waiting time of  
11 1.5 days would achieve the same decrease in AUC as femoral nerve block in the  
12 postoperative period for those same procedures.

#### 14 *Assessment of Bias*

15 The postoperative VAS pain score for waiting list patients was based on Vuorenmaa  
16 et al.<sup>8</sup> If that study alone were used for preoperative pain, the pre- to postoperative  
17 change in pain scores would decrease from 3.5 cm to 2.9 cm. The result would be that a  
18 reduction in waiting time of 1.9 days, rather than 1.5 days, would provide equivalent  
19 AUC as that for femoral nerve blocks after surgery. This bias does not substantively  
20 influence results.

21 For McHugh et al<sup>3</sup>, the preoperative VAS score was from a single point in time, so  
22 there is the possibility that this score did not represent the entire waiting period.  
23 However, a separate analysis of participants performed within the McHugh study found

1 that VAS pain measurements were not significantly changed three months after being  
2 placed on the list, so the VAS scores we used for analysis would not have changed or  
3 influenced conclusions.

4 For Query 3, the study by Nunez et al<sup>26</sup> restricted participation to patients on the  
5 waiting list for knee arthroplasty less than six months, so this study's mean duration of  
6 waiting time may have been biased toward a shorter period of time than if all waiting list  
7 patients had been eligible. This bias also does not change our conclusions.

## 8 9 **Discussion**

10 Our principal finding was that decreasing time spent waiting for knee arthroplasty by  
11 a relatively small amount (about 2 days) can decrease the cumulative pain experienced by  
12 patients by an amount comparable to what a femoral nerve block can accomplish for  
13 postoperative pain. This is because the decrease in pain achieved by arthroplasty itself is  
14 comparable (i.e., within 20%) to the decrease in pain achieved by the use of femoral  
15 nerve block after total knee arthroplasty (Tables 3 and 4). However, the duration of  
16 waiting for surgery can be many months, while benefits of femoral nerve blocks typically  
17 last for no more than 2 days (Table 5). Thus, the potential decrease in the AUC resulting  
18 from the reduction of patient waiting times by as little as 2 days could equal the benefits  
19 of the block. This does not imply that regional techniques are not effective or detract  
20 from their proven benefit; rather, this study simply places the potential benefit of  
21 reducing waiting times into perspective and suggests the possibility of expansion of the  
22 anesthesiologist's role as a perioperative consultant in addressing preoperative pain in  
23 addition to postoperative pain.

1       The benefits of improving access to knee arthroplasty are not just fewer days spent in  
2   pain but reduced costs to society as a whole. Despite the costs associated with surgery,  
3   the amount of money spent on nonsurgical treatments and the amount lost due to missed  
4   work or disability payments appears to be greater.<sup>29</sup>

5       Expediting patients to surgery could potentially be accomplished in several different  
6   ways. Through actions such as improved operating room (OR) scheduling and  
7   longitudinal monitoring of surgeons' schedules, waiting times can be reduced.<sup>30-34</sup>  
8   Techniques exist to assess the efficacy of such management interventions.<sup>35</sup> Just as  
9   regional analgesia has substantially improved postoperative pain control, so should  
10   systems-based practice interventions be applied to reduce preoperative pain. Application  
11   of mathematical models combined with the lowering of organizational institutional  
12   barriers can improve OR efficiency.<sup>31</sup> If there is a master surgical schedule of at least  
13   one week, the maximum waiting time cannot be less than four weeks in order to  
14   maximize OR efficiency.<sup>30</sup> As this relationship between the length of the master surgical  
15   schedule and maximum waiting time depends only on physical principles of durations of  
16   the workday and predictive variability in surgical durations, the relationship applies  
17   across health systems.<sup>30</sup> The implication is that the potential impact of reducing  
18   maximum waiting times to 4 weeks would be substantial, given the waiting list range of  
19   16 to 43 weeks reported in several studies (Table 5).

20       Teaching the core competency of systems-based practice to anesthesiologists can be  
21   effectively accomplished through a 3.5-day course.<sup>36</sup> By applying the knowledge gained  
22   through such a course, anesthesiologists may be better equipped to assist with OR  
23   scheduling and improve patient flow. Principally, this has to do with calculating the

1 hours into which cases are scheduled for each day of the week using appropriate  
2 statistical techniques.<sup>37-40</sup>

3 Our study has several limitations. First, the preoperative pain scores and waiting  
4 times we report represent a combination of both hip and knee arthroplasty patients, while  
5 the postoperative pain scores are taken from a study by Vuorenmaa et al<sup>8</sup> with knee  
6 arthroplasty patients only. However, preoperative VAS scores are similar between  
7 patients undergoing both hip and knee arthroplasty, so this would not likely change our  
8 conclusions.<sup>3,41</sup> Second, few studies provided mean pain scores in a format amenable to  
9 our analysis. Several studies, for example, provided mean pain scores only in graphical  
10 format, rather than a VAS number, which limited the number of studies for analysis.  
11 Finally, when comparing preoperative pain on the waiting list to postoperative pain, we  
12 are assuming that the nature and quality of the pain are similar. This may not always be  
13 the case. However, for the purpose of analysis, the quality of the pain is impossible to  
14 account for, and the similar changes in VAS scores imply similar perception of pain.

1        In conclusion, we have shown that a reduction in knee arthroplasty waiting list time  
2        by approximately 2 days could reduce patients' preoperative cumulative pain as  
3        measured by AUC by an amount comparable to the decrease in postoperative pain  
4        possible with femoral nerve blocks. Further studies are needed to determine feasibility  
5        and how best to allocate resources to accomplish this goal of decreasing the wait for  
6        surgery.

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