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

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Abstract

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

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

Results: The decrease in knee pain subsequent to arthroplasty (6.4/10 vs. 2.9/10) is similar to the decrease in pain afforded by femoral nerve blocks for knee arthroplasty (4.7/10 vs. 2.0/10). Waiting times in many countries exceed 3 months. A decrease in waiting time by about 2 days results in a decrease in the area under the curve of pain comparable to that afforded by femoral nerve blocks.

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

Introduction

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

Regional analgesia has proven benefit for knee arthroplasty patients. Femoral nerve blocks provide superior analgesia compared to patient-controlled analgesia (PCA) for knee arthroplasty [1]. Given the importance of regional anesthesia and analgesia, expected competencies for anesthesiology residents include technical skills in regional anesthesia.a

In the U.S., milestones for anesthesiologists also include "[using] system resources to facilitate and optimize cost-effective and safe longitudinal perioperative care" and "[participating] in performance improvement efforts within health care systems to improve patient outcomes."[a] It is within this context that improvement in patients' cumulative pain waiting for surgery could potentially be accomplished. Regional techniques, despite their proven benefit, are inherently limited to the intra- and postoperative periods. As anesthesiologists continue to emphasize their role as perioperative physicians, systems-based efforts that begin preoperatively are important.

The purposes of this study were: 1) to quantify the AUC for pain scores rated by all patients on joint arthroplasty waiting lists; and 2) to determine how much of a decrease in waiting time would be necessary to achieve the same decrease in AUC that femoral nerve blocks provide after knee arthroplasty. To accomplish this, we first performed a review that involved three separate search queries designed to identify all published studies that: 1) provided a preoperative visual analog scale

[a]Stony Brook Medicine, Department of Anesthesiology. Available at http://anesthesia.stonybrook.edu/anesfiles/AnesthesiologyMilestones_Version2012.11.11.pdf. Last accessed September 27, 2013.

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(VAS) pain score for patients awaiting joint arthroplasty; 2) provided postoperative VAS pain scores for patients given a femoral nerve block and VAS pain scores for those given opioids alone; and 3) provided a mean duration of waiting list time for patients scheduled for joint arthroplasty.

Methods

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

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

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

All published articles in PubMed in all languages were included with no limitations on date of publication, number of participants, or study type (prospective or retrospective). Search protocols were last accessed September 25, 2013. Studies meeting initial criteria and published in a language other than English were translated using Google Translate. Abstracts of articles that were identified from the initial query were 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 [3,8-28]. 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 [3,8-12] were returned initially and, after application of inclusion criteria, three articles [3,8,9] 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 [13-21] were returned initially and, after application of inclusion criteria, two articles [13,20] were included in the analysis. Femoral nerve blocks decreased the weighted mean knee arthroplasty pain from 4.7 (opioid group) to 2.0 cm (femoral nerve group) in the recovery room and on postoperative day #1 (Tables 3 and 4).

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

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

Query	Pub Med Search Protocol
1 – Waiting list VAS	("total joint arthroplasty"[All Fields] OR "total joint replacement"[All Fields] OR "total hip arthroplasty"[All Fields] OR "total hip replacement"[All Fields] OR "total knee arthroplasty"[All Fields] OR "total knee replacement"[All Fields]) AND ("visual analog scale"[All Fields] OR "visual analogue scale"[All Fields] OR VAS[All Fields]) AND ("waiting list"[All Fields] OR "waiting time"[All Fields] OR wait[All Fields] OR "Queue"[All Fields])
2 – knee VAS	("total knee arthroplasty"[All Fields] OR "total knee replacement"[All Fields]) AND ("femoral nerve block"[All Fields] OR "femoral block"[All Fields]) AND ("visual analog scale"[All Fields] OR "visual analogue scale"[All Fields] OR VAS[All Fields] OR "WOMAC VAS"[All Fields]) AND ("patient controlled analgesia"[All Fields] OR "analgesics, opioid"[MeSH Terms] OR "opioid analgesics"[All Fields] OR "opioids"[All Fields] OR "analgesics, opioid"[Pharmacological Action] OR ("analgesics"[All Fields] AND "opioid"[All Fields])) AND ("control group"[All Fields] OR "prevention and control"[Subheading] OR "prevention and control"[All Fields] OR "control"[All Fields] OR "control groups"[MeSH Terms] OR "control groups"[All Fields] OR controls[All Fields] OR ("control"[All Fields] AND "groups"[All Fields]) OR ("prevention"[All Fields] AND "control"[All Fields]))
3 – Waiting list duration	("total joint arthroplasty"[All Fields] OR "total joint replacement"[All Fields] OR "total hip arthroplasty"[All Fields] OR "total hip replacement"[All Fields] OR "total knee arthroplasty"[All Fields] OR "total knee replacement"[All Fields]) AND ("mean waiting time"[All Fields] OR (duration[All Fields]) AND ("waiting lists"[All Fields] OR "waiting list"[All Fields] OR ("waiting"[All Fields] AND "lists"[All Fields]) OR ("waiting"[All Fields] AND "list"[All Fields])))

Table 1: Search protocols.

Query	Inclusion Criteria	Criteria Applied	Number of articles	Reference numbers of articles meeting inclusion criteria
1 – Waiting list VAS	A. Must report a mean VAS pain score or mean WOMAC pain score, standard deviation, and sample size	None	6	3, 8, 9, 10, 11, 12
		A	3	3, 8, 9
2 – knee VAS	E. Treatment group must receive femoral nerve block, either single-injection or continuous	None	9	13, 14, 15, 16, 17, 18, 19, 20, 21
		E	9	13, 14, 15, 16, 17, 18, 19, 20, 21
	F. Control group must receive intravenous opioids alone	E, F	7	13, 16, 17, 18, 19, 20, 21
	G. Must report mean VAS pain score, standard deviation, and sample size for both treatment and control groups	E, F, G	2	13, 20
3 – Waiting list duration	H. Must report a mean duration of time spent on waiting list and standard deviation	None	8	8, 22, 24, 25, 26, 27, 28
		H	3	8, 22, 26

Table 2: Inclusion criteria and search results.

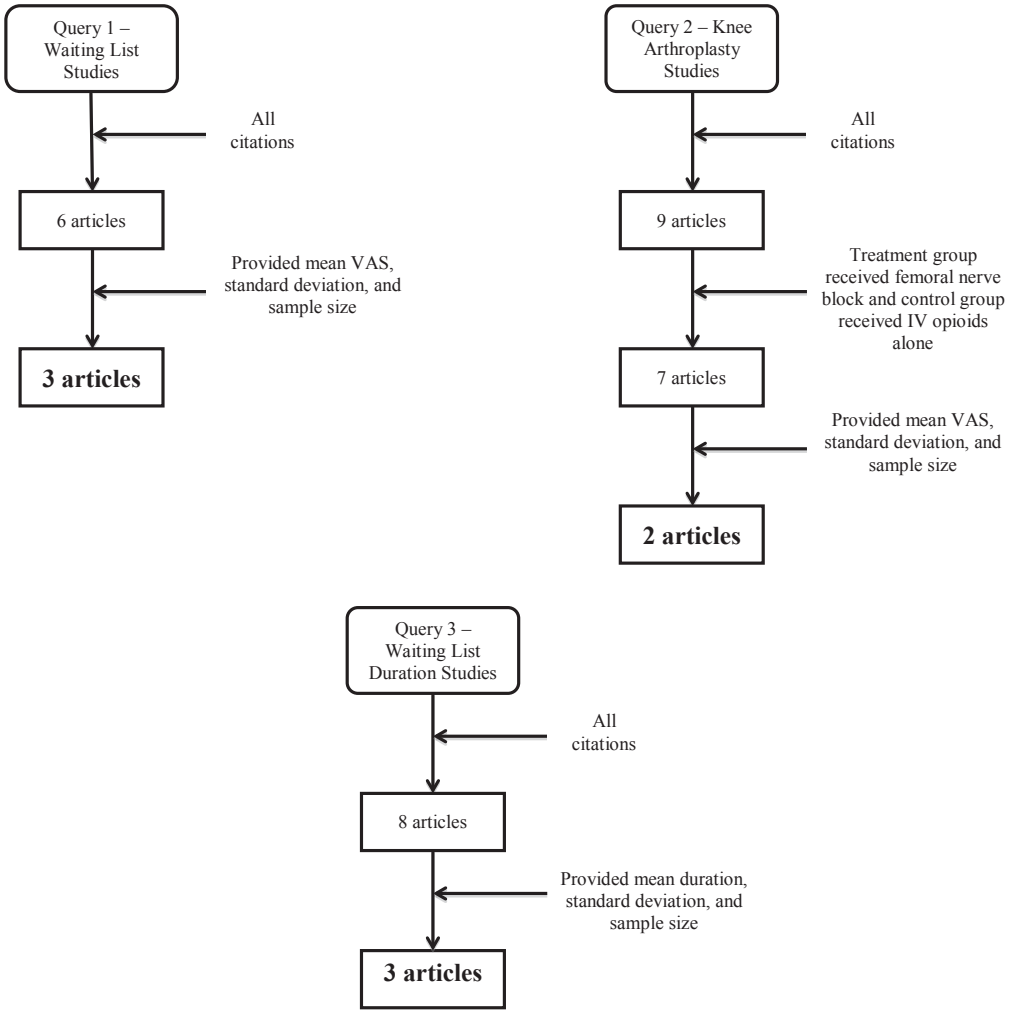

Figure 1: Flow diagrams of study queries.

Assessment of Bias

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

For McHugh et al. [3], the preoperative VAS score was from a single point in time, so there is the possibility that this score did not represent the entire waiting period. However, a separate analysis of participants performed within the McHugh study found that VAS pain measurements were not significantly changed three months after being placed on the list, so the VAS scores we used for analysis would not have changed or influenced conclusions.

For Query 3, the study by Nunez et al. [26] restricted participation

Author	Joint	Mean preoperative VAS, cm (SD)	Number of patients in group	Mean postoperative VAS, cm (SD)
Casale – physiotherapy group	Hip, knee	6.3 (1.2)	22	NR*
Casale – physiotherapy + drug group	Hip, knee	6.7 (1.3)	22	NR
McHugh	Knee	6.9 (2.2)	57	NR
Vuorenmaa	Knee	5.8 (1.8)	43	2.9 (2.8)
Weighted Mean VAS Score:		**6.4**		**2.9**

*Not reported

Table 3: VAS pain scores for patients on arthroplasty waiting lists.

Author	Time of Assessment	Mean control (opioid) group VAS, cm (SD)	Number of patients in group	Mean regional (femoral block) group VAS, cm (SD)	Number of patients in group
Wang	Recovery room	7.8 (1.6)	15	4.2 (2.9)	15
Wang	POD 1§	5.5 (2.1)	15	2.7 (2.6)	15
Chan – pre-op block group	POD 1	3.9 (1.2)	20	1.9 (1.2)	20
Chan – post-op block group	POD 1	3.8 (1.3)	21	1.6 (1.3)	21
Weighted Mean VAS Score:		**4.7**		**2.0**	

§Postoperative Day #1

Table 4: VAS postoperative pain scores for knee arthroplasty.

Author	Country	Joint	Mean duration on waiting list, weeks (SD)	Number of Patients
Vuorenmaa	Finland	knee	43.4 (34.7)	43
Tuominen	Finland	hip	27.7 (25)	169
Nunez - physiotherapy group	Spain	knee	16.4 (7.57)	51
Nunez - control group	Spain	knee	16.1 (7.43)	49

Note: Because the search was performed to identify as many studies as possible that reported mean waiting times, both hips and knees were included.

Table 5: Waiting list duration.

to patients on the waiting list for knee arthroplasty less than six months, so this study's mean duration of waiting time may have been biased toward a shorter period of time than if all waiting list patients had been eligible. This bias also does not change our conclusions.

Discussion

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

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

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

Teaching the core competency of systems-based practice to anesthesiologists can be effectively accomplished through a 3.5-day course [36]. By applying the knowledge gained through such a course, anesthesiologists may be better equipped to assist with OR scheduling and improve patient flow. Principally, this has to do with calculating the hours into which cases are scheduled for each day of the week using appropriate statistical techniques [37-40].

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

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

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