The Efficacy of Multimodal High-volume Wound Infiltration in Primary Total Hip Replacement

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abstract

Multimodal wound infiltration with local anesthetics, adrenaline, and nonsteroidal anti-inflammatory agents can lower the opiate intake, reduce the length of stay, and enhance early mobilization after total hip arthroplasty (THA). A retrospective review of 204 patients undergoing primary THA was undertaken. One hundred two patients had their wounds infiltrated with ropivacaine, adrenaline, and ketorolac by the operating surgeon intraoperatively. Subsequently, a 19-gauge wound catheter was inserted percutaneously into the hip joint. Patients received 2 further top-up doses of 20 mL of ropivacaine (7.5mg/mL) at 10 and 20 hours postoperatively. These patients were compared to a control group of 102 patients who received no local infiltration. Both groups were comparable in terms of body mass index and age. Opiate consumption in the first 48 hours after surgery and length of hospital stay were recorded. The mean consumption of morphine in the treatment group was 42.3 mg (standard deviation [SD], 31.2 mg) compared to 60.9 mg (SD, 33.8 mg) in the control group (P<.0001). The mean length of stay was significantly reduced from 5.2 days (SD, 1.6 days) in the control group to 4 days (SD, 1.3 days) in the treatment group (P<.0001). The time needed by the patients to walk for 3 meters after surgery was significantly reduced in the treatment group (median, 25 vs 46.1 hours; interquartile range, 20.7-45.1 vs 27.2-50.9; P<.0001). This is the largest series to demonstrate that a multimodal perioperative wound infiltration technique in primary THA surgery leads to early attainment of immediate postoperative rehabilitation milestones and reduced length of stay along with reduction in postoperative opiate consumption.

ERRATUM

This article has been amended to include a factual correction. An error was identified subsequent to its original printing (2011; 34[9]:e522-e529), which was acknowledged in an erratum printed in 2012; 35(9):793. The online article and its erratum are considered the version of record.

Figure: Intraoperative photograph demonstrating the injection of the inferior capsule of the hip joint after implantation of the acetabular component (arrow in bottom right). A posterior surgical approach was used. Subsequent injections follow, until a total of 50 mL (first bolus dose) are injected circumferentially into the capsule (18-gauge needle used).
Total hip arthroplasty (THA) is a successful procedure for the treatment of degenerative hip disease. Postoperative pain is inevitable and can affect early mobilization and length of hospital stay. With ever-increasing pressure on hospital beds and increasing demand for joint replacement surgery, optimal postoperative pain control would benefit both patients and the health care budget.

Traditional perioperative pain management regimens include spinal and epidural anesthesia, intravenous patient-controlled analgesia, peripheral nerve blocks, intravenous or intramuscular injections, and oral agents. Although opiates provide effective analgesia, they are associated with side effects, such as nausea, vomiting, dizziness, and constipation. Epidural anesthesia may cause postural hypotension. These problems can all delay early mobilization. The use of a lumbar plexus block or femoral and sciatic nerve blocks in THA is becoming more popular, but can be associated with technical difficulties.

Kerr and Kohan, from Sydney, developed a multimodal wound infiltration technique for hip and knee replacement surgery. This strategy facilitates early physical therapy and reduces venous stasis, potentially avoiding the side effects associated with excessive use of opiates.

Röstlund and Kehlet reported that using spinal anesthesia, followed by infiltration of the wound with local anesthetic and nonsteroidal anti-inflammatory drugs (NSAIDs) improved patient comfort and reduced opiate requirements after hip and knee replacement surgery. Andersen et al. reported improved pain control, early mobilization and improved patient satisfaction during the perioperative period using a similar analgesic technique.

This article is a retrospective study of 204 patients who underwent primary THA at our hospital from June 2009 to August 2010. Our inclusion criteria were consecutive patients with no pre-existing physical disabilities who underwent primary THA. We included patients who had surgery performed via either anterolateral or posterior approaches with cemented, uncemented, or hybrid hip replacements. All operations were performed by 11 experienced, high-volume specialist hip surgeons. Five surgeons routinely used periprosthetic wound infiltration, while the other 6 did not. Of the surgeons using the wound infiltration, 2 operated through a standard anterolateral approach, 3 always used a posterior approach to the hip.

Table 1: The Distribution of Patients Operated Via an Anterolateral or a Posterior Approach

<table>
<thead>
<tr>
<th>Approach to the Hip</th>
<th>Patients Infiltrated (N = 102)</th>
<th>Patients Not Infiltrated (N = 102)</th>
<th>p^b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterolateral</td>
<td>41/102</td>
<td>61/102</td>
<td>.11</td>
</tr>
<tr>
<td>Posterior</td>
<td>60/102</td>
<td>42/102</td>
<td>.18</td>
</tr>
</tbody>
</table>

^aAll operations were performed with a standard incision of 15 to 20 cm. None of the patients had minimally invasive surgery or navigated THA.

^bchi square test

This study was authorized by the local R&D Ethical Committee, and was performed in accordance with the ethical standards of the 1964 Declaration of Helsinki as revised in 2000. This being a retrospective case series, no prior informed consent was obtained from patients. However, the data was collected and presented anonymously, so that none of them can be identified in any way. We identified 204 patients (Group A) suitable for inclusion in the study. In the treatment group (n = 102), patients were operated on by surgeons who routinely used wound infiltration. The control group B (n = 102) included patients who were operated on by surgeons who did not routinely use wound infiltration. The case notes were reviewed retrospectively for all data.

Patients in Group A (n = 102) received spinal anesthesia with 10 to 15 mg of bupivacaine. Based on the anesthetic records, no patient received any intravenous analgesia during surgery. Each patient was infiltrated intraoperatively in a systematic manner with a mixture of total volume of 150
The solution consisted of 0.2% (2 mg/mL) ropivacaine, 1 mg adrenaline 1:1000, and 30 mg ketorolac. This solution was divided into three separate bolus doses of 50 mL each, administered in a specific sequence, using an 18-gauge spinal needle: first, 50 mL was injected into the capsular tissue immediately after the implantation of the acetabular component (Figure 1). A second bolus of 50 mL was administered into the glutus medius, glutus minimus, and the short external rotators of the hip after capsular repair. In patients operated via the anterolateral approaches, the second injection was instilled into the hip abductors (gluteus medius and minimus). The last 50 mL was injected into the tensor fasciae latae and the short external rotators of the hip after capsule closure (Figure 2). This technique was adopted to ensure systematic infiltration of the operated field in order to achieve maximum analgesic effect postoperatively.

Prior to closure of the capsule, a 19-gauge multi-hole “fast track wound catheter” (Pajunk GmbH, Geisingen, Germany) was inserted percutaneously through an anterior approach into the hip joint by the operating surgeon. The catheter was flushed with normal saline after it was attached to a 20-micron bacterial filter and was secured on the skin with an occlusive dressing (Figure 3).

Every patient who had wound infiltration intraoperatively received 2 additional bolus doses (top-up doses), each consisting of 20 mL of ropivacaine (7.5 mg/mL) at 10 and 20 hours postoperatively through the wound catheter. Some patients had the top-up earlier, if required. However, the minimum time interval between the doses was 4 hours.

This treatment group of patients was compared to group B (control group, n = 102) who fulfilled the same criteria as above but did not receive wound infiltration. Patients in both groups received a standardized postoperative pain management regimen with paracetamol (1 g orally or intravenously 4 times daily), ibuprofen (400 mg 3 times daily, together with a daily dose of 20 mg omeprazole, unless contraindicated). All patients received 3 doses of 10 mg modified-release oxycodone at 12-hour intervals as a part of the routine postoperative analgesia regimen in our unit. Oral liquid morphine was used for rescue analgesia, and, if necessary, patient-controlled analgesia with intravenous morphine for severe breakthrough pain. Intravenous morphine via patient-controlled analgesia was offered to those patients whose pain did not respond to oral morphine as per the analgesia protocol at our hospital.

Postoperatively, all patients were initially monitored in the postoperative acute care unit. All patients were allowed oral fluids and diet as soon as tolerated. The information about the postoperative analgesic doses was obtained from the patients’ medication charts. Hemoglobin levels were checked at 48 hours postoperatively, and blood transfusion was indicated for patients with hemoglobin <8 mg/dL. For prophylaxis against deep venous thrombosis (DVT), low-molecular-weight heparin (Dalteparin 5000 units) was administered subcutaneously daily for 30 days, starting on the day of surgery.

Trained physical therapy staff assessed all patients within 2 hours of surgery to determine if they were suitable for mobilization (to a bedside chair or walk with a frame). Full weight bearing was allowed on the operated side. Every patient was evaluated after 2 hours irrespective of the

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**Table 2**

**Exclusion Criteria Used in the Present Study**

- Hip resurfacing arthroplasty
- Revision THA
- Conversion of hemiarthroplasty to THA
- Habitual use of opiates
- Inflammatory joint disease
- Use of general anesthesia for THA
- Mental illness
- Neuromuscular disorders
- Allergies to the medications used in the study
- Any contraindication to the use of the medications used in the study
- Major systemic illness (heart failure, renal failure, coagulopathy)

*Abbreviation: THA, total hip arthroplasty.*
time of surgery (morning or afternoon). They progressed to full mobilization if they were able to mobilize safely. This gave every patient equal opportunity to get out of bed if they were operated on later in the day. The on-call doctor or the attending nurse documented any adverse event in the notes.

**Outcome Measures**

The main outcomes included the total opiate consumption (measured in milligrams) during the first 48 hours postoperatively, the length of hospital stay (measured in days), and the time needed to mobilize from bed to the chair and to walk >3 meters postoperatively (measured in hours).

Consumption of opiates was measured by recording the amount of morphine used via the patient-controlled analgesia or orally in the first 48 hours after surgery. The amount of opiates other than morphine was transformed to morphine equivalents according to a conversion table (Table 3). Mobility, as defined above, was assessed by members of the physical therapy team. The length of stay postoperatively was recorded as the full number of days until discharge. Each patient was discharged when well-defined criteria (adequate mobility for activities of daily living, uncomplicated wound healing, satisfactory immediate postoperative radiological assessment, and absence of DVT) were all met. The discharge of patients were determined by the rehabilitation team. The operating surgeons were not directly involved in this decision unless there was a medical or surgical issue that would delay discharge.

**Statistics**

The 1-sample Kolmogorov-Smirnov test was used to test whether key variables (opiate consumption, mobilization, and length of stay) were normally distributed. For each parametric variable, the cases and controls were compared using an unpaired t test, results being presented as means and standard deviations. The non-parametric
variables were analyzed using the Mann-Whitney U test, with results presented as medians and interquartile ranges. The differences in the proportions were analyzed using the chi-square test and association in trends with a chi-square test for trend. For each test, a $P$ value of $<.05$ was considered statistically significant. StatsDirect (Altrincham Cheshire, United Kingdom) software was used for all statistical calculations.

**Demographics**

There were 102 patients in each group. The demographic data was comparable, with no statistically significant differences in terms of age and body mass index (BMI) between the 2 groups (Table 4). There was no significant difference among the number of operations performed via anterolateral approach of posterior approach.

**Drug Consumption**

In the treatment group, no patients used patient-controlled analgesia postoperatively, while 43 patients (42%) in the control group did. The mean amount of opiate analgesics used in the treatment group was 42.3 mg (SD, 31.2 mg) compared to 60.9 mg (SD, 33.8 mg) in the control group ($P=.0001$), for a mean difference of 18.6 mg (95% confidence interval, 9.6-27.6) in favor of the treatment group.

**Mobility**

Patients in the treatment group required a mean of 24.3 hours (SD, 12.7 hours) to mobilize from bed to chair, as compared to 28.6 hours (SD, 10.8 hours) amongst patients in the control group ($P=.01$) for a mean difference of 4.3 hours (95% confidence interval, 1.7-7.5) in favor of the treatment group.

The median time (25 hours; interquartile ranges, 20.7, 45.1) before patients in the treatment group could walk 3 meters with a frame after surgery was significantly lower ($P<.001$) compared to the corresponding median time needed in the control group (46.1 hours; interquartile ranges, 27.2, 50.9), for a median difference of 18.2 (95% confidence interval= 6.8-21.6).

**Length of Stay**

The mean length of stay in the hospital postoperatively was 4 days (SD, 1.3 days) and 5.2 days (SD, 1.6 days) for the treatment and control groups, respective-

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**Table 4**

<table>
<thead>
<tr>
<th>Demographic Variable</th>
<th>Infiltration Group</th>
<th>No Infiltration Group</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y (range)</td>
<td>69.3 (36-87)</td>
<td>69.8 (22-92)</td>
<td>.75</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>45/57</td>
<td>40/62</td>
<td>.47</td>
</tr>
<tr>
<td>BMI</td>
<td>27.9 (17-44)</td>
<td>28.1 (15-45)</td>
<td>.86</td>
</tr>
</tbody>
</table>

*Abbreviation: BMI, body mass index.

$^a$Values are expressed as means, with ranges in parentheses. Basic demographic parameters were not statistically significantly different between the 2 groups. Each group included 102 patients.

$b$Unpaired t test.

$c$Chi square test.

**Table 5**

<table>
<thead>
<tr>
<th>Group</th>
<th>$&lt;3$ d, %</th>
<th>4-6 d, %</th>
<th>$&gt;6$ d, %</th>
<th>Total, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (N=102)</td>
<td>5 (5)</td>
<td>83 (81)</td>
<td>14 (14)</td>
<td>100</td>
</tr>
<tr>
<td>Study (N=102)</td>
<td>41 (40)</td>
<td>56 (55)</td>
<td>5 (5)</td>
<td>100</td>
</tr>
<tr>
<td>Difference, %</td>
<td>35</td>
<td>-26</td>
<td>-9</td>
<td>$P&lt;.001^a$</td>
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</tbody>
</table>

$^a$Chi-squared test for trend.

**Table 6**

<table>
<thead>
<tr>
<th>Outcome Measure</th>
<th>Infiltration Group (N=102)</th>
<th>No Infiltration Group (N=102)</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of stay (days)</td>
<td>4</td>
<td>5.1</td>
<td>.001$^b$</td>
</tr>
<tr>
<td>Consumption of opiates (mg)</td>
<td>42.3</td>
<td>60.9</td>
<td>.001$^b$</td>
</tr>
<tr>
<td>Time needed for patients to mobilize from bed to chair (hours)</td>
<td>24.3</td>
<td>28.6</td>
<td>.01$^b$</td>
</tr>
<tr>
<td>Time needed for patients to walk more than 3 meters (hours)</td>
<td>25</td>
<td>46.1</td>
<td>.001$^c$</td>
</tr>
</tbody>
</table>

$^a$Results are reported as median values for the time needed to mobilize 3 meters postoperatively and mean values for the remaining outcome measures.

$b$Unpaired t test.

$c$Mann-Whitney U test.
ly ($P=0.0001$), for a mean difference of 1.1 days (95% confidence interval, 1.6-0.8).

After stratifying the length of stay in 3-day segments, there was a statistically significant difference ($P<0.01$) between the 2 groups, with more patients in the treatment group having been discharged between days 0 to 3 (Table 5).

**Compilations**

None of the patients included in the study had any significant postoperative medical or surgical complications in the first 48 hours (Table 6).

**Discussion**

Previous investigations on the use of perioperative wound infiltration during primary hip and knee replacement surgery have demonstrated reduced needs for postoperative opiate analgesic intake.15-18 Ours is the first comparative study to report on outcome relating to attainment of in-hospital rehabilitation milestones, showing a clear advantage to the use of wound infiltration in THA in the immediate postoperative period and subsequent reduction in length of stay. Surgeons who use the wound infiltration technique would normally infiltrate in every case, including revision hip replacements. However, we have included the primary THAs, which form the bulk of the cases undertaken by hip surgeons in their normal practice. With respect to consumption of opiates, our results corroborate those of previous reports.10,12,14 In contrast to 42% of patients in the control group, no patient in the treatment group of the present study required use of patient-controlled analgesia. Furthermore, the mean amount of opiate analgesia used in the treatment group was significantly ($P=0.0001$) reduced by a factor of 1.4 times (42.3 vs 60.9 mg).

Pain in the perioperative period is the result of several nociceptive mechanisms. These include encoding of nociceptive stimuli at the surgical wound and injury-induced inflammation. There is sensitization of peripheral somatic and visceral nociceptive nerve terminals and central neurons, and loss of local and descending inhibition of neurons in the brainstem and spinal cord.16 A rational approach to the treatment of postoperative pain is to combine different treatment modalities, working against different pain mechanisms, to improve analgesia and, potentially, reduce side effects.20,21

The combination of medications we used for perioperative pain management is thought to eliminate the generation and transmission of pain impulses in elective joint replacement surgery in a pre-emptive way.11 Ropivacaine is a local anesthetic agent, possessing similar pharmacokinetic properties to bupivacaine, but with a lower toxicity profile and longer duration of action.22 Adrenaline acts as a local vasoconstrictor, effectively reducing the systemic absorption of ropivacaine. It may also have some peripheral analgesic effect.2 Nonsteroidal anti-inflammatory drugs exert their analgesic effect by numerous pathways, such as the inhibition of prostaglandin synthesis, inhibition of cyclooxygenase-2 activity, and, in some NSAIDs, inhibition of the lipoxygenase pathway and interference with G-protein-mediated signal transduction. Moreover, they contribute to dampening down local inflammation.23 This, in turn, may limit postoperative edema of the thigh.7,16

Busch et al14 reported a significant reduction in intravenous morphine use via patient-controlled analgesia at 6 hours postoperatively in 32 patients who received intraoperative wound infiltration with 400 mg of ropivacaine, .6 mg (1:1000) of adrenaline, 30 mg of ketorolac, and 5 mg of morphine. Patients in the control group ($n=32$) had significantly higher visual analog pain scores on mobilization immediately after surgery. No difference in length of stay, visual analog pain scores after 4 hours of surgery or patient-controlled analgesia morphine consumption between 6 to 24 hours after the operation was reported. There was no difference in the patient satisfaction scores either. All patients were younger than 80 years, lighter than 120 kg, and operated on through an anterolateral approach. The addition of morphine to the infiltration, and the absence of postoperative top-up doses constitutes important methodological differences of that study compared to the present one. With the adjunctive use of 2 postoperative top-up doses, we believe that our technique may be more effective in controlling postoperative pain. Moreover, we designed our study with no restriction of age and weight to make the results more pragmatic when used in THA patients.

Andersen et al12 reported their results on 19 patients who underwent primary THA through a posterior approach with a minimally invasive surgical technique. A solution identical to the one used in the present study was infiltrated, but only one postoperative top-up dose was administered. A control group included 18 patients injected with placebo. The authors found a significant reduction in visual analog pain scores at 4 and 8 hours and in the Western Ontario and McMaster University pain scores up to 4 days following surgery, as well as a significantly lower opiate consumption during the first 96 hours postoperatively, all in favor of the treatment group. However, there was no significant reduction in the length of stay (mean, 2.6 vs 2.8 days; $P>0.05$). This study is valuable in showing that wound infiltration does reduce early postoperative pain, despite the fact that it was restricted to patients younger than 80 years undergoing minimally invasive surgery. By including several more commonly used surgical approaches and by including older patients or others with high BMIs, the results of the present investigation may be considered more generalized. We have also added one extra top-up dose, which may have contributed to the earlier mobilization and reduced length of stay. Although Andersen et al12 recorded improvements of the Western Ontario and McMaster University indices on stiffness and physical activities, these were assessed at 1-week postoperatively. By comparison, we have recorded the time taken to achieve the common major physical therapy milestones in the immediate postoperative period, which has direct implications for the length of stay.

Another study18 reported significant re-
duction in opiate intake in 38 patients undergoing THA, infiltrated in a similar manner to ours, but with only 1 top-up injection postoperatively, as compared to a control group of 37 patients who received continuous epidural analgesia. The treatment group had significant reduction in visual analog pain scores and more patients were able to walk 8 hours postoperatively. Although a significant reduction by 2 days in the length of stay ($P<.001$) was reported, the median length of stay in the control group was 7 days, compared to approximately 5 days (Table 4) in our hospital. This delayed length of stay may possibly be attributed to the side effects of epidural opiate analgesia. No patients in our study received epidural analgesia. Therefore, the findings of that study have limited external validity, as our patients were discharged at a mean of 5 days, even with no infiltration. Our data captures exactly how quickly patients achieved their physiotherapy milestones, including their ability to mobilize from bed to chair. Hence, this data can be used to formulate physiotherapy management plans to deliver optimal care among postoperative THA patients.

In a single-surgeon case series of patients undergoing hip and knee replacement, 54 patients undergoing THA through a posterior approach were evaluated. They were infiltrated intraoperatively with a mixture identical to that used in the present study. A routine top-up dose at 15 to 20 hours postoperatively, with 50 mL of a similar solution, followed. A reduced morphine intake (20% of patients used morphine during the first 24 hours and none thereafter) with early resumption of walking (mean, 11 hours) and independent mobilization (mean, 24 hours,) was reported. Mean length of stay was 4.3 days. There was no control group in that study, and the infiltration technique was not uniform, as it varied on the basis of patient age and/or comorbidities. Moreover, a lower concentration of ropivacaine (2.5 mg/mL) was used during top-up infiltrations, which probably forced the authors to use a larger volume (50 mL) for the top-up dose.

Observations regarding mobility in our study revealed a significant ($P=.01$) reduction in the mean number of hours needed for patients to mobilize from bed to chair following surgery in the treatment group. The median time before patients in the treatment group could walk more than 3 meters with a frame was 18.2 hours sooner than in the control group ($P<.0001$). Furthermore, we demonstrated a significant reduction (4 vs 5.2 days) in the mean length of stay for the treatment group compared to the control group ($P=.0001$). These early attainments of rehabilitation milestones, which are essential after THA surgery, were probably the result of perioperative infiltration with local anesthetic agents, and using 2 postoperative top-up doses, which, is the most important finding of the present study.

Weaknesses of this article are fundamental to its retrospective nature. In addition, we did not record any pain scores in the perioperative period. However, our aim was to prove that this technique could result in reduced opiate intake and early rehabilitation after primary THA. Neither the staff assessing outcome nor the patients were blinded, as the wound catheter was apparent. However, every patient was offered identical postoperative regime as considered standard in our hospital. From a practical point of view, leaving an intra-articular catheter in a prosthetic joint for up to 20 hours postoperatively may be of concern, as it could increase a patient’s risk for deep infection. Among previous studies on the use of this technique in THA, (143 THAs in total) no such case has been reported.

There appears to be no agreement as to the optimal medication doses required while using this infiltration technique. Future research should focus on the determination of the most effective mixture for the infiltrate and the number or duration of top-up doses. The technique of perioperative, high-volume local anesthetic infiltration in primary THA appears safe and effective in enhancing postoperative mobilization and reducing in-hospital length of stay.

**REFERENCES**


