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Doubtful effect of continuous intraarticular analgesia after total knee arthroplasty
A randomized, double-blind study of 200 patients

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Background and purpose — Local infiltration analgesia (LIA) is well established for effective postoperative pain relief in total knee arthroplasty (TKA). To prolong the effect of LIA, infusion pumps with local intraarticular analgesia can be used. We evaluated the effect of such an infusion pump for the first 48 h postoperatively regarding pain, knee function, length of stay (LOS) in hospital, and complications.

Patients and methods — 200 patients received peroperative LIA and a continuous intraarticular elastomeric infusion pump set at 2 mL/h. The patients were randomized either to ropivacaine (7.5 mg/mL) or to NaCl (9 mg/mL) in the pump. Visual analog scale (VAS) pain (0–100 mm), analgesic consumption, side effects of medicine, range of motion (ROM), leg-raising ability, LOS, and complications during the first 3 months were recorded.

Results — On the first postoperative day, the ropivacaine group had lower VAS pain (33 vs. 40 at 12 noon and 36 vs. 43 at 8 p.m.; p = 0.02 and 0.03, respectively), but after that all recorded variables were similar between the groups. During the first 3 months, the ropivacaine group had a greater number of superficial and deep surgical wound infections (11 patients vs. 2 patients, p = 0.02). There were no other statistically significant differences between the groups.

Interpretation — Continuous intraarticular analgesia (CIAA) with ropivacaine after TKA has no relevant clinical effect on VAS pain and does not affect LOS, analgesic consumption, ROM, or leg-raising ability. There may, however, be a higher risk of wound-healing complications including deep infections.

Achievement of postoperative pain relief after TKA is demanding. Pain scores peak on the first postoperative day, when two-thirds of TKA patients report moderate-to-severe pain (Wang et al. 2002, Wylde et al. 2011). Intense postoperative pain reduces range of motion (ROM), increases analgesic consumption, and prolongs hospital stay (Horlocker 2010). Periarticular local infiltration analgesia (LIA) has been introduced as a successful and safe method to diminish postoperative pain, and it promote early mobilization after TKA (Busch et al. 2006, Vendittoli et al. 2006, Toftdahl et al. 2007, Kerr and Kohan 2008, Andersen et al. 2010a, Essving et al. 2010). Interestingly, however, periarticular LIA has not been shown to reduce pain or LOS, or to improve morbidity after total hip arthroplasty (THA) (Dobie et al. 2012). Earlier attempts have been made using intraoperative intraarticular local anesthetics to reduce postoperative pain after TKA, with limited or no effect (Mauerhan et al. 1997, Klasen et al. 1999, Ritter et al. 1999, Browne et al. 2004).

Continuous infiltration analgesia is reported to be effective in other surgical procedures (Liu et al. 2006) but not in THA (Specht et al. 2011). As the effect of LIA disappears within the first 24 h, attempts have been made to prolong the analgesic effect using continuous peripheral nerve blocks (Fischer et al. 2008) and continuous intraarticular analgesia (CIAA) (Zhang et al. 2011). There have, however, been controversies about the effect of CIAA after TKA. Some studies have found that it is an effective method (Rasmussen et al. 2004, Gomez-Cardero and Rodriguez-Merchan 2010, Zhang et al. 2011, Goyal et al. 2013), whereas others have not (Williams et al. 2013). We therefore evaluated the effect of CIAA with pain, knee function, length of stay (LOS) in hospital, and complications as endpoints. We conducted a randomized, double-blind...
sungen, Germany) to a Homepump (I-Flow, CA), which con-

through an epidural flat filter (Perifix ONE; B. Braun, Mel-

from the lateral side of the knee. The catheter was connected

All patients had an epidural catheter placed in the knee joint

50 mL ropivacaine (2 mg/mL) was injected subcutaneously.

and 53 mL was injected around the fascia, the anterior cap-

mixture containing ropivacaine (200 mg; 2 mg/mL), ketorolac

(30 mg; 30 mg/mL) and epinephrine (0.5 mg; 0.1 mg/mL),

of which 53 mL was injected into the posterior joint capsule

and 53 mL was injected around the fascia, the anterior cap-

sule, and the lateral and medial collateral ligaments. A further

50 mL ropivacaine (2 mg/mL) was injected subcutaneously.

All patients received a periarticular injection of 106 mL of a

mixture containing ropivacaine (200 mg; 2 mg/mL), ketorolac

(30 mg; 30 mg/mL) and epinephrine (0.5 mg; 0.1 mg/mL),

of which 53 mL was injected into the posterior joint capsule

and 53 mL was injected around the fascia, the anterior cap-

sule, and the lateral and medial collateral ligaments. A further

50 mL ropivacaine (2 mg/mL) was injected subcutaneously.

All patients had an epidural catheter placed in the knee joint

from the lateral side of the knee. The catheter was connected

through an epidural flat filter (Perifix ONE; B. Braun, Mel-
sungen, Germany) to a Homepump (I-Flow, CA), which con-
tained 100 mL of either ropivacaine (7.5 mg/mL) or NaCl (9
gg/mL), with an infusion rate of 2 mL/h for 48 h. Randomiza-
tion was done with a computer-generated list, and a dedicated
nurse who was not involved in the surgery delivered the pump
to each patient during surgery. All others were blind regard-

The standard method of anesthesia was spinal (87%),
and the remaining patients received general anesthesia. All
patients received a standardized premedication and postop-
erative analgesia consisting of paracetamol (500 mg 2 × 4),
diclofenac (25 mg 1 × 3), and a patch with buprenorphine (10
µg/h) that was changed once a week for a total of 3 weeks.
Additional oxycodone (5 mg) was administered as required,
and registered.

VAS pain (0–100 mm, where 0 = no pain and 100 = intoler-
able pain) was evaluated by the patient at rest and recorded
by a dedicated nurse twice daily at 12 noon and 8 p.m. for 3
days. Furthermore, LOS, additional analgesics (apart from the
standardized regime), occasions with nausea and/or vomiting,
and number of changes of wound dressings during the hospital
stay were registered. Active ROM of the knee (goniometry)
and straight leg-raising ability were measured and recorded
by physiotherapy staff both preoperatively and 3 days post-
operatively.

2 weeks and 3 months postoperatively, VAS pain, analge-
sic consumption, and wound-healing complications were
recorded again. ROM was also recorded at 3 months. The ran-
domization list was kept secret until 3 months after operation
of the last patient to be included.

Statistics
Block randomization was done with a computer-generated
list, which was used by a nurse to deliver the appropriate
pump to each patient. Block size for randomization was 20
patients. The primary endpoint of this study was the VAS pain
assessment 3 days postoperatively. We considered a difference
in VAS between the groups of 10–20 mm to be a clinically
relevant difference. A power analysis then estimated that 200
patients (100 in each group) would be sufficient for detection
of a statistical significance of 5% with 90% power, using a
2-sided Student t-test when the VAS SD was 20 mm. Fisher’s
exact test was used for binomial variable analysis. A p-value
of < 0.05 was considered statistically significant. Stata version
12.0 was used for data analyses.

Ethics
The study and study registration was performed in compliance
with the Helsinki Declaration, and all patients had given their
informed written consent. The ethics committee of the Fac-
ulty of Medicine, Lund University, approved the study (Dnr
2009/368), which was also registered at ClinicalTrials.gov
(identifier: NCT01726686).
8 patients were excluded, 3 in the therapy group and 5 in the control group (Figure 1). The remaining 192 patients were followed up for 3 months. Baseline data were similar between groups (Table 1).

There was a statistically significant difference in VAS pain between groups at postoperative day 1 only. Mean VAS at 12 noon in the therapy group was 33, and it was 40 in the control group (p = 0.02); the corresponding values at 8 p.m. were 36 and 43 (p = 0.03) (Figure 2). We also found a significant difference between the groups regarding postoperative wound infection (p = 0.02). All other recorded variables were similar between the groups (Table 2).

13 patients had a superficial or deep infection of the surgical site, which was verified by bacterial culture. 11 of these patients were in the therapy group (6 superficial and 5 deep infections). The 2 corresponding patients in the control group had 1 superficial and 1 deep infection. All 7 patients with superficial infection were treated successfully with antibiotics. 4 of the 6 patients with deep infection were revised successfully by debridement and change of insert, and 2 patients were reoperated successfully with 2-stage revision of the prosthesis.

### Table 1. Patient characteristics

<table>
<thead>
<tr>
<th></th>
<th>Therapy group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age, years</strong></td>
<td>69 (9)</td>
<td>69 (8)</td>
</tr>
<tr>
<td><strong>Sex (female/male)</strong></td>
<td>65/35</td>
<td>62/38</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
<td>29 (5)</td>
<td>30 (5)</td>
</tr>
<tr>
<td><strong>ASA classification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASA 1</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>ASA 2</td>
<td>69</td>
<td>66</td>
</tr>
<tr>
<td>ASA 3</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td><strong>Charney classification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>23</td>
<td>32</td>
</tr>
<tr>
<td>C</td>
<td>42</td>
<td>38</td>
</tr>
<tr>
<td><strong>Side TKA (right/left)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>52/48</td>
<td>60/40</td>
</tr>
<tr>
<td><strong>Anesthesia (spinal/general)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spinal</td>
<td>83/17</td>
<td>92/8</td>
</tr>
</tbody>
</table>

*a* mean (SD).

### Table 2. Results. Data are mean (SD) or number of patients

<table>
<thead>
<tr>
<th>Variables</th>
<th>Therapy group</th>
<th>Control group</th>
<th>No. of missing observations</th>
<th>p-value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS preop. (0–100)</td>
<td>60 (16)</td>
<td>61 (15)</td>
<td>0.9</td>
<td>−3.5 to 5.4</td>
<td></td>
</tr>
<tr>
<td>VAS on op. day, 8 p.m.</td>
<td>14 (20)</td>
<td>21 (25)</td>
<td>1.0</td>
<td>−0.3 to 13</td>
<td></td>
</tr>
<tr>
<td>VAS on day 1, 12 noon</td>
<td>33 (24)</td>
<td>40 (22)</td>
<td>0.02</td>
<td>1 to 14</td>
<td></td>
</tr>
<tr>
<td>VAS on day 1, 8 p.m.</td>
<td>36 (24)</td>
<td>43 (21)</td>
<td>1.0</td>
<td>0.8 to 14</td>
<td></td>
</tr>
<tr>
<td>VAS on day 2, 12 noon</td>
<td>34 (24)</td>
<td>33 (25)</td>
<td>0.8</td>
<td>−8.3 to 5.8</td>
<td></td>
</tr>
<tr>
<td>VAS on day 2, 8 p.m.</td>
<td>27 (20)</td>
<td>30 (22)</td>
<td>3.0</td>
<td>−3.8 to 8.5</td>
<td></td>
</tr>
<tr>
<td>VAS on day 3, 12 noon</td>
<td>26 (19)</td>
<td>23 (20)</td>
<td>11.0</td>
<td>−8.9 to 2.9</td>
<td></td>
</tr>
<tr>
<td>VAS 2 weeks postop.</td>
<td>34 (24)</td>
<td>29 (19)</td>
<td>3</td>
<td>−12 to 0.7</td>
<td></td>
</tr>
<tr>
<td>VAS 3 months postop.</td>
<td>19 (21)</td>
<td>17 (19)</td>
<td>6</td>
<td>−8.6 to 3.2</td>
<td></td>
</tr>
<tr>
<td>ROM preop., degrees</td>
<td>112 (16)</td>
<td>109 (23)</td>
<td>0.2</td>
<td>−8.2 to 3</td>
<td></td>
</tr>
<tr>
<td>ROM on day 3 postop.</td>
<td>82 (16)</td>
<td>84 (12)</td>
<td>0.6</td>
<td>−3.6 to 4</td>
<td></td>
</tr>
<tr>
<td>ROM 3 months postop.</td>
<td>113 (12)</td>
<td>110 (13)</td>
<td>2</td>
<td>−6.3 to 0.7</td>
<td></td>
</tr>
<tr>
<td>Dressing change</td>
<td>0.5 (0.9)</td>
<td>0.7 (1.1)</td>
<td>0.2</td>
<td>−0.5 to 0.1</td>
<td></td>
</tr>
<tr>
<td>Postop. stay, days</td>
<td>4.1 (0.9)</td>
<td>4.1 (1.0)</td>
<td>0.8</td>
<td>−0.2 to 0.3</td>
<td></td>
</tr>
<tr>
<td>Nausea/vomiting</td>
<td>0.8 (1.4)</td>
<td>1.1 (2.0)</td>
<td>0.2</td>
<td>−0.8 to 0.2</td>
<td></td>
</tr>
<tr>
<td>Leg-raising ability preop.</td>
<td>96 (9)</td>
<td>93 (2)</td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leg-raising ability on day 3</td>
<td>93 (9)</td>
<td>92 (2)</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wound infection</td>
<td>11</td>
<td>2</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total additional oxycodone, 5 mg</td>
<td>4 (5)</td>
<td>5 (6)</td>
<td>0.06</td>
<td>−0.1 to 3.2</td>
<td></td>
</tr>
</tbody>
</table>

*a* number of patients

### Figure 2. Difference in VAS pain between groups.

### Discussion

The use of LIA in TKA is increasing, as an effective method to reduce postoperative pain (Busch et al. 2006, Venditti et al. 2006, Tofthedahl et al. 2007, Kerr and Kohan 2008, Andersen et al. 2010a, Essving et al. 2010). The effect of LIA disappears within 24 h, however, and patients receiving LIA tend to experience more pain on the second postoperative day than on the first (Niemielenen et al. 2014).

The area of application of LIA can differ. Andersen et al. (2008b, 2010b) found no difference between use of postoperative intraarticular LIA and use of extraarticular/intracapsular LIA. Dobryndjov et al. (2011) found no difference between intraarticular and extraarticular continuous LIA at rest, while intraarticular LIA appeared to reduce pain intensity during the first exercises.
Gomez-Cardero and Rodriguez-Merchan (2010) found that an analgesic infusion pump after TKA reduced postoperative pain, opioid use, and length of hospital stay without increasing the risk of complications. However, their study included only 50 patients. In a randomized, double-blind placebo-controlled trial in TKA, Andersen et al. (2008a) found that high-volume ropivacaine—given first as a periarticular dose and then postoperatively as 2 intraarticular doses—reduced the pain for up to 32 h at rest and during movement. However, in our study both groups received periarticular LIA during surgery and randomization to postoperative ropivacaine or placebo did not allow us to detect any clinically relevant difference in VAS pain between the groups. To our knowledge, there has been no other prospective randomized double-blind study similar to our study.

Good pain control is essential for early mobilization after TKA. However, we consider the small difference that we found between the 2 groups regarding VAS pain on the first postoperative day to be clinically irrelevant. One limitation of our study could be that we recorded VAS pain only at rest. We chose this measure to standardize the measurement as much as possible. VAS pain during activity is very much dependent on what type of activity the patient has had, something that is difficult to control. In addition to this, intensive postoperative pain at rest is not uncommon after TKA—in contrast to THA, where patients may have more weight bearing–related pain.

Several studies have shown that there is no increased risk of infection with intraarticular catheter placement for up to 72 h (Bianconi et al. 2003, Rasmussen et al. 2004, Vendittoli et al. 2006). In contrast to this, we found a higher rate of superficial and deep wound infections in the therapy group. This finding is remarkable and difficult to explain, and to our knowledge it has not been found in other, similar studies. Both groups had the same type of pump, and only the contents were different. Theoretically, the pump preparation method may have introduced a risk of contamination in the therapy group, as filling a pump with 100 mL ropivacaine required five 20 mL ampoules, while the control group required only a single bag of saline to fill 10 pumps. However, pump filling was entirely done under sterile conditions in the pharmacy. One might speculate that ropivacaine could cause tissue irritation when administered continuously over 48 h. However, it has been shown that ropivacaine has an antiseptic effect (Batai et al. 2002, Kampe et al. 2003). The finding of more infections in the ropivacaine group might be a coincidence, but it is too remarkable to be neglected and should be followed up in other studies.

In conclusion, CIIA in TKA does not appear to have any clinically relevant effect on postoperative pain and has no effect on length of hospital stay, side effects of medications, ROM, or straight leg-raising ability. To our surprise, we inexplicably found more infections in the therapy group and we have therefore discontinued the use of CIAA.

We thank Professor Jonas Ranstam, RC Syd, Clinical Sciences, Lund University, for valuable advice on statistics, and all the medical staff of the Orthopedics Department, Trelleborg Hospital, for excellent cooperation. The study was supported financially by Region Skåne and by the Erik and Angelica Sparre Sparre Foundation.

AA collected and analyzed all the data and prepared the manuscript. GF and MS designed the study and helped in writing the manuscript. All the authors recruited patients, performed the operations, and followed up the patients.

No competing interests declared.


