Regional Anesthesia for Total Knee Arthroplasty

José A. Aguirre, MD, MSc
jose.aguirre@balgrist.ch
Agenda

• Femoral / sciatic nerve block
• Obturator nerve block
• Do we need motor block?
  – adductor canal block
  – other fancy blocks
• Local infiltration analgesia (LIA)
• Encapsulated forms of bupivacaine
• Recommendations & Conclusions
KEY POINTS

- Regional analgesia techniques are cornerstones of multimodal analgesia in hip and knee replacement surgery. Patients are profiting from reduced pain scores and lesser opioid consumption.

- Femoral nerve blocks can be viewed as the gold standard for pain management after TKA. The advantage of routinely used sciatic nerve blocks has not been adequately clarified.

- Lumbar epidurals have an unfavourable risk/benefit ratio and regional techniques provide comparable pain control.

- The standard application of catheter techniques remains controversial. Single-shot techniques often provide sufficient analgesia for the first 24h and early ambulation is most often not delayed.

- LIA and adductor canal blocks may initiate the change away from femoral nerve blocks to the desired ‘pure analgesic’ blocks in total knee replacement surgery; however, the exact advantages need to be determined.
SFB / CFB (+ PCA) are a good alternative for PCA or epidural analgesia for postoperative analgesia in patients after TKA.

Currently there is no evidence supporting the use of either a SSB or CFB in addition to a single-injection FB!
Femoral nerve blocks for acute postoperative pain after knee replacement surgery (Review)

Chan EY, Fransen M, Parker DA, Assam PN, Chua N

45 RCTs (2'710 patients), 20 RCTs having > 2 allocation groups.
- 29 RCTs compared FNB vs PCA opioid
- 10 RCTs compared FNB vs EDA
- 5 RCTs compared FNB vs LIA
- 1 RCT compared FNB vs oral analgesia
- 4 RCTs compared cFNB vs ssFNB

FNB provides more effective analgesia than PCA opioid, similar analgesia than EDA and less PONV than PCA opioid and EDA.
Continuous FNB provides better analgesia than ssFNB
RCTs insufficient to allow comparison between FNB and LIA or oral analgesia

c/ss FNB: continuous / single shot femoral nerve block
EDA: epidural analgesia
LIA: local infiltration analgesia
## The Association Between Lower Extremity Continuous Peripheral Nerve Blocks and Patient Falls After Knee and Hip Arthroplasty

Brian M. Ilfeld, MD, MS, Kimberly B. Duke, MS, and Michael C. Donohue, PhD

### Table 1. Details on the Individual Patient Falls

<table>
<thead>
<tr>
<th>No.</th>
<th>Joint replaced</th>
<th>Catheter location</th>
<th>Postoperative day, time</th>
<th>Ropivacaine infusion rate</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1‡</td>
<td>Knee</td>
<td>Femoral</td>
<td>4, 11:00</td>
<td>5 mL/h</td>
<td>Tripped walking through front door of home after successfully ambulating for 4 days—quadriceps weakness denied. Readmission, no injury.</td>
</tr>
<tr>
<td>2º</td>
<td>Hip</td>
<td>Posterior lumbar plexus</td>
<td>1, 21:00</td>
<td>8 mL/h</td>
<td>Walking from hospital bed to bathroom after successfully ambulating twice earlier that day—possible quadriceps weakness. No injury.</td>
</tr>
<tr>
<td>3º</td>
<td>Hip</td>
<td>Posterior lumbar plexus</td>
<td>3, 20:00</td>
<td>5 mL/h</td>
<td>Standing at sink at home and fell backward—quadriceps weakness contribution unclear. Readmission, no injury.</td>
</tr>
<tr>
<td>4º</td>
<td>Hip</td>
<td>Posterior lumbar plexus</td>
<td>3, 22:00</td>
<td>5 mL/h</td>
<td>Walking from hospital bed to bathroom after successfully ambulating for 3 days—quadriceps weakness denied. Concurrent anemia and dizziness. No injury.</td>
</tr>
<tr>
<td>5¹⁰</td>
<td>Knee</td>
<td>Femoral</td>
<td>2, 16:00</td>
<td>6 mL/h</td>
<td>Standing at hospital bedside after successfully ambulating for 2 days—quadriceps weakness contribution unclear. No injury.</td>
</tr>
<tr>
<td>6¹⁰</td>
<td>Knee</td>
<td>Femoral</td>
<td>3, 12:00</td>
<td>5 mL/h</td>
<td>Exiting vehicle upon returning home after ambulating successfully for 3 days—quadriceps weakness denied. No injury.</td>
</tr>
<tr>
<td>7¹⁰</td>
<td>Knee</td>
<td>Femoral</td>
<td>4, 11:00</td>
<td>5 mL/h</td>
<td>Same subject as fall 6. Fell backward “slowly” while walking her dog at home—quadriceps weakness denied. No injury.</td>
</tr>
</tbody>
</table>
# Postoperative Falls After Total Knee Arthroplasty in Patients With a Femoral Nerve Catheter: Can We Reduce the Incidence?

Christopher E. Pelt, MD, Anthony W. Anderson, MD, Mike B. Anderson, MS, ATC,

**The Journal of Arthroplasty 29 (2014) 1154–1157**

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Arthroplasty Type</th>
<th>Anesthetic</th>
<th>FNC or FNB, Concentration</th>
<th>Fall Rate</th>
<th>Fall Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beebe et al [26]</td>
<td>77</td>
<td>Primary</td>
<td>Bupivacaine</td>
<td>FNC, 0.125%</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Feibel et al [13]</td>
<td>1190</td>
<td>Primary &amp; Revision</td>
<td>Ropivacaine</td>
<td>FNC, 0.12%</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>Sharma et al [27]</td>
<td>1018</td>
<td>Primary &amp; Revision</td>
<td>Ropivacaine</td>
<td>0.4%–1.6%</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>Wasserstein et al [18]</td>
<td>2197</td>
<td>Primary</td>
<td>Bupivacaine</td>
<td>FNB, FNC, or continuous epidural</td>
<td>2.7%</td>
<td>Yes</td>
</tr>
<tr>
<td>Pelt et al [22]</td>
<td>244</td>
<td>Primary</td>
<td>Bupivacaine</td>
<td>FNC, 0.25%</td>
<td>2.7%</td>
<td>Yes</td>
</tr>
<tr>
<td>Clarke et al [28]</td>
<td>94</td>
<td>Primary</td>
<td>aNR</td>
<td>FNC, aNR</td>
<td>0%–4%</td>
<td>Yes–No</td>
</tr>
<tr>
<td>Reinhardt et al [28]</td>
<td>171</td>
<td>Primary</td>
<td>Ropivacaine</td>
<td>Spinal with FNB, 0.25%</td>
<td>4.1%</td>
<td>NR</td>
</tr>
<tr>
<td>Ilfeld et al [29]</td>
<td>171</td>
<td>Knee &amp; Hip Arthroplasty</td>
<td>Ropivacaine</td>
<td>FNC, 0.2%</td>
<td>7%</td>
<td>No</td>
</tr>
</tbody>
</table>

*NR = Not Reported.*
# Iatrogenic femoral nerve injury: a systematic review

Abigail E. Moore · Mark D. Stringer


### Table 4 Other reports of iatrogenic femoral nerve injury (2000–2010)

<table>
<thead>
<tr>
<th>Regional anesthesia</th>
<th>Femoral nerve block</th>
<th>0.03% (3/10,309)</th>
<th>Auroy et al. [3]</th>
<th>Outcome of this group uncertain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Case report</td>
<td>Schafhalter-Zoppoth et al. [51]</td>
<td>Transient sensory deficit after intraneural injection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Continuous block (postoperative infusions)</td>
<td>0.5% (1/211)</td>
<td>Cuvillon et al. [15]</td>
<td>Sensory disturbance; partial recovery after 1 yr</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.4% (3/683)</td>
<td>Capdevila et al. [10]</td>
<td>Full recovery within 10 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.8% (9/1,190)</td>
<td>Feibel et al. [23]</td>
<td>Most resolved by 3 months; 2 had persistent symptoms</td>
</tr>
<tr>
<td>Ilio-inguinal nerve block</td>
<td>Performed blindly or under direct vision</td>
<td>5% (10/200)</td>
<td>Ghani et al. [25]</td>
<td>Transient femoral neuropathy resolving within 24 h</td>
</tr>
<tr>
<td>Continuous psoas compartment block</td>
<td>Probable needle trauma to nerve roots</td>
<td>Case report</td>
<td>Al-Nasser and Palacios [2]</td>
<td>Complete recovery by 6 months</td>
</tr>
</tbody>
</table>
Sciatic nerve block in addition to continuous femoral block

• 90 patients for TKA randomized in 3 groups:
  • cFNB; cFNB+SNB; cFNB+cSNB until POD2
  • **Main outcome**: discharge readiness. **Secondary outcomes**: knee function, pain, morphine consumption, local anesthetic consumption, PONV

• **No** difference in time to discharge / knee function / LA consumption, PONV.

• Pain POD0: cFNB>cFNB+SNB/cFNB+cSNB (p<0.01).

• Morphine consumption highest in cFNB group (POD0+1).

• Pain in cFNB+cSNB group lower until POD2 (p<0.01).

TKA: total knee arthroplasty
cFNB: continuous femoral nerve block
cSNB: continuous sciatic nerve block
POD: postoperative day

Wegener JT et al. RAPM 2011; 36:481-88
Is Sciatic Nerve Block Advantageous When Combined With Femoral Nerve Block for Postoperative Analgesia Following Total Knee Arthroplasty?

A Systematic Review

- 4 RCT (intermediate quality) and 3 observational studies: 391 patients:
  - 3 of 4 studies investigating addition of ssSNB to FNB and 2 of 3 studies investigating the addition of cSNB to FNB showed better analgesia at rest and less opioid consumption
  - Only 2 studies specifically assessed posterior knee pain

Inconclusive evidence in the literature to define the effect of adding SNB to FNB on acute pain and related outcomes compared with FNB alone for TKA.

TKA: total knee arthroplasty

c/ss FNB: continuous/single shot femoral nerve block

cSNB: continuous/single shot sciatic nerve block

Abdallah FW et al. RAPM 2011; 36:493-98
Sciatic nerve block for TKA

- FNB & SNB may improve analgesia after TKA, but benefits uncertain.
- ssSNB & cFNB vs. cFNB: no benefit
- cSNB & cFNB vs. cFNB: better analgesia
- cSNB & cPCB vs. ssSNB & cPCB: better analgesia & early rehabilitation
- cSNB & cFNB vs ssSNB & cFNB: better analgesia

**Abbreviations:**
c/ssSNB: continuous/single shot sciatic nerve block
cFNB: continuous femoral nerve block
cPNB: continuous psoas compartment block
TKA: total knee arthroplasty

**References:**
- Morin A et al. RAPM 2005; 30:434–445
- Pham Dang RAPM 2005; 30:128–133
- Cappelleri G et al. RAPM 2011;36:489–492
- Sato K et al. RAPM 2014;39: 225–229
To block or not to block?

- **Sciatic nerve block**
  - SN injury after TKA incidence: 0.2% to 2.4%
  - risk factors: valgus deformity $> 10^\circ$, total tourniquet time $> 120$ min, preexisting neuropathy, and bleeding

SN: sciatic nerve
TKA: total knee arthroplasty
EMG: electromyography

Mariano ER et al. RAPM 2009; 34:480–485
Obturator nerve block

- No clinical evidence for routinely block the obturator nerve for postoperative TKA pain
- Absolutely needed if TKA in only peripheral nerve block is planned (triple block)
- Combination with fancy blocks possible


TKA: total knee arthroplasty

Choquet O et al. Anesthesiology 2005;103:1238-45
Continuous adductor-canal-blockade for adjuvant post-operative analgesia after major knee surgery: preliminary results

Double-blind, RCT, 48 patients for TKA under SA. Continuous ACB or FB (30ml 0.5% ropivacaine bolus; 0.2% ropivacaine, 8m/h for 24h).

Primary outcome: quadriceps muscle strength
Secondary outcomes: morphine consumption, pain at rest and during flexion of knee, adductor muscle strength.

- ACB preserved quadriceps muscle strength better than FB.
- No significant difference in postoperative pain and morphine consumption.

TKA: total knee arthroplasty
SA: spinal anesthesia
ACB: adductor canal block
FB: femoral nerve block

Adductor Canal Block Versus Femoral Nerve Block for Analgesia After Total Knee Arthroplasty

A Randomized, Double-blind Study

Muscle strength

ACB: adductor canal block
FB: femoral nerve block

Adductor Canal Block Versus Femoral Nerve Block for Analgesia After Total Knee Arthroplasty
A Randomized, Double-blind Study

Pain during flexion of the knee

ACB: adductor canal block
FB: femoral nerve block

Adductor canal block

- ACB vs ssFNB for TKA: less motor block for first 6-8h post op. Pain and opioid consumption comparable.
- ACB vs ssFNB: no advantages regarding motor function, similar analgesia
- cACB vs cFNB: better ambulation and early functional recovery, similar analgesia.

ACB: adductor canal block
TKA: total knee arthroplasty
ssFNB: single shot femoral nerve block

Kim DH et al. Anesthesiology 2014; 120:540-50
Memtsoudis SG et al. Internat Ortho 2014 (online)
Shah NA et al. J Arthroplasty 2014 (ahead of print)
Fancy blocks

• **Ideas**
  – block selectively sensory nerves
  – block as distal as possible to avoid motor block

• **Problems**
  – only with good ultrasound skills possible
  – no catheter techniques
  – if repeated in the postoperative period: near to the surgical wound
  – presented at congresses like „I-can-even-do-that“ tools more than therapy
Fig 3 Cutaneous analgesia following infrapatellar nerve block. Circles represent mean values (for numerical values and so please see Table 2).

Fig 1 Probe position at the level of injection.

Fig 2 Ultrasonographic pictures of the relevant anatomy. (A) Saphenous nerve, (B) saphenous and infrapatellar nerves.

Ultrasound-guided infrapatellar nerve block in human volunteers: description of a novel technique.
Lundblad M, Kapral S, Marhofer P, Lönnqvist PA.
Local infiltration analgesia

- High volume infiltration, different mixtures (opioids, NSAIDs, steroids, clonidine...)
- No direct drug- and dose- finding study to support one specific mixture
- Efficient pain relief without motor block
- Kehlet supports intraoperative use for TKA
- Catheters: no advantage over systemic analgesia for pain and LOS

LIA: local infiltration analgesia
TKA: total knee arthroplasty
LOS: length of stay

Gibbs DM et al. JBJS 2012; 94:1154–1159
Andersen LO et al. BJA 2014; 113: 360-74
Local infiltration analgesia

- Plasma level study of elderly patients (360mg bupivacaine) shows levels below toxic threshold
- Unclear if intraarticular LIA better compared to soft tissue LIA
- In some studies LIA better pain control compared to FNB
Future directions?

Extended release liposomes:

- Encapsulated forms of bupivacaine
- Superior compared to placebo
- Comparable to bupivacaine tissue injections

Davidson EM A&A 2010; 110:1018-23
### Table 1. Overview of randomized, double-blind, controlled wound infiltration studies.

<table>
<thead>
<tr>
<th>Study/Identifier</th>
<th>Phase</th>
<th>Surgical Setting</th>
<th>Study Treatments and Dosages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (NCT01203644)</td>
<td>2</td>
<td>Inguinal hernia repair</td>
<td>Liposome bupivacaine 155, 199, 266, and 310 mg vs bupivacaine HCl 100 mg</td>
</tr>
<tr>
<td>2 (NCT00485433)</td>
<td>2</td>
<td>Inguinal hernia repair</td>
<td>Liposome bupivacaine 93, 160, and 306 mg vs bupivacaine HCl 105 mg</td>
</tr>
<tr>
<td>3 (NCT00485693)</td>
<td>2</td>
<td>Total knee arthroplasty</td>
<td>Liposome bupivacaine 133, 266, 399, and 532 mg vs bupivacaine HCl 150 mg</td>
</tr>
<tr>
<td>4 (NCT00529126)</td>
<td>2</td>
<td>Hemorrhoidectomy</td>
<td>Liposome bupivacaine 66, 199, and 266 mg vs bupivacaine HCl 75 mg</td>
</tr>
<tr>
<td>5 (NCT01206608)</td>
<td>2</td>
<td>Breast augmentation</td>
<td>Liposome bupivacaine 133 and 266 mg vs bupivacaine HCl 75 mg</td>
</tr>
<tr>
<td>6 (NCT00745290)</td>
<td>3</td>
<td>Total knee arthroplasty</td>
<td>Liposome bupivacaine 532 mg vs bupivacaine HCl 200 mg</td>
</tr>
<tr>
<td>7 (NCT00744848)</td>
<td>3</td>
<td>Hemorrhoidectomy</td>
<td>Liposome bupivacaine 266 mg vs bupivacaine HCl 100 mg</td>
</tr>
<tr>
<td>8 (NCT00813111)</td>
<td>3</td>
<td>Breast augmentation</td>
<td>Liposome bupivacaine 532 mg (266 mg in each breast pocket) vs bupivacaine HCl 200 mg (100 mg in each breast pocket)</td>
</tr>
<tr>
<td>9 (NCT00890721)</td>
<td>3</td>
<td>Hemorrhoidectomy</td>
<td>Liposome bupivacaine 266 mg vs placebo (saline)</td>
</tr>
<tr>
<td>10 (NCT00890682)</td>
<td>3</td>
<td>Bunionectomy</td>
<td>Liposome bupivacaine 106 mg vs placebo (saline)</td>
</tr>
</tbody>
</table>
No one single study comparing liposome bupivacaine wound infusion with peripheral catheters!
Liposome bupivacaine not (yet) for perineural injection!
Only one safety study on animal nerves to assess neurotoxicity!

The average wholesale price (AWP) of a 10-mL (133mg) vial of Exparel is $140; the AWP of a 20-mL (266mg) vial is $285.
Impact on costs

- Anesthesiology costs are estimated to be 5.6% for common procedures.
- Regional anesthesia cost benefits:
  - reduction of PONV
  - reduced length of stay
  - successful same day discharge with a catheter
  - reduction or even elimination of PACU stay
  - reduction of operating room time without increase in turnover time (reduction of the ACT)

The average wholesale price (AWP) of a 10-mL (133mg) vial of Exparel is $140; the AWP of a 20-mL (266mg) vial is $285.

PONV: post anesthesia nausea and vomiting
PACU: post anesthesia care unit
ACT: anesthesia controlled time: patient enters OR until readiness for positioning + end of surgery until patient leaves the OR

Williams BA et al. Anesthesiology 2004; 100:697-706
Ilfeld BM et al. Anesthesiology 2008; 108:703-13
Hadzic A et al. A&A 2005; 100; 976-81
Gonano C et al. BJA 2009; 103:428-33
Conclusions

- Peripheral nerve blocks
  - FNB:
    - if ssFNB: consider avoiding complete motor block (dose reduction, ropivacaine 0.2-0.3%)
    - if cFNB: consider starting the block after tourniquet release (ischemia, compression, local toxicity??)
  - SNB: only ssSNB, only if varus deformity, consider as only recue block, catheter only in selected cases
  - ONB: only rescue block
Conclusions 2

- Adductor canal block / fancy blocks
  - ACB is a good alternative to FNB, superiority unclear
  - catheter technique described
  - avoid volumes which make same motor block than FNB
  - do not inject in the region below the tourniquet → go distal
  - combination with LIA / fancy blocks possible

Conclusions 3

• Local infiltration techniques
  – good alternative if no skilled anesthesiologist around
  – mixture, injection site, additives, : unclear
  – catheters not shown to be superior to systemic analgesia
  – Eventually same pain quality compared to FNB without motor block but no pain control for > 48 hours → long-term benefits unclear

Kehlet H et al. BJA 2014; 113: 360-74
Conclusions 4

- Encapsulated forms of bupivacaine for TKA
  - NO
    - Expensive
    - No clear superiority data
    - No comparison with «golden standard» (cFNB, ssSNB)
    - No clear toxicity data on human tissue in clinical settings

TKA: total knee arthroplasty
Conclusions 5

- Encapsulated forms of bupivacaine for TKA
  - NO
    - Expensive
    - No superiority data
    - No comparison with «golden standard» (cFNC, ssSNB)
    - No clear toxicity data on human tissue