Evidence-based management of postoperative pain in adults undergoing open inguinal hernia surgery

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Background: Open inguinal hernia repair is associated with moderate postoperative pain, but optimal analgesia remains controversial. The aim of this systematic review was to evaluate the available literature on the management of pain after open hernia surgery.

Methods: Randomized studies, in English, published between January 1966 and March 2009, assessing analgesic and anaesthetic interventions in adult open hernia surgery, and reporting pain scores, were retrieved from the Embase and MEDLINE databases. In addition to published evidence, clinical practice was taken into account to ensure that the recommendations had clinical validity.

Results: Of the 334 randomized studies identified, 79 were included. Quantitative analysis suggested that regional anaesthesia was superior to general anaesthesia for reducing postoperative pain. Spinal anaesthesia was associated with a higher incidence of urinary retention and increased time to home-readiness compared with regional anaesthesia.

Conclusion: Field block with, or without wound infiltration, either as a sole anaesthetic/analgesic technique or as an adjunct to general anaesthesia, is recommended to reduce postoperative pain. Continuous local anaesthetic infusion of a surgical wound provides a longer duration of analgesia. Conventional non-steroidal anti-inflammatory drugs or cyclo-oxygenase 2-selective inhibitors in combination with paracetamol, administered in time to provide sufficient analgesia in the early recovery phase, are optimal. In addition, weak opioids are recommended for moderate pain, and strong opioids for severe pain, on request.

*Members of the PROSPECT Working Group are co-authors of this study and can be found under the heading Collaborators

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Introduction

Pain after open hernia surgery can be moderate to severe and may be associated with prolonged hospital stay, unanticipated hospital admission and delayed return to normal daily activities¹,². In addition, there is some suggestion that inadequately treated postoperative pain may be a risk factor for persistent pain after hernia surgery³. A review found that 11 per cent of patients suffered chronic pain after mesh inguinal hernia repair, and that almost one-third of patients had limitations in daily leisure activities as a consequence of chronic pain⁴. Multiple approaches, including pharmacological interventions, have been used to manage pain after hernia surgery, but optimal evidence-based pain therapy remains unknown. Recently, the European Hernia Society published guidelines on treatment of inguinal hernia in adult patients⁵, but postoperative pain management was not addressed adequately, except for suggesting that local anaesthetic (LA) techniques were preferable. Importantly, multimodal analgesia techniques, particularly including the use of non-opioid analgesics, were not evaluated⁵.
The PROcedure-SPECific postoperative pain management (PROSPECT) Working Group is a collaboration of surgeons/surgical scientists and anaesthetists working to formulate evidence-based recommendations for pain management that are specific for different surgical procedures. Graded recommendations are based on procedure-specific evidence from a systematic review, supplementary transferable evidence from other relevant procedures, and clinical practice information (http://www.postoppain.org).

The aim of this systematic review was to evaluate the available literature on the management of pain after hernia surgery. Postoperative pain outcomes (pain scores and supplementary analgesic requirements) were the primary focus of this review, but other recovery outcomes (adverse effects) were also assessed, where reported, and the limitations of the data were reviewed.

Methods
A systematic review of the literature concerning analgesia after inguinal hernia surgery was conducted according the protocol recommended by the Cochrane Collaboration. The literature search was performed in Embase and MEDLINE between January 1966 and March 2009. Search terms related to pain and interventions for hernia surgery: pain OR postoperative pain OR analgesi* OR anaesthe* OR anesthe* OR vas OR 'visual analog*' OR vrs OR mcgill OR epidural OR neuraxial OR intrathecal OR paravertebral OR spinal OR infiltration OR NSAID OR COX-2 OR paracetamol OR acetaminophen OR gabapenten OR pregabalin OR clonidine OR opioid OR ketamine OR corticosteroid OR EMLA OR herniorrhaphy OR hernia inguinal OR inguinal hernia repair OR heavyweignt mesh OR polypropylene mesh. The search was limited to randomised controlled study or trial, randomized controlled study or trial, clinical study or trial, language = English, and human or humans.

Study inclusion criteria
Randomized controlled trials (RCTs) in the English language assessing analgesic and anaesthetic interventions in adult inguinal hernia surgery, and reporting pain on a linear analogue, verbal or numerical rating scale, were included. Laparoscopic inguinal hernia repair was excluded.

Quality of included studies
The criteria used to assess the quality of eligible studies are shown in Table 1. Statistical analyses and patient follow-up assessment indicated whether statistical analyses were reported and whether patient follow-up was greater or less than 80 per cent. Allocation concealment assessment indicated whether there was adequate prevention of foreknowledge of treatment assignment by those involved in recruitment (A, adequate; B, unclear; C, inadequate; D, not used). Numerical scores (total 1–5) for study quality were assigned using the method proposed by Jadad and colleagues to indicate whether a study reported appropriate randomization, double-blinding and statements of possible withdrawals. Additional study quality assessment included an assessment of how closely the study report met the requirements of the Consolidated Standards of Reporting Trials (CONSORT) statement.

Analyses of outcomes
Summary information for each included study was extracted and recorded in data tables. This information included pain scores, supplementary analgesic use, the time to first analgesic request, functional outcomes and adverse effects. It was assumed that the postoperative pain scores were assessed at rest, unless otherwise specified in the study report.

Studies were stratified according to regimen (analgesic and anaesthetic), mode of delivery (systemic, neuraxial or local) and class of agent. Most open herniorrhaphy studies did not describe LA methodology consistently and used differing terminology. Owing to the variation in technique descriptions, ilioinguinal, iliohypogastric and/or genitofemoral nerve and infiltration into the superficial and deeper structures in the field of surgery (which may result in a block of the ilioinguinal, iliohypogastric and/or genitofemoral nerve) were grouped together and labelled as field block.

The effectiveness of each intervention for each outcome was evaluated qualitatively, by assessing the number of studies showing a significant difference between treatment arms ( \( P < 0.050 \) as reported in the study publication).

Statistical analysis
Quantitative analyses were performed on postoperative outcomes using Review Manager software (RevMan version 4.2 for Windows; The Nordic Cochrane Centre, Copenhagen, Denmark), which calculates the weighted mean difference for continuous data and the odds ratio for dichotomous data, between active and control groups for each study, with an overall estimate of the pooled effect. Mean(s.d.) values were extracted from the text, tables or graphs within the studies. RevMan software performed

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Table 1  Relationship between quality and source of evidence, levels of evidence and grades of recommendation

<table>
<thead>
<tr>
<th>Study type</th>
<th>Statistical analyses and patient follow-up assessment</th>
<th>Allocation concealment</th>
<th>Jadad score</th>
<th>Additional assessment of overall study quality required to judge LoE</th>
<th>Grade of recommendation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systematic review with homogeneous results</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>1</td>
<td>A (based on two or more studies or a single large, well designed study)</td>
</tr>
<tr>
<td>RCT</td>
<td>Statistics reported and &gt; 80% follow-up and</td>
<td>A (adequate)</td>
<td>1–5</td>
<td>NA</td>
<td>A (based on two or more studies or a single large, well designed study)</td>
</tr>
<tr>
<td>RCT</td>
<td>B (unclear)</td>
<td>3–5</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCT</td>
<td>Statistics not reported or questionable or &lt; 80% follow-up and/or</td>
<td>B (unclear)</td>
<td>1–2</td>
<td>Yes</td>
<td>B (or extrapolation from one procedure-specific LoE 1 study)</td>
</tr>
<tr>
<td>Clinical practice information (expert opinion); inconsistent evidence</td>
<td>NA</td>
<td>NA</td>
<td>4</td>
<td></td>
<td>D</td>
</tr>
</tbody>
</table>

*Based on overall level of evidence (LoE), considering balance of clinical practice information and evidence. RCT, randomized controlled trial; NA, not applicable.

heterogeneity analyses; data that were not significantly heterogeneous ($P > 0.100$) were analysed using a fixed-effects model, and heterogeneous data ($P \leq 0.100$) using a random-effects model. For quantitative analyses, pain scores on a verbal rating scale or numerical rating scale were converted to 0–100 mm scale pain scores. Studies could not be included in the meta-analyses if they did not report mean(s.d.) or mean(s.e.m.) values, or the proportion of patients. Limited studies could be included in a meta-analysis because of variation in design.

**Other sources of information used to formulate recommendations**

Evidence from the systematic review was supplemented by data from studies of other procedures with similar pain profiles (transferable evidence), where relevant, and included to support the procedure-specific evidence where this was insufficient to formulate the recommendation. Details of the transferable evidence used in this review are available on the PROSPECT website (http://www.postoppain.org). Studies that reported data pooled from patients undergoing mixed surgical procedures, including hernia surgery, were excluded from the procedure-specific systematic review, but have been used as additional transferable evidence where appropriate.

Current clinical practice information was taken into account, in addition to procedure-specific and transferable evidence, to ensure that the recommendations had clinical validity. The recommendations were formulated by the PROSPECT Working Group, using the Delphi method to collate rounds of individual comments on the evidence and draft recommendations, followed by round-table discussion, and then further Delphi rounds, to achieve final consensus.

The recommendations for optimal pain relief were graded A–D according to the overall level of evidence (LoE), as determined by the quality of studies included, consistency of evidence and source of evidence, including transferable evidence (Table 1).

**Search results**

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed for the description of this study (Fig. 1). A total of 334 studies of analgesic interventions in adult hernia surgery were identified, of which 79 were included in the systematic review. The most common reasons for study exclusion were that pain scores were not reported or that the study was not a RCT (Fig. 1). In addition, randomized trials of non-pharmacological interventions and operative interventions were excluded, as that was not the focus of this review. Studies of analgesic interventions following laparoscopic hernia surgery were also excluded.
from the systematic review because there is evidence that the laparoscopic approach is associated with a different postoperative pain profile. The results regarding excluded trials are available on the PROSPECT website (http://www.postoppain.org).

The trials were allocated into two broad groups for qualitative analysis: pharmacological interventions and anaesthetic interventions.

**Pharmacological interventions**

The trials in this section were grouped into conventional analgesics (paracetamol, conventional non-steroidal anti-inflammatory drugs (NSAIDs), cyclo-oxygenase (COX) 2-selective inhibitors, and opioids); adjunct drugs with analgesic activity (α₂ agonists, glucocorticoids, N-methyl-D-aspartate (NMDA) antagonists, magnesium and α₂δ ligands (gabapentin and pregabalin)); and regional anaesthesia (RA) techniques (field block (including ilioinguinal, iliohypogastric and genitofemoral nerve blocks) with or without LA wound infiltration).

**Paracetamol/propacetamol**

One study compared the effects of intravenous (i.v.) propacetamol (2 g slow infusion over 15 min at the end of surgery and 6 h later; n = 90) with i.v. parecoxib (40 mg; n = 92) administered at the end of surgery. Pain scores at rest and on coughing were not significantly different between the groups at 1, 6 and 12 h. However, the area under the curve (AUC) of pain scores at rest over the first 12 h after surgery was significantly smaller with parecoxib than with propacetamol, although there was no significant difference between groups in the AUC of pain scores on coughing. Opioid consumption and the incidence of adverse events (nausea, vomiting, pruritus and urinary retention) were not significantly different between groups. Significantly more patients treated with parecoxib rated their pain relief as excellent at 12 h.

**Conventional non-steroidal anti-inflammatory drugs**

A placebo-controlled study compared oral ketorolac 30 mg administered 1 h before surgery, i.v. ketorolac 30 mg and intramuscular (i.m.) ketorolac 30 mg (both administered at the time of placement of a field block) (n = 56). Compared with placebo, ketorolac (oral, i.m. and i.v.) significantly reduced the proportion of patients requiring supplementary analgesia. Parenteral (i.v. and i.m.) ketorolac was superior to oral ketorolac for reducing pain scores at 90 min at rest and on sitting, and for reducing the proportion of patients requiring supplementary analgesics. No differences were found between groups at the time of discharge from the recovery room.

In another placebo-controlled study, rectal naproxen 500 mg administered 30 min before surgery (n = 60) reduced pain at rest, increased the time to first supplementary analgesic dose, and reduced the need for supplementary analgesia, but did not reduce the proportion of patients requiring supplementary analgesics.

Compared with placebo, i.v. tenoxicam 10 or 20 mg before incision (n = 45) reduced pain scores at rest and on movement as well as reducing supplementary analgesic requirements. Preoperative i.v. ketorolac 30 mg and rectal diclofenac 50 mg provided similar pain relief, need for supplementary analgesics, and incidence of post-operative nausea and vomiting (PONV) (n = 108). Rectal and i.m. diclofenac 100 mg (n = 44), administered immediately after induction of general anaesthesia (GA),
resulted in similar pain scores and supplementary analgesic requirements. One study compared the effects of sublingual piroxicam (40 mg) administered 2 h before surgery and postoperative placebo \((n = 25)\) with sublingual piroxicam administered 20 min after surgery and preoperative placebo \((n = 27)\). Postoperative pain scores were significantly lower in the preoperative compared with the postoperative piroxicam group at 6 and 20 h \((P = 0.03)\), although there was no significant difference between groups in the recovery room or at 30 h. Cumulative opioid consumption at 30 h after surgery was significantly lower in the preoperative piroxicam group \((P = 0.045)\). The incidence of nausea was similar in the two groups.

Oral meloxicam 15 mg administered 30 min before operation significantly reduced pain scores and need for supplementary analgesics compared with no treatment. Overall, NSAIDs reduced postoperative pain scores as well as reducing the need for supplementary analgesia.

Topical non-steroidal anti-inflammatory drugs

A placebo-controlled trial compared piroxicam gel, 15 g applied topically to the wound site 2 h before surgery, with inguinal nerve block with bupivacaine 0.375 per cent after induction of GA. Topical piroxicam was superior to placebo for reducing pain scores during the first 4 h \((P < 0.050)\) but not between 4 and 24 h. However, topical piroxicam was superior for reducing supplementary analgesic requirements during the first 24 h \((P < 0.005)\), but did not increase the time to first analgesic. Topical piroxicam was equally effective as field block in reducing pain scores at rest during the first 24 h, reducing analgesic requirements and increasing the time to first analgesic request.

Cyclo-oxygenase 2-selective inhibitors

A placebo-controlled study evaluated the effects of oral rofecoxib 50 mg, administered 30–40 min before surgery and on the first postoperative morning \((n = 60)\). Rofecoxib significantly reduced pain scores at 1 h, but not at other time points. Rofecoxib reduced the requirement for supplementary analgesics before as well as after discharge home. Rofecoxib allowed for early recovery leading to an earlier discharge home. There were no differences in the rate of PONV, or other postdischarge recovery measures between the groups.

Another placebo-controlled study evaluated the effects of a combination of rofecoxib 50 mg administered before and 5 days after surgery plus preincisional field block (combination group, \(n = 26)\) with field block alone \((n = 25)\). All groups received 10 ml LA beneath the external oblique fascia at the end of surgery. Patients receiving field block had reduced intraoperative opioid requirements. The combination group had reduced duration of postanaesthesia care unit (PACU) or recovery room stay. Maximum pain scores, pain symptom distress scores \((0–5)\) and need for supplementary analgesics were significantly lower with the combination treatment compared with field block alone and placebo at 24 h, but not at 48 h or 7 days. However, there were no significant differences in levels of pain on rising, walking or coughing between the groups at 24 or 48 h after surgery. Patient satisfaction scores \((0–6)\) recorded at 48 h were significantly higher in the combination group compared with placebo alone, but not compared with field block alone.

A placebo-controlled study evaluated the effects of rofecoxib 50 mg before surgery (at bedtime) and after operation (immediately after the procedure, then once daily for 5 days) \((n = 26)\) and preoperative placebo and postoperative rofecoxib \((n = 21)\). Analgesic use on days 1–5 and pain scores at 6 weeks after surgery were significantly lower with postoperative rofecoxib compared with the placebo and preoperative rofecoxib groups. There were no significant differences in pain scores at rest and in physical or mental health composite scores between the groups at 6 weeks after surgery.

Opioids

Codeine 30 mg plus paracetamol 500 mg was compared with lysine clonixinate 125 mg, each administered orally after recovery from anaesthetic, every 4 h for 48 h \((n = 151)\). Both groups had similar pain relief at rest or on coughing, sitting or applied pressure during the first 2 days, and the need for supplementary analgesics was similar.

Another study compared dihydrocodeine 10 mg plus paracetamol 500 mg, one or two tablets orally every 4 h, with sustained-release morphine 30 mg, one tablet every 12 h on days 1 and 2, followed by dihydrocodeine 30 mg, one tablet orally every 4–6 h, on days 3–5 \((n = 50)\). Sustained-release morphine was superior in reducing pain scores during the first 5 days. However, it was also associated with more postoperative nausea.

One study compared the effect of oral premedication with ketobemidone 10 mg \((n = 29)\), sustained-release oxycodone 10 mg \((n = 30)\) and placebo \((n = 30)\). Preoperative sedation scores on arrival in the operating room...
were similar in the three groups. There were no significant differences in pain scores between the three groups at 2, 4 or 8 h, or on days 1 and 2 after surgery. Postoperative opioid consumption (i.v. ketobemidone) was significantly lower in the oxycodone group compared with the placebo group, but there were no significant differences between ketobemidone versus placebo or ketobemidone versus oxy-
codon. There were no significant differences in nausea and tiredness scores between the groups at any of the time points assessed.

α2 Agonists

One study compared the effects of i.v. clonidine 150 µg administered during GA (n = 12), spinal anaesthesia (SA) with bupivacaine 0·5 per cent plus sufentanil and 150 µg clonidine (n = 10), and SA with bupivacaine 0·5 per cent plus sufentanil and placebo (n = 14)31. The requirements for postoperative analgesics (paracetamol and ketorolac) were significantly higher in the group that received i.v. clonidine (GA group) compared with intrathecal clonidine (SA groups). There were no significant differences in pain scores between groups at 48 h and 10 days after surgery.

Glucocorticoids

Dexamethasone 10 mg i.v. administered immediately before SA was similar to placebo with respect to pain scores, supplementary analgesic requirements, and time to first analgesic request, as well as the incidence of PONV (n = 60)32.

N-methyl-D-aspartate antagonists

There were no procedure-specific studies with NMDA antagonists.

Magnesium

One study compared i.v. magnesium 4 g administered before incision (n = 41) with placebo (n = 39)33. All patients received preoperative diclofenac 100 mg rectally and intraoperative ilioinguinal–iliohypogastric nerve block. There were no differences between the groups with respect to pain scores at rest or on movement, as well as the time to first request for rescue analgesics and need for supplementary analgesia. PONV occurred with a similar frequency in both groups.

α28 Ligands

There were no procedure-specific studies with α28 ligands.

Regional/local anaesthesia techniques

Field block versus placebo or no treatment

Four studies compared field block with placebo (Table 2)24,34–36. Overall, field block was superior to placebo for reducing postoperative pain scores and the use of supplementary analgesics, as well as for extending the time to first analgesic request.

Field block and wound infiltration versus placebo or no treatment

Five studies compared combined field block and wound infiltration techniques with placebo or no treatment (Table 2)37–41. Overall, field block and wound infiltration were superior to no treatment or placebo for reducing postoperative pain scores and supplementary analgesic requirements.

Wound infiltration versus placebo

Four studies compared wound infiltration with placebo (Table 2)42–45. Overall, wound infiltration was superior to placebo for reducing pain scores as well as use of supplementary analgesia and delaying time to first analgesic request.

Subfascial wound infiltration with, or without subcutaneous wound infiltration

Postoperative subfascial LA infiltration was compared with subcutaneous LA infiltration, using a single dose of 10 ml lidocaine 1 per cent through a catheter in the wound (n = 41)46. Pain measurements at rest, on mobilization and on coughing were made at 15, 30, 60, 120 and 180 min. Subfascial infiltration was superior to subcutaneous infiltration for reducing pain scores at rest at 30 min (P < 0·050), on mobilization at 30 and 60 min (P < 0·050), and on coughing at 15 and 30 min (P < 0·050). The need for supplementary analgesia was similar in the two groups.

Combined subfascial and subcutaneous infiltration with bupivacaine 0·25 per cent, 10 ml for each instillation (n = 30), was compared with subfascial infiltration with saline and subcutaneous infiltration with 10 ml bupivacaine 0·25 per cent (n = 30)47. Pain scores at 1, 4–12 and 24 h were significantly lower, the time to first analgesic requirement was significantly longer, and the need for supplementary analgesics was lower with combined subfascial and subcutaneous infiltration.

Local anaesthetic instillation versus placebo or no treatment

Two studies compared LA instillation in the surgical wound at the end of surgery with placebo or no treatment in the following regimens: bupivacaine 0·5 per cent with, or without adrenaline (epinephrine) 1 : 200 000 (5 ml applied...
Postoperative pain in adults undergoing open inguinal hernia surgery

Table 2 Summary of key results from included studies reporting regional anaesthesia interventions in patients undergoing open hernia surgery

<table>
<thead>
<tr>
<th>Reference</th>
<th>Study design</th>
<th>Pain scores</th>
<th>Supplementary analgesia</th>
<th>Time to first analgesic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field block</td>
<td>ilioinguinal–iliohypogastric and genitofemoral nerve block with 20 ml bupivacaine 0.375% before surgery versus placebo (n = 27)</td>
<td>↓ at rest</td>
<td>NS</td>
<td>↑↑</td>
</tr>
<tr>
<td>Field block</td>
<td>ilioinguinal–iliohypogastric nerve block with 10 ml bupivacaine 0.5% before surgery versus no treatment (n = 45)</td>
<td>↓ ↓ at rest</td>
<td>↓ ↓</td>
<td>—</td>
</tr>
<tr>
<td>Field block</td>
<td>ilioinguinal–iliohypogastric nerve block with 30 ml bupivacaine 0.25% 5–10 min before surgery versus placebo (n = 30)</td>
<td>↓ at rest</td>
<td>↓ ↓</td>
<td>—</td>
</tr>
<tr>
<td>Field block</td>
<td>ilioinguinal–iliohypogastric nerve block with 10 ml bupivacaine 0.5% before surgery versus placebo (n = 100)</td>
<td>↓ ↓ at rest</td>
<td>↓ ↓</td>
<td>—</td>
</tr>
<tr>
<td>Wound infiltration</td>
<td>Wound infiltration with 20 ml levobupivacaine 0.5% versus placebo (n = 116)</td>
<td>↓ ↓ on movement</td>
<td>↓ ↓</td>
<td>↑↑</td>
</tr>
<tr>
<td>Wound infiltration</td>
<td>Wound infiltration with ropivacaine 0·25% at end of surgery versus placebo (n = 20)</td>
<td>↓ ↓ ↓ at rest and on movement</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Wound infiltration</td>
<td>Wound infiltration with ropivacaine 0·125, 0·25 or 0·5% at end of surgery versus placebo (n = 102)</td>
<td>↓ ↓ ↓ at rest</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Wound infiltration</td>
<td>Wound infiltration with 40 ml bupivacaine 0·25% before surgery versus no treatment (n = 24)</td>
<td>↓ ↓ at rest and on movement</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Wound infiltration</td>
<td>Wound infiltration with 2 ml levobupivacaine 0·5% versus placebo (n = 100)</td>
<td>↓ ↓ at rest and on movement</td>
<td>↓ ↓</td>
<td>↑↑</td>
</tr>
</tbody>
</table>

↓, Decreased at a minority (50 per cent or less) of time points measured; ↓ ↓, decreased at more than 50 per cent of time points measured; ↑↑, increased at a minority (50 per cent or less) of time points measured; ↑↑, increased at more than 50 per cent of time points measured; NS, no significant difference between groups; —, not reported.

along the spermatic cord, 5 ml instilled into the wound after closure of the external oblique aponeurosis superficial to cord structures and 5 ml instilled subcutaneously before the end of skin closure versus placebo and no treatment (n = 10 in each group)48; and lidocaine 200 mg, 2 ml sprayed evenly on the subcutaneous surface of the wound before skin closure versus placebo (saline spray) or no treatment (n = 10 in each group)49.

Compared with placebo and no treatment, instillation with bupivacaine alone was superior for reducing pain scores at 1, 3, 5 and 7 h (P = 0·05), but not at 9, 12, 16 or 20 h, whereas instillation with bupivacaine plus adrenaline was superior at 1, 3, 5, 7, 9 and 12 h (P = 0·02), but not at 16 or 20 h48. Lidocaine spray was superior (P < 0·050) for reducing pain scores at rest during the first 24 h, but not on day 2; lidocaine spray was superior to no treatment (P < 0·050), but not placebo, for reducing pain on movement at 12–14 h49.

Supplementary analgesic use was reduced in the instillation groups the first 20 h (P < 0·050) and the time to first analgesic request (P < 0·010) was increased with bupivacaine instillation48. Lidocaine spray reduced the need for opioid analgesics (P < 0·010) on day 1, but not on day 249.

Wound infiltration before surgery versus at wound closure

Three studies reported that LA injections before surgery and at wound closure were associated with similar pain scores at rest, on sitting and on coughing on days 1–750·51, and at rest, on coughing and on movement during 2–6 h52. Two of three studies reported that LA injections administered before surgery and at wound closure were associated with similar postoperative analgesic
use\textsuperscript{50,51}, and the time to first analgesic request was similar between groups in one study\textsuperscript{50}. One study reported that preoperative field block and wound infiltration was superior to field block at wound closure and wound infiltration for reducing the proportion of patients requiring supplementary analgesics in the first 6 h ($P < 0.050$) and for increasing the time to first analgesic request ($P < 0.050$)\textsuperscript{52}.

Overall, preoperative LA injection was similar to the same regimen given at wound closure in terms of pain scores and analgesic use.

**Preoperative field block versus wound instillation at wound closure**

Field block with 40 ml bupivacaine 0·25 per cent, administered after induction of GA, was compared with wound instillation with 10 ml bupivacaine 0·5 per cent, administered at wound closure ($n = 50$)\textsuperscript{53}. Preoperative field block and instillation at wound closure were similar with respect to pain scores in the recovery ward, maximum pain, proportions of patients requiring supplementary analgesics, and time to first use of supplementary analgesia.

**Postoperative repeat local anaesthetic boluses or wound infusion**

Three studies compared postoperative repeat-dose LA by catheter in the wound with placebo or no treatment in the following regimens: bupivacaine 0·5 per cent, 10-ml boluses administered subcutaneously via a catheter, immediately after closure and 8 h after surgery versus no treatment ($n = 101$)\textsuperscript{54}; bupivacaine 0·5 per cent, 10-ml boluses administered via a catheter into the surgical wound, before closure and at 6, 12 and 24 h after operation versus metamizole 500 mg orally at 6, 12 and 24 h after surgery ($n = 104$)\textsuperscript{55}; and 5-ml bolus of bupivacaine 0·5 per cent plus meperidine 2 per cent versus placebo administered via a catheter, at an unspecified time on the first postoperative day ($n = 60$)\textsuperscript{56}. Postoperative repeat LA bolus via a catheter in the wound was of no benefit in reducing pain scores and/or supplementary analgesic requirements compared with placebo or no treatment\textsuperscript{54–56}.

Six studies investigated the use of continuous wound infusion with LA versus placebo or no treatment: subfascial infusion of bupivacaine 0·5 per cent via a portable pump for 48 h versus no treatment ($n = 44$)\textsuperscript{57}; wound infusion with bupivacaine 0·5 per cent via a pump at 2 ml/h for 50 h versus placebo ($n = 49$)\textsuperscript{58}; wound infusion with bupivacaine 0·5 per cent at 2 ml/h through a disposable pump for 60 h versus placebo ($n = 72$)\textsuperscript{59}; wound infusion with ropivacaine at 4 ml/h versus placebo ($n = 47$)\textsuperscript{60}; bupivacaine 0·25 per cent at 2 ml/h versus placebo for 48 h ($n = 45$)\textsuperscript{61}; and bupivacaine 0·5 per cent at 2 ml/h for 48 h versus placebo ($n = 52$)\textsuperscript{62}.

Five of six studies showed reduced pain scores with LA infusion: on days 0 and 1 at rest and on coughing ($P < 0·010$), but not on days 2–6\textsuperscript{57}; at rest on day 1 ($P = 0·028$) and day 2 ($P = 0·012$), but not on days 3–5\textsuperscript{58}; at rest on day 1 ($P < 0·050$) and with pain that interfered with daily activities on day 1 ($P < 0·050$), but not on days 2–5\textsuperscript{59}; on day 1 when sitting out of bed and on walking ($P = 0·02$ and $P = 0·006$ respectively), but not at rest on day 1\textsuperscript{60}; and on days 2, 3, 4 and 5 ($P < 0·05$) at rest, but not at rest in the recovery room or on day 1\textsuperscript{61}. The remaining study found no significant differences in pain scores at rest on days 1–5\textsuperscript{62}.

Three of six studies showed reduced supplementary analgesic use and/or a reduced proportion of patients requiring supplementary analgesia with LA wound infusion\textsuperscript{57,60,62}. However, there was no significant difference in analgesic use in the other three studies\textsuperscript{58,59,61}.

**Type of local anaesthetic**

One study compared bupivacaine 0·25 per cent (racemic mixture) with levobupivacaine 0·25 per cent for field block and wound infiltration ($n = 69$)\textsuperscript{63}, and found that both provided similar pain relief. Three studies compared ropivacaine and bupivacaine for field block and infiltration in the following regimens: ropivacaine 0·25 per cent versus bupivacaine 0·25 per cent administered before surgical incision ($n = 32$)\textsuperscript{64}; ropivacaine 0·75 per cent versus bupivacaine 0·25 per cent, administered at the end of surgery ($n = 144$)\textsuperscript{65}; and ropivacaine 0·25 per cent versus bupivacaine 0·25 per cent administered as boluses via a catheter in the surgical wound when the pain score exceeded 3 ($n = 51$)\textsuperscript{66}. All studies reported that ropivacaine and bupivacaine were similar for pain scores at rest, on mobilization and on coughing, as well as with respect to the need for supplementary analgesia and time to the first analgesic request\textsuperscript{64–66}. Two studies also reported that there were no differences in the incidence of PONV\textsuperscript{65,66}.

**Local anaesthetic dose comparison**

Two studies compared different doses of ropivacaine for field block/infiltration in the following regimens: ropivacaine 0·25 and 0·5 per cent ($n = 130$)\textsuperscript{39}; and ropivacaine 0·125, 0·25 and 0·5 per cent administered at the end of surgery ($n = 102$)\textsuperscript{43}.

Ropivacaine 0·5 per cent was superior to 0·25 per cent for pain scores on movement at 6 h and at 7 days ($P < 0·050$), but not at 3, 10 or 24 h, and pain scores at rest were similar at 3, 6, 10 and 24 h and at 7 days\textsuperscript{39}. In addition, ropivacaine 0·5 per cent reduced the use of
supplementary analgesics ($P < 0.050$). The incidence of PONV was similar for ropivacaine 0·25 and 0·5 per cent.

Pain scores at rest and on coughing were similar with ropivacaine 0·25 or 0·5 per cent at 1, 3, and 5 h, but superior to those for ropivacaine 0·125 per cent$^{43}$. Ropivacaine 0·5 per cent had a significantly greater effect in reducing total analgesic use compared with 0·125 and 0·25 per cent. The time to first analgesic use was increased by ropivacaine 0·25 and 0·5 per cent compared with 0·125 per cent ($P < 0·020$). Overall, ropivacaine 0·5 and 0·25 per cent were superior to 0·125 per cent.

Composition of local anaesthetic solution

Two studies evaluated the effects of clonidine added to LA solution (Table 3)$^{67,68}$. Overall, there was no improvement in pain relief or reduction in need for supplementary analgesics. Except for the incidence of orthostatic hypotension, which was significantly greater in the clonidine group ($P < 0·050$), the incidence of side-effects was similar for bradycardia, sedation, arterial hypotension, urinary retention and PONV$^{68}$.

Six studies evaluated the effects of conventional NSAIDs (tenoxicam, meloxicam) (Table 3)$^{17,19,69–72}$. Overall, there was no difference in pain scores at rest or on movement, need for supplementary analgesics, and time to first analgesic request.

Four studies evaluated the effects of incisional opioids (morphine, fentanyl, tramadol) (Table 3)$^{73–76}$. These studies reported inconsistent results for pain relief and supplementary analgesic requirements.

Wound infiltration with dextran did not significantly reduce pain scores and analgesic use, or increase the time to first analgesic request (Table 3)$^{77,78}$.

Addition of triamcinolone to local bupivacaine injection was of no benefit in reducing pain scores, compared with bupivacaine alone, at 4, 8, 12, 20, 28, 36 h or 2–14 days, and was of no benefit in reducing morphine use over 24 h ($n = 30$)$^{79}$.

Wound instillation with bupivacaine 0·5 per cent plus adrenaline 1:200 000 was compared with bupivacaine 0·5 per cent ($n = 17$)$^{48}$. Wound instillation with LA plus adrenaline provided no significant benefit over LA alone for reducing postoperative pain scores or analgesic requirements, or for increasing the time to first analgesic request.

Anaesthetic interventions

Spinal versus general anaesthesia

Four studies compared SA with GA in the following regimens: SA versus GA ($n = 24^{44} , n = 50^{80} , n = 33^{81}$) and SA plus field block ($n = 35$) versus GA plus field block ($n = 35$)$^{82}$. Three of four studies showed a reduction in pain scores with SA versus GA, but these data were inconclusive: pain scores at rest and on movement were lower at 24 and 48 h ($P < 0·001$), but not at 10 days$^{84}$; pain scores were lower at 1 h ($P < 0·050$), but there was no benefit at 3, 7 or 24 h or at 6 weeks$^{80}$; pain scores at rest were significantly lower at 30 and 60 min ($P < 0·001$) and 120 min ($P < 0·050$) but not at 180 min after surgery, and at rest or during movement during the first 7 days after discharge$^{82}$; and the number of patients reporting pain scores of 4 or more (based on a 10-point scale) at the time of discharge was similar with SA and GA$^{81}$.

Two studies reported an increased time until first analgesic request with SA versus GA$^{44,82}$. Results for supplementary analgesic requirements with SA versus GA were inconclusive: opioid consumption in the PACU was significantly lower in the SA compared with the GA group ($P < 0·01$), although ketorolac consumption was similar in both groups$^{82}$; there was a significant reduction in use of supplementary diclofenac with SA compared with GA ($P = 0·02$)$^{80}$; and a similar amount of analgesics (ibuprofen plus codeine) was consumed in the first 7 days after discharge$^{82}$. One study reported that the number of patients requiring postoperative analgesics in the PACU was similar$^{81}$.

Patient discharge times were significantly shorter with GA than with SA, with, and without voiding ($P < 0·001$ and $P < 0·050$ respectively)$^{82}$. One of two studies reporting PONV found that SA reduced the incidence of nausea compared with GA$^{80}$, whereas the other study found no significant difference$^{81}$. There was no significant difference between groups in the incidence of adverse events before discharge or for the first 7 days after surgery$^{82}$. Overall patient satisfaction was similar with SA and GA$^{81}$.

Spinal versus regional anaesthesia (field block with, or without wound infiltration)

Six studies compared SA with RA in the following regimens: SA versus RA (both groups received wound infiltration with bupivacaine at the end of the operation) ($n = 23$)$^{83}$; RA using a 50:50 mixture of mepivacaine 1 per cent and bupivacaine 0·5 per cent versus SA (82 per cent) or epidural anaesthesia (18 per cent) (in accordance with the local routine, sedation was optional, and wound infiltration with 10–20 ml bupivacaine 0·25 per cent was recommended, but not compulsory, before or after repair, for patients in both groups) ($n = 412$)$^{84}$; RA with 1 ml/kg lidocaine 0·5 per cent plus bupivacaine 0·125 per cent versus SA ($n = 50$)$^{80}$; RA with 30 ml bupivacaine
Table 3 Summary of key results from included studies reporting composition of local anaesthetic solution used for local/regional anaesthesia in patients undergoing open hernia repair surgery

<table>
<thead>
<tr>
<th>Reference</th>
<th>Study design</th>
<th>Pain scores</th>
<th>Supplementary analgesia</th>
<th>Time to first analgesic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ilioinguinal block/wound infiltration with clonidine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>Wound infiltration with clonidine 150 µg versus i.m. clonidine 150 µg and placebo; all groups received wound infiltration (n = 31)</td>
<td>NS versus placebo</td>
<td>NS versus placebo and i.m. clonidine</td>
<td>—</td>
</tr>
<tr>
<td>68</td>
<td>Clonidine 75 µg added to ropivacaine 0.75% versus ropivacaine alone for ilioinguinal block (n = 40)</td>
<td>NS at rest</td>
<td>—</td>
<td>NS</td>
</tr>
<tr>
<td>Wound infiltration with conventional NSAIDs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Wound infiltration with ketorolac 30 mg versus oral ketorolac 1 h before surgery versus i.v. and i.m. ketorolac 30 mg before field block (n = 56)</td>
<td>↓ versus placebo and oral ketorolac</td>
<td>↓↓ versus placebo and oral ketorolac</td>
<td>—</td>
</tr>
<tr>
<td>19</td>
<td>Wound infiltration with tenoxicam 10 mg versus i.v. tenoxicam 10 and 20 mg (n = 45)</td>
<td>↓ at rest and on movement versus i.v. tenoxicam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>Wound infiltration with tenoxicam 7.5 mg versus i.m. tenoxicam 7.5 mg (n = 44)</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>Wound infiltration with meloxicam 7.5 mg versus i.v. meloxicam 7.5 mg (n = 56)</td>
<td>NS at rest and on movement</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>71</td>
<td>Ketorolac 30 mg added to lidocaine 0.5% versus ketorolac 30 mg s.c.; both groups received wound infiltration with lidocaine 0.5% (n = 40)</td>
<td>NS at rest and on movement</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>72</td>
<td>Ketorolac 60 mg added to bupivacaine 0.5% versus bupivacaine alone; all groups received ilioinguinal block/wound infiltration (n = 24)</td>
<td>NS at rest and on movement</td>
<td>NS</td>
<td>—</td>
</tr>
<tr>
<td>Wound infiltration with opioids</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>73</td>
<td>Morphine 5 mg infiltrated at end of surgery versus placebo; spinal anaesthesia in both groups (n = 30)</td>
<td>NS at rest and on movement</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>74</td>
<td>Morphine 5 mg infiltrated at end of surgery versus i.v. morphine 5 mg versus s.c. morphine 5 mg; general anaesthesia in all groups (n = 34)</td>
<td>NS at rest and on movement</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>75</td>
<td>Wound infiltration with fentanyl 10 µg versus i.m. fentanyl 10 µg (n = 20)</td>
<td>↓↓ at rest and on movement</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>76</td>
<td>Wound infiltration with tramadol 1 mg/kg versus bupivacaine alone (n = 43)</td>
<td>↓↓ at rest and on movement</td>
<td>↓↓</td>
<td>↓↓</td>
</tr>
<tr>
<td>Local anaesthetic plus dextran</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>77</td>
<td>Dextran 110 added to bupivacaine 0.25% versus bupivacaine 0.25% alone for ilioinguinal block/wound infiltration (n = 50)</td>
<td>NS</td>
<td>NS</td>
<td>—</td>
</tr>
<tr>
<td>78</td>
<td>Dextran added to local anaesthetic versus local anaesthetic alone (n = 40)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

↓, Decreased at a minority (50 per cent or less) of time points measured; ↓↓, decreased at more than 50 per cent of time points measured; ††, increased at a minority (50 per cent or less) of time points measured; NS, no significant difference between groups; —, not reported; i.m., intramuscular; NSAID, non-steroidal anti-inflammatory drug; i.v., intravenous; s.c., subcutaneous.

0.25 per cent/lidocaine 1 per cent versus SA (both groups received infiltration with bupivacaine and lidocaine before and after incision) (n = 53)\textsuperscript{85}; RA with 10 ml lidocaine 1 per cent, 2 ml adrenaline 1:200 000 plus lidocaine, and 30 ml bupivacaine 0.5 per cent mixture versus SA (n = 100)\textsuperscript{86}; and RA with 60 ml lidocaine 0.5 per cent plus adrenaline 1:200 000 versus SA (n = 84)\textsuperscript{87}.

Three of six studies showed that RA (with, or without wound infiltration) was superior to SA (with, or without wound infiltration) for reducing pain scores, as follows: pain scores at rest on day 2 (P < 0.050) but not on days 1, 7 or 30\textsuperscript{85}; pain scores at rest during the early postoperative period (P < 0.001) but not on days 8 or 30\textsuperscript{84}; and maximum pain scores at rest on day 1 (P < 0.050)\textsuperscript{85}. However, three studies found that RA (with, or without wound infiltration) was not superior to SA (with, or without wound infiltration) for reducing pain scores: SA significantly reduced pain scores at rest at 1 h (P < 0.050) compared with RA, and
Postoperative pain in adults undergoing open inguinal hernia surgery

There was no significant difference at 3, 7 or 24 h or 6 weeks, or on movement at any time \(^{80}\); pain scores were lower with RA versus SA at 4, 8, 12 and 24 h, but these differences were not statistically significant \(^{86}\), and there were no significant differences in pain scores with RA versus SA at 3 h or on days 1–3 \(^{87}\).

Supplementary analgesic requirements were similar for RA and SA, in terms of the duration of requirement for analgesics \(^{84}\), diclofenac use \(^{80}\), total weekly analgesic use \(^{83}\), diclofenac/pethidine use \(^{87}\), and proportion of patients requiring oral analgesics after discharge \((n = 56)\) \(^{85}\). One study reported that patients who received RA spent significantly less time in the operating room than patients in the SA group \((P < 0.001)\) \(^{86}\). RA was similar to SA with regard to the rate of PONV in two of three studies \(^{80,85}\), but significantly reduced nausea scores compared with SA in the third study \(^{84}\). One study found that the incidence of postoperative complications (skin infection, minor haematoma) was similar with SA and RA \(^{86}\). There was no significant difference in the level of patient satisfaction (assessed on a 3-point scale) between the groups \(^{87}\).

Five studies found that RA was associated with a lower incidence of urinary retention than SA: four of five reported that the incidence of urinary retention was significantly lower with RA compared with SA \((P < 0.050)\) \(^{80,84,85,87}\). The fifth study reported fewer patients with urinary retention in the RA group compared with the SA group \((0 \text{ versus } 3 \text{ respectively})\), but no statistics were reported \(^{86}\). In a meta-analysis of the incidence of urinary retention including five studies, RA was superior to SA (odds ratio 0.03, 95 per cent confidence interval 0.01 to 0.09; \(P < 0.001\)) (Fig. 2).

Three of five studies found that RA was associated with a reduced length of hospital stay or time to home-readiness compared with SA. Two of five studies reported that RA significantly reduced the duration of hospital stay or time to home-readiness compared with SA \((P < 0.050)\) and \(P < 0.001\) \(^{85}\). One study reported that a greater proportion of patients left hospital on the day of surgery in the RA group compared with the SA group, but no statistical analysis was provided \(^{87}\). Two studies showed no significant difference between RA and SA in the duration of hospital stay \(^{80,83}\). One study reported that the time to the first experience of postoperative pain was similar with RA and SA \(^{87}\).

**General versus regional anaesthesia (field block with, or without wound infiltration)**

Seven studies compared GA with RA in the following regimens: RA using 50–60 ml ropivacaine 0.5 per cent versus GA plus wound infiltration with 15–20 ml bupivacaine 0.25 per cent at the end of surgery \((n = 60)\) \(^{88}\); RA with prilocaine 2 per cent diluted 1:4 with saline versus GA \((n = 50)\) \(^{89}\); RA using a 50:50 mixture of mepivacaine 1 per cent and bupivacaine 0.5 per cent versus GA in accordance with the local routine plus recommended, but not compulsory, wound infiltration with 10–20 ml bupivacaine 0.25 per cent before or after repair \((n = 413)\) \(^{84}\); RA using lidocaine 1 per cent plus adrenaline 1:200 000 versus GA \((n = 276)\) \(^{90}\); RA with 1 ml/kg lidocaine 0.5 per cent plus bupivacaine 0.125 per cent versus GA \((n = 50)\) \(^{80}\); RA with 30 ml bupivacaine 0.25 per cent/lidocaine 1 per cent versus GA \((n = 56)\) \(^{85}\); and RA with lidocaine 350 mg (10 ml lidocaine 1 per cent to block the ilioinguinal
and iliohypogastric nerves and up to 50 ml lidocaine 0·5 per cent for local infiltration) versus GA (n = 103)91.

Six of seven studies showed that RA was superior to GA for the following: reducing pain scores at rest on admission to the recovery room (P < 0·001), at 1 h (P < 0·001) and 2 h (P = 0·002), and on sitting or standing after surgery (P < 0·001), as well as reducing pain scores at rest at 1 h (P < 0·001), 2 h (P = 0·02), 24 h (P = 0·01), 48 h (P < 0·001) and 7 days (P = 0·005), and on activity at 48 h (P = 0·01) but not at 24 h or 7 days88; reducing pain scores at rest at 8 h (P < 0·001) and on movement at 8 h (P = 0·036) and 24 h (P = 0·019) (n = 50)89; reducing pain scores at rest during the early postoperative period (P < 0·001) but not after 8 or 30 days84; reducing pain scores on movement at 6 h (P = 0·041), but not at rest at 6, 24 or 72 h, or on movement at 24 or 72 h90; reducing pain scores at rest at 1 h (P = 0·008) but not at 3, 7 or 24 h or 6 weeks, or on movement at any time80; and reducing maximum pain scores85. One study showed no significant benefit of RA (with lidocaine alone) compared with GA for reducing pain scores at rest at 6 or 24 h or 7 days93.

Three of six studies showed that, compared with GA, RA was associated with a significant reduction in the incidence of nausea (P < 0·050)80, PONV (P < 0·050)85, vomiting at 6 h (P < 0·010) and 24 h (P < 0·020), and nausea at 6 h (P < 0·010)91. The remaining three studies showed no significant difference between RA and GA in the incidence of PONV88, grade of nausea89 or nausea score on a visual analogue scale (VAS) (n = 404)84.

Overall, compared with GA, RA was associated with reduced PONV, postoperative sore throat, urinary retention and duration of hospital stay. No meta-analysis was carried out because of variations in study design.

Field block with, or without wound infiltration anaesthesia

The effects of combined field block (injection of 10 ml bupivacaine 0·25 per cent medially to the anterior superior iliac spine) and bupivacaine 0·25 per cent infiltrated subcutaneously and subfascially (n = 78) were compared with placebo (field block with 10 ml isotonic saline) and wound infiltration with bupivacaine (n = 79)92. The doses of midazolam required for intraoperative sedation were similar in both groups. Intraoperative median pain scores were significantly lower with field block (P = 0·02), as was the number of patients with an intraoperative pain score of at least 30 (P < 0·050). There were no significant differences in pain scores and total analgesic consumption between the groups at 24 or 48 h.

Paravertebral block

Paravertebral block (PVB) with 35 ml ropivacaine 0·5 per cent plus adrenaline 1·400 000 (7 ml at each of five levels) before surgery was compared with peripheral nerve block at the end of surgery with 200 mg ropivacaine 0·5 per cent plus adrenaline 1·400 000 (10 ml for ilioinguinal and iliohypogastric nerve block; 15 ml for T10, T11 and T12 nerve block; 15 ml for infiltration of incision) (n = 46)93. There were no significant differences in pain scores at rest, on movement and on coughing between the groups, or in the proportion of patients requiring supplementary analgesics in first 72 h or the time to first analgesic request. PVB was superior to peripheral nerve block for reducing the proportion of patients requiring supplementary analgesia (P = 0·002) and the incidence of PONV (P < 0·001) in the PACU.

One study compared inguinal hernia repair under PVB or GA (n = 24 per group)94. Fewer patients receiving PVB reported moderate or severe pain (score 4 or more on a 10-point VAS scale) compared with those receiving GA (P = 0·05). Fewer patients in the PVB group required rescue analgesics (paracetamol 325 mg plus codeine 30 mg every 4 h as needed) (P = 0·005). The incidence of nausea was lower with PVB (P = 0·05), but there was no significant difference between groups in the incidence of vomiting.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Overall recommendations for management of pain associated with open hernia surgery in adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative/intraoperative</td>
<td>Regional anaesthesia (field block ± wound infiltration) or general anaesthesia in combination with regional anaesthetic techniques</td>
</tr>
<tr>
<td>Postoperative 0–6 h including PACU</td>
<td>In addition to above, conventional NSAIDs or COX-2-selective inhibitors (use weak opioids when conventional NSAIDs/COX-2-selective inhibitors are contraindicated), combined with paracetamol. Add weak opioid when VAS score &gt; 30 but &lt; 50*. Add strong opioid when VAS score ≥ 50*</td>
</tr>
<tr>
<td>Postoperative &gt; 6 h</td>
<td>Wound infusion of long-acting local anaesthetic, when possible. Continue standard medication: conventional NSAIDs or COX-2-selective inhibitors (use weak opioids when conventional NSAIDs/COX-2-selective inhibitors are contraindicated), combined with paracetamol. Add weak opioid when VAS score &gt; 30 but &lt; 50*. Add strong opioid when VAS score ≥ 50*</td>
</tr>
</tbody>
</table>

*Pain ratings on a 1–100-mm visual analogue scale (VAS): score 30 or less, low-intensity pain; over 30 but less than 50, moderate-intensity pain; 50 or more, high-intensity pain. PACU, postanaesthesia care unit; NSAID, non-steroidal anti-inflammatory drug; COX, cyclo-oxygenase.
The length of hospital stay was significantly shorter with PVB compared with GA ($P = 0.001$).

**Discussion**

This systematic review provided the basis for clinically relevant recommendations for pain management in patients undergoing open hernia surgery (Table 4). This approach combined the evidence from single-modality randomized trials for a specific procedure, with evidence from other surgical procedures that produced comparable postoperative pain, as well as current clinical best practice.

One of the main findings of this systematic review was that the use of field blocks (ilioinguinal, iliohypogastric and genitofemoral nerve blocks) with, or without wound infiltration, either as sole anaesthetic/analgesic technique or as an adjunct to GA or SA, provided significant postoperative pain relief (LoE 1). Therefore, RA techniques are recommended for all patients undergoing open hernia surgery (grade A). Furthermore, continuous LA infusion of the surgical wound provided a longer duration of analgesia and should be considered (LoE 1), when possible.

However, no specific recommendation can be made regarding the choice of subfascial LA infiltration in preference to subcutaneous infiltration because of limited data (grade D). In addition, the analgesic efficacy of preoperative LA administration was comparable to that of postoperative administration. Wound instillation with LA and postoperative repeat wound injections did not provide any significant benefit, and thus are not recommended (grade D). Addition of clonidine, dextran, steroids, NSAIDs, opioids or adrenaline to LA solution for wound infiltration is not recommended (grade B) because limited procedure-specific evidence showed little analgesic benefit (LoE 2).

Importantly, RA techniques are recommended because they provide superior pain relief and additional recovery benefits (grade A). If RA is not possible (or not appropriate), GA is preferred over neuraxial anaesthesia (SA or epidural anaesthesia). Although SA provides excellent surgical anaesthesia and early postoperative analgesia, potential limitations (delayed ambulation and urinary retention) could impact on discharge after ambulatory surgery. A recent study showed that shorter-acting LAs such as prilocaine 2 per cent allowed early recovery; however, the incidence of urinary retention remained high, with 23 per cent of patients requiring urinary catheterization.

PVB is not recommended (grade D) because it has only a marginal analgesic benefit over other regional anaesthetic techniques and is a more complex method.

Of note, the choice of anaesthetic technique depends on a number of factors such as patient preference, anaesthetists’ experience with the technique and local circumstances.

Because opioid-related adverse effects may delay recovery, non-opioid analgesics (paracetamol and conventional NSAIDs/COX-2 specific inhibitors) should be used when possible (grade B). Paracetamol is ineffective as a single therapy for treatment of moderate to severe pain (VAS 50 mm or more); therefore, it is best used in combination with conventional NSAIDs or COX-2-selective inhibitors, which may be supplemented with weak opioids for postoperative pain of low to moderate intensity (VAS less than 50 mm) (grade B), and with strong opioids for pain of moderate to high intensity (grade B). These drugs should be administered at the appropriate time (before or during surgery) to provide sufficient analgesia in the early recovery phase, and also continued after operation (transferable evidence, LoE 1). There is not enough evidence at this time to recommend one conventional NSAID or COX-2-selective inhibitor in preference to another. The use of these medications should depend on assessment of individual patient risks (grade B). Parenteral glucocorticoids (dexamethasone 4–8 mg) may be considered (grade B), based on transferable evidence (LoE 1) of analgesic and antiemetic efficacy.

Some of the interventions cannot be recommended as there were insufficient studies, limited or conflicting evidence, heterogeneity of study design, methodological weakness, or an adverse risk to benefit ratio. These include preoperative strong opioids (grade D, LoE 4) because of limited procedure-specific data and associated side-effects (transferable evidence, LoE 1); perioperative clonidine (grade D) owing to limited procedure-specific evidence and potential adverse effects (hypotension, sedation, dizziness and bradycardia), which may delay early ambulation; and NMDA antagonists (ketamine and dextromethorphan) (grade D, LoE 4) because there is no procedure-specific evidence and the risk to benefit ratio is not sufficiently favourable for this ambulatory procedure, despite analgesic efficacy in other procedures (transferable evidence, LoE 1). Magnesium cannot be recommended (grade B) because of limited procedure-specific data showing a lack of analgesic efficacy (LoE 2). The α2δ receptor modulators (gabapentin and pregabalin) cannot be recommended (grade D, LoE 4) because there is no procedure-specific evidence and the risk to benefit ratio is not favourable for this day-surgery procedure, despite analgesic efficacy in other procedures.
One of the major limitations of this review was the significant variation in methodological quality of the randomized trials included. In addition, allocation concealment, an important source of bias, was unclear, and some studies were not double-blind. Furthermore, although postoperative pain was the primary outcome of interest and a criterion for inclusion in the systematic review, it was not always the primary outcome of the included studies, and measurements were often reported at limited time points, using different scales, and without statistical analyses; however, this approach reduced the risk of publication bias.

There are several areas where current data are insufficient or conflicting. The role of transversus abdominis plane (TAP) block, which involves administration of local anaesthetic between the layers of internal oblique and transversus abdominis muscles, needs to be evaluated. Ultrasound-guided TAP block is easy to perform and has a high success rate. There is a need to compare this with traditional field block. In addition, the risk to benefit of continuous LA wound infusion needs to be compared with that of single-shot field block or TAP block combined with multimodal analgesia. There is also a need to evaluate a multimodal analgesia technique including combinations of paracetamol and NSAID/COX-2-selective inhibitor (preferably started before or during surgery), and regional anaesthetic techniques, with oral opioids administered as rescue after surgery. Intrawound capsaicin has been shown to provide excellent analgesia, and requires further evaluation. Furthermore, the role of ketamine and δ ligands, particularly in patients at high risk of persistent postoperative pain, should be evaluated. Finally, there is also a need for preoperative identification of high pain responders and patients at risk of developing persistent postoperative pain.

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