Systematic review and meta-analysis of continuous local anaesthetic wound infiltration *versus* epidural analgesia for postoperative pain following abdominal surgery

N. T. Ventham, M. Hughes, S. O'Neill, N. Johns, R. R. Brady and S. J. Wigmore

Department of Clinical Surgery, Royal Infirmary of Edinburgh, 51 Little France Crescent, Edinburgh EH16 4SA, UK
Correspondence to: Mr N. T. Ventham (e-mail: n.ventham@doctors.org.uk)

Background: **Local anaesthetic wound infiltration techniques reduce opiate requirements and pain scores. Wound catheters have been introduced to increase the duration of action of local anaesthetic by continuous infusion. The aim was to compare these infiltration techniques with the current standard of epidural analgesia.**

Methods: **A meta-analysis of randomized clinical trials (RCTs) evaluating wound infiltration *versus* epidural analgesia in abdominal surgery was performed. The primary outcome was pain score at rest after 24 h on a numerical rating scale. Secondary outcomes were pain scores at rest at 48 h, and on movement at 24 and 48 h, with subgroup analysis according to incision type and administration regimen (continuous *versus* bolus), opiate requirements, nausea and vomiting, urinary retention, catheter-related complications and treatment failure.**

Results: **Nine RCTs with a total of 505 patients were included. No differences in pain scores at rest 24 h after surgery were detected between epidural and wound infiltration. There were no significant differences in pain score at rest after 48 h, or on movement at 24 or 48 h after surgery. Epidural analgesia demonstrated a non-significant a trend towards reduced pain scores on movement and reduced opiate requirements. There was a reduced incidence of urinary retention in the wound catheter group.**

Conclusion: **Within a heterogeneous group of RCTs, use of local anaesthetic wound infiltration was associated with pain scores comparable to those obtained with epidural analgesia. Further procedure-specific RCTs including broader measures of recovery are recommended to compare the overall efficacy of epidural and wound infiltration analgesic techniques.**

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Introduction

Epidural analgesia is frequently used to relieve pain after major abdominal surgery[1]. The benefits of epidural analgesia over opioid-based analgesia include a reduction in postoperative nausea and vomiting and gastrointestinal paralysis[2]. Epidural analgesia may also reduce cardiorespiratory morbidity and mortality in high-risk groups, although the number needed to treat is high[3–7]. However, epidural analgesia is also associated with a failure rate of approximately one in four and potentially serious, albeit rare, complications such as epidural haematoma, which has an incidence of between one in 1368 and one in 3600[8–11]. In contrast, local anaesthetic infiltration techniques may reduce the risk of severe complications, and the side-effect burden of opioid-based analgesia[12]. As such, a direct comparison of local anaesthetic wound infiltration *versus* epidural analgesia is warranted[13–15].

Wound infiltration with local anaesthetic is becoming increasingly popular as part of a multimodal regimen of analgesia following abdominal surgery[16]. Meta-analyses examining the outcomes of transversus abdominis plane blocks have reported their efficacy in reducing post-operative opiate requirements, nausea and vomiting, and pain scores[17–19]. Innovative variations of such techniques, including ultrasound-guided and surgeon-administered transversus abdominis plane blocks at the time of abdominal closure, have also been reported[20–22]. The main limitation of such blocks remains the duration of action, even of long-acting local anaesthetics; this restricts their analgesic efficacy to around 24 h.

In an attempt to prolong the duration of action, indwelling catheters that allow a continuous infusion of local anaesthetic agents using elastomeric pumps have been developed. An early meta-analysis demonstrated that use of wound catheters was associated with reduced morphine requirements, improved pain scores and satisfaction, and earlier discharge[23]. However, the results of a more recent meta-analysis demonstrated only a modest effect in a subgroup undergoing gynaecological or obstetric surgery[24].

To date, there has been no meta-analysis comparing epidural with continuous local anaesthetic wound infiltration techniques. The primary aim of this study was to compare these two methods with regard to postoperative pain assessed by means of a numerical rating scale. Secondary aims were to compare opiate requirements, nausea and vomiting, urinary retention, local catheter-related complications and treatment failure.

Methods

A literature search was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations[25]. The trial protocol was registered prospectively with PROSPERO, the international prospective register of systematic reviews (trial no. CRD42012002983; http://www.crd.york.ac.uk/PROSPERO). Two authors independently performed an electronic search of Ovid, MEDLINE/PubMed, Embase and the Cochrane Library on 1 Feburary 2013. To minimize publication bias, trials registered at http://www.clinicaltrials.gov were also searched. The search was limited to humans, but no language or time restrictions were applied. The electronic search was supplemented with a manual search of bibliographies from included papers.

Search terms were: 'local analgesia' OR medical subject heading (MeSH) terms (local anesthesia or local anesthetics or lignocaine or bupivacaine) AND MeSH term 'postoperative pain' AND MeSH term 'epidural analgesia' OR keyword 'continuous' OR keyword 'wound infiltration' OR keyword 'infiltration' OR keyword 'infusion' OR MeSH term 'catheter' OR keyword 'elastomeric' OR keyword 'On Q' AND keyword 'abdominal surgery' (OR MeSH term 'caesarean' OR MeSH term 'gynaecological surgical procedure' OR keyword 'gynaecological surgery' OR MeSH term 'urological surgical procedure', 'prostatectomy' OR keyword 'urological surgery').

Study selection

Selected abstracts were scrutinized independently by two reviewers. Trial inclusion criteria were: randomized clinical trial (RCT), adult patients, humans and abdominal surgery (gastrointestinal, gynaecological including caesarean, urological). Exclusion criteria were: non-randomized study, children aged less than 16 years, non-intra-abdominal operation (such as abdominoplasty), pharmacodynamic or kinetic studies, and irrelevant techniques. The intervention was defined as continuous or patient-controlled wound infusion of local anaesthetic using a wound catheter. Excluded interventions included intra-abdominal wound catheter and rectus sheath block. The comparator group comprised continuous or patient-controlled epidural analgesia with local anaesthetic, and/or opiates. Excluded comparators were pre-emptive anaesthesia, intrathecal analgesia and paraspinal blocks.

Data extraction

Two authors independently extracted data using a pro forma (*Table S1*, supporting information). At the same time the papers were assessed independently for bias using the Cochrane bias assessment tool[26], and a combined score encompassing criteria from Jadad and colleagues[27] and Chalmers *et al*.[28]. Data were extracted for synthesis either directly from the paper, extrapolated from graphs using Plot digitizer® (http://www.plotdigitizer.sourceforge.net) or, if this was not possible, the corresponding authors were contacted for the required data (*Table S2*, supporting information).

Endpoints

Primary endpoint

The primary endpoint was comparison of pain scored on a numerical rating scale (0, no pain; 10, severe pain) at rest 24 h after operation between wound infiltration and epidural analgesia groups. All scores were converted to a continuous scale from 0 to 10; any scores originally measured on a visual analogue pain scale from 0 to 100 mm were converted to a scale from 0 to 10 for this review. Data reported as medians were converted to mean(s.d.) log normal distribution[29].

Secondary endpoints

Further comparisons of pain scores between wound infiltration and epidural analgesia groups were undertaken, at rest 48 h after surgery, and at 24 and 48 h on movement (such as coughing). Subgroup analysis was performed according to incision type: subcostal, lower abdominal, and midline and transverse. Further subgroup analysis was undertaken to compare the effects of different wound infiltration and epidural protocols (continuous *versus* nurse- or patient-administered bolus).

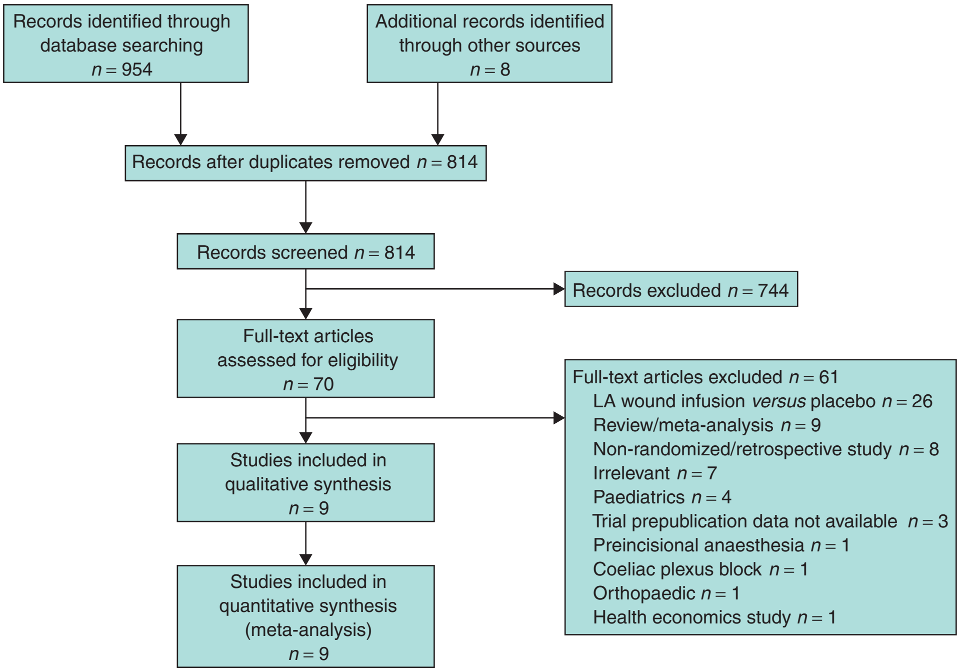

Fig. 1 Flow chart showing selection of articles for review. LA, local anaesthetic

Postoperative morphine requirement was compared between groups. Other forms of opiate analgesia were converted to intravenous morphine equivalents as follows: oral tramadol (1 : 20) parenteral fentanyl (10 : 1) and intravenous oxycodone (1 : 1)[30–32].

Presence or absence of nausea and vomiting, urinary retention, wound infection and local catheter complications (infection, dislodged catheter, local pain/discomfort) were documented, each classified as a dichotomous variable (where multiple values given, taken at 24 h). Treatment failure was described as abandonment of either wound infiltration or epidural for use of another analgesic modality (for example morphine patient-controlled analgesia).

Statistical analysis

Data extracted or obtained from authors were included in meta-analysis performed using Review Manager (RevMan version 5.1.7; The Cochrane Collaboration, Copenhagen, Denmark). Dichotomous variables were evaluated using a pooled odds ratio (OR) and continuous variables were analysed using a weighted mean difference (WMD), allowing weighting according to different sample sizes. A random-effects derSimonian and Laird model was chosen to provide the most conservative estimate of effects. Results are presented with 95 per cent confidence intervals (c.i.). Heterogeneity was assessed by means of t^2, χ^2 and I^2. Heterogeneity was considered significant when $P < 0{\cdot}050$ or I^2 exceeded 50 per cent.

Results

The outcome of the literature search is detailed in *Fig. 1*. Nine studies met the inclusion criteria and are summarized in *Table 1*[33–41]. All papers were assessed for risk of bias (*Table 2*).

Primary outcome

Eight studies with a total of 463 patients (232 wound infiltration, 231 epidural) reported pain at rest 24 h after operation[33–36,38–41]. There was significant heterogeneity between included studies ($I^2 = 77$ per cent, $P < 0{\cdot}001$). Using a random-effects model, there was no significant difference in pain scores between wound infiltration and epidural (WMD 0·03, 95 per cent c.i. −0·61 to 0·66; $P = 0{\cdot}94$) (*Fig. 2*). Subgroup analysis demonstrated that pain scores were not significantly different between epidural and wound infiltration according to incision type (subcostal: 3 studies, 181 patients; lower abdominal: 2 studies, 108 patients; midline/transverse: 2 studies, 144 patients) or protocol of administration (continuous *versus* bolus).

Secondary outcomes

Pain score at rest 48 h after surgery

Seven studies with a total of 425 patients (wound infiltration 213, epidural 212) reported pain at rest at 48 h[33–36,38,39,41].

Table 1 Characteristics of included studies

Reference	Operation	Incision	Analgesia type	*n* per group*	Age (years)	Intervention protocol	Drugs administered	ERP	Additional drugs
Subcostal incision									
Renghi *et al.*[33]	Aortic aneurysm repair	Left subcostal	WI	30 (7)	69	Surgeon placed double multiperforated catheter in subfascial and subcutaneous positions	Continuous 0·25% levobupivacaine at 4 ml/h, adjustable between 2 and 8 ml/h	Yes	Ibuprofen 600 mg every 8 h; rescue medication ketorolac 30 mg
			Epi	29 (10)	72	T6/7 epidural	Continuous 0·25% levobupivacaine at 4 ml/h, adjustable between 2 and 8 ml/h		
Revie *et al.*[34]	Liver resection	Right subcostal	WI	33 (48)	60	Surgeon inserted two 12·5-cm multihole catheters between transversus abdominis and internal oblique	20-ml 0·25% levobupivacaine bolus; continuous infusion of 0·375% levobupivacaine at 4 ml/h	Yes	Paracetamol 1 g every 6 h, ibuprofen 400 mg every 8 h, oxycodone 10 mg as required up to every hour; i.v. morphine as rescue medication
			Epi	31 (39)	60	T7/8 epidural	Continuous 0·1% bupivacaine and 2 µg/ml fentanyl at 7–10 ml/h		
Niraj *et al.*[35]	Upper abdominal surgery	Extended right subhepatic and rooftop	WI	27 (34)	64	Postop. insertion under ultrasound guidance; bilateral epidural catheter inserted 6–7 cm into transversus abdominis plane	Intermittent bolus 0·375% bupivacaine 1 mg/kg every 8 h	No	Paracetamol 1 g every 6 h and i.v. tramadol 50–100 mg every 6 h; i.v. morphine PCA as rescue medication
			Epi	31 (36)	64	T7–9 epidural	20-ml 0·25% bupivacaine bolus; background infusion 0·125% bupivacaine and 2 µg/ml fentanyl at 6 ml/h increasing up to 12 ml/h, with patient-controlled boluses of 2 ml		
Lower abdominal incision									
Fant *et al.*[36]	Radical retropubic prostatectomy	Lower abdominal midline	WI	25 (0)	64	Retroperitoneal surgical placement of one multiholed catheter brought out 2–3 cm lateral from wound edge	Patient-administered 10-ml 2 mg/ml ropivacaine bolus, maximum one dose per h	No	Paracetamol 1 g every 6 h; i.v. morphine as rescue medication
			Epi	25 (0)	63	T9–12 epidural	Continuous 1 mg/ml ropivacaine, 2 µg/ml fentanyl, 2 µg/ml adrenaline (epinephrine) at 10 ml/h		
Ranta *et al.*[37]	Caesarean	Pfannenstiel	WI	20 (100)	29	Surgeon inserted multihole 22-G catheter along length of wound in subfascial plane, tunnelled 5 cm from wound	100-ml 0·25% bupivacaine, then 10-ml boluses 0·25% levobupivacaine, administered by nurse	No	Paracetamol 1 g every 6 h; oxycodone 0·05 mg/kg i.v. as rescue analgesia
			Epi	20 (100)	28	L1/2 epidural	10-ml bolus 0·125% levobupivacaine administered by nurse		
O'Neill *et al.*[38]	Caesarean	Pfannenstiel	WI	29 (100)	33	One surgically placed 15-cm perforated catheter in subfascial/preperitoneal plane, brought out 2 cm lateral to wound	10 mg/ml ropivacaine bolus, then continuous 2 mg/ml at 5 ml/h	No	Paracetamol 1 g every 6 h, diclofenac 75 mg i.m. every 8 h
			Epi	29 (100)	33	Not detailed	2 mg per 10 ml epidural morphine bolus every 12 h		
Midline incision									
Bertoglio *et al.*[39]	Colorectal resection	Midline (91%) Paramedian (6%) Transverse (3%)	WI	53 (47)	66	Surgeon placed one 19-G multihole catheter preperitoneally, 3–5 cm from lower edge of surgical wound	Continuous 0·2% ropivacaine 10 ml/h	No	Morphine 1-mg bolus i.v. PCA, 10 min lockout; ketorolac i.v. 30 mg every 8 h, paracetamol 1 g every 6 h
			Epi	53 (49)	65	T8–L1 epidural	Continuous 0·2% ropivacaine 10 ml/h		

Table 1 Continued

Reference	Operation	Incision	Analgesia type	*n* per group*	Age (years)	Intervention protocol	Drugs administered	ERP	Additional drugs
de Almeida *et al*.[40]	Elective abdominal surgery	Midline or transverse	WI	20 (58)	50	Surgeon inserted two multihole catheters above rectus aponeurosis, brought out 4 cm from end of incision	10-ml 0·2% ropivacaine bolus; continuous infusion of 0·2% ropivacaine at 5 ml/h; patient-administered bolus of 2 ml at 15-min intervals	No	Paracetamol 1 g every 6 h, regular NSAIDs, i.v. morphine and oral tramadol
			Epi	19 (47)	56	Thoracolumbar epidural	Continuous 40-ml 0·75% ropivacaine, 250 µg fentanyl, 33 ml 0·9% saline at 2 ml/h; patient-administered bolus of 2 ml at 15-min intervals		
Laparoscopic									
Boulind *et al*.[41]	Elective laparoscopic colorectal resection	Laparoscopic	WI	17 (32)	68	Surgeon inserted one ON-Q® wound catheter into preperitoneal space	Continuous 0·125 mg/ml levobupivacaine at 2 ml/h	Yes	Paracetamol 1 g every 6 h, 400 mg ibuprofen every 8 h; i.v. morphine as rescue analgesia
			Epi	14 (43)	74	T9/10 or T10/11	Continuous 0·125 mg/ml levobupivacaine and 100 µl per 50 ml fentanyl at 4 ml/h		

*Values in parentheses are percentage of women. ERP, enhanced recovery protocol; WI, wound infiltration; Epi, epidural; i.v., intravenous; PCA, patient-controlled analgesia; i.m., intramuscular; NSAID, non-steroidal anti-inflammatory drug. ON-Q® (Braun, Melsungun, Germany).

Table 2 Quality assessment of included trials

	Risk of bias							
	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias	Modified quality score
Renghi *et al*.[33]	+	+	?	−	+	+	+	12
Revie *et al*.[34]	+	+	−	−	+	+	−	11
Niraj *et al*.[35]	+	?	−	−	+	+	+	11
Fant *et al*.[36]	+	+	+	+	+	+	+	13
Ranta *et al*.[37]	+	+	+	+	−	+	+	12
O'Neill *et al*.[38]	+	+	−	−	−	+	+	12
Bertoglio *et al*.[39]	+	+	−	−	+	+	+	12
de Almeida *et al*.[40]	?	?	−	−	+	+	−	6
Boulind *et al*.[41]	+	+	+	+	+	−	+	13

+, Low risk of bias; −, high risk of bias; ?, unclear risk of bias.

There was significant heterogeneity between studies ($I^2 = 64$ per cent, $P = 0{\cdot}01$). There was no significant difference in pain scores between epidural and wound infiltration (WMD −0·31, −0·79 to 0·16; $P = 0{\cdot}19$). Subgroup analysis showed no difference in pain scores when results were stratified according to incision type or treatment protocol (continuous *versus* bolus).

Pain scores on movement

Pain scores on movement at 24 h after surgery were recorded in seven studies with a total of 433 patients (216 wound infiltration, 217 epidural)[33–36,38–40]. There was significant heterogeneity between studies ($I^2 = 92$ per cent, $P < 0{\cdot}001$). Using a random-effects model, there were no significant differences between groups (WMD 1.08, −0·31 to 2·48; $P = 0{\cdot}13$). Pain scores on movement at 48 h were recorded in six studies with a total of 395 patients (wound infiltration 197, epidural 198)[33–36,38,39]. There was significant heterogeneity between studies ($I^2 = 89$ per cent; $P < 0{\cdot}001$). Again, there were no significant differences in pain scores between epidural and wound infiltration (WMD 0·57, −0·53 to 1·68; $P = 0{\cdot}31$). When grouped according to incision, no difference in pain scores between wound infiltration and epidural was found. Subgroup analysis demonstrated a non-significant trend towards improved pain scores in the epidural group when a continuous epidural protocol was used at 24 and 48 h.

Reference	Wound infiltration Score*	Wound infiltration Total	Epidural Score*	Epidural Total	Weight (%)	Mean difference
Bertoglio *et al.*[39]	2·1(1·1)	53	2·4(1·3)	53	15·8	−0·30 (−0·76, 0·16)
Boulind *et al.*[41]	2·6(2·2)	16	2·1(2)	14	8·8	0·20 (−1·30, 1·70)
de Almeida *et al.*[40]	3(3)	19	5(1)	19	9·3	−2·00 (−3·42, −0·58)
Fant *et al.*[36]	2·5(1·7)	25	1·3(1·5)	25	12·9	1·20 (0·31, 2·09)
Niraj *et al.*[35]	1·4(1·5)	27	1·6(1·6)	31	13·6	−0·20 (−1·00, 0·60)
O'Neill *et al.*[38]	1·8(2)	29	2·7(1·4)	29	12·9	−0·90 (−1·79, −0·01)
Renghi *et al.*[33]	1·5(1·7)	30	1(1·7)	29	13·1	0·50 (−0·37, 1·37)
Revie *et al.*[34]	2·4(1·7)	33	1·2(1·5)	31	13·7	1·20 (0·42, 1·98)
Total		232		231	100·0	0·03 (−0·61, 0·66)

Heterogeneity: $\tau^2 = 0{\cdot}61$; $\chi^2 = 30{\cdot}73$, 7 d.f., $P < 0{\cdot}001$; $I^2 = 77\%$
Test for overall effect: $Z = 0{\cdot}08$, $P = 0{\cdot}94$

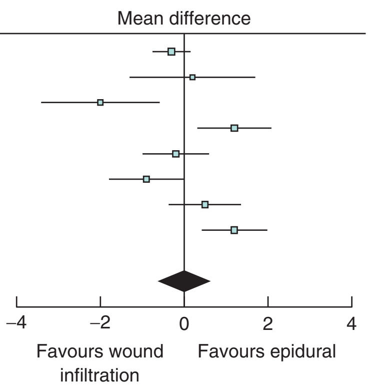

Fig. 2 Forest plot showing pain scores at rest 24 h after surgery on a numerical rating scale from 0 to 10 in wound infiltration and epidural groups. An inverse variance random-effects model was used for meta-analysis. *Values are mean(s.d.). Mean differences are shown with 95 per cent confidence intervals

Reference	Wound infiltration Total (mg)*	Wound infiltration Total	Epidural Total (mg)*	Epidural Total	Weight (%)	Mean difference (mg)
Bertoglio *et al.*[39]	14·3(10·7)	53	17·2(13)	53	25·5	−2·90 (−7·43, 1·63)
Fant *et al.*[36]	19(17·4)	25	4·6(7·8)	25	23·7	14·40 (6·93, 21·87)
Niraj *et al.*[35]	25·2(16·7)	27	15·2(11·1)	31	23·8	10·00 (2·59, 17·41)
Ranta *et al.*[37]	37(23)	20	37(27)	20	17·5	0·00 (−15·54, 15·54)
Revie *et al.*[34]	73·3(70·5)	33	20·9(45·0)	31	9·5	52·40 (23·61, 81·19)
Total		158		160	100·0	10·04 (−1·03, 21·12)

Heterogeneity: $\tau^2 = 119{\cdot}86$; $\chi^2 = 29{\cdot}96$, 4 d.f., $P < 0{\cdot}001$; $I^2 = 87\%$
Test for overall effect: $Z = 1{\cdot}78$, $P = 0{\cdot}08$

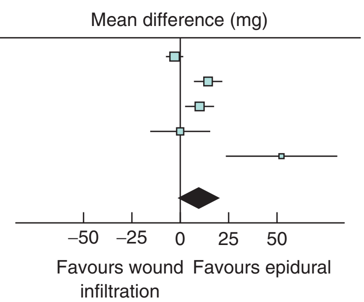

Fig. 3 Forest plot showing total cumulative opiate use in wound infiltration and epidural groups. An inverse variance random-effects model was used for meta-analysis. *Values are mean(s.d.). Mean differences are shown with 95 per cent confidence intervals

Morphine use

Opiate use was recorded in five studies with a total of 318 patients (wound infiltration 158, epidural 160)[34–37,39]. Three studies recorded morphine use[34,36,39]; the other two trials used different opiates: intravenous oxycodone[37] and oral tramadol[35] (converted to morphine equivalents). There was significant heterogeneity between studies ($I^2 = 87$ per cent, $P < 0{\cdot}001$). There was a non-significant trend towards lower opiate consumption in the epidural group: WMD 10·04 (95 per cent c.i. −1.03 to 21·12) mg ($P = 0{\cdot}08$) (*Fig. 3*).

Nausea and vomiting

Postoperative nausea and vomiting was recorded in eight studies with 473 patients (wound infiltration 236, epidural 237)[33–40]. There was no significant heterogeneity among the trials ($I^2 = 43$ per cent; $P = 0{\cdot}09$). The incidence of postoperative nausea and vomiting was similar for epidural and wound infiltration (OR 0·72, 95 per cent c.i. 0·37 to 1·40; $P = 0{\cdot}33$).

Urinary retention

Urinary retention was recorded in three studies with a total of 160 patients (81 wound infiltration, 79 epidural)[34,38,40]. In these three studies, urinary retention was defined by the requirement for insertion or reinsertion of a urinary catheter more than 24 h after surgery. There was significant heterogeneity among included studies ($I^2 = 53$ per cent, $P = 0{\cdot}12$). The incidence of urinary retention was significantly lower in the wound infiltration group (OR 0·14, 0·04 to 0·47; $P = 0{\cdot}002$).

Local catheter complications and abdominal wound infections

Seven of the nine studies commented explicitly on local catheter-related complications (396 patients; 199 wound infiltration, 197 epidural)[34,35,37–41]. There was no significant heterogeneity between studies ($I^2 = 0$ per cent, $P = 0{\cdot}85$). Five catheter-related complications were described in each group (wound catheter group: dislodged 2, kinked 1, pain at catheter site that resolved on removal of catheter 1, tubing accidentally cut 1; epidural group:

dislodged 4, pain at catheter site that resolved on catheter removal 1) (OR 0·98, 0·29 to 3·27; $P = 0{\cdot}97$). There were three wound infections in the wound infiltration and five in the epidural group (OR 0·61, 0·15 to 2·47; $P = 0{\cdot}49$).

Treatment failure

Six trials with a total of 275 patients (137 wound infiltration, 138 epidural) recorded treatment failure, defined as stopping the intervention (epidural/wound infiltration) to commence an alternative type of analgesia (such as morphine patient-controlled analgesia)[33,35–37,40,41]. There was no significant heterogeneity between studies ($I^2 = 0$ per cent, $P = 0{\cdot}79$). Use of an epidural was associated with fewer treatment failures (15 *versus* 18 in wound catheter group), but this failed to reach statistical significance (OR 1·34, 0·63 to 2·83; $P = 0{\cdot}45$).

Discussion

This meta-analysis demonstrates that local anaesthetic infiltration via wound catheters is not inferior to epidural with regard to pain scores in abdominal surgery. Epidural analgesia was associated with non-significant trends towards reduced opiate requirements, and lower pain scores on movement when administered in continuously. Epidural analgesia was associated with a higher incidence of urinary retention. Low rates of local catheter-related complications were seen in both groups.

Local analgesic techniques have been shown to reduce morphine requirements in the immediate postoperative period. However, intraoperative 'single-shot' local anaesthetic administration is unlikely to provide long-term analgesia[24]. The specific aim of this study was to evaluate the analgesic efficacy of wound infiltration techniques 24 h after surgery. Group analysis demonstrated local anaesthetic administered via a wound catheter to be equivalent to epidural in terms of pain scores at rest 24 and 48 h after surgery. Opiate requirements, a surrogate marker of pain, and pain scores on movement were lower in the epidural group, but the results failed to reach statistical significance. The findings suggest that epidural analgesia may provide better dynamic pain control.

Continuous administration of local anaesthetic to the site of surgical insult may have benefits additional to the analgesic action. There is some evidence that local anaesthetic may attenuate the local inflammatory stress response[42,43]. The sustained exposure of the operative site to local anaesthetic is theoretically attractive and warrants further investigation.

Within this developing field, there is no consensus regarding the optimal position of the wound catheter. Wound catheters have been placed in the subfascial[44,45], preperitoneal[46,47], transversus abdominis plane[48], rectus sheath, suprafascial/subcutaneous[49] and intra-abdominal positions. Some evidence suggests that subfascial placement is more effective than the suprafascial or subcutaneous position[44,50]. All but one of the trials[40] in the present meta-analysis used a subfascial or transversus abdominis plane position. Subgroup analysis excluding the single trial using a suprafascial position yielded no significant difference in pain scores between epidural and wound infiltration (data not shown).

Previous studies have shown local anaesthetic wound infiltration to reduce opiate requirements[24] and nausea and vomiting[17] compared with placebo. This meta-analysis found no difference in the incidence of nausea and vomiting between the two groups. There was a higher incidence of urinary retention in the epidural group in the three studies that reported this outcome[34,38,40]. There is evidence suggesting that epidural analgesia, especially with opiates, predisposes to urinary retention[51–53].

Concerns regarding wound catheter use include technical failure, wound infection and the catheter becoming dislodged. Existing meta-analyses have demonstrated that wound breakdown is less likely in those having local anaesthetic wound infiltration[24]. In the present study there was a low incidence of local complications, with five catheter-related problems in each group. All complications involved the epidural or wound catheter becoming dislodged, or local pain necessitating removal of the catheter. Three cases of abdominal wound infection were reported in the wound catheter group and five in the epidural group. Insufficient data were reported on systemic adverse outcomes (such as venous thromboembolism, pulmonary complications, hypotension requiring vasopressors) to provide a meaningful basis for comparison.

All analyses of continuous data demonstrated significant statistical heterogeneity (I^2 over 50 per cent). This may be related to the different types of surgery included, the variation in treatment regimens and the use of different types of anaesthetic/analgesia. There have been calls, specifically regarding wound catheters, to rationalize meta-analysis, including use of subgroup analysis to ensure meaningful comparison between similar interventions, rather than the pooling of as many patients as possible[54,55]. An attempt was made to pool the studies according to incision type, with the aim of providing more generalizable conclusions. Subgroup analysis according to incision type (subcostal, lower abdominal, midline/transverse) yielded no difference in pain scores between epidural and wound infiltration. The different treatment regimens (continuous *versus* bolus) were also analysed separately, to determine whether one protocol was favourable. Continuous epidural infusion was associated with lower pain scores than wound infiltration on movement at 24 and 48 h, but the results were not statistically significant. However, the number of patients included in this subgroup analysis, and consequently the discriminatory power of these calculations, was reduced.

The inclusion of various types of abdominal surgery has been noted to undermine previous meta-analyses in the field[23,24]. The present analysis includes procedures ranging from liver resection to prostatectomy and caesarean section. Although much of the postoperative pain is derived from the abdominal wall incision, the extent of intraperitoneal dissection varies between these surgical procedures[56,57].

The studies included in this meta-analysis used different types of opiate analgesia (for example morphine, oxycodone and tramadol). Opiate requirements were included as an objective variable for analysis, and opiate doses were converted to morphine-equivalent doses. Although opioid conversion has been used previously in similar meta-analyses[58], the conversion of opioids is an area with much reported variation[59]. In addition to randomized interventions, the trials also used supplementary analgesics such as paracetamol and non-steroidal anti-inflammatory drugs (*Table 1*). Although use of these analgesics was standardized in both groups within each trial, it adds an extra layer of complexity when comparing different trials. There was also a lack of standardization in postoperative care pathways, which contributed to the heterogeneity of the analysis. Three studies were specifically conducted within a predefined enhanced recovery programme[33,34,41].

In an attempt to reduce publication bias, the search included trials registered with ClinicalTrials.gov. Three unpublished studies met the inclusion criteria but could not be included (the authors were contacted, but the studies were either incomplete, results were not available, or there was no author response).

This study showed equipoise in pain scores and opiate requirements between epidural and local anaesthetic wound infiltration. However, it is not possible to extrapolate this to suggest equivalence in terms of overall clinical recovery. Future comparisons should take place within standardized enhanced recovery pathways with a focus on specific markers of recovery (mobility, resumption of diet, bowel function, length of hospital stay and systemic complications). Furthermore, homogeneous RCTs comparing wound catheters and epidurals on a procedure-specific basis are required[56]. The procedure-specific postoperative pain management (PROSPECT) group is working towards these aims by providing recommendations in the context of specific operations[60]. The hope is that future research will reveal the most efficacious analgesic modalities for each defined surgical procedure.

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