

# Wound infiltration with local anaesthetics in ambulatory surgery

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## Purpose of review

Wound infiltration analgesia using local anaesthetics has been used for several decades. Recently, newer techniques to prolong analgesia have developed, including the use of catheters and injection of local anaesthetics or other adjuvants, and local infiltration analgesia using large volumes of local anaesthetics injected into different tissue planes. The aim of this review is to present the current status of wound infiltration analgesia in management of postoperative pain and to highlight the risks of this technique in clinical practice.

## Recent findings

Several studies have shown beneficial effects of local anaesthetics, with or without adjuvant drugs, in the management of postoperative pain. Specifically, the use of local anaesthetics injected via catheters to prolong analgesia reduces postoperative pain, albeit to a limited extent. The use of large volumes of local anaesthetics into tissue planes during surgery is also beneficial in pain management. Single doses of local anaesthetics provide pain relief, but the short duration of effect can be a limiting factor. There is a growing concern about some side-effects associated with the use of local anaesthetics, specifically toxicity when drugs are injected in large doses, chondrotoxicity when bupivacaine is injected intra-articularly in higher concentrations and over a period and finally, infection when using catheters that are retained *in situ*.

## Summary

Used correctly and in adequate doses, wound infiltration analgesia can be used in a multimodal analgesic regime without major complications. It offers the benefit of providing analgesia at a low cost when used as a single injection.

## Keywords

ambulatory surgery, local anaesthetics, postoperative pain

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## Introduction

Wound infiltration with local anaesthetics is a simple, effective and inexpensive means of providing good analgesia for a variety of surgical procedures without any major side-effects. Particularly, local anaesthetic toxicity, wound infection and healing do not appear to be major problems. Although wound infiltration of local anaesthetics has been used for several decades, a single injection of local anaesthetics into the wound is unlikely to have long-lasting effects. Therefore, new techniques for wound infiltration have evolved during the last 10 years and several of them are today used routinely during ambulatory surgery and even in the inpatient setting. One such technique is the use of catheters inserted into incision, fascia, intra-articularly and intraabdominally for the intermittent injection or continuous infusion of local anaesthetics and adjuvants for pain management. Another technique is called local infiltration analgesia (LIA), which involves the administration of large

volumes of local anaesthetics with or without adjuvants into different tissue planes perioperatively.

Although there has been an explosion in publications on the use of wound catheters, the results appear to be equivocal. Many studies have inserted catheters perineurally, which is not relevant to the discussions in this review. Those that have specifically studied patients with wound catheters or infiltration of local anaesthetics and adjuvants have been mostly performed in the inpatient setting. Well designed, large, randomized studies comparing intermittent injections or infusions of local anaesthetics with placebo or standard of care would improve our understanding of the efficacy of this method in the management of postoperative pain and help in the future design of studies. Specifically, the question as to the site of catheter placement, the drugs and concentrations recommended, the technique of administration and side-effects of the technique, including toxicity of local anaesthetics has not been clearly defined. Finally, it

remains unclear as to whether this technique is useful in all types of surgery or should preferably be used for specific operations.

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### Efficacy of local anaesthetics

In order that local anaesthetics can be used for wound infiltration, it is important that efficacy is demonstrated. Ideally, efficacy should be procedure-specific, as some procedures appear to be more amenable to the analgesic effects of local anaesthetics than others. A number of systematic reviews have been published on the efficacy of local anaesthetics used for infiltration, some are procedure-specific, whereas others have included a mixed population of patients undergoing both ambulatory and inpatient surgery. The important reviews are summarised below.

#### Systematic reviews

In one meta-analysis of the literature including seven studies, the authors concluded that bupivacaine infiltration appears to be a well tolerated and effective method for relief of postadenotonsillectomy pain in children and reduces rescue analgesic requirement [1]. In another systematic review of the literature, Møiniche *et al.* [2] found some evidence for a reduction of postoperative pain after intra-articular local anaesthetics in patients undergoing arthroscopic knee surgery. Intraperitoneal local anaesthetics and mesosalpinx block also have some positive impact on postoperative pain after laparoscopy [3] and Boddy *et al.* [4] concluded that the use of intraperitoneal local anaesthetics is well tolerated, and results in a reduction in early postoperative abdominal pain. In another systematic review of the literature on the efficacy of continuous wound catheters delivering local anaesthetics for postoperative analgesia and including all published studies in adults, the authors concluded that this method resulted in improved analgesia, reduced opioid use and side-effects, increased patient satisfaction and perhaps even reduced hospital stay [5]. However, there was a marked heterogeneity between the studies. In summary, systematic reviews and meta-analysis have shown that local anaesthetics is efficacious when injected intra-articularly, intraperitoneally, perianally and following adenotonsillectomy for the management of postoperative pain. In addition, side-effects and complications are few or absent. However, the analgesia is mild-moderate and most outcome variables do not show any differences between local anaesthetics and placebo.

#### Procedure-specific efficacy

Local anaesthetics infiltration in wounds is useful in providing postoperative pain relief following some but not all surgeries. In one study, the authors found that postoperative subfascial infusion of the wound with 0.5% bupivacaine achieved superior analgesia compared with

oral analgesics alone following inguinal herniorrhaphy [6]. In another study, Schurr *et al.* [7] found that continuous infusion of local anaesthetics after inguinal herniorrhaphy reduces pain scores and functional outcomes when compared with placebo. However, these effects are limited to the first postoperative day. In a study of 222 patients undergoing anorectal surgery, the authors found that perianal anaesthetic infiltration allows the surgeons to perform day-case surgery safely and effectively with a low incidence of urinary retention [8]. In contrast, Fong *et al.* [9] found that wound infiltration with local anaesthetics did not significantly reduce pain or opioid requirement after gynaecological laparoscopy. Following breast reconstruction surgery, levobupivacaine injected locally every third hour as a supplement to paracetamol orally and morphine given by patient-controlled analgesia (PCA) resulted in improved pain relief at rest and during mobilization compared with placebo [10]. Axelsson *et al.* [11] found that preoperative intrabursal prilocaine with epinephrine and postoperative subacromial administration of ropivacaine by patient-controlled regional analgesia technique using local anaesthetics provided the best analgesia with no major side-effects.

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### Site of catheter placement

Wound catheters have been placed in different sites following ambulatory and inpatient surgery. Not only have catheters been placed intra-abdominally, but even subfascially, subcutaneously, intra-articularly, intrapleurally, substernally and perineurally. Unfortunately, there is no universal agreement where wound catheters should be placed in order to achieve best pain relief. Very few studies have compared different sites for catheter placement. In one study in patients undergoing knee arthroplasty, the authors concluded that local anaesthetics injected intracapsular have similar analgesic efficacy to intra-articular local anaesthetics [12]. In another study in patients undergoing abdominal hysterectomy, it was found that bupivacaine wound infusion above the fascia provides better postoperative analgesia compared with infusion below the fascia in the first 12 h [13].

#### Intra-articular analgesia

There are several reviews in the literature examining the effects of local anaesthetics [2] and other drugs injected intra-articularly for pain relief [14]. In general, minor diagnostic and minimally invasive knee arthroscopic procedures can be performed using local anaesthetics alone. However, postoperative pain relief is of short duration when using local anaesthetics [2]. Therefore, catheters have been inserted intra-articularly in order to prolong analgesia through intermittent injection or continuous infusion of local anaesthetics or adjuvants. Rasmussen *et al.* [15] used a continuous infusion of a combination of ropivacaine and morphine following total knee

replacement in a nonrandomized, nonblinded study and found that it reduced pain and enhanced rehabilitation after total knee replacement. In another study, we found that addition of morphine and ketorolac to ropivacaine intra-articularly enhances analgesic efficacy of local anaesthetics, reduces postdischarge analgesic consumption and improve activities of daily living without increasing side-effects in patients undergoing arthroscopy [16]. A continuous infusion of morphine and bupivacaine has also been used for pain relief after subacromial arthroscopy and found to be efficacious compared with isotonic saline infusion [17].

### **Intraperitoneal analgesia**

Single-dose local anaesthetics at the end of surgery have been used for postoperative analgesia, but the effect is often short lasting. Thus, catheters have recently been used intraperitoneally or preperitoneally and local anaesthetics injected through the catheter. In general, the method seems to be efficacious in reducing supplemental analgesic requirements. Most studies have, however, been done in inpatients [18] and experience with this technique in the ambulatory setting is very limited [19]. In one study, the authors injected 0.2% ropivacaine intraperitoneally following laparoscopic cholecystectomy and found lower pain scores in the early postoperative period compared with saline [19]. However, pain was mild in intensity and, therefore, the technique has not been routinely used in this setting. More studies in ambulatory surgical patients experiencing moderate-severe postoperative pain are needed in the literature before this technique can be recommended routinely.

### **Local infiltration analgesia**

Several surgical procedures, previously considered to be inpatients, are now moving out into the ambulatory surgery setting. Among others, unilateral knee arthroplasty and even total knee arthroplasty, procedures usually associated with moderate-to-severe pain, are increasingly being performed as 24h surgery. In an attempt to improve pain relief following these procedures, a LIA technique was recently developed [20]. A long-acting local anaesthetics (ropivacaine), a NSAID (ketorolac) and epinephrine are infiltrated periarticularly intraoperatively and via an intra-articular catheter postoperatively in order to provide good postoperative pain relief. Several studies have now been published supporting the benefits of LIA technique in knee arthroplasties [21,22]. Despite the great variability in drug combinations using the LIA technique, most studies have found effective postoperative analgesia. A recent double-blind controlled study on unicompartamental knee arthroplasty (UKA) performed with minimal invasive technique, using the LIA technique found significantly shorter hospital stay, lower morphine consumption and pain intensity compared with placebo [23\*\*]. More stu-

dies in patients undergoing major ambulatory knee and hip surgery are needed in the literature, as these surgeries are likely to be performed on an ambulatory basis (<24h hospital stay) in the future.

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### **Choice of catheters**

Several catheters are available in the market today and some companies suggest better and more uniform distribution of drugs into the tissues using multihole systems. To my knowledge, only one study has been published looking into the efficacy of two different catheters used during wound infiltration. Andersen *et al.* [24\*] found that wound spread of a bolus injection through a 15 cm multiholed catheter was similar to a triple-orifice epidural catheter when placed subfascially following total hip arthroplasty. More studies are needed in the literature evaluating these catheters in patients undergoing different operative procedures before firm recommendations can be made.

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### **Systemic or local effect**

Local anaesthetics block sodium channels, thereby, preventing transmission of nerve impulse along the axonal fibre. This is a local effect at the site of injection. However, local anaesthetics are also absorbed into the systemic circulation from the site of injection and, depending on the dose and rate of absorption, may have systemic analgesic effects. Thus, local anaesthetics have been administered as intravenous infusion with good results, specifically after major surgery [25]. In one recent study, the authors showed that perioperative systemic lidocaine significantly reduces opioid requirements in the ambulatory setting without affecting time to discharge [26]. Can suppression of the inflammatory process play a more important role when local anaesthetics are given intravenously? Hollmann and Durieux [27] found that there was a reduction in ileus and hospital stay when lidocaine was given intravenously following major abdominal surgery. Therefore, when administered in larger doses during wound infiltration analgesia, it is possible that some of the analgesic effect seen is via systemic absorption and anti-inflammation. Although local anaesthetics have anti-inflammatory effects, it has (to my knowledge) never been shown that local anaesthetics injected into wounds provide analgesia through systemic absorption and anti-inflammation.

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### **Method of drug administration**

Several techniques are available for the delivery of drugs locally into the tissues. The commonest methods include continuous infusion, intermittent injection or a combination of the two. No studies are available in the literature in which these techniques have been compared

during wound infiltration analgesia. Continuous local anaesthetics administration has its advantage in that the patient has adequate pain relief most of the time. However, during periods of activity, the pain could be more severe, which may hamper mobilization. Intermittent injections (also sometimes referred to as patient-controlled regional analgesia) have the advantage that pain relief can be timed in order to achieve maximal effect during the painful periods such as during mobilization. However, the disadvantage is that sleep quality may be disturbed, as patients sometimes wake up at night due to severe pain, which may be annoying and can also be a cause of patient dissatisfaction. Therefore, methods using pumps that have a dual function with low-dose continuous infusion combined with self-administered bolus doses during mobilization are ideal. Several such pumps are available in the market today, including mechanical (elastometric) and electronic. The former are disposable, but not very accurate. On the contrary, electronic pumps are very accurate, but expensive but also are cost-effective over a longer period. Specifically for ambulatory surgery, disposable pumps offer the advantage that the patient does not have to return to the hospital.

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### Side-effects and toxicity

Local anaesthetics are, in general, well tolerated, provided they are used correctly and in the correct doses. When used for LIA, and specifically through catheters, several concerns have been expressed in the literature including the risk of infection, chondrolysis and systemic local anaesthetics toxicity. In addition to these, technical problems may prevent good analgesia when using these catheters. The complications associated with the use of adjuvant drugs used together with local anaesthetics have not been discussed here. Each of the other issues is addressed below.

### Risk of infection

Local anaesthetics are bacteriostatic and, therefore, the risk for local infections is small. Several studies have been performed wherein evidence of infection has been assessed by performing bacterial cultures from catheter tips, and systemic signs of infection measured by laboratory tests including leucocyte count and C-reacting protein concentrations [11,28]. Although positive cultures have been reported in several studies, the incidence of minor infection is less than 0.1% and only isolated cases of deep infection have been reported despite more than 10 years of experience. Therefore, it can be concluded that the risks of local or systemic infections using the catheter are very low.

### Chondrolysis

Recently, several reports of chondrolysis have been described following the injection of local anaesthetics

into the joints. Findings from these reports suggest that bupivacaine is more toxic than ropivacaine (no studies with ropivacaine have demonstrated chondrolysis), the higher the concentration of bupivacaine, the greater the risk of injury and, the longer the duration of exposure, the greater the risk of chondrolysis [29<sup>\*</sup>]. Thus, single doses of bupivacaine are acceptable, but when using intermittent injections in joints, ropivacaine in low concentrations is to be preferred. Almost all reports have been in patients undergoing shoulder surgery. One recent report suggests that the chondrocyte death may be due to chemical incompatibility between the local anaesthetics and cell culture medium or human synovial fluid, but not epinephrine or acidity of the local anaesthetics solution [30]. Whether the chondrolysis seen in all the studies to date is specifically related to the shoulder joint or not remains uncertain.

### Systemic toxicity

As mentioned earlier, local anaesthetics are absorbed from their site of injection, even after wound infiltration. Despite injection of high volumes, however, the concentrations of local anaesthetics remain much lower than known systemic toxic concentrations in humans (bupivacaine = 0.34 mg/l). In one study, the authors injected 500 mg ropivacaine subacromially into the wound and the maximum plasma concentration obtained in any patient and at any time was 0.2 mg/l [11]. In another study, Perniola *et al.* [18] injected varying doses of levobupivacaine intraperitoneally (200–300 mg per day) as an infusion. There was some evidence of accumulation of local anaesthetics with time and patients given a higher dose had a greater plasma concentration of local anaesthetics. However, the maximum concentration seen in any patient was 0.22 mg/l. Therefore, in spite of theoretically high doses of local anaesthetics administered by the authors, plasma concentrations were not high and the risk of systemic toxicity of local anaesthetics following wound infiltration is probably very low. It is important to state here that it is the free plasma concentration rather than total plasma concentration of local anaesthetics that should be measured because local anaesthetics bind to  $\alpha$ 1-acid glycoprotein in the plasma and the concentration of this protein increases following surgery [31].

### Technical problems with pumps and catheters

In some studies, it has been reported that the catheter can be dislodged, disconnected or be partially blocked at the outlet. Elastometric pumps may deliver inappropriate amounts of local anaesthetics with inaccuracy higher than 15% and failure to deflate is also not uncommon [32]. The latter could explain a lack of efficacy in some cases. It is recommended that these pumps should be weighed periodically in order to be

certain that they have deflated. These problems can often be avoided when using electronic pumps.

### The future

Although wound infiltration with local anaesthetics appears to be a simple method, the role of adjuvants like ketorolac, clonidine and morphine needs to be better described. Comparative studies with both multimodal analgesia and ultrasound-guided nerve blocks are needed in order to understand the place of wound infiltration with or without catheters. The problems of chondrolysis when using local anaesthetics intra-articularly need to be further understood. The mechanism of action of local anaesthetics when injected into wounds needs to be elucidated and their systemic effects confirmed or excluded. Finally, the role of local anaesthetics as anti-inflammatory agents needs to be further studied in clinical practice.

### Conclusion

In conclusion, the efficacy of the catheter technique when using local anaesthetics has been confirmed in several studies including some meta-analyses. Local anaesthetics used for wound infiltration as a single dose such as following LIA are also efficacious. However, only a few studies have compared this technique to a standard of care, which could include multimodal analgesic technique, nerve block and other adjuvant drugs. Therefore, it remains to be seen whether these minimally invasive methods are equally efficacious and have a similar side-effect profile before they can be recommended for routine use. In an era of cost-containment, cost–efficacy analyses need to be done. The risk for local anaesthetics toxicity is minimal and, although there is a potential risk for infection using catheter techniques, only isolated cases of deep infection have been reported in the literature. The use of local anaesthetics to prolong analgesia with a catheter *in situ* may lead to chondrolysis, specifically when using bupivacaine, but more studies are needed in the literature.

### References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:

- of special interest
- of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (pp. 778–779).

- 1 Sun J, Wu X, Meng Y, Jin L. Bupivacaine versus normal saline for relief of postadenotonsillectomy pain in children: a meta-analysis. *Int J Pediatr Otorhinolaryngol* 2010; 74:369–373.
- 2 Møiniche S, Mikkelsen S, Wetterslev J, Dahl JB. A systematic review of intra-articular local anesthesia for postoperative pain relief after arthroscopic knee surgery. *Reg Anesth Pain Med* 1999; 24:430–437.
- 3 Møiniche S, Jørgensen H, Wetterslev J, Dahl JB. Local anesthetic infiltration for postoperative pain relief after laparoscopy: a qualitative and quantitative systematic review of intraperitoneal, port-site infiltration and mesosalpinx block. *Anesth Analg* 2000; 90:899–912.
- 4 Boddy AP, Mehta S, Rhodes M. The effect of intraperitoneal local anesthesia in laparoscopic cholecystectomy: a systematic review and meta-analysis. *Anesth Analg* 2006; 103:682–688.
- 5 Liu SS, Richman JM, Thirlby RC, Wu CL. Efficacy of continuous wound catheters delivering local anesthetic for postoperative analgesia: a quantitative and qualitative systematic review of randomized controlled trials. *J Am Coll Surg* 2006; 203:914–932.
- 6 Lau H, Patil NG, Lee F. Randomized clinical trial of postoperative subfascial infusion with bupivacaine following ambulatory open mesh repair of inguinal hernia. *Dig Surg* 2003; 20:285–289.
- 7 Schurr MJ, Gordon DB, Pellino TA, Scanlon TA. Continuous local anesthetic infusion for pain management after outpatient inguinal herniorrhaphy. *Surgery* 2004; 136:761–769.
- 8 Lohsiriwat V, Lohsiriwat D. Ambulatory anorectal surgery under perianal anesthetics infiltration: analysis of 222 cases. *J Med Assoc Thai* 2007; 90:278–281.
- 9 Fong SY, Pavy TJ, Yeo ST, *et al.* Assessment of wound infiltration with bupivacaine in women undergoing day-case gynecological laparoscopy. *Reg Anesth Pain Med* 2001; 26:131–136.
- 10 Legeby M, Jurell G, Beausang-Linder M, Olofsson C. Placebo-controlled trial of local anaesthesia for treatment of pain after breast reconstruction. *Scand J Plast Reconstr Surg Hand Surg* 2009; 43:315–319.
- 11 Axelsson K, Nordenson U, Johanson E, *et al.* Patient-controlled regional analgesia (PCRA) with ropivacaine after arthroscopic subacromial decompression. *Acta Anaesthesiol Scand* 2003; 47:993–1000.
- 12 Andersen LO, Husted H, Kristensen BB, *et al.* Analgesic efficacy of intra-capsular and intra-articular local anaesthesia for knee arthroplasty. *Anaesthesia* 2010. [Epub ahead of print]
- 13 Hafizoglu MC, Katircioglu K, Ozkalkanli MY, Savaci S. Bupivacaine infusion above or below the fascia for postoperative pain treatment after abdominal hysterectomy. *Anesth Analg* 2008; 107:2068–2072.
- 14 Kalso E, Tramèr MR, Carroll D, *et al.* Pain relief from intra-articular morphine after knee surgery: a qualitative systematic review. *Pain* 1997; 71:127–134.
- 15 Rasmussen S, Kramhøft MU, Sperling KP, Pedersen JH. Increased flexion and reduced hospital stay with continuous intraarticular morphine and ropivacaine after primary total knee replacement: open intervention study of efficacy and safety in 154 patients. *Acta Orthop Scand* 2004; 75:606–609.
- 16 Gupta A, Axelsson K, Allvin R, *et al.* Postoperative pain following knee arthroscopy: the effects of intra-articular ketorolac and/or morphine. *Reg Anesth Pain Med* 1999; 24:225–230.
- 17 Park JY, Lee GW, Kim Y, Yoo MJ. The efficacy of continuous intrabursal infusion with morphine and bupivacaine for postoperative analgesia after subacromial arthroscopy. *Reg Anesth Pain Med* 2002; 27:145–149.
- 18 Perniola A, Gupta A, Crafoord K, *et al.* Intraabdominal local anaesthetics for postoperative pain relief following abdominal hysterectomy: a randomized, double-blind, dose-finding study. *Eur J Anaesthesiol* 2009; 26:421–429.
- 19 Gupta A, Thörn SE, Axelsson K, *et al.* Postoperative pain relief using intermittent injections of 0.5% ropivacaine through a catheter after laparoscopic cholecystectomy. *Anesth Analg* 2002; 95:450–456.
- 20 Kerr DR, Kohan L. Local infiltration analgesia: a technique for the control of acute postoperative pain following knee and hip surgery – a case study of 325 patients. *Acta Orthop* 2008; 79:174–183.
- 21 Essving P, Axelsson K, Kjellberg J, *et al.* Reduced morphine consumption and pain intensity with local infiltration analgesia (LIA) following total knee arthroplasty. *Acta Orthop* 2010; 81:354–360.
- 22 Andersen LØ, Husted H, Otte KS, *et al.* High-volume infiltration analgesia in total knee arthroplasty: a randomized, double-blind, placebo-controlled trial. *Acta Anaesthesiol Scand* 2008; 52:1331–1335.
- 23 Essving P, Axelsson K, Kjellberg J, *et al.* Reduced hospital stay, morphine consumption, and pain intensity with local infiltration analgesia after unicompartmental knee arthroplasty. *Acta Orthop* 2009; 80:213–219.

The authors studied 40 patients undergoing UKA under general anaesthesia. They found that local LIA periarticularly at the end of the operation and intra-articularly at 21 h postoperatively provided excellent pain relief and earlier home discharge following UKA. There was a high degree of patient satisfaction in all patients after 6 months.

- 24** Andersen LØ, Kristensen BB, Madsen JL, *et al.* Wound spread of radiolabeled saline with multi- versus few-hole catheters. *Reg Anesth Pain Med* 2010; 35:200–202.

In order to determine wound spread through a 15 cm multiholed catheter versus triple-orifice epidural catheters, the authors injected a bolus of local anaesthetics and found that there is a similar spread with subfascial catheter placement in total hip arthroplasty.

- 25** Yardeni IZ, Beilin B, Mayburd E, *et al.* The effect of perioperative intravenous lidocaine on postoperative pain and immune function. *Anesth Analg* 2009; 109:1464–1469.
- 26** McKay A, Gottschalk A, Ploppa A, *et al.* Systemic lidocaine decreased the perioperative opioid analgesic requirements but failed to reduce discharge time after ambulatory surgery. *Anesth Analg* 2009; 109:1805–1808.
- 27** Hollmann MW, Durieux ME. Local anesthetics and the inflammatory response: a new therapeutic indication? *Anesthesiology* 2000; 93:858–875.
- 28** Gupta A, Perniola A, Axelsson K, *et al.* Postoperative pain after abdominal hysterectomy: a double-blind comparison between placebo and local anesthetic infused intraperitoneally. *Anesth Analg* 2004; 99:1173–1179.

- 29** Webb ST, Ghosh S. Intra-articular bupivacaine: potentially chondrotoxic? *Br J Anaesth* 2009; 102:439–441.

In this editorial, the authors summarize current literature on chondrotoxicity of local anaesthetics. The dose-dependent and time-dependent human chondrotoxicity of local anaesthetics, particularly bupivacaine, would suggest that prolonged, continuous intra-articular administration of higher concentrations of bupivacaine may result in adverse clinical effects, whereas a single injection of low-concentration bupivacaine appears to be well tolerated.

- 30** Bogatch MT, Ferachi DG, Kyle B, *et al.* Is chemical incompatibility responsible for chondrocyte death induced by local anesthetics? *Am J Sports Med* 2010; 38:520–526.
- 31** Yokogawa K, Shimomura S, Ishizaki J, *et al.* Involvement of alpha1-acid glycoprotein in inter-individual variation of disposition kinetics of ropivacaine following epidural infusion in off-pump coronary artery bypass grafting. *J Pharm Pharmacol* 2007; 59:67–73.
- 32** Remerand F, Vuitton AS, Palud M, *et al.* Elastomeric pump reliability in postoperative regional anesthesia: a survey of 430 consecutive devices. *Anesth Analg* 2008; 107:2079–2084.