Role of Regional Anesthesia in the Ambulatory Environment

Adam K. Jacob, MD, Michael T. Walsh, MD, John A. Dilger, MD*

KEYWORDS

• Regional anesthesia • Nerve block • Ambulatory • Outpatient

Ambulatory surgery has undergone tremendous growth in the past decade, from 20.8 million procedures in 1996 to 34.7 million in 2006.[1] Several factors have fueled this growth, including less-invasive surgical techniques, changes in practice patterns, and the use of anesthetic agents and techniques associated with fewer postoperative side effects. Postoperative pain management represents a particular challenge with ambulatory surgery because 40% of patients experience severe pain despite treatment.[2] Studies show that regional anesthesia (RA) improves pain scores, decreases narcotic use, and lowers the incidence of postoperative nausea and vomiting,[3,4] Thus, more patients can be discharged home in less time with high satisfaction.[5]

ORTHOPEDIC SURGERY

Perhaps more than any other specialty, orthopedic surgery lends itself to the practice of RA. Peripheral nerve or neuraxial blocks may be used as a primary anesthetic or as part of a combined technique to provide postoperative analgesia. For single-injection techniques, benefits generally last 8 to 12 hours, depending on the type of local anesthetic and adjuvants used. These short-term benefits include improved analgesia, fewer opioid-related side effects, and shorter length of stay in the ambulatory setting.[6–14] To further prolong postoperative analgesia, a continuous infusion of local anesthesia can be delivered through a perineural catheter. The use of continuous regional techniques for promise to broaden the scope of outpatient procedures that can be performed in an outpatient setting such as total shoulder and total hip arthroplasty.[15,16] These continuous techniques are discussed in detail, see the article by Swenson and colleagues elsewhere in this issue for further exploration of this topic.

This work was supported by Mayo Clinic Department of Anesthesiology.
Department of Anesthesiology, Mayo Clinic, 200 First Street Southwest, Rochester, MN 55905, USA
* Corresponding author.
E-mail address: dilger.john@mayo.edu

Anesthesiology Clin 28 (2010) 251–266
doi:10.1016/j.anclin.2010.02.009 **anesthesiology.theclinics.com**
1932-2275/10/$ – see front matter

Upper Extremity Surgery

Interscalene blockade (ISB) is a common technique for shoulder surgery. In a prospective study of 50 patients undergoing outpatient rotator cuff repair, patients randomized to receive single-injection ISB (vs general anesthesia [GA]) were more likely to bypass the postanesthesia care unit (PACU), report less pain, ambulate earlier, and meet home discharge criteria sooner.[8] Not unexpectedly, no difference was observed between groups in pain scores or opioid consumption at 24, 48, and 72 hours. These results support earlier retrospective findings comparing single-injection ISB with GA.[13,14] Because single-injection techniques can only provide 12 to 24 hours of relief when long-acting local anesthetics are used, patients may experience severe pain after the block resolves.[6] The addition of a perineural catheter and infusion may sustain analgesia for several days after surgery.[7,12,17,18] The benefits of catheter-based analgesia after shoulder surgery, however, remain controversial.[6,19]

Given the high incidence of phrenic nerve blockade during ISB, this technique may be contraindicated in patients who may not tolerate phrenic nerve blockade (eg, severe chronic obstructive pulmonary disease). Suprascapular nerve blockade (SSB) is an alternative technique that may provide analgesia after shoulder surgery. The suprascapular nerve innervates up to 70% of the posterior shoulder joint, the acromioclavicular joint, the subacromial bursa, and the coracoclavicular ligament. Furthermore, the location of blockade (in the supraspinatus fossa) eliminates the risk of inadvertent phrenic nerve blockade commonly encountered during ISB. In a study comparing single-injection ISB, SSB, intra-articular (IA) injection, and parenteral analgesia, SSB patients had lower pain verbal analog scale (VAS) scores with rest and movement up to 24 hours compared with parenteral or IA analgesia.[9] ISB patients consistently had the lowest pain scores overall, however.

For procedures below the shoulder, RA techniques also provide superior analgesia and shorter time to discharge compared with GA or systemic analgesics. Patients randomized to single-injection axillary brachial plexus block (vs GA) for ambulatory hand surgery were more likely to be fast-track eligible with a shorter duration of stay in the PACU and in the hospital after surgery.[10] In the RA group, pain scores up to 120 minutes after surgery were lower, but again there was no difference in pain, opioid consumption, adverse effects, Pain Disability Index, or satisfaction by postoperative day 1.

Infraclavicular brachial plexus blockade (INB), an alternative approach to upper extremity blockade for hand and wrist surgery, also provides short-term benefits in an ambulatory setting compared with GA. In a 2004 study by Hadzic and colleagues,[11] 52 patients undergoing outpatient hand or wrist surgery were randomized to INB or GA plus wound infiltration with local anesthetic. Compared with patients in the GA group, fewer patients in the INB group had pain (VAS >3) on arrival to the PACU and none requested treatment for pain when in the hospital (vs 48% of GA patients). Patients in the INB group reported less nausea, vomiting, and sore throat than GA patients and were, on average, discharged home approximately 100 minutes sooner than patients randomized to GA.

Lower Extremity Surgery

Hip arthroscopy is a surgical technique growing in popularity for treatment of a variety of painful hip conditions. Like many arthroscopic procedures, hip arthroscopy is commonly performed as outpatient surgery. Postoperative pain intensity may be a limiting factor for dismissing patients home postoperatively. IA bupivacaine injected at the conclusion of surgery lowers average pain scores at rest for 24 hours (18 vs 28 on 100-point scale) and with movement (23 vs 46 on 100-point scale) compared with 0.9% normal saline.[20] When 2-level paravertebral blockade (PVB) (L1 and L2) was added to IA bupivacaine, 2 patients experienced analgesia up to 36 and 48 hours, respectively.[21]

Total hip arthroplasty, a procedure that once required 2.5 to 3 weeks of inpatient recovery,[22] can now be performed on an ambulatory basis thanks to better pain control with continuous RA techniques. Investigators have described clinical pathways that include the use of 1 or more regional techniques, including lumbar plexus catheter and single-injection sciatic blockade, that enable patients undergoing minimally invasive total hip arthroplasty to be dismissed fewer than 23 hours after surgery.[16,23]

A variety of anesthetic and analgesic techniques are described for outpatient knee procedures. The most common methods of providing analgesia after knee arthroscopy, particularly with procedures involving ligament reconstruction, include femoral nerve blockade (with or without sciatic nerve blockade), lumbar plexus (ie, psoas) blockade, and IA injection. An ideal technique remains controversial.[24] Previous investigations have inconsistently compared the techniques, and variation in results may be due to differences in surgical and patient expectations as well as variations in postoperative nursing management.

Use of IA local anesthesia, often given in combination with an opioid, improves pain scores and early analgesic consumption after outpatient knee arthroscopy, regardless if the IA dose is administered pre- or post surgery.[25] Adding tramadol may potentiate the analgesic effects. In a recent study,[26] a combination of tramadol and 0.25% bupivacaine resulted in significantly lower pain VAS scores, decreased 24-hour analgesic consumption, prolonged time to first rescue analgesic, and shortened time to discharge compared with IA bupivacaine or tramadol alone. These benefits were seen without any detectable systemic effects. Recent evidence, however, suggests local anesthetics may be harmful to chondrocytes and may cause chondrolysis after IA infusion or even single injection.[27–30]

When used as a primary anesthetic agent, lumbar plexus blockade with or without sciatic nerve blockade provides short-term benefits compared with GA for outpatient knee surgery.[31,32] Patients who underwent peripheral blockade with 2-chloroprocaine 3% or mepivacaine 1.5% had lower immediate postoperative pain scores, shorter time to hospital dismissal, and higher satisfaction compared with patients who underwent GA.

In patients undergoing surgical procedures of the ankle or foot, several RA techniques exist that can provide anesthesia or analgesia of the operative extremity. Choice of technique largely depends on factors, such as surgical site (eg, hallux vs ankle), type of procedure (eg, hallux valgus correction vs ankle arthrodesis), use of a tourniquet, and the immediate weight-bearing status. A 2003 prospective, randomized study compared the analgesic benefits of a foot blockade (FB) (ie, ankle blockade) with 0.5% bupivacaine (20 mL) to sham blockade for outpatient bony midfoot surgery.[33] Patients who received an FB needed fewer intraoperative opioid supplements and, on average, had a significantly longer time to first perception of pain (12 vs 5.5 hours) compared with sham blockade. Again, the measured benefits were gone by postoperative day 1 with this single-injection technique.

The terminal branches of the sciatic and femoral nerves anesthetized during an FB can also be blocked more proximally in the popliteal fossa. In a prospective, randomized study comparing the efficacy of FB to popliteal blockade (PB) for outpatient forefoot surgery, Migues and colleagues[34] demonstrated equivalency of FBs and PBs. Specifically, both blocks were equally efficacious as primary anesthetic, and both blocks provided a similar duration of analgesia (FB, 11.0 hours, vs PB, 14.3 hours; $P = .13$) and patient satisfaction. By using a perineural catheter in the popliteal space, improved analgesia for ambulatory foot and ankle surgery can be extended up to 3 days compared with single-injection techniques.[35–37]

Neuraxial Techniques

A variety of neuraxial techniques have been studied for outpatient lower extremity procedures. With any approach, the anesthetic goals are the same: dense surgical anesthesia with rapid neurologic recovery and avoidance of neurotoxic effects (ie, transient neurologic syndrome). Although many combinations of local anesthetics, doses, additives, and approaches have been studied,[38–50] no single technique has emerged as the optimal choice. Each neuraxial anesthetic must be tailored to the patient and the procedure.

In the past 5 years, chloroprocaine has regained popularity for intrathecal use in ambulatory surgery. The rapid neurologic recovery (approximately 80–120 minutes) after intrathecal chloroprocaine makes it an attractive option for outpatient spinal anesthesia. At one time, chloroprocaine (or more specifically, the preservative sodium bisulfite) was thought to pose a significant risk of neurotoxicity. Recent animal evidence has disproved this,[51] and, thus far, no cases of neurotoxicity have been reported in several human volunteer and clinical studies.[43,52–58] Despite the growing body of clinical evidence illustrating the safety of spinal chloroprocaine, its use remains controversial.

An alternative to chloroprocaine for use in ambulatory surgery is low-dose bupivacaine. Many studies have examined a variety of drug doses, use of hyperbaric and isobaric drug preparations, with or without additives, and unilateral or bilateral spread of medication for a variety of surgical procedures.[39,42,44,55,59–71] Although low (<7.5 mg) and ultralow (2.5–4 mg) doses of spinal bupivacaine are used, these may come at the expense of additional sedation necessary for patient comfort during a procedure. In summary, each spinal anesthetic must be tailored to the patient, the procedure, and the practice style.

GENERAL SURGERY

Pain control after general surgery is challenging, and despite treatment, significant postoperative pain may result in unexpected hospital admission. Local anesthesia is used for subcutaneous injection providing anesthesia and analgesia, but the effects are limited by the short duration. An alternative method of providing prolonged unilateral (or bilateral) somatic and sympathetic nerve blockade is PVB. PVB involves the injection of local anesthetic at the nerve root just lateral to the neuraxial space and can be performed at 1 or more levels to increase the number of anesthetized dermatomes. PVB is commonly used to provide analgesia after procedures on the chest or abdominal wall, including breast surgery, hernia repair, and even laparoscopic procedures (eg, laparoscopic cholecystectomy).

Breast Surgery

PVB is used for major breast surgery. Analgesia for mastectomy, wide local excision, or lumpectomy should include nerve roots T1-T6, whereas procedures involving only sentinel node biopsy or axillary dissection involve nerve roots T1-T3. Injections typically require 3 to 5 mL of local anesthetic at each level (**Fig. 1**) or, alternatively, the entire dermatome coverage divided and a larger volume given at the midpoint. PVB may be used in conjunction with GA or as the primary anesthetic technique with sedation.

Demonstrated advantages of PVB over GA include decreased pain, lower narcotic usage, and earlier hospital discharge compared with patients having GA.[72] In addition to intraoperative anesthesia and analgesia, PVB using long-acting local anesthetics can prolong analgesia until the next day. This sustained analgesia results in significantly more same-day discharges, decreasing the costs associated with major breast surgery.[5] PVB also is associated with significantly less pain at 1, 6, and 12 months post procedure and a lower frequency of postmastectomy syndrome.[73] Additionally, PVB may inhibit the body's stress response to surgery, potentially limiting suppression of the immune system, including the action of natural killer cells, resulting in a lower recurrence of breast cancer up to 3 years after surgery.[74]

Although the benefits of thoracic PVB are well described, clear consideration must be given to the possibility of procedure-related complications, specifically pneumothorax. The risk of pneumothorax after a multiple injection technique is estimated to be 0.6%, and a postoperative chest radiograph is often ordered.[72] Although most pneumothoraces are small and asymptomatic, some may require chest tube placement and hospital admission. Ultrasound-guided PVB may be advantageous in that it allows for real-time visualization of the needle, costotransverse ligament, pleura, and spread of local anesthetic. In theory, the risk of complications, such as pneumothorax or intravascular injection, may be less when PVB is performed using ultrasonography, but these potential advantages are not yet proven.

Inguinal Hernia Repair

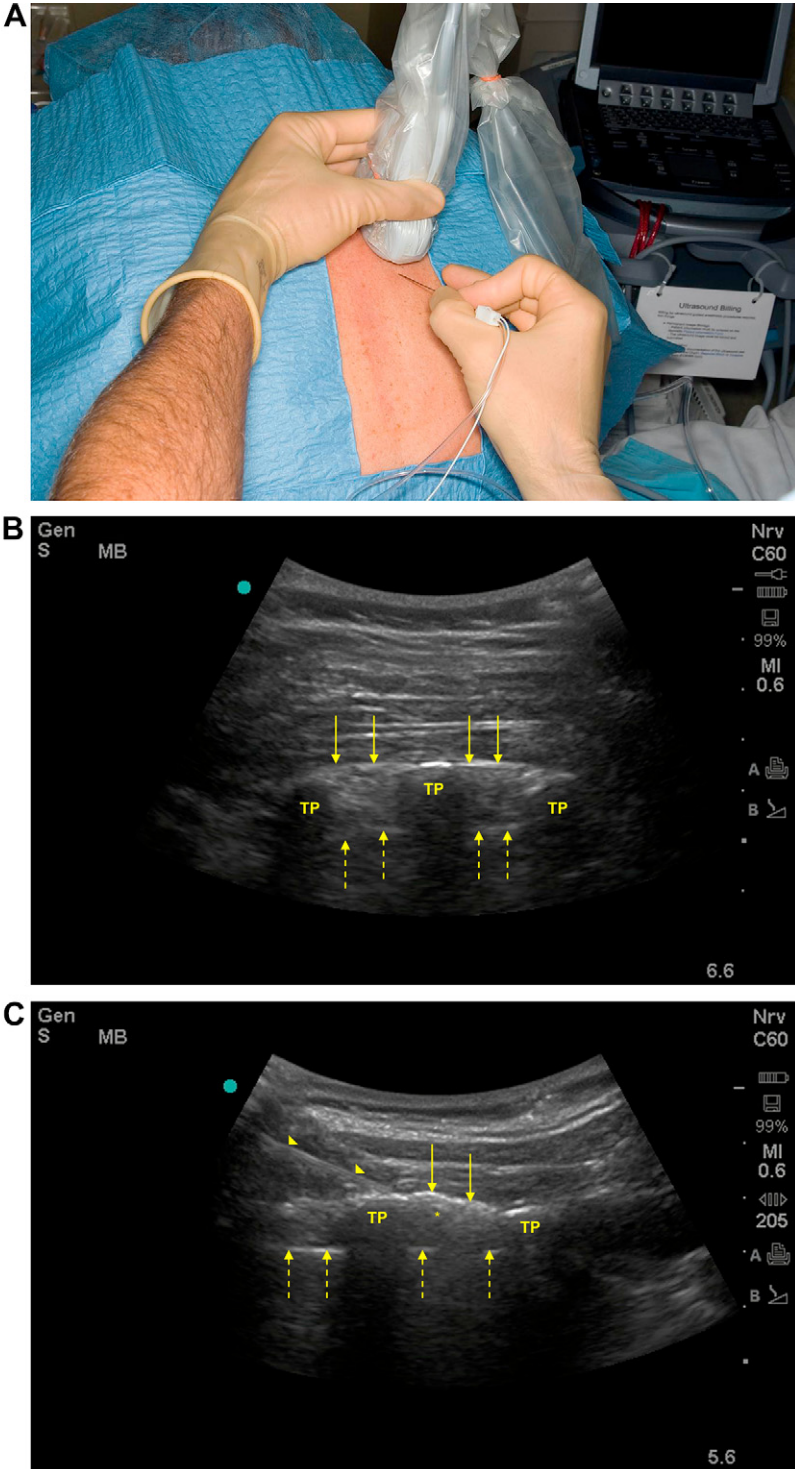
Analgesia after open inguinal herniorrhaphy is managed in many ways, although the use of local anesthesia is used increasingly due to superior outcomes. Simple wound infiltration is used commonly, and it is associated with an efficient recovery because side effects, such as urine retention, are uncommon (<0.5%).[75] The analgesic effects are limited by the brief duration of the local anesthetic used, but analgesia may be extended by placing a catheter in the wound. A continuous infusion for 2 days results in significantly lowered pain scores at 2 and 5 days postoperatively.[76]

PVB is an ideal perioperative technique for inguinal herniorrhaphy and lacks some of the risks (eg, pneumothorax) associated with thoracic-level paravertebral injections. For inguinal hernia surgery, blockade of T11-L2 nerve roots is required for adequate dermatomal analgesia. PVB for inguinal hernia repair is associated with less pain, less nausea, lower opioid requirements, and earlier home readiness compared with GA with local infiltration.[77] In addition, patients were able to urinate significantly sooner in the PVB group (128 vs 213 minutes).

An alternative technique that may be used to provide analgesia after hernia surgery is the transverse abdominus plane (TAP) block. Like PVB, TAP blocks may be unilateral or bilateral and involve injecting local anesthetic between the internal oblique and transverse abdominus muscle planes, resulting in blockade of T10-L3 segmental nerves and possibly the ilioinguinal and iliohypogastric nerves (**Fig. 2**).

Laparoscopic Surgery

Minimally invasive surgery using laparoscopy has dramatically expanded the number and type of cases that can be performed on an ambulatory basis. Cholecystectomy is a prime example. Although there is significantly less pain associated with the laparoscopic approach, pain is still the most common reason for admission to the hospital, with rates as high as 41%. The laparoscopic cholecystectomy pain state is unique even among other laparoscopic procedures with incisional somatic pain, abdominal visceral pain, and referred visceral pain to the shoulder. This complex pain state suggests


A
B
Gen
S
MB
Nrv
C60
99%
MI
0.6
TP
TP
TP
A
B
6.6
C
Gen
S
MB
Nrv
C60
99%
MI
0.6
205
TP
TP
A
B
5.6

a role for multimodal analgesia. Acetaminophen and celecoxib are efficacious, and local anesthetic is applied in many ways to the postoperative pain with varying results.

Injecting the portholes with local anesthesia is efficacious although limited by the duration of local anesthesia. Ropivacaine injected to the portholes provides a median duration of analgesia of 2 to 3 hours, after which pain scores were similar to control patients.[78] Local anesthesia may also be applied to the intraperitoneal space for analgesia. The results have been excellent with an even greater efficacy resulting from injection of local anesthetic at the beginning of the procedure. Analgesia may last up to 4 hours.[79]

Bilateral PVB also seems efficacious after cholecystectomy, with the added benefit of longer duration. A combination of lidocaine and bupivacaine results in significantly less pain at 6, 12, and 24 hours postoperatively.[80]

TAP may be useful during cholecystectomy because it has an opioid-sparing effect perioperatively.[81] PVB and TAP blocks show some promise in managing pain after cholecystectomy, but incisional local combined with oral multimodal medications based on outcome data are the only regimen that demonstrate efficacy.

Many gynecologic procedures are done laparoscopically with GA, and local anesthesia is used to provide postoperative analgesia. When levobupivacaine is injected preoperatively in the port sites, laparoscopy patients experience significantly less pain, require fewer pain treatments, and ambulate earlier than patients not receiving local anesthesia.[82]

Postoperative pain control also is provided with local anesthetics applied to peritoneal surfaces intraoperatively. The efficacy of intraperitoneal local analgesia is conflicting in gynecologic surgery, and there is no compelling evidence to support its routine use as exists after laparoscopic cholecystectomy. The laparoscopic approach is similar in gynecologic and general surgery, but the procedures and pain states seem unique.

PLASTIC SURGERY

Local anesthesia has long been used in cosmetic surgery as much for its anesthetic potential as its vasoconstrictive properties when combined with epinephrine. Surgery may be conducted with the addition of light sedation, and this is preferred in rhytidectomy and blepharoplasty due to superior recovery compared with GA. In rhinoplasty, the local anesthetic cocaine is used for its anesthetic and vasoconstrictive properties, although there is concern for its arrhythmogenicity. Adrenalized lidocaine is also effective and combined with sedation or GA depending on the procedure. Liposuction uses the same lidocaine and epinephrine mixture in a different manner. Tumescent anesthesia, normal saline mixed with lidocaine 0.05% and epinephrine 1:1,000,000, is injected subdermally, so fluid distends adipocytes permitting thin cannula suctioning of the adipose tissue. Considerable amounts may be injected during liposuction raising concerns about hypervolemia and local anesthetic systemic toxicity. The maximum dose of adrenalized lidocaine is 7 mg/kg, but doses as high as 55 mg/kg have been used safely during liposuction, resulting in subtoxic serum lidocaine levels

Fig. 1. Ultrasound-guided thoracic PVB: (*A*) patient position, machine location, and hand position; (*B*) ultrasound anatomy: paraspinous tendon (*solid arrows*), parietal pleura (*dashed arrows*); TP, transverse process; and (*C*) ultrasound image showing needle approach and spread of local anesthetic in paravertebral space: paraspinous tendon (*solid arrows*); parietal pleura (*dashed arrows*); needle image with tip just below paraspinous tendon (*arrowheads*); final position of needle tip (*asterisk*); TP, transverse process.

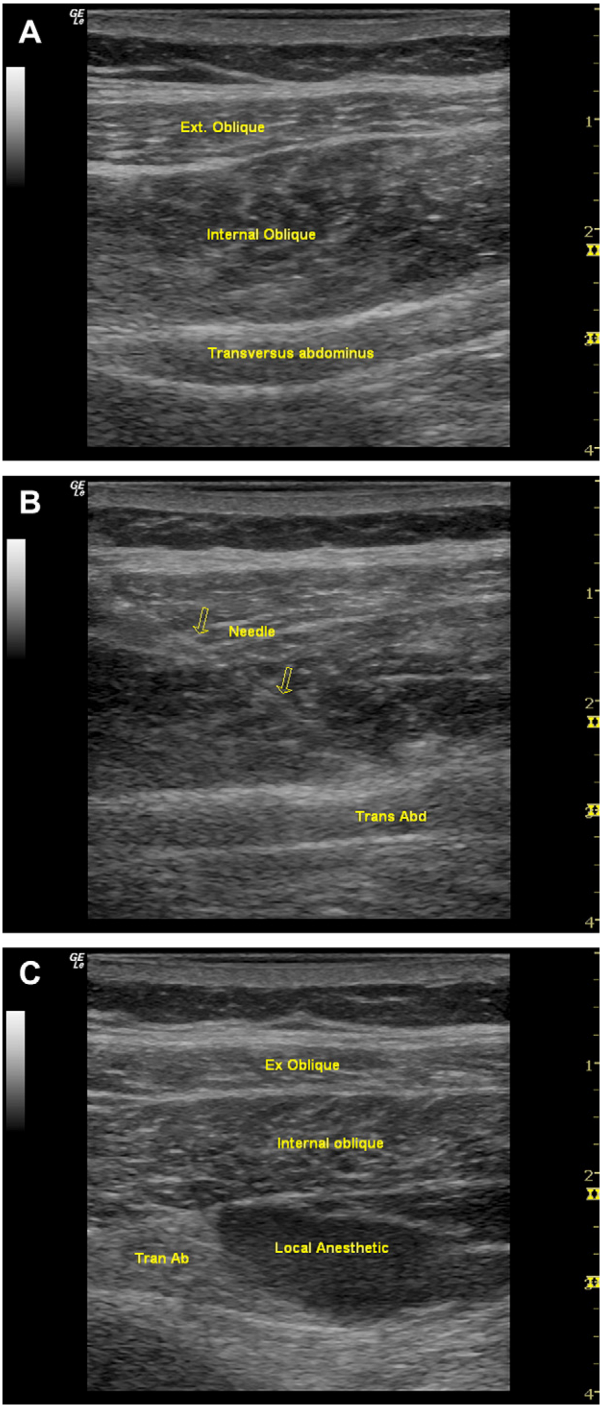


Fig. 2. Ultrasound-guided transversus abdominis plane blockade: (*A*) ultrasound anatomy, (*B*) ultrasound image showing needle (*arrows*) approach, and (*C*) ultrasound image showing injection of local anesthetic deep to fascial plane between transversus abdominis and internal oblique muscles.

(<5 μg/mL).[83] These doses of epinephrine do not cause tachycardia, arrhythmias, or hypertension. Cosmetic procedures use local anesthesia with epinephrine to provide anesthesia and limit bleeding, thus improving the surgical field conditions.

Breast surgery was discussed previously but bears mention because augmentation and reduction mammoplasty are unique. Paravertebral blocks also are used in the setting of plastic surgery. During submuscular breast augmentation, PVB provides intraoperative anesthesia and postoperative pain management, so patients may be discharged efficiently with minimal side effects.[84] Another analgesia technique in this setting involves a surgeon implanting catheters in the wound. Local anesthesia is infused providing prolonged analgesia.[85] Patients have significantly better analgesia, require less pain medication, and are more likely to be discharged on the same day compared with patients not receiving continuous wound infiltration.[86] This technique may have an advantage over PVB because analgesia is extended, no special training is required to place, and there is no risk of pneumothorax.

OFFICE-BASED SURGERY

Most of the growth in ambulatory surgery has taken place in offices or freestanding surgery centers. Although these smaller venues are usually associated with minor and less-invasive procedures, trends favor expansion of larger cases into smaller venues. All of the regional techniques (described previously) can (and eventually probably will) be done in offices as long as sufficient personnel and resources are available. Two examples of common office-based procedures are transrectal prostate biopsy and intrauterine surgery.

Transrectal prostate biopsy is a procedure commonly performed as an office-based procedure or in an ambulatory center. At one time, this procedure was thought well tolerated by most patients. Recent reviews have estimated, however, that 65% to 90% of patients experience discomfort and up to 30% may have significant pain. Many studies, including a recent meta-analysis, have compared the use of periprostatic nerve block to intrarectal local anesthesia or no local anesthesia during transrectal prostate biopsy. Periprostatic nerve block around the neurovascular bundles provided superior analgesia compared with intrarectal local anesthesia or no anesthesia with no increase in procedure-related complications.[87]

Intrauterine procedures, including dilation and curettage, diagnostic and operative hysteroscopy, oocyte retrieval, polypectomy, endometrial ablation, and sterilization, are often performed under GA or RA with sedation. Paracervical blockade, injection of local anesthetic around the cervix, is often used because anesthesia personnel are not present. The paracervical block seems of little value as a primary anesthetic or analgesic technique.[88] Patients anesthetized with paracervical block have equivalent intraoperative and postoperative pain compared with patients who receive no anesthesia at all. Therefore, intrauterine procedures should be done with deep sedation and there is no clear role for local analgesia.

Laparoscopy may be done in an office with only local anesthesia, and the laparoscopes are usually smaller with lower insufflation pressures in this setting. Laparoscopy is typically performed for diagnosis or treatment (eg, sterilization), and performing the procedure in this manner is associated with lower costs.[89] The gynecologic laparoscopic procedure may be done with local anesthesia or analgesia depending on the approach.

REGIONAL ANESTHESIA AND EFFICIENCY

Painful stimuli are initiated by tissue injury and transmitted by Aδ-fiber and C-fiber nociceptors to the spinal cord dorsal horn neurons. In response to this injury, a variety of neurotransmitters, such as prostaglandin, bradykinin, serotonin, and substance P, are released, which leads to increased activity of the dorsal horn neurons. If this input remains unmodulated, the result may be central sensitization. Preemptive analgesia is a pain control strategy implemented before a painful stimulus and in sufficient duration to limit or prevent sensitization of the central nervous system. This should result in less intense pain of shorter duration. Preemptive analgesia has been demonstrated in several animal models. In human studies by Moiniche and colleagues and Dahl and Moiniche and in the most recent meta-analysis by Ong and colleagues, preemptive analgesia could not be proved.[90–92] Their findings demonstrate it is unnecessary to provide analgesia before a painful stimulus, but it is critical to provide effective analgesia of sufficient duration. Local anesthesia inhibits the transmission of noxious afferent stimuli from the operative site to the spinal cord and brain, and it is desirable to maintain this effect well into the postoperative period. This sustained postoperative analgesia decreases the risks of hyperalgesia, allodynia, and increased pain.

The merits of local anesthetic-based analgesia are well established, and it is clear these techniques facilitate an earlier facility discharge with superior pain control. There is bias against RA because of the time commitment and possible delays associated with it. RA techniques may require additional time to perform, and this may have an impact on operating room efficiency and increase costs. Use of regional techniques result in an overall lower cost due to earlier discharge and fewer unplanned admissions.[93] More advanced techniques (eg, ultrasound-guided PVB) take time to administer and are best done in a time-neutral environment outside the operating room (eg, dedicated block room or PACU). Dedicated block rooms are time effective and contribute to an efficient outpatient practice while preserving analgesic outcomes.[94,95] This same level of efficiency and patient care has also been demonstrated in private practice settings.[96] These are barriers that must be overcome to use RA in any practice.[97,98]

SUMMARY

The use of local anesthetics in ambulatory surgery offers multiple benefits in line with the goals of modern-day outpatient surgery. A variety of regional techniques can be used for a wide spectrum of procedures; all are shown to reduce postprocedural pain; reduce the short-term need for opiate medications; reduce adverse effects, such as nausea and vomiting; and reduce the time to dismissal compared with patients who do not receive regional techniques. It is likely that the growth in ambulatory procedures will continue to rise with future advances in surgical techniques, changes in reimbursement, and the evolution of clinical pathways that include superior, sustained postoperative analgesia. Anticipating these changes in practice, the role of and demand for RA in outpatient surgery will continue to grow.

REFERENCES

1. Cullen KA, Hall MJ, Golosinskiy A. In: Ambulatory surgery in the United States, 2006, in reports NHS, vol. 11. Hyattsville (MD): United States Department of Health and Human Services; 2009. p. 1–28.
2. Chung F, Ritchie E, Su J. Postoperative pain in ambulatory surgery. Anesth Analg 1997;85(4):808–16.
3. Klein SM, Bergh A, Steele SM, et al. Thoracic paravertebral block for breast surgery. Anesth Analg 2000;90(6):1402–5.
4. Larsson S, Lundberg D. A prospective survey of postoperative nausea and vomiting with special regard to incidence and relations to patient characteristics,

anesthetic routines and surgical procedures. Acta Anaesthesiol Scand 1995; 39(4):539–45.
5. Boughey JC, Goravanchi F, Parris RN, et al. Improved postoperative pain control using thoracic paravertebral block for breast operations. Breast J 2009;15(5):483–8.
6. Trompeter A, Camilleri G, Narang K, et al. Analgesia requirements after interscalene block for shoulder arthroscopy: the 5 days following surgery. Arch Orthop Trauma Surg 2009;130(3):417–21.
7. Bryan NA, Swenson JD, Greis PE, et al. Indwelling interscalene catheter use in an outpatient setting for shoulder surgery: technique, efficacy, and complications. J Shoulder Elbow Surg 2007;16(4):388–95.
8. Hadzic A, Williams BA, Karaca PE, et al. For outpatient rotator cuff surgery, nerve block anesthesia provides superior same-day recovery over general anesthesia. Anesthesiology 2005;102(5):1001–7.
9. Singelyn FJ, Lhotel L, Fabre B. Pain relief after arthroscopic shoulder surgery: a comparison of intraarticular analgesia, suprascapular nerve block, and interscalene brachial plexus block. Anesth Analg 2004;99(2):589–92.
10. McCartney CJ, Brull R, Chan VW, et al. Early but no long-term benefit of regional compared with general anesthesia for ambulatory hand surgery. Anesthesiology 2004;101(2):461–7.
11. Hadzic A, Arliss J, Kerimoglu B, et al. A comparison of infraclavicular nerve block versus general anesthesia for hand and wrist day-case surgeries. Anesthesiology 2004;101(1):127–32.
12. Ilfeld BM, Morey TE, Wright TW, et al. Continuous interscalene brachial plexus block for postoperative pain control at home: a randomized, double-blinded, placebo-controlled study. Anesth Analg 2003;96(4):1089–95.
13. D'Alessio JG, Rosenblum M, Shea KP, et al. A retrospective comparison of interscalene block and general anesthesia for ambulatory surgery shoulder arthroscopy. Reg Anesth 1995;20(1):62–8.
14. Brown AR, Weiss R, Greenberg C, et al. Interscalene block for shoulder arthroscopy: comparison with general anesthesia. Arthroscopy 1993;9(3):295–300.
15. Ilfeld BM, Wright TW, Enneking FK, et al. Total shoulder arthroplasty as an outpatient procedure using ambulatory perineural local anesthetic infusion: a pilot feasibility study. Anesth Analg 2005;101(5):1319–22.
16. Mears DC, Mears SC, Chelly JE, et al. THA with a minimally invasive technique, multi-modal anesthesia, and home rehabilitation: factors associated with early discharge? Clin Orthop Relat Res 2009;467(6):1412–7.
17. Ilfeld BM, Morey TE, Wright TW, et al. Interscalene perineural ropivacaine infusion:a comparison of two dosing regimens for postoperative analgesia. Reg Anesth Pain Med 2004;29(1):9–16.
18. Nielsen KC, Greengrass RA, Pietrobon R, et al. Continuous interscalene brachial plexus blockade provides good analgesia at home after major shoulder surgery-report of four cases. Can J Anaesth 2003;50(1):57–61.
19. Klein SM, Steele SM, Nielsen KC, et al. The difficulties of ambulatory interscalene and intra-articular infusions for rotator cuff surgery: a preliminary report. Can J Anaesth 2003;50(3):265–9.
20. Morgenthaler K, Bauer C, Ziegeler S, et al. [Intra-articular bupivacaine following hip joint arthroscopy. Effect on postoperative pain]. Anaesthesist 2007;56(11): 1128–32 [in German].
21. Lee EM, Murphy KP, Ben-David B. Postoperative analgesia for hip arthroscopy: combined L1 and L2 paravertebral blocks. J Clin Anesth 2008;20(6): 462–5.

22. Charnley J. Present status of total hip replacement. Ann Rheum Dis 1971;30(6):560–4.
23. Berger RA, Sanders SA, Thill ES, et al. Newer anesthesia and rehabilitation protocols enable outpatient hip replacement in selected patients. Clin Orthop Relat Res 2009;467(6):1424–30.
24. Horlocker TT, Hebl JR. Anesthesia for outpatient knee arthroscopy: is there an optimal technique? Reg Anesth Pain Med 2003;28(1):58–63.
25. Goodwin RC, Parker RD. Comparison of the analgesic effects of intra-articular injections administered preoperatively and postoperatively in knee arthroscopy. J Knee Surg 2005;18(1):17–24.
26. Zeidan A, Kassem R, Nahleh N, et al. Intraarticular tramadol-bupivacaine combination prolongs the duration of postoperative analgesia after outpatient arthroscopic knee surgery. Anesth Analg 2008;107(1):292–9.
27. McNaught AF, McCartney C. Bupivacaine chondrotoxicity. Br J Anaesth 2009;103(1):133 [author reply: 33–4].
28. Dragoo JL, Korotkova T, Kanwar R, et al. The effect of local anesthetics administered via pain pump on chondrocyte viability. Am J Sports Med 2008;36(8):1484–8.
29. Karpie JC, Chu CR. Lidocaine exhibits dose- and time-dependent cytotoxic effects on bovine articular chondrocytes in vitro. Am J Sports Med 2007;35(10):1621–7.
30. Gomoll AH, Kang RW, Williams JM, et al. Chondrolysis after continuous intra-articular bupivacaine infusion: an experimental model investigating chondrotoxicity in the rabbit shoulder. Arthroscopy 2006;22(8):813–9.
31. Hadzic A, Karaca PE, Hobeika P, et al. Peripheral nerve blocks result in superior recovery profile compared with general anesthesia in outpatient knee arthroscopy. Anesth Analg 2005;100(4):976–81.
32. Jankowski CJ, Hebl JR, Stuart MJ, et al. A comparison of psoas compartment block and spinal and general anesthesia for outpatient knee arthroscopy. Anesth Analg 2003;97(4):1003–9.
33. Clough TM, Sandher D, Bale RS, et al. The use of a local anesthetic foot block in patients undergoing outpatient bony forefoot surgery: a prospective randomized controlled trial. J Foot Ankle Surg 2003;42(1):24–9.
34. Migues A, Slullitel G, Vescovo A, et al. Peripheral foot blockade versus popliteal fossa nerve block: a prospective randomized trial in 51 patients. J Foot Ankle Surg 2005;44(5):354–7.
35. Capdevila X, Dadure C, Bringuier S, et al. Effect of patient-controlled perineural analgesia on rehabilitation and pain after ambulatory orthopedic surgery: a multicenter randomized trial. Anesthesiology 2006;105(3):566–73.
36. Zaric D, Boysen K, Christiansen J, et al. Continuous popliteal sciatic nerve block for outpatient foot surgery–a randomized, controlled trial. Acta Anaesthesiol Scand 2004;48(3):337–41.
37. Ilfeld BM, Morey TE, Wang RD, et al. Continuous popliteal sciatic nerve block for postoperative pain control at home: a randomized, double-blinded, placebo-controlled study. Anesthesiology 2002;97(4):959–65.
38. O'Donnell D, Manickam B, Perlas A, et al. Spinal mepivacaine with fentanyl for outpatient knee arthroscopy surgery: a randomized controlled trial. Can J Anaesth 2009;57(1):32–8.
39. Merivirta R, Kuusniemi K, Jaakkola P, et al. Unilateral spinal anaesthesia for outpatient surgery: a comparison between hyperbaric bupivacaine and bupivacaine-clonidine combination. Acta Anaesthesiol Scand 2009;53(6):788–93.

40. Fanelli G, Danelli G, Zasa M, et al. Intrathecal ropivacaine 5 mg/ml for outpatient knee arthroscopy: a comparison with lidocaine 10 mg/ml. Acta Anaesthesiol Scand 2009;53(1):109–15.
41. Diallo T, Dufeu N, Marret E, et al. Walking in PACU after unilateral spinal anesthesia a criteria for hospital discharge: a 100 outpatient survey. Acta Anaesthesiol Belg 2009;60(1):3–6.
42. van Tuijl I, Giezeman MJ, Braithwaite SA, et al. Intrathecal low-dose hyperbaric bupivacaine-clonidine combination in outpatient knee arthroscopy: a randomized controlled trial. Acta Anaesthesiol Scand 2008;52(3):343–9.
43. Sell A, Tein T, Pitkanen M. Spinal 2-chloroprocaine: effective dose for ambulatory surgery. Acta Anaesthesiol Scand 2008;52(5):695–9.
44. Montes FR, Zarate E, Grueso R, et al. Comparison of spinal anesthesia with combined sciatic-femoral nerve block for outpatient knee arthroscopy. J Clin Anesth 2008;20(6):415–20.
45. Casati A, Fanelli G, Danelli G, et al. Spinal anesthesia with lidocaine or preservative-free 2-chlorprocaine for outpatient knee arthroscopy: a prospective, randomized, double-blind comparison. Anesth Analg 2007;104(4):959–64.
46. Boztug N, Bigat Z, Karsli B, et al. Comparison of ropivacaine and bupivacaine for intrathecal anesthesia during outpatient arthroscopic surgery. J Clin Anesth 2006;18(7):521–5.
47. Cappelleri G, Aldegheri G, Danelli G, et al. Spinal anesthesia with hyperbaric levobupivacaine and ropivacaine for outpatient knee arthroscopy: a prospective, randomized, double-blind study. Anesth Analg 2005;101(1):77–82.
48. Korhonen AM, Valanne JV, Jokela RM, et al. A comparison of selective spinal anesthesia with hyperbaric bupivacaine and general anesthesia with desflurane for outpatient knee arthroscopy. Anesth Analg 2004;99(6):1668–73.
49. Gurkan Y, Canatay H, Ozdamar D, et al. Spinal anesthesia for arthroscopic knee surgery. Acta Anaesthesiol Scand 2004;48(4):513–7.
50. Forssblad M, Jacobson E, Weidenhielm L. Knee arthroscopy with different anesthesia methods: a comparison of efficacy and cost. Knee Surg Sports Traumatol Arthrosc 2004;12(5):344–9.
51. Taniguchi M, Bollen AW, Drasner K. Sodium bisulfite: scapegoat for chloroprocaine neurotoxicity? Anesthesiology 2004;100(1):85–91.
52. Davis BR, Kopacz DJ. Spinal 2-chloroprocaine: the effect of added clonidine. Anesth Analg 2005;100(2):559–65.
53. Gonter AF, Kopacz DJ. Spinal 2-chloroprocaine: a comparison with procaine in volunteers. Anesth Analg 2005;100(2):573–9.
54. Kopacz DJ. Spinal 2-chloroprocaine: minimum effective dose. Reg Anesth Pain Med 2005;30(1):36–42.
55. Yoos JR, Kopacz DJ. Spinal 2-chloroprocaine: a comparison with small-dose bupivacaine in volunteers. Anesth Analg 2005;100(2):566–72.
56. Yoos JR, Kopacz DJ. Spinal 2-chloroprocaine for surgery: an initial 10-month experience. Anesth Analg 2005;100(2):553–8.
57. Kouri ME, Kopacz DJ. Spinal 2-chloroprocaine: a comparison with lidocaine in volunteers. Anesth Analg 2004;98(1):75–80.
58. Smith KN, Kopacz DJ, McDonald SB. Spinal 2-chloroprocaine: a dose-ranging study and the effect of added epinephrine. Anesth Analg 2004;98(1):81–8.
59. Kim SY, Cho JE, Hong JY, et al. Comparison of intrathecal fentanyl and sufentanil in low-dose dilute bupivacaine spinal anaesthesia for transurethral prostatectomy. Br J Anaesth 2009;103(5):750–4.

60. Gudaityte J, Marchertiene I, Karbonskiene A, et al. Low-dose spinal hyperbaric bupivacaine for adult anorectal surgery: a double-blinded, randomized, controlled study. J Clin Anesth 2009;21(7):474–81.
61. de Santiago J, Santos-Yglesias J, Giron J, et al. Low-dose 3 mg levobupivacaine plus 10 microg fentanyl selective spinal anesthesia for gynecological outpatient laparoscopy. Anesth Analg 2009;109(5):1456–61.
62. de Santiago J, Santos LJ, Giron J. Low-dose, low-concentration spinal anesthesia may help to detect surgery-related nerve injury. Acta Anaesthesiol Scand 2009; 53(9):1229–30.
63. Cuvas O, Gulec H, Karaaslan M, et al. The use of low dose plain solutions of local anaesthetic agents for spinal anaesthesia in the prone position: bupivacaine compared with levobupivacaine. Anaesthesia 2009;64(1):14–8.
64. Gurbet A, Turker G, Girgin NK, et al. Combination of ultra-low dose bupivacaine and fentanyl for spinal anaesthesia in out-patient anorectal surgery. J Int Med Res 2008;36(5):964–70.
65. Wassef MR, Michaels EI, Rangel JM, et al. Spinal perianal block: a prospective, randomized, double-blind comparison with spinal saddle block. Anesth Analg 2007;104(6):1594–6.
66. Korhonen AM. Use of spinal anaesthesia in day surgery. Curr Opin Anaesthesiol 2006;19(6):612–6.
67. Atallah MM, Shorrab AA, Abdel Mageed YM, et al. Low-dose bupivacaine spinal anaesthesia for percutaneous nephrolithotomy: the suitability and impact of adding intrathecal fentanyl. Acta Anaesthesiol Scand 2006;50(7):798–803.
68. Kaya M, Oguz S, Aslan K, et al. A low-dose bupivacaine: a comparison of hyperbaric and hypobaric solutions for unilateral spinal anesthesia. Reg Anesth Pain Med 2004;29(1):17–22.
69. Kararmaz A, Kaya S, Turhanoglu S, et al. Low-dose bupivacaine-fentanyl spinal anaesthesia for transurethral prostatectomy. Anaesthesia 2003;58(6):526–30.
70. Gupta A, Axelsson K, Thorn SE, et al. Low-dose bupivacaine plus fentanyl for spinal anesthesia during ambulatory inguinal herniorrhaphy: a comparison between 6 mg and 7. 5 mg of bupivacaine. Acta Anaesthesiol Scand 2003; 47(1):13–9.
71. Goel S, Bhardwaj N, Grover VK. Intrathecal fentanyl added to intrathecal bupivacaine for day case surgery: a randomized study. Eur J Anaesthesiol 2003;20(4): 294–7.
72. Coveney E, Weltz CR, Greengrass R, et al. Use of paravertebral block anesthesia in the surgical management of breast cancer: experience in 156 cases. Ann Surg 1998;227(4):496–501.
73. Kairaluoma PM, Bachmann MS, Rosenberg PH, et al. Preincisional paravertebral block reduces the prevalence of chronic pain after breast surgery. Anesth Analg 2006;103(3):703–8.
74. Exadaktylos AK, Buggy DJ, Moriarty DC, et al. Can anesthetic technique for primary breast cancer surgery affect recurrence or metastasis? Anesthesiology 2006;105(4):660–4.
75. Jensen P, Mikkelsen T, Kehlet H. Postherniorrhaphy urinary retention–effect of local, regional, and general anesthesia: a review. Reg Anesth Pain Med 2002; 27(6):612–7.
76. Sanchez B, Waxman K, Tatevossian R, et al. Local anesthetic infusion pumps improve postoperative pain after inguinal hernia repair: a randomized trial. Am Surg 2004;70(11):1002–6.

77. Hadzic A, Kerimoglu B, Loreio D, et al. Paravertebral blocks provide superior same-day recovery over general anesthesia for patients undergoing inguinal hernia repair. Anesth Analg 2006;102(4):1076–81.
78. Bisgaard T, Klarskov B, Kristiansen VB, et al. Multi-regional local anesthetic infiltration during laparoscopic cholecystectomy in patients receiving prophylactic multi-modal analgesia: a randomized, double-blinded, placebo-controlled study. Anesth Analg 1999;89(4):1017–24.
79. 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(3):682–8.
80. Naja MZ, Ziade MF, Lonnqvist PA. General anaesthesia combined with bilateral paravertebral blockade (T5-6) vs. general anaesthesia for laparoscopic cholecystectomy: a prospective, randomized clinical trial. Eur J Anaesthesiol 2004; 21(6):489–95.
81. El-Dawlatly AA, Turkistani A, Kettner SC, et al. Ultrasound-guided transversus abdominis plane block: description of a new technique and comparison with conventional systemic analgesia during laparoscopic cholecystectomy. Br J Anaesth 2009;102(6):763–7.
82. Alessandri F, Lijoi D, Mistrangelo E, et al. Effect of presurgical local infiltration of levobupivacaine in the surgical field on postsurgical wound pain in laparoscopic gynecological surgery. Acta Obstet Gynecol Scand 2006; 85(7):844–9.
83. Ostad A, Kageyama N, Moy RL. Tumescent anesthesia with a lidocaine dose of 55 mg/kg is safe for liposuction. Dermatol Surg 1996;22(11):921–7.
84. Cooter RD, Rudkin GE, Gardiner SE. Day case breast augmentation under paravertebral blockade: a prospective study of 100 consecutive patients. Aesthetic Plast Surg 2007;31(6):666–73.
85. Pacik PT, Nelson CE, Werner C. Pain control in augmentation mammaplasty using indwelling catheters in 687 consecutive patients: data analysis. Aesthet Surg J 2008;28(6):631–41.
86. Lu L, Fine NA. The efficacy of continuous local anesthetic infiltration in breast surgery: reduction mammaplasty and reconstruction. Plast Reconstr Surg 2005;115(7):1927–34 [discussion: 35–6].
87. Tiong HY, Liew LC, Samuel M, et al. A meta-analysis of local anesthesia for transrectal ultrasound-guided biopsy of the prostate. Prostate Cancer Prostatic Dis 2007;10(2):127–36.
88. Tangsiriwatthana T, Sangkomkamhang US, Lumbiganon P, et al. Paracervical local anaesthesia for cervical dilatation and uterine intervention. Cochrane Database Syst Rev 2009;(1):CD005056.
89. DeQuattro N, Hibbert M, Buller J, et al. Microlaparoscopic tubal ligation under local anesthesia. J Am Assoc Gynecol Laparosc 1998;5(1):55–8.
90. Moiniche S, Kehlet H, Dahl JB. A qualitative and quantitative systematic review of preemptive analgesia for postoperative pain relief: the role of timing of analgesia. Anesthesiology 2002;96(3):725–41.
91. Dahl JB, Moiniche S. Pre-emptive analgesia. Br Med Bull 2004;71:13–27.
92. Ong CK, Lirk P, Seymour RA, et al. The efficacy of preemptive analgesia for acute postoperative pain management: a meta-analysis. Anesth Analg 2005;100(3): 757–73.
93. Williams BA, Kentor ML, Vogt MT, et al. Femoral-sciatic nerve blocks for complex outpatient knee surgery are associated with less postoperative pain before

same-day discharge: a review of 1,200 consecutive cases from the period 1996-1999. Anesthesiology 2003;98(5):1206–13.
94. Armstrong KP, Cherry RA. Brachial plexus anesthesia compared to general anesthesia when a block room is available. Can J Anaesth 2004;51(1):41–4.
95. Mariano ER, Chu LF, Peinado CR, et al. Anesthesia-controlled time and turnover time for ambulatory upper extremity surgery performed with regional versus general anesthesia. J Clin Anesth 2009;21(4):253–7.
96. Fredrickson MJ, Ball CM, Dalgleish AJ. Successful continuous interscalene analgesia for ambulatory shoulder surgery in a private practice setting. Reg Anesth Pain Med 2008;33(2):122–8.
97. Mariano ER. Making it work: setting up a regional anesthesia program that provides value. Anesthesiol Clin 2008;26(4):681–92, vi.
98. Williams BA, Kentor ML. Making an ambulatory surgery centre suitable for regional anaesthesia. Best Pract Res Clin Anaesthesiol 2002;16(2):175–94.