BJA

Continuous peripheral nerve blocks in acute pain management

J. E. Chelly*, D. Ghisi and A. Fanelli

Division of Regional Anesthesia and Acute Interventional Perioperative Pain Service, Department of Anesthesiology, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

* Corresponding author. E-mail: chelje@anes.upmc.edu

Key points

- Continuous nerve blocks are useful for the management of postoperative and trauma pain in both the inpatient and ambulatory settings.
- Advantages of this technique include improved analgesia, early functional recovery and discharge from the hospital.
- Combined with thromboprophylaxis, this technique represents a safer alternative to epidural.
- The appropriate use of this technique does not increase the risk of falls.

Summary. The indications for continuous nerve blocks for the perioperative pain management in hospitalized and ambulatory patients have extended well beyond orthopaedics. These techniques are not only used to control pain in patients undergoing major upper and lower extremity surgery, but also to provide perioperative analgesia in patients undergoing abdominal, plastic, urological, gynaecological, thoracic, and trauma surgeries. Infusion regimens of local anaesthetics and supplements must take into consideration the condition of the patient before and after surgery, the nature and intensity of the surgical stress associated with the surgery, and the possible need for immediate functional recovery. Continuous nerve blocks have proved safe and effective in reducing opioid consumption and related side-effects, accelerating recovery, and in many patients reducing the length of hospital stay. Continuous nerve blocks provide a safer alternative to epidural analgesia in patients receiving thromboprophylaxis, especially with low molecular-weight heparin.

Keywords: acute pain; continuous nerve blocks; local anaesthetics; regional anaesthesia

Between 1 July, 2009 and 30 June, 2010, the UPMC (University of Pittsburgh Medical Center) Division of Regional Anesthesia and Acute Interventional Perioperative Pain Service performed more than 20 000 nerve blocks, including 5147 blocks performed with the use of ultrasound and 9287 continuous peripheral nerve blocks (CPNB's: 176 axillary for arm and hand surgery and interscalene for shoulder surgery; 1778 sciatic including 1475 gluteal blocks for total knee replacement and 303 popliteal blocks for foot and ankle surgery; 2143 femoral for total knee replacement and ACL repair; 1006 lumbar plexus for total hip replacement and 4184 paravertebral for thoracotomy, abdominal and pelvic surgery). This represents an increase of 21% from the previous year.

As early as 1946, Ansbro[1] proposed the use of a continuous supraclavicular nerve block technique to prolong the duration of analgesia and to optimize sensory block with minimal residual motor block. Today, these principles remain the basis of regional anaesthesia practice. Continuous peripheral nerve blocks are now mainly indicated for perioperative analgesia, whereas the vast majority of blocks performed for anaesthesia are single-shot blocks.

Historically, perineural catheters were placed for upper extremity blocks to allow prolonged infusion of local anaesthetic solutions.[2] Use of continuous peripheral nerve blocks for outpatient surgery[3–11] has recently become a worldwide trend.

The indications for continuous nerve blocks include perioperative pain management, pain management after trauma,[12] and even chronic pain.[13] Over the past 12 years,[14–16] continuous nerve blocks have gained significant popularity for acute postoperative pain management after major orthopaedic and thoracic surgery, for both inpatients and outpatients, in adults and children, especially in the context of a multimodal approach to postoperative pain treatment.

There is also increasing interest in peripheral nerve blocks because of potential anti-inflammatory[17] benefits and the concern over interactions of anticoagulants and central neuraxial techniques. However, recent guidelines on 'Regional anesthesia in the patient receiving antithrombotic or thrombolytic therapy'[18] have generated significant controversy.[19]

The aim of this review is to offer an updated overview about continuous peripheral nerve blocks as a useful tool in the treatment of acute postoperative pain after elective surgery, trauma, or both.

Advantages of the use of continuous peripheral nerve blocks for the management of perioperative pain

It is well established that the quality of patient's immediate functional recovery after total knee and hip replacement is

directly related to the quality of the postoperative pain management.[20 21] This is best illustrated in patients who underwent minimally invasive surgery.[22–25] Continuous lumbar plexus block in combination with a multimodal approach has led to the feasibility of discharging patients home within 24 h after total hip replacement.[25 26]

In addition to the humanitarian and economical aspects of effective pain management, the use of continuous nerve block provides better postoperative pain control than systemic patient-controlled analgesia (PCA),[27–29] reduces the need for opioids and their related complications, allows earlier mobilization and functional recovery, shortens hospital stay and rehabilitation centre,[7 8] and improves sleep.[3] Most studies agree that opioid consumption is decreased by 40–70% when continuous nerve blocks are used when compared with PCA alone.

Another significant advantage of the use of continuous nerve blocks in the ambulatory patient is that this technique decreases the frequency of unanticipated admissions and re-admissions after same-day surgery and their associated costs.[30]

Indications

Approaches and local anaesthetics

Several techniques have been proposed for the placement of perineural catheters. They include blind techniques as is the case with the placement of a catheter in the psoas compartment and the paravertebral space. Although paraesthesia was a predominant technique in the past, for the past 20 yr the use of neurostimulation represented the predominant approach with or without the use of a stimulating catheter.[31] Recently, the use of ultrasound-guided techniques, alone or in combination with a neurostimulation approach, has been advocated (e.g. for femoral, gluteal, popliteal, upper extremity, and thoracic paravertebral blocks). Comparison of these techniques supports the concept that the use of an ultrasound-guided technique reduces the time necessary for the placement of the perineural catheter and reduces vascular punctures, need for opioids, and the volume of local anaesthetics.[32–35]

Several local anaesthetics have been infused including bupivacaine, ropivacaine, levobupivacaine, and lidocaine. Use of lidocaine in orthopaedics has been limited as it does not produce a preferential sensory block.[36] Various concentrations, rates of infusion, and modes of administration have been described (continuous, patient-controlled, a combination of both, and bolus only).[37 38] It is very difficult to advocate a single standard protocol for all patients that takes into consideration the site of infusion, the pharmacokinetics of local anaesthetic, type of surgery being performed, additional administration of analgesics, need for functional recovery in orthopaedic procedures, and expected length of stay in the hospital. For example, although ropivacaine is usually infused at a concentration of 0.2%, concentrations as low as 0.1% or as high as 0.5% have been proposed. Brodner and colleagues[39] demonstrated that 0.1%

ropivacaine was not effective and that 0.2% and 0.3% ropivacaine were required at a rate of 15 ml h^{-1}. It appears that the amount, not the concentration or infusion rate, represents the most important determinant.[40]

The value of additives such as clonidine[41] and morphine[42] to continuous perineural infusions is controversial and has yet to be established.

The indications for continuous nerve blocks include major orthopaedic procedures, such as shoulder surgery, upper and lower extremity trauma, upper and lower extremity re-implantation procedures, shoulder, elbow, hip, knee and ankle arthroplasty, and prolonged upper and lower extremity physical therapy, plastic, breast, thoracic, urological, abdominal, pelvic surgery, and multiple rib fractures (Table 1).

Joint replacement

Total hip replacement

Several groups have demonstrated the safety and efficacy of continuous lumbar plexus block for perioperative management of total hip replacement.[43–47] This technique has proved more effective than continuous femoral blocks and i.v. hydromorphone PCA.[48] Although continuous femoral nerve blocks have been proposed for the management of pain after total hip replacement,[49] evidence favours the use of lumbar plexus block.[35]

Total knee replacement

Several continuous nerve block techniques have been proposed for the management of perioperative pain after total knee replacement including continuous femoral block and continuous lumbar plexus block.[38–42] The use of sciatic nerve blocks has also been proposed.[50–55] Combined continuous femoral and sciatic block represents an interesting alternative approach compared with an epidural block.[53–54]

Total ankle replacement

Continuous sciatic block is indicated for the perioperative management of pain after total ankle replacement. Although the sciatic nerve can be approached at various levels according to patient anatomy and mobility, a lateral or a posterior popliteal approach is often used.

Total shoulder replacement

Continuous interscalene block[56] represents the technique of choice in these cases.

Total elbow replacement

Continuous infraclavicular block[57] has been reported to provide effective perioperative analgesia for patients undergoing total elbow replacement.

Ambulatory surgery

The use of continuous nerve blocks in patients undergoing ambulatory (day case) procedures has expanded considerably in the past few years. Indications include major upper

Table 1 Indications for continuous nerve blocks in orthopaedic procedures and trauma

Surgical procedure/ trauma	Continuous block	Suggested infusion
Total shoulder arthroplasty, shoulder hemiarthroplasty, rotator cuff repair, shoulder arthrodesis, 'frozen' shoulder PT, biceps surgery, proximal humerus fractures	Interscalene	Initial bolus: 20 ml ropivacaine 0.5%; continuous infusion: 5–10 ml h^{-1} ropivacaine 0.2%
Distal humerus fractures, elbow arthroplasty, elbow arthrodesis, radius fractures and surgery, ulna fractures and surgery, wrist arthrodesis, re-implantation surgery, major upper limb trauma	Supraclavicular, infraclavicular, axillary	Initial bolus: 20 ml ropivacaine 0.5%; continuous infusion: 5–10 ml h^{-1} ropivacaine 0.2%
Unilateral: thoracotomy and major breast surgery (T4–5), rib fractures, nephrectomy (T7) Bilateral: laparotomy (T8), cystectomy (T10)	Thoracic paravertebral	Initial bolus: 15 ml per catheter ropivacaine 0.5%; continuous infusion: 5–10 ml h^{-1} ropivacaine 0.2% per catheter
Primary total hip arthroplasty, revision THA, femur fractures	Lumbar plexus	Initial bolus: 20 ml ropivacaine 0.2–0.5%; continuous infusion: 5–10 ml h^{-1} ropivacaine 0.2%;
Femur fractures, anterior cruciate ligament reconstruction, patella repair, total knee arthroplasty, knee active and passive PT	Femoral nerve	initial bolus: 20 ml ropivacaine 0.2–0.5%; continuous infusion: 5–10 ml h^{-1} ropivacaine 0.2%
Total knee arthroplasty, posterior cruciate ligament reconstruction	Femoral + sciatic (parasacral or gluteal or subgluteal approach)	Initial bolus (after foot dorsi-flexion has been checked): 6–12 ml ropivacaine 0.2%; continuous infusion: 3–8 ml h^{-1} ropivacaine 0.1–0.2%
Tibia fracture and surgery, fibula fracture and surgery, ankle fusion, subtalar fusion, total ankle arthroplasty, hallux valgus repair	Sciatic (anterior or gluteal or subgluteal or lateral popliteal approach)	Initial bolus (after foot active dorsi-flexion has been checked): 5–10 ml ropivacaine 0.2–0.5%; continuous infusion: 5–10 ml h^{-1} ropivacaine 0.1–0.2%
Ankle fusion; total ankle arthroplasty	Femoral or saphenous + sciatic	Initial bolus: 20 ml ropivacaine 0.2%; continuous infusion: 5–10 ml h^{-1} ropivacaine 0.1%

and lower extremity and breast surgery. Recently, the ability to perform joint replacement as an ambulatory procedure has created additional opportunities.

Upper extremity surgery

For major shoulder surgeries many favour continuous inter-scalene block.[58 59] Ultrasound-guided continuous posterior interscalene block provided superior postoperative analgesia, minimized supplemental opioid requirements, and improved sleep quality when compared with a single-injection ropiva-caine interscalene block after shoulder surgery.[60]

For major surgeries below the shoulder, supraclavicular, infraclavicular,[61] or axillary approaches[62] are safe and effective for intra-operative anaesthesia, especially with the advent of ultrasound guidance. The infraclavicular approach to brachial plexus catheterization allows longer stability of in-dwelling catheters with less patient discomfort. Tunnelling supraclavicular and axillary blocks subcutaneously helps prevent catheter dislocation.[63]

Lower extremity surgery

Indications for lower extremity continuous nerve blocks vary according to the procedure.[64] In most cases, patients are discharged home with only one perineural catheter: either a femoral[34] or lumbar plexus catheter after surgery of the thigh, knee, or both or a popliteal sciatic catheter[65 66] after foot and ankle surgery.

Thoracic, abdominal, pelvic, and urological surgery

Continuous paravertebral blocks have been shown to be highly effective for postoperative pain management in patients undergoing breast, thoracic, abdominal, pelvic, and urological surgery.[67–71] Use of a continuous technique has been shown to be superior to single blocks in patients undergoing thoracic surgery.[72] Continuous paravertebral nerve blocks provided better pain at rest and during coughing, less opioid consumption, superior pulmonary function, and were associated with less nausea and hypotension than epidural analgesia.[73–76] Contraindications to thoracic epidural analgesia such as thromboprophylaxis do not preclude the use of a paravertebral block. For thoracic and breast surgery, a unilateral paravertebral catheter is placed at the level of T4. Other indications for a unilateral paravertebral catheter include complete or partial nephrectomy (T8) or liver surgery (T6) with a lateral surgical approach. Bilateral placement of paravertebral catheters is used to satisfy the surgical requirement in cases involving colon resection, abdominal debulking, pancreatectomy, liver resection, cystectomy, and hysterectomy with node dissection at levels T8–T10 depending on the indications.

Trauma

Continuous nerve blocks represent an interesting alternative in managing pain in the trauma patient.[77–79] Trauma patients often require multiple perineural catheters to

provide optimal long-lasting analgesia. Continuous nerve block techniques have been successfully used in military medical care for treating soldiers wounded in combat.

Before performing blocks in trauma patients, it is important to perform a complete neurological examination to document sensory impairments, motor impairments, or both. A pre-existing neurological injury does not represent an absolute contraindication to performing a block, but documentation can provide important medico-legal evidence for future discussion regarding the origin of a nerve injury.

Upper extremity trauma

The choice of the type of continuous nerve blocks being performed depends on the location of the injury and the expected duration of the infusion.[12 80] Interscalene, supraclavicular, and axillary catheters are difficult to be maintained in place for more than a couple of days. If necessary one can tunnel the catheter in order to keep it in place and reduce the risk of infection. In trauma patients, the sympathetectomy associated with the use of continuous nerve blocks is probably beneficial for revascularization, and re-implantation procedures, or in cases where blood flow is compromised.

Patients with upper humerus fractures can develop compression syndromes, a condition considered to be an emergency as it can lead to an irreversible injury of the radial nerve. If a continuous brachial plexus block is performed to provide analgesia for an upper humerus fracture, the rate of infusion should be kept as low as possible to provide sensory but no motor block. If pain that had been controlled should suddenly increase, an orthopaedic consult should be obtained to rule out compression syndrome. An increase in the rate of infusion might control the pain but would not facilitate early diagnosis of compression syndrome.

Lower extremity trauma

Regional anaesthesia of the lower extremity usually includes lumbar plexus block and sacral plexus block at different sites. These nerve block procedures are superior to morphine PCA in providing analgesia for lower extremity trauma,[81 82] and are considered safer than epidural, as many of these patients receive thromboprophylaxis with low molecular-weight heparin.

Depending on the site of injury, either lumbar plexus/femoral or sacral plexus/sciatic blocks or both might be required to provide adequate analgesia. For example, acetabular or femoral neck injury might require only a lumbar plexus block, whereas knee/patellar injuries and ankle injuries require both femoral and sciatic nerve blocks.

When a continuous sciatic block is performed to control the pain of a patient with a tibial plateau fracture, one should provide a sensory block with no motor block to assure that the diagnosis of a compression syndrome is not missed.

Chest trauma

Rib fractures are the most common thoracic injuries with an incidence ranging from 10% to almost 30% in patients after trauma.[83] The mortality rate of patients with rib fractures ranges from 5.8% (single rib fracture) to 34.4% (multiple rib fractures) with an overall rate of 10%. Pain associated with rib fractures usually impairs pulmonary function and increases pulmonary morbidity. Appropriate, timely pain management should be a core intervention in managing these patients.

Epidural analgesia has been considered the gold standard for the management of pain after multiple rib fractures.[84] The increased use of enoxaparin for thromboprophylaxis has limited the use of this technique. Continuous paravertebral blocks represent an interesting alternative, and have been shown to be equi-effective when compared with epidural, continuous paravertebral blocks that produce similar improvements in respiratory function. The use of paravertebral blocks is associated with less hypotension[85] and lower risk of epidural haematoma even when used with enoxaparin.

Over the past few years consideration has been given to the use of wound[86–92] and intra-articular infusion of local anaesthetics[93–97] as an alternative to the use of continuous nerve blocks. However, these blocks are not effective when used in major surgery.[98] Although this technique has been shown to be better than a single block,[99] it has been shown to be less efficacious than continuous nerve blocks.[100–103] Use of a continuous peripheral nerve block technique is associated with less opioid consumption and better recovery at 6 weeks than peri-articular infiltration.[103] In addition, the intra-articular infusion of local anaesthetics can produce chondrolysis.[104 105]

Anticoagulation and continuous nerve blocks

Thrombolytic and antithrombotic therapy and continuous nerve blocks

This is a controversial topic. The most recent ASRA guidelines[17] on regional anaesthesia in patients receiving antithrombotic or thrombolytic therapy recommend applying the same guidelines to deep and plexus blocks as for neuraxial blocks. These recommendations apply to the concomitant administration of thrombolytic therapy, antithrombotic therapy, or both in patients benefiting from blocks and are based on a very small number of case reports. These recommendations are complicated by a number of issues. Haematoma after the performance of nerve blocks has been reported even in the absence of administration of anticoagulation.[106–116] Even in the hands of an expert, vascular punctures occur frequently during the performance of blocks.[109] Retroperitoneal haematoma is an established complication of both hip surgery[117] and thrombolytic therapy.[118–120] Frequently, the clinician is faced with the question of what to do in the case of concomitant administration of thromboprophylaxis (not *thrombolytic* or *antithrombotic* therapy). This distinction is important because the prevention of deep venous thrombosis and pulmonary thrombosis requires

doses of anticoagulant far lower than those used for therapeutic indications.

Table 2 presents bleeding complications and the conditions surrounding these events and their relationship to the use of thrombotic therapy, antithrombotic therapy,[116] [121–127] and thromboprophylaxis. Two patients reported to have renal subcapsular bleeding underwent lumbar plexus blocks at the level of L3. Neither patient received anticoagulant nor anti-inflammatory drugs before they became symptomatic. Major bleeding has been reported in two patients receiving lumbar sympathetic block together with irreversible platelet-aggregation inhibitors, which led to the death of one patient.[123]

Thromboprophylaxis and continuous nerve blocks

Although certain trauma and surgical patients benefit from the administration of thromboprophylaxis for the prevention of deep venous thrombosis and pulmonary embolism, reports of simultaneous thromboprophylaxis and continuous nerve block are very limited.

We have not observed any major bleeding complications when using the following guidelines:[128]

(1) Blocks are performed 12 h after the last dose of enoxaparin and 24 h after the last dose of fondaparinux when used for thromboprophylaxis in patients with an INR<2.0.

(2) Thromboprophylaxis can be initiated after the block is performed.

(3) The perineural catheter can be removed regardless of the drug used for thromboprophylaxis based on the analgesic requirement without consideration for the INR[129] or the type of thromboprophylaxis and its timing.

This approach has been supported in a recent publication[130] that found no major bleeding in 3588 patients who underwent joint replacement (50.2% knee arthroplasty and 49.8% hip arthroplasty) and 6935 blocks in patients receiving thromboprophylaxis. Similar data have been reported with a combination of continuous paravertebral blocks and enoxaparin.[131]

Continuous nerve blocks and falls

Based on anecdotal case reports, small series, or both, it has been claimed that the use of continuous femoral blocks increases the risk of falls in patients undergoing lower extremity orthopaedic surgery.[132–134] Data obtained from 33 328 patients have instead demonstrated that patients with continuous nerve blocks do not fall more frequently than either patients without blocks or other surgical patients.[135] [136] In considering the risk for falls, it is important to take into consideration the concentration of local anaesthetic and the rate of infusion. It is also important to recognize the role played by the preoperative conditions of the

Table 2 Major bleeding after the performance of blocks, administration of antithrombotic, thrombolytic therapy and thromboprophylaxis (number of haematoma). *Complications developing after a blind ilioinguinal/hypogastric block. †One patient died

	No block	Block thrombolytic therapy	Block thrombolytic therapy	Block antithrombotic	Block thromboprophylaxis
Vascular trauma					
Renal subscapular haematoma (lumbar sympathetic block [1]; lumbar plexus [2]	(3)[106] [107]				
Upper extremity haematoma	(2)[108] [109]				
Airway obstruction	(1)[110]				
Prolonged Horner syndrome	(1)[111]				
Pulmonary haemorrahage	(1)[112]				
Small bowel obstruction*	(2)[113] [114]				
Haemoperitoneum*	(1)[115]				
Chest haematoma (with heparin overdose)		(1)[124]			
Retroperitoneal haematoma		(2)[118] [119]			
Femoral blocks					(1)[120]
Pudental block	(1)[116]				
Lumbar plexus sympathetic blocks				(2)[123]†	(1)[121]
With heparin overdose			(1)[122]		
Uncertain origin					
Lumbar plexus and femoral block					(1)[125]
Hip surgery, lumbar plexus, and femoral block					(1)[126]
Very elderly and lumbar plexus					(1)[122]
Major bleeding					
Continuous femoral block					(2)[127]
Continuous superficial sciatic block					(1)[127]

patient (preoperative quadriceps weakness, muscle atrophy, confusion, etc.), surgical technique and the perioperative use of opioids, anti-inflammatory drugs, and sedatives. For example, during total knee replacement, the insertion of the quadriceps muscle to the femur is partly sectioned, which results in mechanical weakness totally independent of the infusion of local anaesthetics. Patients undergoing total knee replacement are at a three-fold higher risk of fall than patients undergoing total hip replacement.[136] It is also critical to recognize that more than 20% of patients fall before a knee replacement.[137]

Complications

Complications associated with perineural catheter placement or maintenance are uncommon[138] (see accompanying review in this issue by Jeng and colleagues).[139] They include local anaesthetic toxicity owing to intravascular placement of the catheter or over-dosage owing to accumulation or intravascular catheter migration. Other complications include bleeding, nerve injury, and infection. In rare instances, the use of this technique can mask the pain resulting from a nerve injury/compression (sciatic injury associated with tibial plateau fracture, radial injury associated with high humeral fracture, sciatic compression in the popliteal fossa after knee replacement), rhabdomyolysis, and consequently can result in delayed diagnosis. In these situations, it should be recognized that pain is not the only warning sign, whereas careful examination of the patient, especially when pain suddenly increases, can help in establishing an early diagnosis.

Infection

Despite the fact that evidence supports the concept that perineural catheters are often colonized,[140 141] abscess at the site of the perineural catheter and septicaemia are very rare with continuous nerve blocks. Even though the incidence of perineural catheter infection is postulated to be very low, its real incidence has not been established.[142 143] Factors explaining this concept include short duration of perineural infusions and the frequent use of antibiotic therapy in major orthopaedic surgery. This observation might explain reports of infections related to the use of continuous nerve block in patients who have undergone ambulatory surgery.[144–148] There is also evidence that local anaesthetic solutions are bacteriostatic.[149] Established risk factors include local inflammation, patients in intensive care units, sex, absence of prophylactic antibiotics, diabetes mellitus, femoral and axillary catheters, and duration of infusion beyond 48 h.[143]

In case of infection, the perineural catheter should be removed and appropriate antibiotics should be given.

Nerve injury

Nerve injury after the performance of a continuous nerve block is a rare event.[150–152] Whether or not ultrasound guidance can reduce the frequency of nerve injury associated

with peripheral nerve blocks remains to be established. In the context of trauma and surgery, it is often difficult to determine whether the cause of the nerve injury is a direct result of the trauma, compression owing to positioning of the tourniquet, or to traction of the nerve. Often the block is unfairly implicated in the nerve injury. Frequently, transient neurological damage is reported.[150–152] Local anaesthetics might play a role as these reports are more frequent with bupivacaine than with ropivacaine.[153]

Serious plexus injuries have been reported with the performance of paravertebral block at the cervical, thoracic, and lumbar levels. While the exception, such injuries can represent a devastating complication including irreversible neurological damage with extensive epidural/subdural or total spinal anaesthesia blocks or in some cases paraplegia, quadriplegia, and death.[59]

Failure to provide adequate pain control and the ability of the catheter to remain in place for the indicated period of time are considered by some as possible complications. The reported success rate varies between 70% and 90–100% for different blocks and approaches. Finally, while it is an exceptional occurrence, rupture of the catheter has been reported[120] and the surgical requirement for a removal of the perineural catheter[5 154] and even in one case a catheter was left in place.[155]

Conclusions

Continuous nerve blocks represent an important therapeutic tool in managing perioperative pain and trauma pain. They have been proved safe and effective, especially when combined with a multimodal approach to pain management.

Conflicts of interest

None declared.

Funding

References

1 Ansbro FP. A method of continuous brachial plexus block. *Am J Surg* 1946; **71**: 716–22

2 Selander D. Catheter technique in axillary plexus block. *Acta Anaesthesiol Scand* 1977; **21**: 324–9

3 Klein S.M. Beyond the hospital: continuous peripheral nerve blocks at home. *Anesthesiology* 2002; **96**: 1283–5

4 Ilfeld BM, Morey TE, Wang RD, Enneking FK. Continuous popliteal sciatic nerve block for postoperative pain control at home: a randomized, double-blinded, placebo-controlled study. *Anesthesiology* 2002; **97**: 959–65

5 Ilfeld BM, Morey TE, Enneking FK. Continuous infraclavicular brachial plexus block for postoperative pain control at home: a randomized double blinded placebo controlled study. *Anesthesiology* 2002; **96**: 1297–304

6 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 1200 consecutive cases from 1996–1999. *Anesthesiology* 2003; **98**: 1206–13

7   Klein SM, Pietrobon R, Nielsen KC, Warner DS, Greengrass RA, Steele SM. Peripheral nerve blockade with long-acting local anaesthetics: a survey of the Society for Ambulatory Anaesthesia. *Anesth Analg* 2002; **94**: 71–6

8   Klein SM, Evans H, Nielsen KC, Tucker MS, Warner DS, Steele SM. Peripheral nerve block techniques for ambulatory surgery. *Anesth Analg* 2005; **101**: 1663–76

9   O'Donnell BD, Iohom G. Regional anaesthesia techniques for ambulatory orthopedic surgery. *Curr Opin Anaesthesiol* 2008; **21**: 723–8

10 Ludot H, Berger J, Pichenot V, Belouadah M, Madi K, Malinovsky JM. Continuous peripheral nerve block for postoperative pain control at home: a prospective feasibility study in children. *Reg Anesth Pain Med* 2008; **33**: 52–6

11 Ivani G, Mossetti V. Continuous central and perineural infusions for postoperative pain control in children. *Curr Opin Anaesthesiol* 2010; **23**: 637–42

12 Plunkett AR, Brown DS, Rogers JM, *et al.* Supraclavicular continuous peripheral nerve block in a wounded soldier: when ultrasound is the only option. *Br J Anaesth* 2006; **97**: 715–7

13 Dadure C, Motais F, Ricard C, Raux O, Troncin R, Capdevila X. Continuous peripheral nerve blocks at home for treatment of recurrent complex regional pain syndrome I in children. *Anesthesiology* 2005; **102**: 387–91

14 Singelyn FJ, Deyaert M, Joris D, Pendeville E, Gouverneur JM. Effects of intravenous patient-controlled analgesia with morphine, continuous epidural analgesia, and continuous three-in-one on postoperative pain and knee rehabilitation after unilateral total knee arthroplasty. *Anesth Analg* 1998; **87**: 88–92

15 Capdevila X, Barthelet Y, Biboulet P, Ryckwaert Y, Rubenovitch J, d'Athis F. Effects of peri-operative analgesic technique on the surgical outcome and duration of rehabilitation after major knee surgery. *Anesthesiology* 1999; **19**: 8–15

16 Chelly JE, Greger J, Gebhard R, *et al.* Continuous femoral blocks improve recovery and outcome of patients undergoing total knee arthroplasty. *J Arthroplasty* 2001; **16**: 436–45

17 Martin F, Martinez V, Mazoit JX, *et al.* Anti-inflammatory effect of peripheral nerve blocks after knee surgery: clinical and biologic evaluation. *Anesthesiology* 2008; **109**: 484–90

18 Horlocker TT, Wedel DJ, Rowlingson JC, *et al.* Regional anaesthesia in the patient receiving antithrombotic or thrombolytic therapy. American Society of Regional Anaesthesia and Pain Medicine Evidence-Based Guidelines (third edition). *Reg Anesth Pain Med* 2010; **35**: 64–101

19 Chelly JE. The most recent recommendations for "deep block" and thromboprophylaxis. Evidence not supporting a thromboprophylaxis therapeutic window. *Reg Anesth Pain Med* 2010; **35**: 402

20 Munin M, Rudy T, Glynn N, Crossett L, Rubash H. Early inpatient rehabilitation after elective hip and knee arthroplasty. *JAMA* 1998; **279**: 847–52

21 Wu CL, Rowlingson AJ, Partin AW, *et al.* Correlation of postoperative pain to quality of recovery in the immediate postoperative period. *Reg Anesth Pain Med* 2005; **30**: 516–22

22 Chelly JE, Ben-David B, Williams BA, Kentor ML. Anaesthesia and postoperative analgesia: effect on patient and provider outcomes following orthopedic surgery. *Orthopedics* 2003; **26**: s865–71

23 Berger RA, Jacobs JJ, Meneghini RM, Della Valle C, Paprosky W, Rosenberg AG. Rapid rehabilitation and recovery with minimally invasive total hip arthroplasty. *Clin Orthop Relat Res* 2004; **429**: 239–47

24 Buvanendran A, Tuman KJ, McCoy DD, Matusic B, Chelly JE. Anesthetic techniques for minimally invasive total knee arthroplasty. *J Knee Surg* 2006; **19**: 133–6

25 Mears DC, Mears SC, Chelly JE, Dai F, Vulakovich KL. THA with a minimally invasive technique, multi-modal anaesthesia, and home rehabilitation: factors associated with early discharge. *Clin Orthop Relat Res* 2009; **467**: 1412–7

26 Ilfeld BM, Gearen PF, Enneking FK, *et al.* Total hip arthroplasty as an overnight-stay procedure using an ambulatory continuous psoas compartment nerve block: a prospective feasibility study. *Reg Anesth Pain Med* 2006; **31**: 113–8

27 Richman JM, Liu SS, Courpas G, *et al.* Does continuous peripheral nerve block provide superior pain control to opioids? A meta-analysis. *Anesth Analg* 2006; **102**: 248–57

28 Macfarlane AJR, Prasad GA, Chan VWS, Brull R. Does regional anaesthesia improve outcome after total hip arthroplasty? A systematic review. *Br J Anaesth* 2009; **103**: 335–45

29 Shum CF, Lo NN, Yeo SJ, Yang KY, Chong HC, Yeo SN. Continuous femoral nerve block in total knee arthroplasty: immediate and two-year outcomes. *J Arthroplasty* 2009; **24**: 204–9

30 Coley KC, Williams BA, DaPos SV, Chen C, Smith RB. Retrospective evaluation of unanticipated admissions and readmissions after same day surgery and associated costs. *J Clin Anesth* 2002; **14**: 349–53

31 Casati A, Fanelli G, Baciarello M, Fanelli A, Ghisi D, Chelly JE. Stimulating or conventional perineural catheters after hallux valgus repair: a double blind, pharmaco-economic evaluation. *Acta Scand* 2006; **50**: 1284–9

32 Tran de QH, Munoz L, Russo G, *et al.* Ultrasonography and stimulating perineural catheters for nerve blockade: a review of evidence. *Can J Anaesth* 2008; **55**: 447–57

33 Mariano ER, Loland VJ, Sandhu NS, *et al.* Ultrasound guidance vs. electrical stimulation for femoral perineural catheter insertion. *J Ultrasound Med* 2009; **28**: 1453–60

34 Fredrickson MJ, Danesh-Clough TK. Ambulatory continuous femoral analgesia for major knee surgery: a randomised study of ultrasound-guided femoral catheter placement. *Anaesth Intensive Care* 2009; **37**: 758–66

35 Aveline C, Le Roux A, Le Hetet H, Vautier P, Cognet F, Bonnet F. Postoperative efficacies of femoral nerve catheters sited using ultrasound combined with neurostimulation compared to neurostimulation alone for total knee arthroplasty. *Eur J Anaesthesiol* 2010; **27**: 978–84

36 Casati A, Vinciguerra F, Scarioni M, *et al.* Lidocaine vs. ropivacaine for continuous interscalene brachial plexus block after open shoulder surgery. *Acta Anaesthesiol Scand* 2003; **47**: 355–60

37 Ilfeld BM, Morey TE, Enneking FK. Infraclavicular perineural local anesthetic infusion: a comparison of three dosing regimens for postoperative analgesia. *Anesthesiology* 2004; **100**: 395–402

38 Ng HP, Cheong KF, Lim A, Lim J, Puhaindran ME. Intraoperative single-shot 3-in-1 femoral nerve block with ropivacaine 0.25%, ropivacaine 0.5% or bupivacaine 0.25% provides comparable 48 h analgesia after unilateral total knee replacement. *Can J Anaesth* 2001; **48**: 1102–8

39 Brodner G, Buerkle H, Van Aken H, *et al.* Postoperative analgesia after knee surgery: a comparison of three different

concentrations of ropivacaine for continuous femoral nerve blockade. *Anesth Analg* 2007; **105**: 256–62

40 Ilfeld BM, Moeller LK, Mariano ER, *et al.* Continuous peripheral nerve blocks: is local anesthetic dose the only factor, or do concentration and volume influence infusion effects as well? *Anesthesiology* 2010; **112**: 347–54

41 Casati A, Vinciguerra F, Cappelleri G, *et al.* Adding clonidine to the induction bolus and postoperative infusion during continuous femoral nerve block delays recovery of motor function after total knee arthroplasty. *Anesth Analg* 2005; **100**: 866–72

42 Crews JC, Hord AH, Denson DD, Schatzman C. A comparison of the analgesic efficacy of 0.25% levobupivacaine combined with 0.005% morphine, 0.25% levobupivacaine alone, or 0.005% morphine alone for the management of postoperative pain in patients undergoing major abdominal surgery. *Anesth Analg* 1999; **89**: 1504–9

43 Chelly JE, Ben-David B, Mears D. Anaesthesia and acute pain management for minimally invasive hip surgery. *Tech Reg Anesth Pain Manage* 2004; **8**: 70–75

44 Siddiqui ZI, Cepeda MS, Denman W, Schumann R, Carr DB. Continuous lumbar plexus block provides improved analgesia with fewer side effects compared to systemic opioids after hip arthroplasty: a randomized controlled trial. *Reg Anesth Pain Med* 2007; **32**: 393–8

45 Marino J, Russo J, Herenstein R, Kenny M, Chelly JE. Continuous psoas compartment block vs. continuous femoral block or PCA for total hip arthroplasty. *J Bone Joint Surg Am* 2009; **91**: 29–37

46 Becchi C, Al Malyan M, Coppini R, Campolo M, Magherini M, Boncinelli S. Opioid-free analgesia by continuous psoas compartment block after total hip arthroplasty. A randomized study. *Eur J Anaesthesiol* 2008; **25**: 418–23

47 Biboulet P, Morau D, Aubas P, Bringuier-Branchereau S, Capdevila X. Postoperative analgesia after total-hip arthroplasty: comparison of intravenous patient-controlled analgesia with morphine and single injection of femoral nerve or psoas compartment block. A prospective, randomized, double-blind study. *Reg Anesth Pain Med* 2004; **29**: 102–9

48 Touray ST, de Leeuw MA, Zuurmond WW, Perez RS. Psoas compartment block for lower extremity surgery: a meta-analysis. *Br J Anaesth* 2008; **101**: 750–60

49 Singelyn FJ, Vanderelst PE, Gouverneur JM. Extended femoral nerve sheath block after total hip arthroplasty: continuous vs. patient-controlled techniques. *Anesth Analg* 2001; **92**: 455–9

50 Mansour NY, Bennetts FE. An observational study of combined continuous lumbar plexus and single-shot sciatic nerve blocks for post-knee surgery analgesia. *Reg Anesth* 1996; **21**: 287–91

51 Ben-David B, Schmalenberger K, Chelly JE. Analgesia after total knee arthroplasty: is continuous sciatic blockade needed in addition to continuous femoral blockade? *Anesth Analg* 2004; **98**: 747–9

52 Morin AM, Kratz CD, Eberhart LH, *et al.* Postoperative analgesia and functional recovery after total-knee replacement: comparison of a continuous posterior lumbar plexus (psoas compartment) block, a continuous femoral nerve block, and the combination of a continuous femoral and sciatic nerve block. *Reg Anesth Pain Med* 2005; **30**: 434–45

53 Zaric D, Boysen K, Christiansen C, Christiansen J, Stephensen S, Christensen B. A comparison of epidural analgesia with combined continuous femoral-sciatic nerve blocks after total knee replacement. *Anesth Analg* 2006; **102**: 1240–6

54 Raimer C, Priem K, Wiese AA, *et al.* Continuous psoas and sciatic block after knee arthroplasty: good effects compared to epidural analgesia or i.v. opioid analgesia: a prospective study of 63 patients. *Acta Orthop* 2007; **78**: 193–200

55 McLeod GA, Dale J, Robinson D, *et al.* Determination of the EC50 of levobupivacaine for femoral and sciatic perineural infusion after total knee arthroplasty. *Br J Anaesth* 2009; **102**: 528–33

56 Ilfeld BM, Vandenborne K, Duncan PW, *et al.* Ambulatory continuous interscalene nerve blocks decrease the time to discharge readiness after total shoulder arthroplasty: a randomized, triple-masked, placebo-controlled study. *Anesthesiology* 2006; **105**: 999–1007

57 Ilfeld BM, Wright TW, Enneking FK, Vandenborne K. Total elbow arthroplasty as an outpatient procedure using a continuous infraclavicular nerve block at home: a prospective case report. *Reg Anesth Pain Med* 2006; **31**: 172–6

58 Le LT, Loland VJ, Mariano ER, *et al.* PAINfRE Investigators. Effects of local anesthetic concentration and dose on continuous interscalene nerve blocks: a dual-center, randomized, observer-masked, controlled study. *Reg Anesth Pain Med* 2008; **33**: 518–25

59 Boezaart AP, Lucas SD, Elliott CE. Paravertebral block: cervical, thoracic, lumbar, and sacral. *Curr Opin Anaesthesiol* 2009; **22**: 637–43

60 Mariano ER, Afra R, Loland VJ, *et al.* Continuous interscalene brachial plexus block via an ultrasound-guided posterior approach: a randomized, triple-masked, placebo-controlled study. *Anesth Analg* 2009; **108**: 1688–94

61 Mariano ER, Loland VJ, Bellars RH, *et al.* Ultrasound guidance vs. electrical stimulation for infraclavicular brachial plexus perineural catheter insertion. *J Ultrasound Med* 2009; **28**: 1211–8

62 Pourtales MC, Kuntzmann H, Bertrand F, Pottecher T, Gouzou S, Liverneaux P. Continuous at-home postoperative analgesia using a catheter in the case of hand surgery: preliminary study about 40 cases. *Chir Main* 2010; **29**: 82–7.32

63 Compère V, Legrand JF, Guitard PG, *et al.* Bacterial colonization after tunneling in 402 perineural catheters: a prospective study. *Anesth Analg* 2009; **108**: 1326–30

64 Chelly JE, Delaunay L, Williams B, Borghi B. Outpatient lower extremity infusions. *Best Pract Res Clin Anaesthesiol* 2002; **16**: 311–20

65 Zaric D, Boysen K, Christiansen J, Haastrup U, Kofoed H, Rawal N. Continuous popliteal sciatic nerve block for outpatient foot surgery–a randomized, controlled trial. *Acta Anaesthesiol Scand* 2004; **48**: 337–41

66 White PF, Issioui T, Skrivanek GD, Early JS, Wakefield C. The use of a continuous popliteal sciatic nerve block after surgery involving the foot and ankle: does it improve the quality of recovery? *Anesth Analg* 2003; **97**: 1303–9

67 Bigler D, Dirkes W, Hansen R, Rosenberg J, Kehlet H. Effects of thoracic paravertebral block with bupivacaine vs. combined thoracic epidural block with bupivacaine and morphine on pain and pulmonary function after cholecystectomy. *Acta Anaesthesiol Scand* 1989; **33**: 561–4

68 Buckenmaier CC 3rd, Steele SM, Nielsen KC, Martin AH, Klein SM. Bilateral continuous paravertebral catheters for reduction mammoplasty. *Acta Anaesthesiol Scand* 2002; **46**: 1042–539

69 Casati A, Alessandrini P, Nuzzi M, Tosi M, *et al.* Prospective, randomized, blinded comparison between continuous thoracic paravertebral and epidural infusion of 0.2% ropivacaine after lung resection surgery. *Eur J Anaesthesiol* 2006; **23**: 999–1004

70 Burns DA, Ben-David B, Chelly JE, Greensmith JE. Intercostally placed paravertebral catheterization: an alternative approach to continuous paravertebral blockade. *Anesth Analg* 2008; **107**: 339–41

71 Ben-Ari AY, Moreno GM, Chelly JE, Bigeleisen PE. Ultrasound guided approach for a continuous interscostal approach to the paravertebral space. *Anesth Analg* 2009; **109**: 1691–4

72 Catala E, Casas JI, Unzueta MC, Diaz X, Aliaga L, Villar LJ. Continuous infusion is superior to bolus doses with thoracic paravertebral blocks after thoracotomies. *J Cardiothorac Vasc Anesth* 1996; **10**: 586–8

73 Richardson J, Sabanathan S, Jones J, Shah RD, Cheema S, Mearns AJ. A prospective, randomized comparison of preoperative and continuous balanced epidural or paravertebral bupivacaine on post-thoracotomy pain, pulmonary function and stress responses. *Br J Anaesth* 1999; **83**: 387–92

74 Matthews PJ, Govenden V. Comparison of continuous paravertebral and extradural infusions of bupivacaine for pain relief after thoracotomy. *Br J Anaesth* 1989; **62**: 204–5

75 Kaiser AM, Zollinger A, De Lorenzi D, Largiader F, Weder W. Prospective, randomized comparison of extrapleural vs. epidural analgesia for post-thoracotomy pain. *Ann Thorac Surg* 1998; **66**: 367–72

76 Davies RG, Myles PS, Graham JM. A comparison of the analgesic efficacy and side-effects of paravertebral vs. epidural blockade for thoracotomy: a systematic review and meta-analysis of randomized trials. *Br J Anesth* 2006; **96**: 418–26

77 Davidson EM, Ginosar Y, Avidan A. Pain management and regional anaesthesia in the trauma patient. *Curr Opin Anaesthesiol* 2005; **18**: 169–74

78 Gregoretti C, Decaroli D, Miletto A, *et al.* Regional anaesthesia in trauma patients. *Anesthesiology Clin* 2007; **25**: 99–11

79 Clark L, Varbanova M. Regional anaesthesia in trauma. *Adv in Anesth* 2009; **27**: 191–222

80 Aguirre J, Ekatodramis G, Ruland P, Borgeat A. Interscalene block should be a block for shoulder and proximal humerus surgery, and nothing else. *J Clin Anaesth* 2010; **22**: 151

81 Chelly JE, Greger J, Casati A, *et al.* Continuous lumbar plexus block for acute postoperative pain management after open reduction and internal fixation of acetabular fractures. *J Orthop Trauma* 2003; **17**: 362–367

82 Chelly JE, Greger J, Casati A, Al-Samsam T, McGarvey W, Clanton T. Continuous lateral sciatic blocks for acute postoperative pain management after major ankle and foot surgery. *Foot Ankle Int* 2002; **23**: 749–52

83 Karmakar MK. Acute pain management of patients with multiple fractured ribs. *J Trauma* 2003; **54**: 615–25

84 Carrier FM, Turgeon AF, Nicole PC, *et al.* Effect of epidural analgesia in patients with traumatic rib fractures: a systematic review and meta-analysis of randomized controlled trials. *Can J Anaesth* 2009; **56**: 230–42

85 Mohta M, Verma P, Saxena AK, *et al.* Prospective, randomized comparison of continuous thoracic epidural and thoracic paravertebral infusion in patients with unilateral multiple fractured ribs: a pilot study. *J Trauma* 2009; **66**: 1096–101

86 Sinclair R, Westlander G, Cassuto J, Hedner T. Postoperative pain relief by topical lidocaine in the surgical wound of hysterectomized patients. *Acta Anaesthesiol Scand* 1996; **40**: 589

87 Klein JR, Heaton JP, Thompson JP, Cotton BR, Davidson AC, Smith G. Infiltration of the abdominal wall with local anaesthetic after total abdominal hysterectomy has no opioid-sparing effect. *Br J Anaesth* 2000; **84**: 248–9

88 Hoenecke HR Jr, Pulido PA, Morris BA, Fronek J. The efficacy of continuous bupivacaine infiltration following anterior cruciate ligament reconstruction. *Arthroscopy* 2002; **18**: 854–8

89 Zohar E, Shapiro A, Phillipov A, Hoppenstein D, Klein Z, Fredman B. The postoperative analgesic efficacy of wound instillation with ropivacaine 0.1% vs. ropivacaine 0.2%. *J Clin Anesth* 2004; **16**: 399–404

90 LeBlanc KA, Bellanger D, Rhynes VK, Hausmann M. Evaluation of continuous infusion of 0.5% bupivacaine by elastomeric pump for postoperative pain management after open inguinal hernia repair. *J Am Coll Surg* 2005; **200**: 198–202

91 Wheatley GH 3rd, Rosenbaum DH, Paul MC, *et al.* Improved pain management outcomes with continuous infusion of a local anesthetic after thoracotomy. *J Thorac Cardiovasc Surg* 2005; **130**: 464–8

92 Ansaloni L, Agnoletti V, Bettini D, *et al.* The analgesic efficacy of continuous elastomeric pump ropivacaine wound instillation after appendectomy. *J Clin Anesth* 2007; **19**: 256–63

93 Nechleba J, Rogers V, Cortina G, Cooney T. Continuous intra-articular infusion of bupivacaine for postoperative pain following total knee arthroplasty. *J Knee Surg* 2005; **18**: 197–202

94 Andersen KV, Pfeiffer-Jensen M, Haraldsted V, Søballe K. Reduced hospital stay and narcotic consumption, and improved mobilization with local and intraarticular infiltration after hip arthroplasty: a randomized clinical trial of an intraarticular technique vs. epidural infusion in 80 patients. *Acta Orthop* 2007; **78**: 180–6

95 Kern DR, Kahan 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**: 174–83

96 Reeves M, Skinner MW. Continuous intra-articular infusion of ropivacaine after unilateral total knee arthroplasty. *Anaesth Intens Care* 2009; **37**: 918–22

97 Gómez-Cardero P, Rodríguez-Merchán EC. Postoperative analgesia in TKA: ropivacaine continuous intraarticular infusion. *Clin Orthop Relat Res* 2010; **468**: 1242

98 Magnano D, Montalbano R, Lamarra M, *et al.* Ineffectiveness of local wound anaesthesia to reduce postoperative pain after median sternotomy. *J Card Surg* 2005; **20**: 314–8

99 Sidiropoulou T, Buonomo O, Fabbi E, *et al.* A prospective comparison of continuous wound infiltration with ropivacaine vs. single-injection paravertebral block after modified radical mastectomy. *Anesth Analg* 2008; **106**: 997–1001

100 De Andrés J, Bellver J, Barrera L, Febre E, Bolinches R. A comparative study of analgesia after knee surgery with intraarticular bupivacaine, intraarticular morphine, and lumbar plexus block. *Anesth Analg* 1993; **77**: 727–30

101 Klein SM, Nielsen KC, Martin A, *et al.* Interscalene brachial plexus block with continuous intraarticular infusion of ropivacaine. *Anesth Analg* 2001; **93**: 601–5

102 DeWeese FT, Akbari Z, Carline E. Pain control after knee arthroplasty: intraarticular vs. epidural anaesthesia. *Clin Orthop Relat Res* 2001; (**392**): 226–31

103 Carli F, Clemente A, Asenjo JF, *et al.* Analgesia and functional outcome after total knee arthroplasty: periarticular infiltration vs. continuous femoral nerve block. *Br J Anaesth* 2010; **105**: 185–95

104 Gomoll AH, Kang RW, Williams JM, Bach BR, Cole BJ. Chondrolysis after continuous intra-articular bupivacaine infusion: an experimental model investigating chondrotoxicity in the rabbit shoulder. *Arthroscopy* 2006; **22**: 813–9

105 Anakwenze OA, Hosalkar H, Huffman GR. Case reports: two cases of glenohumeral chondrolysis after intraarticular pain pumps. *Clin Orthop Relat Res* 2010; **468**: 2545–9

106 Wheatley JK, Motamedi F, Hammonds WD. Page kidney resulting from massive subcapsular hematoma. Complication of lumbar sympathetic nerve block. *Urology* 1984; **24**: 361–3

107 Aida S, Takahashi H, Shimoji K. Renal subcapsular hematoma after lumbar plexus block. *Anesthesiology* 1996; **84**: 452–455

108 Ben-David B, Stahl S. Axillary block complicated by hematoma and radial nerve injury. *Reg Anesth Pain Med* 1999; **24**: 264–6

109 Bergman BD, Hebl JR, Kent J, Horlocker TT. Neurologic complications of 405 consecutive continuous axillary catheters. *Anesth Analg* 2003; **96**: 247–52

110 Mishio M, Matsumoto T, Okuda Y, Kitajima T. Delayed severe airway obstruction due to hematoma following stellate ganglion block. *Reg Anesth Pain Med* 1998; **23**: 516–9

111 Ekatodramis G, Macaire P, Borgeat A. Prolonged Horner syndrome due to neck hematoma after continuous interscalene block. *Anesthesiology* 2001; **95**: 801–3

112 Thomas PW, Sanders DJ, Berrisford RG. Pulmonary haemorrhage after percutaneous paravertebral block. *Br J Anaesth* 1999; **83**: 668–9

113 Amory C, Mariscal A, Guyot E, Chauvet P, Leon A, Poli-Merol ML. Is ilioinguinal/iliohypogastric nerve block always totally safe in children? *Paediatr Anaesth* 2003; **13**: 164–6

114 Frigon C, Mai R, Valois-Gomez T, Desparmet J. Bowel hematoma following an iliohypogastric-ilioinguinal nerve block. *Paediatr Anaesth* 2006; **16**: 993–6

115 Vaisman J. Pelvic hematoma after an ilioinguinal nerve block for orchialgia. *Anesth Analg* 2001; **92**: 1048–9

116 Kurzel RB, Au AH, Rooholamini SA. Retroperitoneal hematoma as a complication of pudendal block. Diagnosis made by computed tomography. *West J Med* 1996; **164**: 523–5

117 Parvizi J, Tarity TD, Herz A, *et al.* Ninety-day mortality after bilateral hip arthroplasty. *J Arthroplasty* 2006; **21**: 931–4

118 Fortina M, Carta S, Del Vecchio EO, Crainz E, Urgelli S, Ferrata P. Retroperitoneal hematoma due to spontaneous lumbar artery rupture during fondaparinux treatment. Case report and review of the literature. *Acta Biomed* 2007; **78**: 46–50

119 Lee MC, Nickisch F, Limbird RS,, Lee MC, Nickisch F, Limbird RS. Massive retroperitoneal hematoma during enoxaparin treatment of pulmonary embolism after primary total hip arthroplasty: case reports and review of the literature. *J Arthroplasty* 2006; **21**: 1209–14

120 Wiegel M, Gottschaldt U, Hennebach R, Hirschberg T, Reske A. Complications and adverse effects associated with continuous peripheral nerve blocks in orthopedic patients. *Anesth Analg* 2007; **104**: 1578–82

121 Dauri M, Faria S, Celidonio L, Tarantino U, Fabbi E, Sabato AF. Retroperitoneal haematoma in a patient with continuous psoas compartment block and enoxaparin administration for total knee replacement. *Br J Anaesth* 2009; **103**: 309–10

122 Weller RS, Gerancher JC, Crews JC, Wade KL. Extensive retroperitoneal hematoma without neurologic deficit in two patients who underwent lumbar plexus block and were later anticoagulated. *Anesthesiology* 2003; **98**: 581–5

123 Maier C, Gleim M, Weiss T, Stachetzki U, Nicolas V, Zenz M. Severe bleeding following lumbar sympathetic blockade in two patients under medication with irreversible platelet aggregation inhibitors. *Anesthesiology* 2002; **97**: 740–3

124 Nielsen CH. Bleeding after intercostal nerve block in a patient anticoagulated with heparin. *Anesthesiology* 1989; **71**: 162–164.21

125 Klein SM, D'Ercole F, Greengrass RA, Warner DS. Enoxaparin associated with psoas hematoma and lumbar plexopathy after lumbar plexus block. *Anesthesiology* 1997; **87**: 1576–1579

126 Aveline C, Bonnet F. Delayed retroperitoneal haematoma after failed lumbar plexus block. *Br J Anaesth* 2004; **93**: 589–91

127 Bickler P, Brandes J, Lee M, Bozic K, Chesbro B, Claassen J. Bleeding complications from femoral and sciatic nerve catheters in patients receiving low molecular weight heparin. *Anesth Analg* 2006; **103**: 1036–7

128 Hantler CB, Despotis GJ, Sinha R, Chelly JE. Guidelines and alternatives for neuraxial anaesthesia and venous thromboembolism prophylaxis in major orthopaedic surgery. *J Arthroplasty* 2004; **19**: 1004–16

129 Chelly JE, Szczodry D, Krystof N. INR and PT values prior to the removal of a lumbar plexus catheter in patients receiving warfarin following total hip replacement. *Br J Anaesth* 2008; **101**: 250–4

130 Chelly JE, Schilling D. Thromboprophylaxis and peripheral nerve blocks in patients undergoing joint arthroplasty. *J Arthroplasty* 2008; **23**: 350–4

131 Gierl B, Alarcon L, Chelly JE. Safety associated with the removal of paravertebral catheters in trauma patients receiving enoxaparin for thromboprophylaxis. *ASRA* 2010

132 Kandasami M, Kinninmonth AW, Sarungi M, Baines J, Scott NB. Femoral nerve block for total knee replacement: a word of caution. *Knee* 2009; **16**: 98–100

133 Feibel RJ, Dervin GF, Kim PR, Beaulé PE. Major complications associated with femoral nerve catheters for knee arthroplasty: a word of caution. *J Arthroplasty* 2009; **24**(Suppl. 6): 132–7

134 Sharma S, Iorio R, Specht LM, Davies-Lepie S, Healy WL. Complications of femoral nerve block for total knee arthroplasty. *Clin Orthop Relat Res* 2010; **468**: 135–40

135 Chelly JE, Miller G, Conroy L, Hudson M, Williams JP. Falls in hospitalized patients in a Community Hospital: an endemic problem. *J Patient Safety* 2008; **4**: 178–83

136 Chelly JE, Misra L, Bertolizio G, Ben-David B, Joshi R. Lower extremity nerve blocks do not increase the risk of falling. *ASA, CD* 2005

137 Swinkels A, Newman JH, Allain TJ. A prospective observational study of falling before and after knee replacement surgery. *Age Ageing* 2009; **38**: 175–81

138 Faccenda K, Finucane BT. Complications of regional anaesthesia. *Drug Saf* 2001; **24**: 413–42

139 Jeng CL, Torrillo TM, Rosenblatt MA. Complications of peripheral nerve blocks. *Br J Anaesth* 2010; **105** (Suppl. 1): i97–i107

140 Cuvillon P, Ripart J, Lalourcey L, *et al.* The continuous femoral nerve block catheter for postoperative analgesia: bacterial colonization, infectious rate and adverse effects. *Anesth Analg* 2001; **93**: 1045–9

141 Neuburger M, Buttner J, Blumenthal S, *et al.* Inflammation and infectious complications of 2295 perineural catheters: a prospective study. *Acta Anaesthesiol Scand* 2007; **51**: 108–14

142 Gasparini JR, Mello SS, Marques RS, Saraiva RA. Postoperative continuous plexus analgesia. A study on the side effects and risk factors of catheter infection. *Rev Bras Anestesiol* 2008; **58**: 602–13

143 Capdevila X, Bringuier S, Borgeat A. Infectious risk of continuous peripheral nerve blocks. *Anesthesiology* 2009; **110**: 182–8

144 Compère V, Cornet C, Fourdrinier V, *et al.* Thigh abscess as a complication of continuous popliteal sciatic nerve block. *Br J Anaesth* 2005; **95**: 255–6

145 Capdevila X, Jaber S, Pesonen P, Borgeat A, Eledjam JJ. Acute neck cellulitis and mediastinitis complicating a continuous interscalene block. *Anesth Analg* 2008; **107**: 1419–21

146 Horlocker TT, Weiss WT, Olson CA. Whodunnit: the mysterious case of mediastinitis after continuous interscalene block. *Anesth Analg* 2008; **107**: 1095–7

147 Clendenen SR, Robards CB, Wang RD, Greengrass RA. Case report: continuous interscalene block associated with neck hematoma and postoperative sepsis. *Anesth Analg* 2010; **110**: 1236–8

148 Tucker CJ, Kirk KL, Ficke JR. Posterior thigh abscess as a complication of continuous popliteal nerve catheter. *Am J Orthop (Belle Mead NJ)* 2010; **39**: E25–7

149 Johnson SM, Saint John BE, Dine AP. Local anaesthetics as antimicrobial agents: a review. *Surg Infect (Larchmt)* 2008; **9**: 205–13

150 Capdevila X, Pirat P, Bringuier S, *et al.* French Study Group on Continuous Peripheral Nerve Blocks. Continuous peripheral nerve blocks on hospital wards after orthopedic surgery: a multicenter prospective analysis of their efficacy and incidences and characteristics of adverse events in 1,416 patients. *Anesthesiology* 2005; **103**: 1035–45

151 Compère V, Rey N, Baert O, *et al.* Major complications after 400 continuous popliteal sciatic nerve blocks for post-operative analgesia. *Acta Anaesthesiol Scand* 2009; **53**: 339–45

152 Borgeat A, Blumenthal S, Lambert M, Theodorou P, Vienne P. The feasibility and complications of the continuous popliteal nerve block: a 1001-case survey. *Anesth Analg* 2006; **103**: 229–33

153 Borgeat A, Kalberer F, Jacob H, Ruetsch YA, Gerber C. Patient-controlled interscalene analgesia with ropivacaine 0.2% versus bupivcaine 0.15% after major open shoulder surgery: effects on hand motor function. *Anesth Analg* 2001; **92**: 218–23

154 Pulley SC, Spofford CM, Brennan TJ. Continuous cervical paravertebral catheter knot. *J Clin Anesth* 2010; **22**: 135–8

155 Rose GL, McLarney JT. Retained continuous lumbar plexus block catheter. *J Clin Anesth* 2009; **21**: 464–5