Regional anesthesia for trauma outside the operating theatre

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Purpose of review
Pain management in the trauma patient can be challenging, especially outside the operating room setting. Traditional analgesics such as opioids and NSAIDs are also problematic in trauma care. In this review, the use of regional anesthetic techniques outside the operating theatre is discussed.

Recent findings
Regional anesthesia is an increasing but still underutilized clinical tool for the trauma patient outside the operating room. Regional anesthesia provides well tolerated and effective analgesia and anesthesia for many indications in the trauma setting including hip fracture, reduction of joint dislocation, wound debridement, laceration repair, and multiple rib fractures. Its use can increase safety and resource allocation in emergency departments. Performance of peripheral nerve blocks, especially with ultrasound, is amenable in various medical environments with minimal training.

Summary
Pain is often poorly managed in the trauma patient. In addition to quality analgesia, regional anesthesia provides a variety of benefits in the trauma setting outside the traditional operating room setting. While further utilization requires increased training and structural changes, existing tools such as ultrasound are removing barriers to the widespread use of peripheral nerve block techniques across multiple disciplines.

Keywords
emergency room, nerve block, prehospital, regional anesthesia, trauma

INTRODUCTION

Pain management in the trauma patient faces a number of challenges. During resuscitation of the critically injured patient, analgesia is clearly not the highest priority. Moreover, even following initial stabilization, pain is often used as a physical sign that clinicians are reluctant to mask (e.g., abdominal pain, cervical spine pain, or pain in a tense musculoskeletal compartment). However, inadequate analgesia should be avoided for more than simply humanitarian reasons; recent studies have shown that untreated pain leads to a higher incidence of conditions, such as chronic pain and post-traumatic stress disorder [1].

Analgesics such as opioids and NSAIDs are often avoided, particularly in chest or neurotrauma, due to side-effects such as respiratory depression, sedation, and bleeding. These limitations have driven the increased use of regional anesthesia in trauma care. Regional anesthetic techniques can provide high-quality, targeted pain relief and lack the side-effects associated with opioids and NSAIDs. Much has been written about the use of regional anesthesia during the operative management of trauma patients. This review will instead focus on the utility of regional anesthesia in the injured patient outside the operating room , and in particular the prehospital setting and the emergency department (ED).

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KEY POINTS

- Regional anesthesia provides site-specific and high-quality analgesia without risk of respiratory depression, obtundation, and bleeding associated with opioids and NSAIDS.
- The growing availability and mobility of ultrasound equipment has allowed for increased performance and teaching of peripheral nerve blocks outside the traditional operating room environment.
- Regional anesthesia techniques offer well tolerated and effective analgesia for specific trauma indications, such as hip fracture, rib fracture, joint dislocations, and minor extremity emergencies.
- Use of peripheral nerve blocks in patients at risk for compartment syndrome remains controversial, but there is no definitive correlation between the use of PNB and possible delay in diagnosing compartment syndrome.
- In stable and selected trauma patients, regional anesthesia outside of the operating room is increasingly feasible but requires additional training and structural changes across multiple disciplines.

THE ADVANTAGES OF REGIONAL ANESTHESIA IN TRAUMA CARE

The benefits of regional anesthesia techniques in the trauma patient have been well described, and are summarized as follows:

(1) site-specific, high-quality analgesia without systemic side-effects;
(2) reduction in opioid use and the associated adverse effects (e.g., respiratory depression and sedation);
(3) decreased need for sedatives and improved neurologic assessment;
(4) reduction in length of stay in ED;
(5) more efficient use of resources: decreased need for supervision/staffing and monitoring;
(6) reduction in stress response to injury; and
(7) potential reduction in risk of chronic pain syndromes and post-traumatic stress disorder.

GENERAL CONSIDERATIONS FOR REGIONAL ANESTHESIA OUTSIDE THE OPERATING ROOM

Initial priorities in trauma care include airway management, control of bleeding, stabilization of the spine, and so on. There are two general strategies to the prehospital management of the injured patient. The first, nicknamed 'scoop-and-run', is based on the principle that on-scene attempts at stabilization ultimately delay transfer to definitive care, and the patient should simply be extricated and transferred expeditiously. The alternative ('stay and play') strategy suggests that some degree of on-scene resuscitation and treatment is beneficial, and should be performed prior to transfer. This is a controversial topic, and several factors influence the appropriateness of either strategy, including the level of training of the Emergency Medical Services team (e.g., physicians versus firefighters), the predicted transfer time to hospital, and most importantly, the clinical status of the patient [2,3].

Regional anesthesia may not be suitable in certain circumstances but can be used safely in selected patients. Clearly, when ongoing resuscitation is still being addressed, analgesia should not be a priority. In addition, the risks of peripheral nerve block may outweigh its benefit under certain conditions, for example, when an injured limb has neurologic or vascular impairment mandating frequent assessments (see section on complications). Although continuous catheter techniques have many advantages in the injured patient, the risk of infection with a catheter is higher in trauma patients admitted to ICU [odds ratio (OR) 5.07] [4].

Peripheral nerve blockade (PNB) requires specialized training that has traditionally been the domain of the operating room anesthesiologist. Increasingly, emergency medicine physicians as well as intensivists and traumatologists with non-anesthesiology backgrounds are gaining experience with PNB techniques [5,6▪]. The routine availability of ultrasound equipment in both the ED and ICU for line placement, cardiac exam, and so on, has contributed to the rise of PNBs in these areas. Emergency medicine fellowship training programs in ultrasonography are now commonly including nerve blocks as part of the curriculum. Recently, portable and relatively low-cost ultrasound machines designed for point-of-care use outside hospital settings have become available and have been helpful during on-scene evaluation and transport in both civilian and military medicine [7].

SPECIFIC INDICATIONS FOR PERIPHERAL NERVE BLOCKADE IN THE TRAUMA PATIENT

There are several common injuries that are well suited to PNB for management of pain and/or therapy, including hip and/or femoral fracture, shoulder dislocation, distal extremity injuries, and fractured ribs.

Hip/femur fracture

Femoral neck fractures in the elderly carry high morbidity and adversely affect quality of life.

Although pain from the fracture site is often moderate-to-severe, opioid administration is often restricted in this population because of concerns of delirium or respiratory depression, and many hip fracture patients are left in considerable discomfort while awaiting surgical repair [8▪].

The femoral nerve innervates much of the femur and hip joint; in patients with femoral neck fractures, there are clear benefits to performing femoral nerve or fascia iliaca blocks (FIB) as early as possible (i.e., in the ED). These include significantly decreased pain scores, a reduction in opioid requirements, aiding in reduction of fracture, and facilitating positioning on the operating room table [9]. Patients often experience delays in surgical repair of up to several days, and repeated daily FIB has been shown to reduce risk of delirium, a significant independent risk factor of morbidity and mortality, in the elderly compared with sham block [10]. Obturator nerve block is also strongly associated with a reduction in pain scores in hip fracture patients [11▪▪].

All three of these blocks are easily performed in the preoperative setting. Performance of FIB in particular has several specific advantages: it requires minimal equipment (e.g., a syringe and needle), is easily learned and performed, and has a high efficacy [12–14]. Lopez *et al.* [13] demonstrated that pain scores were significantly reduced 10 min after the performance of FIB for isolated femur fracture by prehospital personnel in the field, reinforcing the simplicity, and effectiveness of the technique. As it relies on spread of local anesthetic along a fascial plane, a large volume of local anesthetic (20–30 ml) is necessary to ensure blockade of the femoral nerve. The FIB is thought to be a relatively well tolerated block, as the puncture and injection site is sufficiently lateral to prevent vascular or neural injury.

Shoulder reduction

Reduction of a dislocated shoulder is a common procedure performed in the ED. Intravenous procedural sedation using propofol, ketamine, or etomidate is commonly employed to produce sufficient muscle relaxation to reduce the joint [15,16]. However, procedural sedation is not often ideal for such short and limited procedures. Most patients presenting to the emergency room with injuries are assumed to have full stomachs, and as such are at increased risk for gastric aspiration if protective reflexes are abolished with sedation. Hypotension and/or respiratory compromise are real risks, especially with such potent cardiopulmonary depressive agents as propofol. These risks mandate close monitoring and 'one-on-one' care in the emergency room that can occupy nursing resources.

Regional anesthesia, particularly interscalene brachial plexus block (ISB), offers an attractive alternative that eases the requirements for performing shoulder dislocation reduction. ISB provides profound shoulder girdle muscle relaxation by anesthetizing the superior trunk of the brachial plexus. ISB does not require sedation, and although cardiorespiratory monitoring is still required, the risk of apnea or hypotension is virtually nonexistent. Blaivas *et al.* [17] demonstrated that length of stay in the ED and need for one-on-one care is reduced in patients receiving ISB versus procedural sedation for shoulder reduction [17].

Other extremity trauma

Common extremity injuries include fractures, lacerations, crush injuries, and even amputations. Many of these minor injuries are nonoperative, but still require thorough examination, debridement, suturing, and/or reduction in the ED, tasks that can be challenging when analgesic options are limited to local anesthetic infiltration and sedation. For example, using local anesthetic infiltration to anesthetize a laceration on the sole of the foot is very uncomfortable for both patient and clinician; in contrast, a posterior tibial nerve block using 4–5 ml of local anesthetic is relatively pain-free and provides ideal conditions for debridement and closure.

Stone *et al.* [18] demonstrated that ultrasound-guided supraclavicular blocks performed in the emergency room resulted in a shorter length of stay in the ED without affecting patient safety or satisfaction for treatment of upper extremity fractures, dislocations, or abscesses compared with procedural sedation. Further advantages cited by the authors included a reduced requirement for additional oral/parenteral analgesia as well as minimal monitoring and staffing. In crowded EDs with overburdened resources and staffing, the potential to quickly discharge patients is appealing.

For more distal upper extremity injuries, when weakness or numbness of the entire arm may not be warranted, or when experience with brachial plexus blocks is limited, blockade of individual nerves distal to the brachial plexus present an attractive alternative for analgesia or facilitation of interventions outside the operating room. Supracondylar radial nerve blocks have been used to allow for successful closed reduction and splinting of distal radius fractures, a common presentation with trauma [19]. In addition, emergency physicians with little to no experience in placing ultrasound-guided nerve blocks of the median, ulnar, and radial nerves in the forearm were effectively able to provide

analgesia or anesthesia for procedural interventions of the hand after minimal training [20]. Simpson *et al.* [21] showed that a properly trained paramedic team could successfully perform digital blocks in the field to facilitate reduction of a dislocated finger, obviating the need for opioids. Such distal blocks require small doses of local anesthetic (e.g., 4–5 ml/nerve), conferring an added safety advantage with respect to systemic toxicity.

Rib fractures

Rib fractures are a common and potentially serious injury following blunt trauma. Overall morbidity and mortality increases significantly as the number of rib fractures increase, largely because of pulmonary compromise [22]. Quality analgesia is a priority in the patient with rib fractures. This permits deep breathing, coughing, and chest physiotherapy with the aim of preventing respiratory complications. Although useful in the initial setting, opioids are disadvantageous in the stabilized patient, as they can exacerbate hypoventilation, atelectasis, and pulmonary infection. Several regional anesthesia techniques for analgesia are available and offer superior analgesia with reduction in respiratory complications. Each carries its individual risks and benefits, and selection should be tailored accordingly to each trauma patient.

Thoracic epidural analgesia (TEA) is a technique that is ideal for rib fractures, especially if bilateral [22–24]. TEA does not require specialized equipment, and can be performed in the ED, ICU, or virtually any other location in the hospital. Its use is limited primarily by the use of anticoagulants for deep venous thrombosis prophylaxis as well as any sympathectomy that may result in an already hemodynamically unstable trauma patient.

Paravertebral blockade (PVB) appears to provide equivalent analgesia compared with TEA for pain due to rib fracture [25,26▪▪]. Like TEA, PVB is amenable to catheter placement [27], which allows for the reduction in opioids and faster return to function [28]. The unilateral nature of PVB compared with TEA confers several advantages, such as decreased sympathectomy and hypotension, improved neurologic assessment, and a reduction in the incidence of urinary retention. Risks to PVB are small but include pneumothorax, local anesthetic systemic toxicity (LAST), and epidural spread [29–31].

Intercostal nerve block (ICNB) is also effective as an analgesic modality postrib fracture [32], but because spread of injectate is limited between levels anatomically, ICNB typically requires multiple injections and/or catheter placements. This block is particularly well suited to settings outside the operating room because of its ease of performance; the landmark-based technique simply involves walking the needle off the inferior margin of the rib at its angle before aspirating and injecting the local anesthetic. Risks are again small, but include pneumothorax and LAST given its close proximity to both the parietal pleura and intercostal vessels. Performance of this technique is more technically difficult at levels above T7 as the scapula overlies the angles of the ribs. ICNB have been successfully used to reduce the pain associated with chest drain insertion for traumatic pneumothorax in the ED [33].

SPECIAL PROBLEMS: COMPARTMENT SYNDROME

One of the most serious complications of extremity trauma is the development of acute compartment syndrome (ACS), which is most common in men below 35 years following tibial or forearm fracture [34]. ACS occurs when swelling in an injured osteofascial compartment leads to increased pressure and eventual collapse of capillaries, halting tissue circulation, and leading to cellular hypoxia and the release of mediators increasing vascular permeability. The subsequent leakage of fluid through capillary and muscle membranes promotes further edema and worsens the intracompartmental pressure [35].

The use of PNBs in patients at risk for ACS is controversial. Although the analgesia provided by PNBs may be beneficial, some clinicians fear an insensate limb may delay diagnosis of ACS by masking important symptoms such as pain and/or paresthesia [36]. However, the sensitivity of these subjective symptoms appears to be low (<20%) [37], and little is known about the effect of PNBs on these clinical diagnostic tools. To date, only five case reports have been published relating specifically to peripheral nerve blocks and ACS, and none were placed outside the operating room.

Two cases involve continuous catheter techniques wherein the diagnosis and treatment of ACS was facilitated in a timely manner by the onset of breakthrough pain during infusion of 0.2% ropivacaine [38▪▪,39]. The authors suggest that although such a dilute solution may be sufficient for routine acute pain, the severe pain of ischemia is unmasked in early ACS. This may not be the case with patient-controlled opioids, wherein sedation and the ability to self-titrate may confound the perception of worsening pain [40]. A third case of pain breaking through a femoral block performed with 0.75% ropivacaine demonstrated that the need for supplemental opioids despite good initial analgesia may be

a warning sign of ACS [41]. Similarly, Noorpuri *et al.* [42] demonstrated that ankle block with 0.25% bupivacaine for forefoot arthroplasty failed to prevent unremitting pain, leading to the diagnosis of ACS and successful surgical intervention.

In contrast, Hyder *et al.* [43] asserted that a femoral block was responsible for a missed anterior compartment syndrome of the leg following intramedullary nailing. However, the anterior compartment is innervated by the deep peroneal nerve, a branch of the sciatic nerve, making femoral block an unlikely contributing factor.

It is somewhat difficult at the present time to make a definitive correlation between the use of PNBs and the possible delay in diagnosing compartment syndrome. Not only does the nature of this syndrome preclude randomized-controlled trials, but it is also possible that these events are simply underreported or simply avoided in high-risk patients. Rather than focusing on whether to perform a PNB or not, our attention might be better directed toward careful monitoring of analgesic consumption, breakthrough pain, and the use of compartment pressure monitoring for high-risk patients. Vigilance of all medical personnels involved in the patient's care is the key to early detection.

CONCLUSION

Regional anesthesia confers a variety of benefits to trauma patients. Although used widely intraoperatively, its utility should not be limited to the operating room setting. In addition to improving patient comfort, the early use of regional anesthesia in trauma appears to improve outcomes such as, pulmonary morbidity, delirium, chronic pain, and post-traumatic stress disorder. The expansion of regional anesthesia outside the operating room requires structural changes in terms of expert training and equipment suited to ease-of-use and mobility. Improving technology and application of ultrasound as a point-of-care tool allows for the expansion of regional anesthesia through multidisciplinary care providers. When used judiciously and in selected patients, regional anesthesia provides a cost-effective and well tolerated method of relieving pain in injured patients in multiple settings outside of the operating room.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES AND RECOMMENDED READING

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

- ■ of special interest
- ■■ of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (p. 514).

1. Jenson MG, Sorensen RF. Early use of regional and local anesthesia in a combat environment may prevent the development of complex regional pain syndrome in wounded combatants. Mil Med 2006; 171:396–398.
2. Aydin S, Overwater E, Saltzherr TP, *et al.* The association of mobile medical team involvement on on-scene times and mortality in trauma patients. J Trauma 2010; 69:589–594.
3. Nirula R, Maier R, Moore E, *et al.* Scoop and run to the trauma center or stay and play at the local hospital: hospital transfer's effect on mortality. J Trauma 2010; 69:595–599.
4. Capdevila X, Bringuier S, Borgeat A. Infectious risk of continuous peripheral nerve blocks. Anesthesiology 2009; 110:182–188.
5. Reid N, Stella J, Ryan M, Ragg M. Use of ultrasound to facilitate accurate femoral nerve block in the emergency department. Emerg Med Australas 2009; 21:124–130.
6. ■ Bhoi S, Sinha TP, Rodha M, *et al.* Feasibility and safety of ultrasound-guided nerve block for management of limb injuries by emergency care physicians. J Emerg Trauma Shock 2012; 5:28–32.

A prospective observational study reporting high safety and efficacy of ultrasound-guided nerve blocks performed by emergency physicians for limb emergencies.

7. Nations JA, Browning RF. Battlefield applications for handheld ultrasound. Ultrasound Q 2011; 27:171–176.
8. ■ Haslam L, Lansdown A, Lee J, Van der Vyver M. Survey of current practices: peripheral nerve block utilization by ED physicians for treatment of pain in the hip fracture patient population. Can Geriatr J 2013; 16:16–21.

A survey of emergency physicians reflecting current practice that highlights underutilization of nerve blocks in hip fracture patients but favorability to further use of nerve blocks and increased training.

9. Beaudoin FL, Nagdev A, Merchant RC, Becker BM. Ultrasound-guided femoral nerve blocks in elderly patients with hip fractures. Am J Emerg Med 2010; 28:76–81.
10. Mouzopoulos G, Vasiliadis G, Lasanianos N, *et al.* Fascia iliaca block prophylaxis for hip fracture patients at risk for delirium: a randomized placebo-controlled study. J Orthop Traumatol 2009; 10:127–133.
11. ■■ Rashiq S, Vandermeer B, Abou-Setta AM, *et al.* Efficacy of supplemental peripheral nerve blockade for hip fracture surgery: multiple treatment comparison. Can J Anaesth 2013; 60:230–243.

A systematic review of randomized-controlled trials comparing efficacy of multiple peripheral nerve blocks for analgesia and other outcomes in hip fracture patients.

12. Gozlan C, Minville V, Asehnoune K, *et al.* Fascia iliaca block for femoral bone fractures in prehospital medicine. Ann Fr Anesth Reanim 2005; 24:617–620.
13. Lopez S, Gros T, Bernard N, *et al.* Fascia iliaca compartment block for femoral bone fractures in prehospital care. Reg Anesth Pain Med 2003; 28:203–207.
14. Minville V, Gozlan C, Asehnoune K, *et al.* Fascia-iliaca compartment block for femoral bone fracture in prehospital medicine in a 6-yr-old child. Eur J Anaesthesiol 2006; 23:715–716.
15. Vinson DR, Hoehn CL. Sedation-assisted orthopedic reduction in emergency medicine: the safety and success of a one physician/one nurse model. West J Emerg Med 2013; 14:47–54.
16. Denny MA, Manson R, Della-Giustina D. Propofol and etomidate are safe for deep sedation in the emergency department. West J Emerg Med 2011; 12:399–403.
17. Blaivas M, Adhikari S, Lander L. A prospective comparison of procedural sedation and ultrasound-guided interscalene nerve block for shoulder reduction in the emergency department. Acad Emerg Med 2011; 18:922–927.
18. Stone MB, Wang R, Price DD. Ultrasound-guided supraclavicular brachial plexus nerve block vs procedural sedation for the treatment of upper extremity emergencies. Am J Emerg Med 2008; 26:706–710.
19. Frenkel O, Herring AA, Fischer J, *et al.* Supracondylar radial nerve block for treatment of distal radius fractures in the emergency department. J Emerg Med 2011; 41:386–388.
20. Liebmann O, Price D, Mills C, *et al.* Feasibility of forearm ultrasonography-guided nerve blocks of the radial, ulnar, and median nerves for hand procedures in the emergency department. Ann Emerg Med 2006; 48:558–562.
21. Simpson PM, McCabe B, Bendall JC, *et al.* Paramedic-performed digital nerve block to facilitate field reduction of a dislocated finger. Prehosp Emerg Care 2012; 16:415–417.
22. Bulger EM, Arneson MA, Mock CN, Jurkovich GJ. Rib fractures in the elderly. J Trauma 2000; 48:1040–1046.
23. Flagel BT, Luchette FA, Reed RL, *et al.* Half-a-dozen ribs: the breakpoint for mortality. Surgery 2005; 138:717–723.

24. 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; 56:230–242.

25. 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; 66:1096–1101.

26. ■■ Ho AM-H, Karmakar MK, Critchley LAH. Acute pain management of patients with multiple fractured ribs: a focus on regional techniques. Curr Opin Crit Care 2011; 17:323–327.

A review on analgesia options for trauma patients with multiple rib fractures that highlights the advantages of regional techniques over systemic analgesics.

27. Murata H, Salviz EA, Chen S, *et al.* Case report: ultrasound-guided continuous thoracic paravertebral block for outpatient acute pain management of multilevel unilateral rib fractures. Anesth Analg 2013; 116:255–257.

28. Buckley M, Edwards H, Buckenmaier CC 3rd, Plunkett AR. Continuous thoracic paravertebral nerve block in a working anesthesia resident: when opioids are not an option. Mil Med 2011; 176:578–580.

29. Fagenholz PJ, Bowler GMR, Carnochan FM, Walker WS. Systemic local anaesthetic toxicity from continuous thoracic paravertebral block. Br J Anaesth 2012; 109:260–262.

30. Lucas SD, Higdon T, Boezaart AP. Unintended epidural placement of a thoracic paravertebral catheter in a patient with severe chest trauma. Pain Med 2011; 12:1284–1289.

31. Richardson J, Lönnqvist PA, Naja Z. Bilateral thoracic paravertebral block: potential and practice. Br J Anaesth 2011; 106:164–171.

32. Truitt MS, Murry J, Amos J, *et al.* Continuous intercostal nerve blockade for rib fractures: ready for primetime? J Trauma 2011; 71:1548–1552.

33. Stone MB, Carnell J, Fischer JWJ, *et al.* Ultrasound-guided intercostal nerve block for traumatic pneumothorax requiring tube thoracostomy. Am J Emerg Med 2011; 29:697; e1-2.

34. McQueen MM, Gaston P, Court-Brown CM. Acute compartment syndrome. Who is at risk? J Bone Joint Surg Br 2000; 82:200–203.

35. Gadsden J. Regional anesthesia and compartment syndrome. In: Regional anesthesia in trauma. New York: Cambridge University Press; 2012 pp. 26–32.

36. Mar GJ, Barrington MJ, McGuirk BR. Acute compartment syndrome of the lower limb and the effect of postoperative analgesia on diagnosis. Br J Anaesth 2009; 102:3–11.

37. Ulmer T. The clinical diagnosis of compartment syndrome of the lower leg: are clinical findings predictive of the disorder? J Orthop Trauma 2002; 16:572–577.

38. ■■ Walker BJ, Noonan KJ, Bosenberg AT. Evolving compartment syndrome not masked by a continuous peripheral nerve block: evidence-based case management. Reg Anesth Pain Med 2012; 37:393–397.

The prompt diagnosis and treatment of an evolving compartment syndrome due to breakthrough pain while using a continuous peripheral nerve block highlights importance of vigilance and identification of high-risk patients for early diagnosis and prevention.

39. Cometa MA, Esch AT, Boezaart AP. Did continuous femoral and sciatic nerve block obscure the diagnosis or delay the treatment of acute lower leg compartment syndrome? A case report. Pain Med 2011; 12:823–828.

40. Richards H, Langston A, Kulkarni R, Downes EM. Does patient controlled analgesia delay the diagnosis of compartment syndrome following intramedullary nailing of the tibia? Injury 2004; 35:296–298.

41. Uzel A-P, Steinmann G. Thigh compartment syndrome after intramedullary femoral nailing: possible femoral nerve block influence on diagnosis timing. Orthop Traumatol Surg Res 2009; 95:309–313.

42. Noorpuri BS, Shahane SA, Getty CJ. Acute compartment syndrome following revisional arthroplasty of the forefoot: the dangers of ankle-block. Foot Ankle Int 2000; 21:680–682.

43. Hyder N, Kessler S, Jennings AG, De Boer PG. Compartment syndrome in tibial shaft fracture missed because of a local nerve block. J Bone Joint Surg Br 1996; 78:499–500.