

Managing pain on the battlefield: An introduction to continuous peripheral nerve blocks

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Abstract

Objective: To determine the strength of evidence supporting the battlefield use of Continual Peripheral Nerve Blocks (CPNBs).

Methods: Publication review identifying 380 potentially relevant papers.

Results: CPNBs have been well trialled and are used routinely in civilian hospitals. The procedure is not without acute and chronic complications related to agents used, catheters themselves and infection risks. These techniques are being used increasingly in military field hospitals to manage pain, however research concerning their use on the battlefield is limited and further trials are required to confidently conclude efficacy.

Conclusion: CPNBs are just one component within military medicine of a rapidly evolving polymodal system of pain management. Common combat wounds, namely traumatic amputations, are compatible with this technique, however current evidence concerning their battlefield use is limited. Extensive UK military trials are ongoing and the results of which are expected to clarify questions regarding complication rate and efficacy.

Introduction

Evolutions in battlefield medicine including rapid casualty evacuation, damage control resuscitation and body armour have markedly reduced combat fatality rates. Less than 10% of wounded soldiers now die [1]. This welcomed progress in battlefield health care has presented military medical teams with a new set of challenges involving the management of pain in those with multiple complex injuries who would previously have perished.

The recent evolution of a polymodal system of pain management which is aggressively instigated at the point of wounding marks a paradigm shift in battlefield casualty care. One strand of this is the development of the continuous peripheral nerve block (CPNB). This paper examines whether the endorsement of CPNBs as a reliable pain management therapy in an austere environment is currently justified.

Background

Battlefield trauma commonly involves extensive extremity damage via numerous injury mechanisms including blast, penetrating, blunt and burn trauma [2]. These injuries may be associated with severe pain which is complicated by a protracted and logistically complex repatriation chain.

Since 2003, when the first battlefield CPNB was administered, regional anaesthesia is now complimenting a pain management tradition that has remained extant for two centuries. Regional anaesthesia for pain management is not new having been documented as early as 1946 [3] and again during the Vietnam conflict [4]. However, modern technology has refined this technique by introducing a catheter administered continuous

infusion of local anaesthetic adjacent to a specific nerve or nerve plexus. Traditionally this was attempted using a nerve stimulating catheter. However, direct visualisation using portable ultra-sound sonography is now possible allowing use in cases of atypical anatomy and circumstances when traumatic neural disruption reduces nerve stimulation feedback [5] (as in the case of traumatic amputation). CPNBs can be administered for a period of weeks with the intention of providing pre, peri and post operative pain relief.

Methods

This paper is a review of publications on Medline, Pubmed, Cochrane Database, BMJ, Science Direct and Swetswise using MeSH terms “continuous peripheral nerve blocks”/AND/OR “regional anaesthesia” /AND/OR “battlefield pain relief” /AND/OR “trauma”. Non-English language papers were excluded from the search. Reference sections of selected studies were also reviewed for additional citations. 380 relevant papers were identified and reviewed, of which 19 were found to be directly relevant to this paper.

Results and Discussions

From 2001 – 2006, 423 of 8058 repatriated US casualties from Iraq and Afghanistan underwent major limb amputation [6], a tragic manifestation of the current vogue for improvised explosive devices. CPNBs have played an important role in managing the acute pain of wounded soldiers during injury stabilisation, initial surgery and repatriation. Advocates of this intervention [1] report improved recovery rates and reduced incidences of chronic neuropathic pain, however these initial observations are not yet supported by strong evidence.

CPNBs may provide superior pain control to opioids [7]. Whilst there are no battlefield studies to support this statement, civilian hospital based research has proved favourable. Chelly et al [8] found that a femoral nerve blockade afforded a higher

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therapeutic index than intravenous patient controlled morphine for total knee arthroplasty analgesia. They found that regional anaesthesia reduced postoperative morphine requirement by 74% ($p < 0.05$) when compared to patient administered analgesia. The CPNB group also benefited from a recovery time reduced by up to 20%. However, the study found that there were no great differences in levels of discomfort between patient groups after 12 weeks and no data for long term outcome. Furthermore, the procedure and patient profile were atypical of common battlefield trauma cases.

Regional anaesthesia does not share the same undesirable sedative effects as opioids; such as respiratory depression, mental status impairment, hypotension, nausea and constipation [9]. However, regional anaesthesia is not without risk, the most common of which is failure, occurring in 8-10% of cases [10]. Furthermore, there are fears that it can delay the diagnosis of acute compartment syndrome as a blocked neural pathway can mask pain on passive stretch of a compartment; an early warning red light which Ulmer and colleagues report has a diagnostic sensitivity of 68% [11]. They found that 17% of 146 returned questionnaires from hospital based orthopaedic consultants using regional anaesthesia in the treatment of lower limb fractures had seen compartment syndrome masked by their anaesthetic regimen. This study was based on subjective recall and not clinical diagnosis and therefore subject to bias. A systematic review of acute compartment syndrome was undertaken by the Defence Medical Services [12] and used to encourage the use of CPNBs in the deployed setting where prophylactic fasciotomy may be necessary to prevent the development of acute compartment syndrome during repatriation [13].

Allegri et al [14] collated previous research on the peripheral neuropathic complications of regional anaesthesia; specifically neurotoxicity from the local anaesthetic, direct nerve injury and infection from the catheter. Their large prospective study in 2002, found serious peripheral neuropathy in 12 patients of 23784 participants (c. 1 in 2,000). Placement adjuncts, procedural expertise and pharmacological technology have improved significantly over the last few years to lower this risk further.

There are limited battlefield studies of CPNB. Stojadinovic et al [15] undertook a retrospective analysis at the Walter Reed Army Medical Center from 2003-2004 involving 287 participants with traumatic extremity injuries requiring 900 surgical operations (634 of these under regional anaesthesia); 37.3% suffered traumatic amputations. The study looked at CPNBs and single injection peripheral nerve blocks in conjunction with NSAID and opioid analgesics in predominantly young adult male participants. The majority of CPNBs were inserted not on the battlefield but once back in the United States. Clinical pain scores were measured using the VAS and regional anaesthetic complications were investigated. Pain data was regularly measured from the point at which regional anaesthesia was applied up to a maximum of 7 days. The median follow up period of 25 days limited comment to the early acute pain phase only. Only, 1.9% of catheter placements developed a superficial skin infection which resolved following catheter removal and 11.9% of catheters developed minor technical complications. The study found mean pain scores fell from 3.7 to 2.2 ($p < 0.0001$) following placement of the CPNB. However, the study's retrospective design did not accommodate a control group receiving only traditional pain management regimens. It was also conducted at a specialist hospital with a highly selective population which may not be representative. The VAS data

collection was collated from existing observation charts which may be subject to observer or patient bias. VAS also relies on patient understanding, recall and communication which may be challenging in the battlefield environment especially as 60% of United States battlefield casualties have been reported as suffering a traumatic brain injury [2]. Finally, the confounding effects of adjuvant analgesics used in combination with regional anaesthesia were not grouped or adjusted.

Due to the risk of haematoma, regional anaesthesia is cautioned in anticoagulated patients. Low molecular weight heparin (LMWH) is a common post-operative prophylactic therapy to prevent pulmonary embolism or thrombosis especially if rapid long haul air evacuation is indicated. Buckenmaier et al [16] studied 187 anticoagulated combat patients with 305 CPNB catheters and receiving LMWH injections (30mg enoxaparin). Of the 3.7% complication rate, none involved catheter related bleeding complications. However, this study was not without limitations. Firstly, the study participants were predominantly fit and male which is not a representative population of those injured in conflict zones which include elderly and young non-combatants. Secondly, anticoagulation regimens were not standardised or grouped. Thirdly, the study was limited to a single specialist pain management facility which may account for the low complication rate. Finally, the prevalence of haematoma caused by epidural anaesthesia is estimated at 1 in 3000 [17], thus it is unsurprising that such a small study using a related technique had no complications. Due to different dose regimes used worldwide, more research is needed to quantify safe dosage levels and whether the site of infusion catheters affects the risk.

One of the concerns with CPNBs is the length of time the catheters are left in close proximity to peripheral nerves. The complex design of nerve stimulating catheters has a risk of adherence to viscera or adjacent neural structures. Animal studies using Sprague-Dawley rats [18] have highlighted significant variations in the adhesion of different types of non-infusing catheters when sutured to the parietal peritoneal wall between experimental abdominal wall injuries. Whilst a non-infusing catheter sutured to an area of high inflammation in a rodent has marked differences to a live regional nerve block in a human subject; this study raises an important question regarding safe duration guidelines for catheters especially as their design is rapidly advancing. The opposite effect may also prove to be problematic, where the infusion catheter becomes displaced; however despite numerous anecdotal reports, there is limited evidence to quantify this risk.

Two key case studies undertaken in austere environments mount a compelling logistical case for the use of CPNB as an analgesic and anaesthetic "force multiplier" [19]. Whilst it takes longer to establish a block than general anaesthetic, once working it frees up anaesthetists to attend to concurrent pain relief or resuscitation duties. The improvement in post operative stay times reduces a patient's impact on the often limited resources of a field hospital and facilitates the involvement of the patient in their own evacuation. General anaesthesia requires sophisticated resuscitation resources especially as hypovolaemic patients are at risk of profound hypotension. Regional anaesthesia also reduces the risk of aspiration of gastric contents and hypothermia [20]. However, one of the most significant drawbacks of CPNBs is its success ultimately hinges on the skill of the anaesthetist inserting the catheter together with the appropriate skills of those doctors and nurses managing the catheter once inserted.

A UK military CPNB trial is well advanced and should help to clarify many of the questions regarding their complication rate, in-situ catheter duration times and pain reduction effectiveness. This additional data coupled with the advancements in technology, including reliable ultrasound machines, nerve stimulating catheters and advanced patient administered infusion systems, provide every opportunity for CPNBs to earn their keep. Whether battlefield pain from point of injury to rehabilitation can ever be fully controlled is beyond the reach of current medical technology, however the fact this aspiration receives such prominence is more significant than the interventions that support it.

Conclusion

Robust civilian hospital based trialling supported by an initial limited body of field based observations suggests that CPNBs may have good efficacy, however there is currently insufficient battlefield research to draw this conclusion confidently. This limited research is understandable as randomised controlled trials are not easy to manage within a war zone especially when subjects are rapidly moved through a complex repatriation chain.

As catheter placements lengthen, the concern over pathological sequelae requires additional study. Current protocols advocating 7-10 days appear to be warranted by the existing low complication rate.

Whilst CPNBs are playing an increasingly important role in battlefield pain management, they must be placed into perspective as the offspring of a more fundamental philosophical shift. War injuries and pain are no longer related in the way they have been since the dawn of conflict. Opioids are no longer thought of as the panacea of pain management, however CPNBs cannot claim this title either. As modern day medicine is stretched to keep pace with the output of contemporary warfare, we must ensure the evolution of pain management maintains a similar velocity.

References

1. Buckenmaier III C. For Amputations and Phantom Limbs, New Nerve Blocking Therapies Come of Age in the Iraqi War. *Neurology Today* 2007; 7(21): 10-11.
2. Clark M, Bair MJ, Buckenmaier III CC, Girona RJ, Walker RL. Pain and combat injuries in soldiers returning from Operations Enduring Freedom and Iraqi Freedom: Implications for research and practice. *J Rehab Res Dev* 2007; 44(2): 179-94
3. Navas A, Gutierrez TV, Moreno ME. Continuous peripheral nerve blockade in lower extremity surgery. *Acta Anaesthesiol Scand* 2005; 49: 1048-55.
4. Thompson GE. Narration: anesthesia for battle casualties in Vietnam. *JAMA* 1967; 201: 218-219.
5. Plunkett AR, Brown DS, Rogers JM, Buckenmaier III CC. Supraclavicular continuous peripheral nerve block in a wounded soldier: when ultrasound is the only option. *Br J Anaesth*. 2006 Nov;97(5):715-7
6. Stansbury LG, Lalliss SJ, Branstetter JG, Bagg MR, Holcomb JB. Amputations in US military personnel in the current conflicts in Afghanistan and Iraq. *J Orthop Trauma* 2008; 22(1): 43-6.
7. Grant SA, Nielsen KC, Greengrass RA, Steele SM, Klein SM. Continuous peripheral nerve block for ambulatory surgery. *Reg Anesth Pain Med* 2001; 26: 209-14.
8. Chelly JE, Greger J, Gebhard R. Continuous femoral blocks improve recovery and outcome of patients undergoing total knee arthroplasty. *J Arthroplasty* 2001; 16: 436-45.
9. Hebl JR, Dilger, Byer DE et al. A pre-emptive multimodal pathway featuring peripheral nerve block improves perioperative outcomes after major orthopaedic surgery. *Reg Anesth Pain Med* 2008; 33 (6): 510-517
10. Capdevila X, Ponrouch M, Morau D. The role of regional anesthesia in patient outcome: ambulatory surgery. *Tech Reg Anesth Pain Management* 2008;12, 194-198
11. Ulmer T. The clinical diagnosis of compartment syndrome of the lower leg: are the clinical findings predictive of the disorder? *J Orthop Trauma* 2002; 16 (8): 572-7.
12. Hayakawa H, Aldington D, Moore RA. Acute traumatic compartment syndrome: a systematic review of results of fasciotomy. *J Trauma* 2009; 11(1): 5-35
13. Clasper J, Aldington DJ. Regional Anaesthesia, Ballistic Limb Trauma and Acute Compartment Syndrome. *J R Army Med Corps* 2010; 156(2): 77-8
14. Allegri M, Grossi P, Ferrari F, Borghi B. Regional anaesthesia and side effects: is it safe? *Euro J Pain Supp* 2008; 2: 31-35
15. Stojadinovic A, Auton A, Peoples GE et al. Responding to challenges in modern combat casualty care: innovative use of advanced regional anesthesia. *Am Acad Pain Med* 2006; 7(4): 330-8.
16. Buckenmaier III CC, Shields CH, Auton AA et al. Continuous peripheral nerve block in combat casualties receiving low-molecular weight heparin. *Br J Anaesth* 2006; 97(6): 874-7.
17. Horlocker TT, Wedel DJ, Benzon H. Regional anesthesia in the anticoagulated patient: defining the risks. *Reg Anesth Pain Med* 2003; 28: 172-97
18. Buckenmaier III CC, Auton AA, Flournoy WS. Continuous peripheral nerve block catheter tip adhesion in a rat model. *Acta Anaesthesiol Scand* 2006; 50: 694-698
19. Buckenmaier III CC, Lee EH, Shields CH, Sampson JB, Chiles JH. Regional anesthesia in austere environments. *Reg Anesth Pain Med* 2003; 28(4):321-7.
20. Mellor AJ. Anaesthesia in austere environments. *J R Army Med Corps* 2005; 151: 272-276