Monitoring regional blockade

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Summary

This review attempts to draw on the published literature to address three practical clinical questions. First, what means of testing the degree of regional blockade pre-operatively are available, and can eventual success or failure be determined soon after injection? Second, is it possible to predict if a block inserted after the induction of general anaesthesia will be effective when the patient wakes? Third, what features, and what duration, should cause concern when a block does not resolve as expected after surgery? Although the relevant literature is limited, we recommend testing of multiple sensory modalities before surgery commences; temperature and thermographic changes may offer additional early warning of success or failure. There are a number of existing methods of assessing nociception under general anaesthesia, but none has yet been applied to gauge the onset of a regional block. Finally, criteria for further investigation and neurological referral when block symptoms persist postoperatively are presented.

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Introduction

Regional anaesthesia is widely used. When successful, it allows for pain-free surgery and provides excellent postoperative analgesia. However, it is not without its problems. Sometimes the block fails completely, and conversion to general anaesthesia is necessary for surgery to take place. Sometimes a block inserted for postoperative analgesia is also ineffective. Finally, although the postoperative pain relief provided by regional blocks is usually welcomed by patients and staff alike, sometimes the effect persists for longer than might be desirable. This review attempts to examine published literature in order to answer three practical questions. First, what means of testing a regional block are available, and can eventual success or failure be determined soon after injection? Second, is it possible to predict if a block inserted after the induction of general anaesthesia will be effective at emergence? Third, what features, and what duration, should cause concerns when a block does not apparently resolve as expected after surgery? We will not deal with general intra-operative monitoring of the patient who has had a regional anaesthetic, nor with general postoperative observation and care of such patients, as these aspects are well covered elsewhere [1, 2].

Testing of onset and assessing readiness for surgery

Block testing is necessary, not only to ensure that the degree of blockade is sufficient for the surgery proposed, but also to detect side-effects such as hypotension in spinal anaesthesia. Experience suggests that there is great variation in practice for testing regional blockade after injection of local anaesthetic. What
happens in clinical practice is largely unknown. Authoritative textbooks may not even mention how blocks should be tested [3]. The degree of testing and the meticulousness of documentation probably depend not only on the practitioner but also on the type of surgery, the possibility that the effect of the block can be directly assessed and the context. Testing before caesarean section under spinal anaesthesia may well be more carefully performed and noted [4] than, for instance, a transverse abdominis plane block performed after induction of general anaesthesia [5].

One might expect research reports to offer some insight, in that they are often undertaken by enthusiasts for regional anaesthesia. However, it is not clear if the descriptions reflect the authors’ usual clinical practice, or are a deliberate attempt to use a more detailed and reproducible method that is restricted to the research setting. Recently published papers have used a variety of testing strategies. For instance, Koh et al. tested the effect of axillary brachial plexus block using pinprick, assessing the results on a 3-point scale and gauging motor block by evaluating muscle power in areas supplied by the median, radial, ulnar and musculocutaneous nerves [6]. Calderon et al. used only sensory testing, as would be expected for a cervical block, but the three points of their 3-point scale differed from that of Koh et al. [7]. Kelpinger et al. gave a detailed and reproducible description of sensory testing using pinprick, and expressed as a percentage of normal in increments of 10%, and also used a 4-point motor scale [8]. On the other hand, Gan et al. used a simple assessment of sensation to cold and pinprick and what they described simply as ‘leg weakness’ after epidural ropivacaine [9].

Furthermore, one might expect greater consensus when testing neuraxial blockade for obstetric anaesthesia, as it is most often studied, commonly performed and patient expectations are high. However, a recent survey of published medical literature and anaesthetic textbooks revealed wide variation, both in the sensory testing modalities used among researchers and in the versions presented of the Bromage scoring system for weakness of the legs, with authors reporting different scales from 0–3 and from 1–6.

Variability in testing practice is probably not surprising; nerve block assessment before surgery is innately difficult. Pain, being a sensory and emotional experience, is difficult to define and measure objectively; devising a standardised regimen is therefore problematic. Furthermore, there is a paradox inherent in assessing nerve blocks in clinical settings, in that the prime purpose of the test is to assess the integrity of the pain pathway, not to inflict undue pain or lasting damage on the patient. Additionally, for a truly comprehensive test to exist, all pain pathways should be testable, which evidently they are not. Visceral pain, for example, is testable in current clinical settings; in laboratory settings with animal models, visceral pain is modelled by injecting irritants such as acetic acid into the peritoneal cavity, thereby inducing a ‘writhing response’ [10]. Clearly, this testing modality is inappropriate for human clinical practice! There is thus no ideal test for regional blockade, although it is possible to set out what characteristics such a test might have [11] (Table 1).

What means, then, are currently available? Clinical signs are the simplest. As Charlton noted: ‘useful signs are vasodilatation in the area of the nerve or plexus block or heaviness of the arms or legs’ [12]. Also, if patients are in pain before the block, the gradual development of analgesia is evident. One study also assessed patients’ reports of sensations in their upper extremity after block injection [13]. Other modalities commonly tested include: light touch (e.g. cotton wool, monofilament); pain (e.g. pinprick, movement of painful joint); cold sensation (e.g. ethyl chloride, ice); associated motor blockade; heat; pressure and electrical stimulation. These and other modalities were reviewed

Table 1 Properties of an ideal test for assessing nerve blockade in anaesthetic practice

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<th>Property</th>
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<td>Reproducible</td>
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<tr>
<td>Observer-independent</td>
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<tr>
<td>Non-damaging to patient</td>
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<td>Acceptable to patients</td>
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<tr>
<td>Not reliant on patient’s ability to communicate</td>
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<td>Able to assess any part of the body including visceral and deep pain</td>
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<td>Selectivity for pain and/or sensory receptor type</td>
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<tr>
<td>Assesses both distribution and density of the block</td>
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<td>Quick and easy to apply</td>
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<tr>
<td>Cheap</td>
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Modified from Curatolo et al. [11].
Failure rates for peripheral blocks may also vary. It would thus seem sensible to expect rigorous testing to take place to assess the effectiveness of nerve blocks before surgery. Practitioners probably rely on their experience of previous blocks (part of the ‘tacit knowledge’ of anaesthetic practice [35, 36]) to guide them in their assessment of the block as it develops, and prediction of failure or success based on the ‘feel’ of the procedure [37], equipment used and other signs [38]. However, a number of the above studies have attempted to calculate the predictive value of the tests used. Galvin et al., tested thermographic temperature measurement with an infrared camera in patients after axillary brachial plexus blockade and compared the assessment with response to cold and pinprick. They found higher sensitivity, specificity, and positive and negative predictive values for thermography than either cold and pinprick at all time intervals [23]. For thermography, these results were echoed by Asghar et al. [22] and van Haren et al. [24]. Similarly, higher sensitivity and specificity were found for perfusion indices [31]. However, even the simplest study (measuring skin temperature by simple touch) achieved a 92% sensitivity, with a positive predictive value of 95% [29]. Likewise, patients who reported an illusory sensation of limb swelling were more likely to have a successful block in the relevant cutaneous distribution, with a sensitivity of 100% and a specificity of 92% [13].

Assessment of block under general anaesthesia

Assessment of blocks placed under general anaesthesia would be useful, if only to avoid the patient waking in pain at the end of the procedure. However, in the anaesthetised patient, any testing options that rely on conscious co-operation are no longer possible. We are not aware of any study that has addressed the question of how a block might be assessed under general anaesthesia, but a recent publication has carefully reviewed objective markers of pain and nociception in conscious subjects [39]. There are, however, a number of studies that have attempted to assess general nociception in anaesthetised patients. Given that the painful stimulus of surgery should be blocked by a successful injection of local anaesthetic, similar methods also have the
potential to assess the adequacy of local anaesthetic blocks in anaesthetised patients.

Most such studies of nociception rely on evaluating the response of the autonomic nervous system to pain; a number of methods have been studied. Heart rate variability reflects the interaction between the sympathetic and parasympathetic nervous systems. In a recent systematic review, Koenig et al. suggested that heart rate variability may be a better index of short-term nociception than the ‘raw’ measurement of heart rate and/or blood pressure [40]. Possible confounding factors are age, gender, comorbidity and medications [39]. In an attempt to address these, investigators have developed a ‘cardiorespiratory coherence index’ [41], an ‘analgesia nociception index’ [42, 43] and a software programme that examines beat-to-beat variability in heart rate and blood pressure [44]. All were tested in small groups of patients, but show promise.

The electroencephalogram (EEG) may also change with nociceptive stimuli; not only the ‘raw’ EEG [45] but also specific bands within it (gamma band oscillations may vary [46]). Processed versions, including entropy indices [47] and the bispectral index [48] have been tried, again in relatively small observational studies. Other investigators have correlated changes in pupillary size to painful stimuli in order to assess nociception under general anaesthesia [49]. Finally, skin conductance and its associated temperature changes have also been evaluated as an objective measure of postoperative pain [50]. This method may also be feasible for intra-operative use, but we are not aware of any such work at present.

Cowen et al. summarised the use of other biopotentials, biomarkers and imaging techniques for pain assessment [39]. However, despite the availability of a wide range of possible techniques for pain assessment in the anaesthetised patient, few are clinically practical, and most have only been used in a research setting.

Unexpected persistence of block after surgery

The notion of recovery from anaesthesia was recently examined by Bowyer and Royse [51]. They argued that ‘recovery’ can denote one of two types of event. They distinguish between recovery above a particular ‘threshold’ (for instance complete resolution of spinal block) and what they term a ‘continuous variable’ (for instance, an epidural or other regional anaesthetic infusion continued postoperatively, which allows for the return of some sensation and movement, but abolishes pain).

In addition to standard postoperative observations, the patient who has had a regional anaesthetic block should be monitored for dynamic pain scores, sedation, dermatomal level/distribution and motor blockade. If a catheter has been left in place the insertion site should be inspected twice a day [52], and regular review by the Acute Pain Team should also take place [52]. Persistence of block should always be taken seriously. In the case of epidural infusion, Wheatley and colleagues suggest stopping the infusion and re-assessing after 2 h. If there is no neurological improvement after this time (assuming low-dose local anaesthetic mixtures have been infused), further investigation should be considered. The recent American Society of Regional Anesthesia advisory document adds: ‘Weakness that is more intense than expected, recurrent after initial resolution, progressive and/or in an area inconsistent with the block (e.g. lower leg or foot weakness associated with a thoracic epidural) can be the first presenting symptom of a significant neuraxial injury’ [53].

Persisting neurological effects after other local anaesthetic blocks should likewise raise the possibility of peripheral nerve injury [53]. This may not be due to the block itself, nor a complication thereof; indeed, it can be difficult to recognise postoperative peripheral nerve injury whatever the cause. Furthermore, block durations can be unpredictable, but as offset time is likely to be normally distributed in the population, individual slow resolution might simply represent a patient at one extreme of the distribution curve. Peripheral nerve injuries should also be attended to promptly, as many factors such as injury from intrinsic or extrinsic compression are time sensitive but easily correctable. Pure sensory deficits within the territory of the block, or at a common ‘compression point’ may occur, and should resolve within days or weeks. If the deficit involves motor function, is progressive, difficult to localise or is at odds with the surgery or expected distribution of the anaesthetic block, a neurological referral should be made [53]. Chronic postsurgical
pain may also result, but that is beyond the scope of this review.

Further research in this area could usefully include a larger study comparing skin temperature changes with sensory-based testing, as this is potentially more objective and offers the promise of early warning of block failure. Other work could investigate nociception during general anaesthesia when regional blockade is used. Finally, it might be useful to collate data on the expected durations of blocks, even though these will vary with differences in insertion techniques, injection sites and additives. This should enable a more informed judgement as to when a block is unusually persistent.

In terms of practical recommendations, it seems prudent to continue to employ and document multiple testing modalities, such as testing for cold, touch and motor block as advocated in the Obstetric Anaesthetists Association’s 2011 guidelines [54]. We also recommend that anaesthetists make more use of the assessment of temperature changes in the affected area as an early indicator of block success or failure.

Competing interests
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