NATIONAL INSTITUTE FOR HEALTH AND CLINICAL EXCELLENCE

INTERVENTIONAL PROCEDURES PROGRAMME

Interventional procedure overview of ultrasound-guided regional nerve block

Regional anaesthesia is used in several conditions to enable surgery to be performed on specific parts of the body. Ultrasound-guided regional nerve block uses ultrasound to facilitate easy and accurate positioning of the needles that deliver the anaesthetic drugs close to the nerves.

Introduction

This overview has been prepared to assist members of the Interventional Procedures Advisory Committee (IPAC) in making recommendations about the safety and efficacy of an interventional procedure. It is based on a rapid review of the medical literature and specialist opinion. It should not be regarded as a definitive assessment of the procedure.

Date prepared

This overview was prepared in March 2008

Procedure name

- Ultrasound-guided regional nerve block

Specialty societies

- Association of Anaesthetists of Great Britain and Ireland
- Royal College of Anaesthetists
- The Pain Society.

Description

Indications

Regional anaesthesia or peripheral nerve block is used to enable surgery to be performed or for the management of chronic pain. Nerve-blocking procedures using anaesthesia and/or analgesia may be performed at several

different sites around the body (for example, brachial plexus for arm surgery), and may be undertaken in conjunction with general anaesthesia.

Current treatment and alternatives

Regional anaesthesia has traditionally been delivered by positioning a needle in close proximity to the target nerve via ‘blind’ insertion using anatomical landmarks. In some techniques the detection of a ‘click’ when the fascia overlying or surrounding the nerve is breached is used to confirm position. More recently nerve stimulation has been used to help confirm that the nerve has been correctly identified.

What the procedure involves

High-resolution real-time ultrasound imaging is used to visualise the relevant nerve to be blocked and then to guide accurate needle tip placement immediately adjacent to the nerve. Ideally ultrasound imaging systems should allow visualisation of the target nerve and surrounding structures including muscles, vessels, pleura and abdominal contents. Anaesthetic drugs are then injected as for conventional nerve block techniques. The correct placement of the anaesthetic solution is confirmed using ultrasound. The needle may be repositioned in cases of maldistribution. The ability to monitor the distribution of the anaesthetic allows the minimum volume of drug to be used.

Efficacy

Success of the regional nerve block technique in terms of sensor and motor function was defined differently across the studies identified, making comparison of outcomes difficult.

One randomised controlled trial of 188 patients reported that nerve blocks were more often successful with ultrasound guidance (82.8%, p = 0.01) or with combined ultrasound and nerve stimulation guidance (80.7%, p = 0.03) than with nerve stimulation guidance alone (62.9%) (absolute numbers not reported)[1].

A second randomised controlled trial of 60 patients reported that nerve block failure occurred in 5% (1/20) of patients following ultrasound-guided regional nerve block for post-trauma hip surgery compared with 10% (2/20) of patients receiving the same volume of anaesthesia with nerve stimulation guidance (not statistically significant)[2].

A third randomised controlled trial of 160 patients reported that nerve block for post-trauma shoulder or arm surgery was statistically more often successful following ultrasound-guided regional nerve block 99% (79/80) of patients compared with patients receiving the anaesthesia with nerve stimulation guidance 91% (73/80) (p < 0.01).

A non-randomised controlled study of 248 patients requiring any one of four different peripheral nerve blocks reported that nerve block failure occurred in 2% (3/124) of patients having combined ultrasound and nerve stimulation-guided blocks compared with 6% (8/124) of patients with nerve stimulation guidance alone. This difference was not statistically significant (p = 0.334)[3]. However, the mean number of insertion attempts required was significantly fewer with combined ultrasound and nerve stimulation guidance (two passes), than with nerve stimulation guidance alone (six passes) (p < 0.001).

A third randomised controlled trial of 40 patients reported that the nerve block was significantly more successful with ultrasound guidance than with anatomical landmark guidance (p = 0.003), and that the onset of block was significantly quicker (p = 0.011) (absolute numbers not reported)[4]. In this study, conversion to general anaesthesia was required in 5% (1/20) of patients in the ultrasound-guided group and 10% (2/20) of patients in the landmark-guided group.

A fourth randomised controlled trial of 100 patients reported that the mean volume of anaesthesia required to produce an effective block was significantly lower when using ultrasound guidance for ilioinguinal and iliohypogastric nerve block (0.19 ml/kg) than when using anatomical landmark guidance (facial click) (0.3 ml/kg) (p < 0.0001)[5]. In addition, a smaller proportion of patients required rectal acetaminophen for postoperative analgesia purposes in the ultrasound-guided group (6%) than the fascial click group (40%) (p < 0.0001) (absolute numbers not reported).

In two case series of 1146 and 520 patients a successful block was recorded in 99% (1138/1146) of patients having upper limb or hand surgery[6] and 94% of patients undergoing undefined surgery requiring ultrasound-guided regional nerve block[7] (absolute numbers not reported).

A case series of 620 patients receiving a catheter and fixed rate infuser for post-discharge pain control following surgery on a joint reported that 2% (13/620) had inadequate pain control requiring an additional intervention[8].

Safety

One randomised controlled trial reported that transient postblock paraesthesia (up to 5 days) occurred in 20% (13/64) of patients receiving ultrasound-guided block, 21% (13/62) of patients receiving nerve stimulation-guided block and 15% (9/62) of patients receiving combined ultrasound- and nerve stimulation-guided block (measure of significance not reported)[1].

A case report of one patient treated with ultrasound-guided nerve block for valgus impaction syndrome of the elbow reported delayed paresis of the arm and hand following discharge. This resolved spontaneously at 23 hours follow-up after readmission for observation[9].

A case series of 620 patients receiving ultrasound-guided catheter insertion reported that nerve injury occurred in less than 1% (2/620) of patients[8]. In one patient this resolved spontaneously at 6-week follow-up. The second patient reported severe burning pain and allodynia in the plantar and dorsal aspects of the foot at 5-day follow-up. Examination of the foot revealed oedema and colour change consistent with complex regional pain syndrome, but without motor or sensory deficit. A series of three sympathetic blocks of the lower extremity rapidly resolved symptoms 2 weeks later.

A second randomised controlled trial reported that vascular puncture causing haematoma occurred in 10% (4/40) of patients following nerve stimulation-guided block, but there were no cases in 20 patients following ultrasound-guided nerve block (measure of significance not reported)[2].

A third randomised controlled trial reported that arterial puncture occurred in 15% (3/20) of anatomical landmark-guided blocks but there were no cases in 20 patients treated with ultrasound-guided blocks (not statistically significant)[4]. In the same study the incidence of paraesthesia was significantly higher in the landmark-guided group than the ultrasound-guided group ($p = 0.012$) (absolute numbers not reported).

A non-randomised controlled trial of 662 patients having had wrist or elbow surgery reported that major complications were statistically more frequent following traditional block delivery methods 3% (4/127) than with US guidance <1% (2/535) ($p = 0.014$).

A case series of 1146 patients reported that arterial puncture occurred in less than 1% (8/1146) of patients. All cases were described as inconsequential[6]. A fourth randomised controlled trial reported no complications in either the ultrasound-guided or facial click-guided regional nerve block groups[5].

Literature review

Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to ultrasound-guided regional nerve block. Searches were conducted of the following databases, covering the period from their commencement to 10/03/2008 and updated to 29/08.2008: MEDLINE, PREMEDLINE, EMBASE, Cochrane Library and other databases. Trial registries and the Internet were also searched. No language restriction was applied to the searches. (See appendix C for details of search strategy.)

The following selection criteria (table 1) were applied to the abstracts identified by the literature search. Where these criteria could not be determined from the abstracts the full paper was retrieved.

Table 1 Inclusion criteria for identification of relevant studies

Characteristic	Criteria
Publication type	Clinical studies were included. Emphasis was placed on identifying good quality studies. Abstracts were excluded where no clinical outcomes were reported, or where the paper was a review, editorial, laboratory or animal study. Conference abstracts were also excluded because of the difficulty of appraising methodology, unless they reported specific adverse events that were not available in the published literature.
Patient	Patients requiring regional anaesthesia.
Intervention/test	Ultrasound-guided regional nerve block.
Outcome	Articles were retrieved if the abstract contained information relevant to the safety and/or efficacy.
Language	Non-English-language articles were excluded unless they were thought to add substantively to the English-language evidence base.

List of studies included in the overview

This overview is based on five randomised controlled trials[1, 2, 4, 5,] , two non-randomised controlled trials[3,], three case series[6, 8, 7], and one case report[9], including a total of approximately 3180 patients undergoing ultrasound-guided regional nerve block.

Other studies that were considered to be relevant to the procedure but were not included in the main extraction table (table 2) have been listed in appendix A.

Existing reviews on this procedure

There were no published systematic reviews or evidence-based guidelines of good quality identified at the time of the literature search.

Related NICE guidance

Below is a list of NICE guidance related to this procedure. Appendix B gives details of the recommendations made in each piece of guidance listed below.

Interventional procedures

- Ultrasound-guided catheterisation of the epidural space. NICE interventional procedures guidance 249 (2008). Available from www.nice.org.uk/IPG249

Technology appraisals

- None

Clinical guidelines

- None

Public health guidance

- None

Table 2 Summary of key efficacy and safety findings on ultrasound-guided regional nerve block

Abbreviations used: ASA, American Society of Anesthesiologists; BMI, body mass index; IQR, inter-quartile range; NR, not reported; NS, nerve stimulation; US, ultrasound

Study details	Key efficacy findings	Key safety findings	Comments
Chan VWS (2007)[1] **Randomised controlled trial** Canada Study period: not stated **n = 188** (62 NS, 64 US guided, 62 combined NS and US) Population: mean age = 46 years, male = 59%, mean BMI = 27 kg/m^2, ASA class I–III Indications: patients undergoing elective hand surgery Technique: US-guided block using a 5–12 MHz probe and 22 G needle vs injection with NS guidance vs injection with NS and US guidance **Follow-up: 7 days** Disclosure of interest: study supported by manufacturer and academic grant	**Anaesthetic characteristics** Quality of the nerve block (assessed by pin prick test from 0 'no sensation' to 2 'normal sensation') at 30 minutes **Outcome** / **NS** / **US** / **US and NS** Block success: 62.9% / 82.8% (p = 0.01 vs NS) / 80.7% (p = 0.03 vs NS) Block procedure time (minutes): 11.2 ± 4.2 / 9.3 ± 4.0 (p = 0.01 vs NS) / 12.4 ± 4.8 Additional anaesthesia required: 15% (9/62) / 5% (3/64) / 8% (5/62) No significant differences Blockade of each individual targeted nerve was also more successful in the US and combined US and NS groups than the NS group	**Complications** No major complications (intravascular injection, persistent neurological deficit) occurred in any of the groups **Outcome** / **NS** / **US** / **US and NS** Transient postblock parathesia (<5 days): 21% (13/62) / 20% (13/64) / 15% (9/62) Local bruising: 13% (8/62) / 3% (2/64) / 0% Local axillary pain: 16% (10/62) / 5% (3/64) / 5% (3/62)	Not clear if the same surgery was being conducted on all patients. Computer-generated randomisation and concealment in sealed envelopes. An independent observer recorded the block procedure time, and a blinded observer assessed the onset and progression of motor and sensory anaesthesia. Power calculation made to estimate study sample size. Patient demographic and clinical characteristics did not differ significantly between the groups.

Abbreviations used: ASA, American Society of Anesthesiologists; BMI, body mass index; IQR, inter-quartile range; NR, not reported; NS, nerve stimulation; US, ultrasound

Study details	Key efficacy findings	Key safety findings	Comments
Kapral S (2008) **Randomised controlled trial** Austria Study period: not stated **n = 160** (80 US guided) Population: mean age = 74 years, male = 44%, ASA class I–III Indications: patients undergoing trauma related surgery of shoulder or upper arm Technique: US-guided block using a 22 G needle vs injection with NS guidance. **Follow-up: not reported** Disclosure of interest: not reported	**Anaesthetic characteristics** Outcome / US guided / NS guided / p= Successful surgical anaesthesia / 99% (79/80) / 91% (73/80) / < 0.01 Mean block onset time (min) / 10 (6 to 13) / 22 (11 to 28) / < 0.05	**Complications** Safety outcomes were not reported on.	Performance of nerve blocks was undertaken by one anaesthetist blinded to the study. Method of randomisation or concealment of allocation are not described. All blocks undertaken by three anesthesiologists with experience in both techniques.

Abbreviations used: ASA, American Society of Anesthesiologists; BMI, body mass index; IQR, inter-quartile range; NR, not reported; NS, nerve stimulation; US, ultrasound

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>Marhofer P (1998)[2]

Randomised controlled trial

Austria

Study period: not stated.

n = 60 (2 × 20 NS guided with 20 and 30 ml anaesthetic volume, 20 US guided with 20 ml anaesthetic volume)

Population: mean age = 72 years (range 54–86), male = NR, mean body surface area = 1.78 m^2, ASA class II–III

Indications: patients undergoing hip surgery following trauma

Technique: US guided 3 in 1 block using portable unit and a 7.5 MHz probe and 24 G needle vs injection with NS confirmation

Follow-up: 1 hour

Disclosure of interest: study supported by manufacturer</td>
<td>Nerve visualisation
The femoral nerve was successfully identified with US imaging in 95% (19/20) of patients in the US group

Anaesthetic characteristics

<table>
<tr><th>Outcome</th><th>US 20 ml</th><th>NS 20 ml</th><th>NS 30 ml</th><th>p</th></tr>
<tr><td>Onset time (minutes)</td><td>13 ± 16</td><td>27 ± 12</td><td>26 ± 13</td><td><0.01*</td></tr>
<tr><td>3 in 1 block</td><td>95% (19/20)</td><td>80% (16/20)</td><td>80% (16/20)</td><td>NR</td></tr>
<tr><td>2 in 1 block</td><td>0%</td><td>5% (1/20)</td><td>20% (4/20)</td><td>NR</td></tr>
<tr><td>1 in 1 block</td><td>0%</td><td>5% (1/20)</td><td>5% (1/20)</td><td>NR</td></tr>
<tr><td>Total block failure</td><td>5% (1/20)</td><td>10% (2/20)</td><td>5% (1/20)</td><td>NR</td></tr>
</table>
*US vs both NS groups

Onset time of sensory block in each single nerve was significantly better with US guidance compared with both NS-guided groups

Quality of the nerve block (assessed by pin prick test) was significantly better in the US group than both the NS groups ($p < 0.01$)</td>
<td>Complications
Heart rate, blood pressure, and oxygen saturation were stable in all patients in all groups

<table>
<tr><th>Outcome</th><th>US 20 ml</th><th>NS 20 ml</th><th>NS 30 ml</th></tr>
<tr><td>Vascular puncture causing haematoma</td><td>0% (0/20)</td><td>10% (2/20)</td><td>10% (2/20)</td></tr>
</table>
(Level of significance not reported)

The analgesic effect of the 3 in 1 block had dissipated in all patients within 24 hours. There were no complications at this time</td>
<td>ASA score rates patients' physical status prior to surgery from 1 (healthy) to 6 (brain dead – organs removed for transplant)

All blocks conducted by one anaesthetist, with a second "blinded" anaesthetist providing monitoring.

Quality of sensory block was calculated by pooling data from observations at 30, 40, 50 and 60 minutes.

Not clear why an arm with 30 ml anaesthetic given with US guidance was not included in the study design.

Subjective measure of quality of nerve block was used.

Not clear if the same surgery was being conducted on all patients.</td>
</tr>
</table>

Abbreviations used: ASA, American Society of Anesthesiologists; BMI, body mass index; IQR, inter-quartile range; NR, not reported; NS, nerve stimulation; US, ultrasound

Study details	Key efficacy findings	Key safety findings	Comments
Soeding PE (2005)[4] **Randomised controlled trial** Australia Study period: not stated **n = 40** (20 US guided) Population: no patient demographic data were presented Indications: patients undergoing elective upper limb surgery Technique: US-guided block using a 13 MHz probe and Doppler imaging vs injection with anatomical landmark guidance **Follow-up: 7 days** Disclosure of interest: not stated	**Anaesthetic characteristics** Conversion to general anaesthesia was required in 5% (1/20) of patients in the US-guided group and 10% (2/20) of patients in the landmark-guided group Sensory block was assessed by response to ice at eight points on the upper limb. Motor block was examined by testing muscle power in eight muscle groups **Outcome** / **US guided** / **Landmark** / **p** Duration of analgesia (hours) / 11.2 ± 0.59 / 10.3 ± 0.62 / 0.271 The onset of sensory block was significantly quicker with US guidance than with landmark guidance (p = 0.011) (absolute figures not reported) The block was significantly more successful with US guidance than with landmark guidance (p = 0.003) (absolute figures not reported). 100% (20/20) of patients in the US group and 95% (19/20) of patients in the landmark group were very satisfied with the anaesthetic technique	**Complications** Arterial puncture occurred in 0% (0/20) of the US-guided patients and 15% (3/20) of landmark-guided patients. This difference was not statistically significant The incidence of paraesthesia during block installation was significantly higher in the landmark group than the US group (p = 0.012) (absolute figures not reported) No patients in either group reported seizure or neurapraxia	Different surgery was being conducted on different patients from shoulder to wrist surgery, so different nerves were being identified. Power calculation made to estimate study sample size. One anaesthetist with training in US guidance performed all the blocks. A second investigator independently evaluated anaesthetic efficacy. Patients were not blinded to treatment allocation. Patient demographic and clinical characteristics did not differ significantly between the groups. The authors state that US-guided regional anaesthesia requires practice and preliminary training for good performance.

Abbreviations used: ASA, American Society of Anesthesiologists; BMI, body mass index; IQR, inter-quartile range; NR, not reported; NS, nerve stimulation; US, ultrasound

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>Willschke H (2005)[5]

Randomised controlled study

South Africa

Study period: not stated

n = 100 (number in the US-guided group not stated)

Population: mean age = 41 months (range 2–96 months), male = NR, mean weight = 13.5 kg, mean height = 91 cm

Technique: US-guided local anaesthesia using portable unit and a 5–10 MHz probe and 22 G needle vs standard injection with a facial click for inguinal hernia repair

Mean follow-up: NR

Disclosure of interest: study supported by manufacturer</td>
<td>Nerve visualisation
The ilioinguinal and iliohypogastric nerves were successfully visualised in 100% of patients in the US group (absolute numbers not reported)

Anaesthetic characteristics

<table>
<tr><th>Outcome</th><th>US guided</th><th>Fascial click</th><th>p</th></tr>
<tr><td>Heart rate increase on incision</td><td>6%</td><td>22%</td><td><0.001</td></tr>
<tr><td>Additional fentanyl necessary</td><td>4%</td><td>26%</td><td>0.004</td></tr>
<tr><td>Targeted nerves surrounded by anaesthetic (by US after injection in the facial click group)</td><td>100%</td><td>50%</td><td><0.0001</td></tr>
<tr><td>Volume of anaesthetic (ml/kg)</td><td>0.19</td><td>0.3</td><td><0.0001</td></tr>
<tr><td>Postoperative rectal acetaminophen necessary</td><td>6%</td><td>40%</td><td><0.0001</td></tr>
</table>
(Absolute numbers not reported)</td>
<td>Complications
All anaesthetic procedures were uneventful. There was no small bowel perforation or major vessel puncture

No vasoactive drugs were required in either group</td>
<td>Randomisation external to the study centre and allocation concealment using opaque envelopes.

No details provided of blinding of outcome assessors.

All surgery undertaken by one surgeon, and all blocks performed by one of two anaesthetists experienced in US-guided regional anaesthesia in children.

The number of patients in each group is not clearly specified in the study report.

Demographic and clinical characteristics of the two groups were not significantly different at baseline.

Efficacy of postoperative analgesia was measured using the Objective Pain Score which rates five behavioural variables (crying, facial expression, position of legs and torso, and motor restlessness) on a three-point scale from none to severe, providing a total score of 0–15 (higher scores worse).</td>
</tr>
</table>

Abbreviations used: ASA, American Society of Anesthesiologists; BMI, body mass index; IQR, inter-quartile range; NR, not reported; NS, nerve stimulation; US, ultrasound

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>Orebaugh SL (2007)[3]

Non-randomised controlled study

USA

Study period: not stated

n = 248 (124 US guided)

Population: patient demographic and clinical characteristics not available

Indications: patients requiring any one of four peripheral nerve blocks: interscalene, axillary, femoral or posterior popliteal fossa block of sciatic nerve

Technique: US-guided local anaesthesia using portable unit and a 5–10 MHz probe and 22 G needle with NS guidance vs injection with NS confirmation. Dosing volume parameters were the same for both groups

Follow-up: 24 hours
Disclosure of interest: none</td>
<td>Anaesthetic characteristics
Time required to perform the regional nerve block was recorded as the time from initial needle insertion to beginning of anaesthetic injection

The number of needle insertions was recoded as the number of times the needle was brought to the skin surface and directed or redirected to the target nerve

Block effectiveness was assessed by light touch and pinch stimulus, and strength against gravity or resistance

<table>
<tr><th>Outcome</th><th>US and NS guided</th><th>NS guided</th><th>P</th></tr>
<tr><td>Time to perform (minutes) median (IQR)</td><td>1.8 (0.8–6.9)</td><td>6.5 (3.1–12.5)</td><td><0.001</td></tr>
<tr><td>Mean number of insertion attempts required median (IQR)</td><td>2 (1–4)</td><td>6 (3–9)</td><td><0.001</td></tr>
<tr><td>Block failure</td><td>2% (3/124)</td><td>6% (8/124)</td><td>0.334</td></tr>
</table>
Not statistically significant</td>
<td>Complications

<table>
<tr><th>Outcome</th><th>US and NS guided</th><th>NS guided</th><th>p</th></tr>
<tr><td>Blood vessel puncture</td><td>3% (3/124)</td><td>10% (12/124)</td><td>0.03</td></tr>
</table>
No patient in either group developed pneumothorax or local anaesthetic toxicity or displayed evidence of peripheral nerve injury at 24-hour follow-up</td>
<td>Retrospective database analysis. One author recorded data from 14 junior doctors being trained to perform peripheral nerve blocks. Two weeks of training were allowed before analysis begun.

Consecutive patients presenting for orthopaedic procedures in the upper or lower limb.

The decision to use US guidance for block delivery was made before the junior doctor had met the patient. No randomisation was used but anecdotally alternative patients were treated with or without US guidance.

Power calculation made to estimate study sample size.

Time to perform nerve block did not include the ‘set-up’ time required for US and NS guidance systems

Patient demographic and clinical characteristics were not available as cases were evaluated from an anonymised database.</td>
</tr>
</table>

Abbreviations used: ASA, American Society of Anesthesiologists; BMI, body mass index; IQR, inter-quartile range; NR, not reported; NS, nerve stimulation; US, ultrasound

Study details	Key efficacy findings	Key safety findings	Comments
Sandhu NS (2006)[6] **Case series** USA **n = 1146** Study period: June 2002–April 2005 Population: mean age = 39 years, male = 80%, mean BMI = 26.2, mean duration of surgical procedure = 165 minutes Indications: patients requiring surgery of the upper limb or hand (n = 1145), or for postoperative pain (n = 1) with multiple fasciotomies Technique: US-guided local anaesthesia using a 4–7 MHz probe and 17 G needle. In some cases a catheter was introduced (n = 840) **Follow-up: NR** Disclosure of interest: supported by academic grant	**Anaesthetic characteristics** A successful block was recorded in 99% (1138/1146) of patients. There was no significant difference in the success rate between anaesthetists of different seniority A block was rated successful if so recorded at the time by the attending anaesthetist, and no sedative or opiod was given beyond those routinely administered, there was no supplementation of the block by surgeons, and no general anaesthesia was given Conversion to general anaesthetic was required in 2% (19/1146) of patients Propofol was administered in 3% (35/1146) of patients for sedation (injected)	**Complications** Arterial punctures occurred in <1% (8/1146) of patients. All were described as inconsequential No patients had inadvertent intravascular injury, local toxicity or symptoms of peripheral nerve injury	Retrospective database analysis. Not clear what primary endpoint was for the study. Additional general anaesthetic or sedation was often given in patients requiring microscopic surgery of the hand. 97% of the blocks were performed by 88 different junior doctors under supervision from 37 different anaesthetists, which represents a 'real world' experience. Height and weight details were not available for 105 patients so the BMI could not be calculated for the cohort.

Abbreviations used: ASA, American Society of Anesthesiologists; BMI, body mass index; IQR, inter-quartile range; NR, not reported; NS, nerve stimulation; US, ultrasound

Study details	Key efficacy findings	Key safety findings	Comments
Lo N (2008) **NRCT** Canada **n = 662** (535 US guided) Study period: October 2003–November 2006 Population: mean age = 46 years, male = 56% Indications: patients requiring axillary brachial plexus block for surgery of the hand, wrist or elbow Technique: US-guided local block using a 23 G needle vs traditional method, e.g. NS-guided block or transarterial approach **Follow-up: not reported** Disclosure of interest: not stated	**Anaesthetic characteristics** In the US-guided group 92% (490/535) of patients had a complete block, 5% (27/535) had an incomplete block, and 3% (18/535) had a failed block. In the traditional block group 82% (104/127) had a complete block, 11% (14/127) had an incomplete block, and 7% (9/127). This was a statistically significant difference across the groups (p = 0.003). Outcome / US guided / traditional / p= Mean local anaesthetic volume (ml) / 39.8 ± 6.4 / 46.7 ± 17.1 / <0.0001 Mean time in block room (min) / 30.6 ± 14.2 / 40.1 ± 27.3 / <0.0001	**Complications** Outcome / US guided / traditional / p= Major complications / <1% (2/535) / 3% (4/127) / 0.014 The two complications in the US-guided group were intravascular local anaesthetic injection. In the traditional block group there were two intravascular local anaesthetic injections; one had a generalised seizure, and one had postoperative neuropathy.	Retrospective case note review. Missing patient data not described. The traditional block group were subdivided for analysis into groups that had NS block and those treated with a transarterial technique. 54 clinicians undertook the blocks (all types) the volume that each performed is not stated. It is likely that some performed very few. Possibly the same patients as reported in Chan (2007) RCT.

Abbreviations used: ASA, American Society of Anesthesiologists; BMI, body mass index; IQR, inter-quartile range; NR, not reported; NS, nerve stimulation; US, ultrasound

Study details	Key efficacy findings	Key safety findings	Comments
Swenson JD (2006)[8] **Case series** USA **n = 620** Study period: November 2004–January 2006 Population: mean age = NR, male = 60% Indications: patients requiring surgery of the shoulder, foot and ankle, or knee Technique: US-guided local block using a 18 G needle and a 20 G catheter. Test injection of 3 ml of anaesthesia to confirm correct placement. Discharged with a fixed rate infuser **Follow-up: to 2 weeks** Disclosure of interest: not stated	**Anaesthetic characteristics** An additional intervention from an anaesthetist following discharge was required in 4% (26/620) of patients **Outcome** / **Frequency** Patient education/information required for successful block delivery: 1% (9/620) Inadequate pain control requiring additional intervention: 2% (13/620)	**Complications** **Outcome** / **Frequency** Equipment malfunction: <1% (4/620) Infection: 0% Toxicity: 0% Nerve injury: <1% (2/620) Both nerve injury complications occurred in patients with a catheter positioned in the popliteal fossa The first patient had weakness and sensory loss in the distribution of the common peroneal nerve at 1-week follow-up. This resolved spontaneously at 6 weeks The second patient reported severe burning pain and allodynia in the plantar and dorsal aspects of the foot at 5-day follow-up. Examination of the foot revealed oedema and colour change consistent with complex regional pain syndrome, but without motor or sensory deficit. A series of three sympathetic blocks of the lower extremity rapidly resolved symptoms 2 weeks later The continuous peripheral nerve block could not be removed at home in <1% (1/620) of patients The catheter was accidentally dislodged in 1% (5/620) of patients. All these had interscalene blocks	Retrospective analysis from a single site. All outcomes for the three different nerve sites (brachial plexus, femoral or sciatic nerves) have been compiled in the safety and efficacy columns. Different surgical procedures were being conducted on different patients. Some complications relate to the need to keep an indwelling catheter postdischarge rather than its placement. This is unlikely to be influenced by US guidance.

Abbreviations used: ASA, American Society of Anesthesiologists; BMI, body mass index; IQR, inter-quartile range; NR, not reported; NS, nerve stimulation; US, ultrasound

Study details	Key efficacy findings	Key safety findings	Comments
Sites BD (2007)[7] **Case series** USA **n = 520** Study period: not stated Population: mean age = NR Indications: patients requiring regional nerve block for surgery. No further details provided Technique: US-guided local block also using NS. No further description **Follow-up: NR** Disclosure of interest: supported by grant from an academic institution	**Anaesthetic characteristics** Errors in technique were evaluated by video analysis and recordings of US images by experienced anaesthetists. In total there were 398 errors during 520 blocks. The most common errors were needle not visualised while being advanced (44%), and unintentional movement of the US probe (27%) Blocks were analysed by sensation to ice from 0 (no loss of sensation) to 2 (no sensation), and on motor effect from 0 (no weakness) to 2 (complete paresis). Blocks were recorded as successful if they scored 1 or 2 on both parameters. Additionally unplanned conversion to general anaesthesia was also considered a failure. Overall 94% of blocks were successful	**Complications** Vascular puncture (venous or arterial) occurred in 1% (3/520) of patients. The location of the needle was identified before injection of anaesthesia in all cases. One patient with multiple sclerosis developed prolonged brachial plexus injury following interscalene nerve block and total shoulder replacement. The patient had minimal sensory or motor function in the entire arm at 2-month follow-up. Magnetic resonance imaging suggested a surgical stretch injury to the roots of the brachial plexus. Sensory and motor function slowly recovered to 90% of baseline	The records of six junior doctors were analysed for the study. Those with previous US-guided regional anaesthesia experience were excluded. All juniors were given introductory training. Time to perform block was calculated as the time from sterile preparation to withdrawal of the needle. Both speed and accuracy of the block improved with experience (measure of significance not reported). A needle accuracy score was also recorded, being a composite score of correct needle positioning, block success and intravascular puncture events. However scores were not reported. There is a discrepancy in the absolute numbers and percentage of successful blocks in the study report.

Abbreviations used: ASA, American Society of Anesthesiologists; BMI, body mass index; IQR, inter-quartile range; NR, not reported; NS, nerve stimulation; US, ultrasound

Study details	Key efficacy findings	Key safety findings	Comments
Sites BD (2006)[9] **Case report** USA **n =1** Study period: NR Population: age = 21, male = 100%, height = 1.78 m, weight = 78 kg Indications: patient with a valgus impaction syndrome of the right elbow, with no neurological deficit at baseline Technique: supraclavicular regional block for postoperative pain management. US-guided local block with 12 MHz probe and 22 g needle, plus general anaesthetic for elbow surgery **Follow-up: 23 hours** Disclosure of interest: supported by manufacturer	**Anaesthetic characteristics** The regional block of 25 ml 0.375% bupivacaine and 2.5 micrograms per ml of epinephrine was delivered at a single attempt. The anaesthetic was visualised spreading circumferentially around the brachial plexus. The block was completed at 07:00. 25 minutes after injection the patient had decreased sensation to ice, and near complete partial paresis of wrist flexion and extension and straight finger abduction. There was complete paresis of elbow flexion. On arrival at the recovery room at 11:15 the patient still had weakness in the wrist and complete paresis of the biceps muscle, although the anaesthesia resident documented more movement in the hand than prior to surgery. At discharge (12:30) the patient stated that he had increased strength and sensation in his hand. After discharge the patient was unable to move or feel his hand or forearm. He returned to hospital at 16:40. Examination showed a normal incision site and minimal swelling, and the block puncture site was without swelling or bruising. The patient was completely insatiate in the arm distal to the shoulder, and had complete paresis of his arm and hand. A CT scan was normal except for a small amount of air (<0.5 ml) adjacent to the brachial plexus injection site, and no haematoma was visualised. After admission for observation the block completely resolved by 06:00 the following day.		Experience of anaesthetist performing the block was not described. The number of US-guided regional anaesthesia blocks performed at the institution is not described. However the report comes from the same authors as Sites (2007)[7], which reports a case series of 520 patients. The authors state that the abnormal progression of the block most likely represented a non-pathological but atypical pharmacokinetic response to the anaesthetic. A potential mechanism of this response was the presence of an isolated volume ('pocket') of anaesthetic that subsequently came into contact with the nerve during movement of the arm.

Validity and generalisability of the studies

- Few studies reported follow-up beyond 1 hour or the duration of the surgery for which regional nerve block was being performed.
- A number of different outcome measures were used to determine block effectiveness (both sensory and motor effects) across the studies included in Table 2, making comparison between studies difficult.
- Some studies evaluated the effect of adding ultrasound guidance to neurostimulation, rather than adding to visual or landmark guidance. One randomised controlled trial compared ultrasound guidance with nerve stimulation positioning, using two different volumes of anaesthetic in a three-arm trial.
- Some studies used endoscopic ultrasound guidance for block placement rather than external or surface ultrasound guidance.
- Some studies used a catheter inserted though the needle for delivery rather than needle insertion to provide regional nerve block, particularly for treatment of chronic pain.
- A number of studies were conducted in children rather than adults, in whom most nerves are relatively superficial and therefore more readily amenable to identification by US imaging.
- It is not clear whether real-time US imaging was used in all the studies.

Specialist Advisers' opinions

Specialist advice was sought from consultants who have been nominated or ratified by their Specialist Society or Royal College. The advice received is their individual opinion and does not represent the view of the society.

Dr N Bedforth (Association of Anaesthetists of Great Britain and Ireland), Dr R Blanco (Association of Anaesthetists of Great Britain and Ireland), Dr B Fischer (Association of Anaesthetists of Great Britain and Ireland), Dr B Nichols (Royal College of Anaesthetists), Dr S Ward (The Pain Society).

- All five Specialist Advisers considered this procedure to be established and no longer a new technique.
- The range of adverse events associated with this procedure were thought to be similar to those of blind or nerve stimulation-guided regional nerve blocks.
- Known or reported adverse events include organ damage, pneumothorax, nerve damage, intravascular injection, bleeding, systemic toxicity and intraneural injection (without sequaleae).
- Other theoretical adverse events may include inability to identify structures, misplacement, pain, paraesthesia and risks associated with the use of high energy US.
- There are currently few controlled data comparing US guidance with standard methods of guiding regional nerve block.
- An Australian group are undertaking a prospective audit and are keen to make this a multicentre study.
- There are currently no national standards or obligatory training programmes in place for this procedure. The Royal College of Anaesthetists should incorporate relevant training into postgraduate specialist programmes (SpR) in anaesthesia.
- Successful outcomes are related to operator experience and training. Inadequate training may increase complication rates.
- The main comparator should be nerve stimulation-guided or anatomical landmark-guided regional nerve block.
- The key safety outcomes for this procedure are the rate of complications such as nerve damage and systemic toxicity.
- The key efficacy outcomes for this procedure are block success rate, volume of anaesthesia required, speed of block onset and patient pain scores.
- All five Specialist Advisers thought that the procedure would be offered at most or all district general hospitals if found to be safe and efficacious.

Issues for consideration by IPAC

- Non-English language studies were excluded given the availability of a large evidence base in English.
- Studies on using nerve block as anaesthetic during operations (at any site/nerve) and on treatment of chronic pain are included in the overview.

References

1 Chan VW, Perlas A, McCartney CJ et al. (2007) Ultrasound guidance improves success rate of axillary brachial plexus block. Canadian Journal of Anesthesia 54: 176–82.

2 Marhofer P, Schrögendorfer K, Wallner T et al. (1998) Ultrasonographic guidance reduces the amount of local anesthetic for 3-in-1 blocks. Regional Anesthesia and Pain Medicine 23: 584–8.

3 Orebaugh SL, Williams BA, Kentor ML (2007) Ultrasound guidance with nerve stimulation reduces the time necessary for resident peripheral nerve blockade. Regional Anesthesia and Pain Medicine 32: 448–54.

4 Soeding PE, Sha S, Royse CE et al. (2005) A randomized trial of ultrasound-guided brachial plexus anaesthesia in upper limb surgery. Anaesthesia and Intensive Care 33: 719–25.

5 Willschke H, Marhofer P, Bosenberg A et al. (2005) Ultrasonography for ilioinguinal/iliohypogastric nerve blocks in children. British Journal of Anaesthesia 95: 226–30.

6 Sandhu NS (2006) Sonographically guided infraclavicular brachial plexus block in adults: a retrospective analysis of 1146 cases. Journal of Ultrasound in Medicine 25: 1555–61.

7 Sites BD, Spence BC, Gallagher JD et al. (2007) Characterizing novice behavior associated with learning ultrasound-guided peripheral regional anesthesia. Regional Anesthesia and Pain Medicine 32: 107–15.

8 Swenson JD, Bay N, Loose E et al. (2006) Outpatient management of continuous peripheral nerve catheters placed using ultrasound guidance: an experience in 620 patients. Anesthesia and Analgesia 103: 1436–43.

9 Sites BD, Bertrand ML, Gallagher JD (2006) An abnormal clinical course of an ultrasound-guided supraclavicular brachial plexus block using 0.375% bupivacaine. Journal of Clinical Anesthesia 18: 449–51.

Appendix A: Additional papers on ultrasound-guided regional nerve block

The following table outlines the studies that are considered potentially relevant to the overview but were not included in the main data extraction table (table 2). It is by no means an exhaustive list of potentially relevant studies.

This table is limited to relevant studies with sample size of at least 10 patients.

Article	Number of patients/follow-up (FU)	Direction of conclusions	Reasons for non-inclusion in Table 2
Bigeleisen PE (2006) Nerve puncture and apparent intraneural injection during ultrasound-guided axillary block does not invariably result in neurologic injury. Anesthesiology 105: 779–83	Case series n = 26 Follow-up to 6 months	22 of 26 patients had puncture of at least one nerve. Sensory nerve testing at 6 months was unchanged	Larger studies are included in table 2
Casati A, Baciarello M, Di Cianni S et al. (2007) Effects of ultrasound guidance on the minimum effective anaesthetic volume required to block the femoral nerve. British Journal of Anaesthesia 98: 823–7	Non-randomised controlled trial n = 60 (30 US) Follow-up = 30 minutes	Ultrasound (US) guidance provided a 42% reduction in the minimum anaesthesia requirement compared with nerve stimulation (NS) guidance	Larger studies are included in table 2
Casati A, Danelli G, Baciarello M et al. (2007) A prospective, randomized comparison between ultrasound and nerve stimulation guidance for multiple injection axillary brachial plexus block. Anesthesiology 106: 992–6	Randomised controlled trial n = 60 (30 US) Follow-up = 24 hours	Multiple injection blocks with US provide similar success rates and comparable complications to NS guidance	Studies with longer follow-up are included in table 2
Chan VW, Perlas A, Rawson R, Odukoya O (2003) Ultrasound-guided supraclavicular brachial plexus block. Anesthesia and Analgesia 97: 1514–17	Case series n = 40 Follow-up = to 48 hours	Block was successful after first attempt in 95% of patients	Larger studies are included in table 2
de Jose MB, Gotzens V, Mabrok M (2007) Ultrasound-guided umbilical nerve block in children: a brief description of a new approach. Paediatric Anaesthesia 17: 44–50	Case series n = 10 Follow-up = 2 hours	The intercostal nerve could not be visualised but all blocks were effective during surgery	Larger studies are included in table 2
Domingo-Triado V, Selfa S, Martinez F et al. (2007) Ultrasound guidance for lateral midfemoral sciatic nerve block: a prospective, comparative, randomized study. Anesthesia and Analgesia 104: 1270–4	Randomised controlled trial n= 61 (30 US) Follow-up = not stated	Successful nerve block at the first attempt was significantly more frequent in the US group (77%) than in the NS guided (alone) group	Studies with longer follow-up are included in table 2
Gress F, Schmitt C, Sherman S et al. (2001) Endoscopic ultrasound-guided celiac plexus block for managing abdominal pain associated with chronic pancreatitis: a prospective single center experience. American Journal of Gastroenterology 96: 409–16	Case series n = 90 Follow-up = 8 weeks	A significant improvement in pain scores occurred in 55% of patients	Larger studies are included in table 2

Hannan L, Reader A, Nist R et al. (1999) The use of ultrasound for guiding needle placement for inferior alveolar nerve blocks. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics 87: 658–65	Randomised controlled trial n = 40 (20 × 2 US) Follow-up = 60 minutes	100% of both groups had profound lip numbness following regional block. There was no significant difference between the two groups in terms of anaesthesia success for individual teeth	Larger studies are included in table 2
Helayel PE, da Conceicao DB, Pavei P et al. (2007) Ultrasound-guided obturator nerve block: a preliminary report of a case series. Regional Anesthesia and Pain Medicine 32: 221–6	Case series n = 22 Follow-up = 60 days	Opiod supplementation was required in 14% of patients, but none required general anaesthesia to complete surgery	Larger studies are included in table 2
Hurdle MF, Weingarten TN, Crisostomo RA et al. (2007) Ultrasound-guided blockade of the lateral femoral cutaneous nerve: technical description and review of 10 cases. Archives of Physical Medicine and Rehabilitation 88: 1362–4	Case series n = 10 Follow-up = 30 minutes	All 10 patients (five of whom were obese) underwent successful regional nerve block. There were no complications	Larger studies are included in table 2
Kapral S, Krafft P, Eibenberger K et al. (1994) Ultrasound-guided supraclavicular approach for regional anesthesia of the brachial plexus. Anesthesia and Analgesia 78: 507–13	Randomised controlled trial n = 40 (20 × 2 US) Follow-up = 40 minutes	Satisfactory surgical anaesthesia was achieved in 95% of both groups	Larger studies are included in table 2 Comparison of two US techniques without 'blind' control
Kapral S, Krafft P, Gosch M et al. (1995) Ultrasound imaging for stellate ganglion block: direct visualization of puncture site and local anesthetic spread. A pilot study. Regional Anesthesia 20: 323–8	Non-randomised controlled trial n = 12 (12 US acting as own control) Follow-up = not stated	Regional block was successful in 100% of patients with US guidance	Larger studies are included in table 2
Liebmann O, Price D, Mills C et al. (2006) Feasibility of forearm ultrasonography-guided nerve blocks of the radial, ulnar, and median nerves for hand procedures in the emergency department. Annals of Emergency Medicine 48: 558–62	Case series n = 11 Follow-up = 3 months	All procedures were completed without additional anaesthesia or analgesia. 92% of patients reported that they would have the procedure again for similar injuries. There were no complications	Larger studies are included in table 2
Liu FC, Liou JT, Tsai YF et al. (2005) Efficacy of ultrasound-guided axillary brachial plexus block: a comparative study with	Randomised controlled trial	70% of patients in the NS-guided double-injection group and the US-guided single-	Studies with longer follow-up are included in table 2

nerve stimulator-guided method. Chang Gung Medical Journal 28: 396–402	n = 90 (60 US) Follow-up = 40 minutes	injection group obtained satisfactory block, as did 73% of patients in the single-injection US group	
Liu FC, Lee LI, Liou JT et al. (2005) Ultrasound-guided axillary brachial plexus block in patients with chronic renal failure: report of sixteen cases. Chang Gung Medical Journal 28: 180–5	Case series n = 16 Follow-up = not stated	Three patients who complained of pain required supplementary narcotics. There were no complications	Larger studies are included in table 2
Marhofer P, Schrögendorfer K, Koinig H et al. (1997) Ultrasonographic guidance improves sensory block and onset time of three-in-one blocks. Anesthesia and Analgesia 85: 854–7	Randomised controlled trial n = 40 (20 US) Follow-up = 1 day	The quality of the sensory block in the US group (15% of baseline) was significantly better than the NS group (27% of baseline) ($p < 0.05$)	Larger studies are included in table 2 Studies with longer follow-up are included in table 2
Marhofer P, Sitzwohl C, Greher M, Kapral S (2004) Ultrasound guidance for infraclavicular brachial plexus anaesthesia in children. Anaesthesia 59: 642–6	Case series n = 40 Follow-up = 30 min	Direct US visualisation was successful in all patients	Larger studies are included in table 2
Oberndorfer U, Marhofer P, Bosenberg A et al. (2007) Ultrasonographic guidance for sciatic and femoral nerve blocks in children. British Journal of Anaesthesia 98: 797–801	Randomised controlled trial n = 46 (23 US) Follow-up = until first analgesic given	Two blocks in the NS and none in the US-guided groups failed. Mean volume of anaesthesia was significantly lower in the US group ($p < 0.001$)	Studies with longer follow-up are included in table 2
Ootaki C, Hayashi H, Amano M (2000) Ultrasound-guided infraclavicular brachial plexus block: an alternative technique to anatomical landmark-guided approaches. Regional Anesthesia and Pain Medicine 25: 600–4	Case series n = 57 Follow-up =30 minutes	In 95% of patients surgery was completed without supplementation of anaesthesia or analgesia. There were no complications	Larger studies are included in table 2
Roessel T, Wiessner D, Heller AR et al. (2007) High-resolution ultrasound-guided high interscalene plexus block for carotid endarterectomy. Regional Anesthesia and Pain Medicine 32: 247–53	Case series n = 14 Follow-up = to 24 hours	High-resolution US allowed a clear delineation of minor blood vessels and adjacent structures, as well as accurate needle placement	Larger studies are included in table 2
Schwemmer U, Markus CK, Greim CA et al. (2005) Ultrasound-guided anaesthesia of the axillary brachial plexus: efficacy of multiple injection approach. Ultraschall in der Medizin 26: 114–19	Case series n = 46 Follow-up = not stated	Complete anaesthesia of the brachial plexus was achieved in all cases, with an onset time of 7 minutes	Larger studies are included in table 2

Shim J, Moon J, Yoon K et al. (2006) Ultrasound-guided lumbar medial-branch block: a clinical study with fluoroscopy control. Regional Anesthesia and Pain Medicine 31: 451–4	Case series n = 20 Follow-up = not stated	95% success rate of needle positioning. Intravascular spread of contrast dye was reported for two injections	Larger studies are included in table 2
Sinha A, Chan VW (2004) Ultrasound imaging for popliteal sciatic nerve block. Regional Anesthesia and Pain Medicine 29: 130–4	Case series n = 10 Follow-up = 20 minutes	Circumferential local anaesthetic spread within the facial sheath correlated with rapid onset and completeness of block	Larger studies are included in table 2
Sites BD, Beach ML, Spence BC et al. (2006) Ultrasound guidance improves the success rate of a perivascular axillary plexus block. Acta Anaesthesiologica Scandinavica 50: 678–84	Randomised controlled trial n = 56 (28 US) Follow-up = 30 minutes	Patients treated with a conventional approach sustained more failures (inability to identify the nerve or conversion to general anaesthesia) (29%) than those in the US group (0%) ($p < 0.01$)	Studies with longer follow-up are included in table 2
van Geffen GJ, Rettig HC, Koornwinder T et al. (2007) Ultrasound-guided training in the performance of brachial plexus block by the posterior approach: an observational study. Anaesthesia 62: 1024–8	Case series n = 21 Follow-up = 30 minutes	Complete block was achieved in 95% of patients	Larger studies are included in table 2
Williams SR (2003) Ultrasound guidance speeds execution and improves the quality of supraclavicular block. Anesthesia and Analgesia 97: 1518–23	Randomised controlled trial n = 80 (40 US) Follow-up = 30 minutes	At 30 minutes 95% of patients in the US group and 85% of patients in the NS group had partial or complete blocks ($p = 0.13$)	Studies with longer follow-up are included in table 2

Appendix B: Related NICE guidance for ultrasound-guided regional nerve block

Guidance	Recommendation
Interventional procedures	**Ultrasound-guided catheterisation of the epidural space. NICE interventional procedures guidance 249 (2008)** 1.1 Evidence on ultrasound-guided catheterisation of the epidural space is limited in amount, but suggests that it is safe and may be helpful in achieving correct placement. The procedure may be used provided that normal arrangements are in place for clinical governance, consent and audit. Normal consent should include informing patients about the possibility of rare but serious complications of catheterisation of the epidural space.
Technology appraisals	None
Clinical guidelines	None
Public health	None

Appendix C: Literature search for ultrasound-guided regional nerve block

IP 661: Ultrasound-guided regional nerve block		
Database	**Date searched**	**Version searched**
Cochrane Library	10/03/2008	Issue 4, 2007
CRD databases (DARE and HTA)	10/03/2008	Issue 4, 2007
EMBASE	10/03/2008	1980 to 2008 Week 09
MEDLINE	10/03/2008	1950 to February Week 4 2008
PREMEDLINE	10/03/2008	December 03, 2007
CINAHL	10/03/2008	1982 to February Week 5 2008
British Library Inside Conferences		–
NRR		Issue 4, 2007
Controlled Trials Registry	10/03/2008	–

The following search strategy was used to identify papers in MEDLINE. A similar strategy was used to identify papers in other databases.

1	exp Nerve Block/
2	(nerv$ adj3 block$).tw.
3	Anesthesia, Conduction/
4	Anesthesia, Local/
5	or/1-4
6	Ultrasonics/
7	(ultraso$ adj3 guid$).tw.
8	Ultrasonography/
9	Ultrasonography, Interventional/
10	echograph$.tw.
11	or/6-10
12	5 and 11
13	(ultraso$ adj3 guid$ adj3 (local$ or regional$ or locoregional$ or conduct$ or block$) adj3 an?esthe$).tw.

14	12 or 13
15	Animals/
16	Humans/
17	15 not 16
18	14 not 17
19	limit 18 to yr="2000 - 2008"
20	from 19 keep 1-355