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GUIDELINES

European Society of Anaesthesiology Guidelines on peri-operative use of ultrasound for regional anaesthesia (PERSEUS regional anesthesia)

Peripheral nerves blocks and neuraxial anaesthesia

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Nowadays, ultrasound-guidance is commonly used in regional anaesthesia (USGRA) and to locate the spinal anatomy in neuraxial analgesia. The aim of this second guideline on the PERi-operative uSE of UltraSound (PERSEUS-RA) is to provide evidence as to which areas of regional anaesthesia the use of ultrasound guidance should be considered a gold standard or beneficial to the patient. The PERSEUS Taskforce members were asked to define relevant outcomes and rank the relative importance of outcomes following the GRADE process. Whenever the literature was not able to provide enough evidence, we decided to use the RAND method with a modified Delphi process. Whenever compared with alternative techniques, the use of USGRA is considered well tolerated and effective for some nerve blocks but there are certain areas, such as truncal blocks, where a lack of robust data precludes useful comparison. The new frontiers for further research are represented by the application of USG during epidural analgesia or spinal anaesthesia as, in these cases, the evidence for the value of the use of ultrasound is limited to the preprocedure identification of the anatomy, providing the operator with a better idea of the depth and angle of the epidural or spinal space. USGRA can be considered an essential part of the curriculum of the anaesthesiologist with a defined training and certification path. Our recommendations will require considerable changes to some training programmes, and it will be necessary for these to be phased in before compliance becomes mandatory.

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Summary of recommendations

The grading of recommendations is shown in bold type.

Upper limb blocks

Interscalene brachial plexus block

(1) The quality of evidence on which to base recommendations is generally weak, with data from small studies with considerable heterogeneity.

(2) We suggest that ultrasound guidance is used for interscalene brachial plexus block because of its theoretical advantages, its high success rates and evidence that it requires fewer needle passes and lower volumes of local anaesthetic agent. There is evidence that ultrasound guidance does not increase harm and it may be associated with a reduced rate of complications (**2C**).

(3) We suggest that whatever technique is used for interscalene brachial plexus block, the minimum success rate compatible with expert practice is 95% and the maximum total incidence of complication should be no more than 7% (**2C**).

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Supraclavicular brachial plexus block

(1) The quality of evidence on which to base recommendations is generally weak, with data from few small randomised controlled trials.
(2) We recommend that ultrasound guidance is used for supraclavicular brachial plexus block because of its theoretical advantages and evidence for its reduced risk of inadequate block. There is evidence that ultrasound guidance does not increase harm and it may be associated with a reduced rate of complications, the incidence of which is low (**1C**).
(3) We suggest that whatever technique is used for supraclavicular brachial plexus block, the minimum success rate compatible with expert practice is 86% and the total incidence of pneumothorax or vascular puncture should be no more than 1% (**2C**).

Infraclavicular brachial plexus block

(1) The quality of evidence on which to base recommendations is generally weak, with data from only small randomised controlled trials with a high degree of heterogeneity.
(2) We recommend that ultrasound guidance is used for infraclavicular brachial plexus block because of its theoretical advantages and possible evidence for a reduced risk of inadequate block. There is evidence that ultrasound guidance does not increase harm and is associated with a reduced rate of vascular puncture (**1C**).
(3) We suggest that whatever technique is used for infraclavicular brachial plexus block, the minimum success rate compatible with expert practice is 86% and the maximum incidence of vascular puncture should be no more than 4% (**2C**).

Axillary brachial plexus block

(1) The quality of evidence on which to base recommendations is generally weak, with randomised controlled trials that have a high degree of heterogeneity.
(2) We recommend that ultrasound guidance is used for axillary brachial plexus block because of its theoretical advantages and possible evidence for a reduced risk of inadequate block. There is evidence that USG does not increase harm and is associated with a possible reduced rate of vascular puncture and a reduced incidence of pain during the procedure (**1C**).
(3) We suggest that whatever technique is used for axillary brachial plexus block, the minimum success rate compatible with expert practice is 87% and the maximum incidence of vascular puncture should be no more than 7% (**2C**).

Lower limb blocks

Femoral nerve block

(1) The quality of evidence on which to base recommendations is generally weak, with data from only a few, small, clinically heterogeneous randomised controlled trials.
(2) We recommend that ultrasound guidance is used for femoral nerve block because of its theoretical advantages and evidence for a reduced dose of local anaesthetic to produce an effective block. There is evidence that ultrasound guidance does not increase harm and is associated with a possible reduced rate of vascular puncture (**1B**).
(3) We suggest that whatever technique is used for femoral nerve block, the maximum incidence of vascular puncture should be no more than 7.5% (**2C**).

Subgluteal sciatic nerve block

(1) The quality of evidence on which to base recommendations is weak, with data from only one, small randomised controlled trial designed to assess the dose of local anaesthetic required.
(2) We suggest that ultrasound guidance is used for subgluteal sciatic nerve block because of its theoretical advantages and evidence for a reduced dose of local anaesthetic to produce an effective block. There is evidence that ultrasound guidance does not increase harm (**2B**).

Popliteal sciatic nerve block

(1) The quality of evidence on which to base recommendations is generally weak, from only a few small RCTs that have a high degree of heterogeneity and some methodological problems.
(2) We recommend that ultrasound guidance is used for popliteal sciatic nerve block because of its theoretical advantages and possible evidence for a reduced risk of inadequate block. There is evidence that ultrasound guidance does not increase harm and is associated with a possible reduced rate of vascular puncture and reduced procedural time in obese patients (**1C**).
(3) We suggest that whatever technique is used for popliteal sciatic nerve block, the minimum success rate compatible with expert practice is 90% and the maximum incidence of vascular puncture should be no more than 3% (**2C**).

Abdominal and thoracic truncal blocks

Transversus abdominis plane block

(1) The quality of evidence on which to base recommendations is generally weak, with mostly small RCTs that have a high degree of heterogeneity.
(2) We are unable to make any recommendations about the use of ultrasound-guided transversus abdominis plane block on the basis of improved analgesia, reduced morphine consumption, incidence of the majority of complications, time to hospital discharge or patient satisfaction, although there is no evidence to suggest it is inferior to alternative methods of analgesia.

(3) We cannot exclude the possibility that ultrasound-guided transversus abdominis plane block has advantages for specific patient groups and there is a possibility that it may be associated with a reduced incidence of postoperative nausea and vomiting and shorter postoperative mobilisation times.

Rectus sheath block

(1) The quality of evidence on which to base recommendations is weak, with only a few small randomised controlled trials some of which have methodological problems.
(2) We are unable to make any recommendations about the use of ultrasound-guided rectus sheath block on the basis of improved analgesia, reduced morphine consumption, incidence of complications, postoperative mobilisation times, time to hospital discharge or patient satisfaction, although there is no evidence to suggest it is inferior to alternative methods of analgesia.
(3) We cannot exclude the possibility that ultrasound-guided rectus sheath block has advantages for specific patient groups.

Iliohypogastric–ilioinguinal nerve block

(1) The quality of evidence on which to base recommendations is generally weak, with only a few mostly small randomised controlled trials that have a high degree of heterogeneity.
(2) We recommend the use of ultrasound-guided iliohypogastric–ilioinguinal nerve block over spinal anaesthesia for inguinal hernia repair as the analgesia appears to be not inferior, there is a reduced incidence of urinary retention and it eliminates the risk of spinal cord and spinal nerve injury associated with spinal anaesthesia (**1C**).
(3) We are unable to make any recommendations about the use of ultrasound-guided iliohypogastric–ilioinguinal nerve block for other comparisons on the basis of improved analgesia, reduced morphine consumption, incidence of complications, postoperative mobilisation times, time to hospital discharge or patient satisfaction, although there is no evidence to suggest it is inferior to alternative methods of analgesia.

Pectoral blocks

(1) The quality of evidence on which to base recommendations is weak, with only a few small randomised controlled trials.
(2) We are unable to make any recommendations about the use of ultrasound-guided pectoral blocks.

Serratus plane block

(1) The quality of evidence on which to base recommendations is weak, with only a few small randomised controlled trials.
(2) We are unable to make any recommendations about the use of ultrasound-guided serratus plane block.

Neuraxial blocks

Paravertebral block

(1) The quality of evidence on which to base recommendations is weak, with only one small observational study and one small randomised controlled trial with methodological concerns.
(2) We recommend the use of preprocedural ultrasound scanning to provide better accuracy in identifying the intended paravertebral space (**1B**).
(3) We are unable to make any other recommendations about the use of USG for paravertebral block.

Epidural analgesia

(1) The quality of evidence on which to base recommendations is generally weak, with only a few RCTs that have a high degree of heterogeneity.
(2) We recommend the use of preprocedural ultrasound scanning to provide better accuracy in identifying the intended intervertebral space (**1C**).
(3) We are unable to make any recommendations about the use of preprocedural ultrasound scanning for other comparisons on the basis of improved success, incidence of complications, patient discomfort, number of skin punctures, postprocedural back pain or patient satisfaction, although there is no evidence to suggest it is inferior to landmark/palpation techniques.
(4) We suggest any increase in time to perform epidural anaesthesia with the use of preprocedural ultrasound scanning is not clinically important (**2C**).
(5) We recommend the use of preprocedural ultrasound scanning for epidural anaesthesia by anaesthetists in training to reduce the number of skin punctures (**1B**).

Spinal anaesthesia

(1) The quality of evidence on which to base recommendations is generally weak, with a few RCTs that have a high degree of heterogeneity.
(2) We recommend the use of preprocedural ultrasound scanning to provide better accuracy in identifying the intended intervertebral space (**1C**).
(3) We are unable to make any recommendations about the use of preprocedural ultrasound scanning for other comparisons on the basis of improved success, incidence of complications, number of skin punctures, postprocedural back pain or patient satisfaction, although there is no evidence to suggest it is inferior to landmark/palpation techniques.
(4) We suggest any increase in time to perform spinal anaesthesia with the use of preprocedural ultrasound scanning is not clinically important (**2C**).

Training in ultrasound-guidance for regional anaesthesia

Specific learning/training objectives for ultrasound-guided regional anaesthesia

At the completion of their training, the practitioner, in addition to achieving the generic objectives, should be able to demonstrate:

(1) Knowledge of the sectional and ultrasonic anatomy of the brachial plexus and its branches, sciatic nerve and its branches, femoral nerve and its branches, vertebral column and epidural space, paravertebral space, anatomy relevant to truncal blocks. This includes identification of vascular, muscular, fascial, bone, pleural, vertebral and paravertebral structures.
(2) That they can recognise relevant variant anatomy using ultrasound, for example, anatomical relations of nerves, branching of nerves, abnormal nerve morphology, perineural blood vessels.
(3) Supplementary techniques to confirm needle tip location.
(4) Knowledge of perineural catheter techniques.

Training and assessment methods for ultrasound-guided regional anaesthesia

(1) Before attempting their first directly supervised attempt for each ultrasound-guided regional anaesthesia procedure, the practitioner should have observed five ultrasound-guided procedures of that type and performed five ultrasound scans on patients scheduled for that ultrasound-guided procedure.
(2) The practitioner undergoing training in ultrasound-guided regional anaesthesia should maintain a logbook that documents every procedure they perform. In addition to the level of supervision, this should contain at a minimum the information required to complete 'Performance indicators for ultrasound-guided regional anaesthesia procedures' (see below).
(3) For each ultrasound-guided regional anaesthesia procedure, the practitioner should be directly observed for at least five procedures of that type before they perform the procedure with distant supervision.
(4) For each ultrasound-guided regional anaesthesia procedure, the practitioner should be signed off as appropriately skilled for that procedure by an expert trainer using a global rating scale before they perform the procedure with distant supervision.
(5) To be eligible for completion of competency-based training in ultrasound-guided regional anaesthesia, cumulative summated outcomes for key performance indicators should be within the tolerance limits of expert practice standards.
(6) Maintenance of competence in ultrasound-guided regional anaesthesia will require cumulative summated outcomes for key performance indicators to be within the tolerance limits of expert practice standards.
(7) Maintenance of competence in ultrasound-guided regional anaesthesia will require evidence of regular continuing professional development activities relevant to ultrasound-guided regional anaesthesia.
(8) Maintenance of competence in ultrasound-guided regional anaesthesia should be based on performance indicators only and not number of procedures.

All these recommendations reached strong consensus.

Performance indicators for ultrasound-guided regional anaesthesia procedures

The following are useful performance indicators for ultrasound-guided regional anaesthesia:

(1) Successful block rate (no supplementation).
(2) Rate of conversion to unplanned general anaesthesia.
(3) Completion of procedure within 30 min.
(4) Total procedural time.
(5) Incidence of major complications.
(6) Incidence of all complications.
(7) Patient satisfaction.

All these recommendations reached strong consensus.

Criteria for defining an expert trainer in ultrasound-guided regional anaesthesia

An expert trainer in ultrasound-guided regional anaesthesia must be able to demonstrate:

(1) One year of independent practice in ultrasound-guided regional anaesthesia following completion of competency-based training, or continuous independent practice in ultrasound-guided regional anaesthesia for at least 3 years and which began before the introduction of competency-based training ('Grandfather clause').
(2) Cumulative summated outcomes for key performance indicators to be within the tolerance limits of expert practice standards.
(3) Evidence of regular continuing professional development activities relevant to ultrasound-guided regional anaesthesia and education/training.
(4) Maintenance of competence in ultrasound-guided regional anaesthesia should be based on performance indicators only and not number of procedures.

All these recommendations reached strong consensus.

Introduction

This is one of two guideline documents concerning the PERi-operative uSE of UltraSound (PERSEUS) and it focuses on ultrasound guidance for regional anaesthesia (USGRA), including peripheral nerve and neuraxial blocks. Prior to the technological developments that led to the availability of ultrasound machines with sufficient image quality to enable USGRA in operating theatres, anaesthetists used 'blind' techniques that relied on their knowledge of anatomy and various surrogates for assessing the correct needle tip location before injection of local anaesthetic. These surrogates varied according to the block: placement of the needle adjacent to bones or arteries with known anatomical relations to the target nerves, the 'feel' of the needle as it passes through fascial planes, loss-of-resistance techniques as the needle is advanced (especially for epidural and paravertebral blocks), and the use of nerve stimulation through the

block needle. All of these techniques are associated with a failure rate and, aside from neuraxial blocks, it was only the most experienced practitioners who could achieve success rates greater than 90%.[1,2] This resulted in peripheral nerve blocks being used much less frequently than they are today.

In developing these guidelines, we sought evidence based on high-quality randomised controlled clinical trials and relevant cohort studies but there proved to be remarkably little good evidence of this nature. Some of the reasons for this were predicted in an editorial written more than 10 years ago.[3] When comparing techniques in a research setting, it is necessary for each technique to be performed by operators equally experienced in each technique. More relevant to clinical practice, however, is the comparative difficulty in acquiring expertise in the techniques and how easy it is to maintain that expertise. Again, there is a paucity of research evidence that addresses these questions but it is the experience of all the authors of these guidelines that the availability of appropriate ultrasound equipment in our departments has led to an increase in the number of anaesthesiologists practicing peripheral nerve blocks and the number of patients receiving regional anaesthesia techniques. The advantages of USGRA are also illustrated by the development of new regional anaesthesia techniques that have been enabled by the technology, such as the pectoral (PECs)[4,5] and serratus plane[6] blocks. Our recommendations on the use of these techniques draw primarily on the evidence for their efficacy compared with alternative methods of providing analgesia.

The use of ultrasound is very variable across all European countries because of financial constraints or to different regulations that, sometimes, do not allow all anaesthesiologists to use USGRA routinely. The aim of this second guideline is to provide evidence to indicate for which areas of regional anaesthesia the use of ultrasound guidance should be considered a gold standard or beneficial to the patient. Our main focus is not on potential legal implications if the clinical guidelines are not followed but to encourage anaesthesiologists to use them properly depending on the context of the situation.[7] The final decision whether to follow a recommendation rests with the physician, according to the patient's needs and wishes, patient safety, available resources (including the expertise of the physician), local hospital policy and national laws. If the physician decides not to follow an evidence-based guideline, it is their responsibility to obtain the patient's consent and document the reason for not applying a recommendation.

Materials and methods

Selection of the task force

Through an open call in the European Society of Anaesthesiology (ESA) website, ESA members with a specific interest in peri-operative ultrasound guided procedures were invited to apply. Five ESA members (ML, ND, DGB, EB, JPE) were selected by the ESA Guidelines Committee. In addition to those members, one was appointed by the European Board of Anaesthesiology (AM). The Chairman of the Task Force (ML) was appointed by the Task Force during a preliminary meeting held at the 2016 ESA Conference in London. After that meeting, five more members (MP, DV, MS, RF, VT) were selected on the basis of their specific expertise in vascular access, peripheral and neuraxial blocks and for their experience in delivering training courses around Europe on point-of-care ultrasound.

All members of the same Task Force were involved in both parts of the PERSEUS guidelines: role of ultrasound in peripheral nerve and neuraxial blocks (discussed in the present article) and the role of ultrasound for peri-operative placement of vascular accesses (discussed in a separate document: https://journals.lww.com/ejaanaesthesiology/Fulltext/2020/05000/European_Society_of_Anaesthesiology_guidelines_on.2.aspx).[8]

To frame the literature search, we created separated questions and inclusion and exclusion criteria according to the PICOT process (Population, Intervention, Comparison, Outcome, Timing).[9] The literature search protocol and its implementation were supported and performed by a professional librarian (Janne Vendt) from the Cochrane Anaesthesia, Critical and Emergency Care Group (ACE), Herlev, Denmark.

Literature search

We identified relevant studies by developing subject-specific search strategies, as described in Appendix 1, http://links.lww.com/EJA/A426. The search strategies consisted of subject terms specific for each database in combination with free text terms. Wherever appropriate, the search strategy was expanded with search filters for humans or age. We searched the following databases from January 2010 to August 2017 for relevant studies: PubMed, EMBASE (Ovid SP), Cochrane Central Register of Controlled Trials (CENTRAL), CINAHL (EBSCO). We also scanned the following trial registries for on-going and unpublished studies: Clinical Trials (clinicaltrials.gov), WHO, International Clinical Trials Register (ICTRP), Search Portal. All relevant studies published after August 2017 up to September 2018 were also reviewed and considered in our analysis.

Duplicates were removed by EndNote X9 reference management software (Clavariate Analytics, Philadelphia, USA) and the search results were screened by ML, EB, DB and PH. We limited our search to guidelines, systematic reviews, meta-analyses and controlled study designs and restricted our search to human-only studies.

Eligibility criteria

We included the following publication types: randomised controlled trials, prospective cohort studies, retrospective cohort studies, case series with a sample size greater than 100 patients, studies published in a European language. We checked the reference lists and the citations of the included studies and relevant reviews, for further references to additional studies. In every section, inclusion and exclusion criteria were identified based on the PICOT process. We included studies on USGRA carried out in adult patients. Narrative reviews, editorials, case series or case reports and publications in a non-European language were rejected. All abstracts were screened and only selected articles that were relevant to the key clinical questions were retrieved for analysis. Specifically, all articles comparing the use of ultrasound guidance to any other technique for regional or neuraxial block placement were selected. We applied no limitation on study duration or length of follow-up.

Study selection

Three members evaluated each title and each abstract identified in the literature search, verifying its eligibility and relevance for the key clinical questions. A fourth reviewer solved possible disagreements. Studies included by title and abstract underwent subsequent full-text review. Final inclusions of the abstract review process were documented in an EndNote bibliographic database for each cluster. An overview of the total number of abstracts screened and articles finally included for each cluster is summarised in Appendix 2, http://links.lww.com/EJA/A427. Three members of each thematic cluster performed full-text review and assessment of evidence following the recommendations of the *Cochrane Handbook for Systematic Reviews of Interventions*.[10] Disagreements were solved by consensus or consulting a fourth reviewer.

Strength of evidence

The ESA guidelines committee selected the GRADE system for assessing levels of evidence and grading of recommendation. This approach classifies recommendations into two levels, strong and weak (Appendix 3, http://links.lww.com/EJA/A428). A two-level grading system has the merit of simplicity. Two levels also simplify the interpretation of strong and weak recommendations by clinicians. The PERSEUS Taskforce members were asked to define relevant outcomes across all clusters and rank the relative importance of outcomes, following a process proposed by the GRADE group. After selecting the relevant articles for each cluster, one member per group – expert in the use of RevMan10 and GRADEpro11 – was in charge for the final grading of the papers (EB, PH). All relevant results in RevMan have been reported in Appendix 4, http://links.lww.com/EJA/A429 for each cluster section. Whenever the literature was not able to provide enough evidence, we used the RAND method with a modified Delphi process: we adapted the RAND/UCLA Appropriateness Method for enabling expert consensus[11] using iterative Delphi rounds conducted online. Statements were generated by the panel in order to develop consensus on aspects of training in ultrasound-guided vascular access and regional anaesthesia wherever evidence was lacking, incomplete and/or of low quality. We also included statements that assessed the appropriateness, in the context of anaesthesia training, of recommendations from other organisations who have produced guidelines for training of nonradiologists in interventional ultrasound-guided procedures. In the Delphi rounds, the panel members rated the appropriateness of each statement on a scale of 1 (completely inappropriate) to 9 (completely appropriate). The median appropriateness score (MAS) was used to categorise a statement as inappropriate (MAS 1 – 3.4), of uncertain appropriateness (MAS 3.5–6.9) or appropriate (MAS 7–9). To quantify consensus, we used the disagreement index, a dimensionless variable that is independent of the size of the expert panel. The smaller the value of disagreement index, the greater is the consensus: a disagreement index greater than 1 indicates a lack of consensus.[12] Delphi rounds were planned to continue until an a priori stopping rule was reached for each statement as follows: if MAS greater than 7 or less than 4 and disagreement index less than 0.5, or if disagreement index improves less than 15% in successive rounds.[13] The Delphi process was managed by one author (PMH).

Round 1

Agreed statements were sent to panel members using an online questionnaire generated in Google forms. Panel members were instructed to rate each statement on a scale of 1 (completely inappropriate) to 9 (completely appropriate) with an option not to respond to statements that were outside their expertise. Respondents were also asked to provide freehand comments, for example, on the wording of the statements or to suggest additional statements.

Round 2 and subsequent rounds

Raw scores and freehand comments from Round 1 were extracted from Google forms, converted into an Excel spreadsheet and de-identified. Before Round 2, panel members received their own Round 1 scores, the de-identified scores of other panel members (as raw data and summary bar charts), the calculated MAS and disagreement index values and information on how these should be interpreted.

Round 1 statements that met a stopping criterion were not included in Round 2. Other Round 1 statements were included in Round 2 unchanged or were amended based on the freehand comments from Round 1. If panel members made suggestions for additional statements in Round 1, these were included in Round 2. The Round

2 statements were formatted as an online questionnaire as for Round 1, and the panel members were asked to complete these as for Round 1. If the stopping criteria were not met for all statements after Round 2, the process for subsequent rounds would follow that of Round 2.

A series of 92 statements subdivided into 10 themes, regarding PICOTs where scientific evidence was lacking for the use of ultrasound in vascular access and regional anaesthesia, were agreed for Round 1. Twelve out of 13 panel members responded in Round 1.

Sixty-one of the statements were rated as appropriate with MAS greater than 7 and disagreement index less than 0.5. Eleven statements were not carried forward to Round 2 either as they were considered inappropriate (MAS <4 and disagreement index <0.5) or as a mutually exclusive statement met the stopping criteria for appropriateness.

Round 2 consisted of 29 statements including 13 new statements derived from freehand comments made by panel members in Round 1. All 13 panel members participated in Round 2. Nineteen statements were rated as appropriate with MAS greater than 7 and disagreement index less than 0.5. One statement (volume of local anaesthetic used is a useful performance indicator for ultrasound guided regional anaesthesia) met a stopping criterion (disagreement index improved by less than 15% on previous round) but only achieved a MAS of 7. Ten statements were not carried forward to Round 3 as a mutually exclusive statement met the stopping criteria for appropriateness.

Review process

The ESA Guidelines Committee supervised and coordinated the preparation of guidelines. The final draft of the guidelines underwent a review process previously agreed upon by the ESA Guidelines Committee. The draft was posted on the ESA website from 5 August to 4 September, and the link sent to all full ESA members (around 10 000) individual or national (thus including most European national anaesthesia societies). We invited comments within this 4-week consultation period. We received 12 comments from all these resources and a more extensive review from one member, all of these comments have been addressed. The Taskforce also sent the draft for review to 10 internationally known experts, external to ESA, with specific expertise and peer-reviewed publications in these specific area of interest (ultrasound guidance for regional anaesthesia and neuraxial blocks). The external reviewers were contacted by the Taskforce chairman and they were asked to complete their review within 2 weeks from submission. Only two of them responded, and their comments were used to modify the document. After final approval, the ESA will be responsible for publication of the guidelines and for implementation programmes for education at different levels. Finally, application of the guidelines throughout Europe will be monitored and a regular update of the guidelines is planned every 5 years from publication.

Definitions

The main focus of the ESA Task Force was to answer the question, 'Should ultrasound be used routinely as the gold standard during peripheral nerve blocks and neuraxial anaesthesia'?

We first agreed, through a Delphi consensus, some definitions on the use of the ultrasound technique that are common to any ultrasound-guided procedure, then we identified specific PICOT questions on the use of ultrasound that were answered after a revision and analysis of the literature.

Definitions regarding ultrasound techniques

As there was lack of clarity in the literature on how procedures using ultrasound should be performed, this Task Force formulated some definitions based on a Delphi consensus.

A procedure is defined as ultrasound-assisted when ultrasound scanning is used to verify the presence and the position of a suitable target nerve or vertebral interspace (or any anatomic variations or disorder) before needle insertion, without real-time ultrasound needle guidance.

A procedure is defined as ultrasound-guided when ultrasound scanning is used not only to verify the presence and position of a suitable target nerve before skin puncture but also to perform a real-time ultrasound imaging to guide the needle tip to the appropriate nerve or position.

The longitudinal view or long-axis view is an ultrasound imaging approach that describes the relationship between the plane of the probe and the axis of the nerve. In the long-axis view, the plane of the probe is parallel to the long axis of the nerve.

The transverse view or short-axis view is an ultrasound imaging approach that describes the relationship between the plane of the probe and the axis of the vessel or nerve. In the short-axis view, the plane of the probe is perpendicular to the axis of the nerve.

The oblique axis view is obtained by initially locating the vessel or nerve in the short axis, followed by rotation of the probe to almost midway between the short-axis and long-axis views.

As regards the visualisation of the needle during the procedure, the Taskforce agreed on the definition of two approaches:

(1) the in-plane approach, where – regardless of the nerve view – the needle is advanced 'in-plane', that is within the plane of the array of transducer elements within the probe, that is providing a long-axis view

with visualisation of the whole shaft of the needle as it progresses towards the target.

(2) 2) the out-of-plane approach, where – regardless of the nerve view – the needle is advanced 'out-of-plane' that is perpendicular to the plane of the array of transducer elements within the probe, providing a short-axis view of the needle, visualised as a hyperechoic dot.

Applications of ultrasound to regional anaesthesia

To provide adequate anaesthesia and analgesia while improving patient comfort and safety are the main objectives when performing regional anaesthesia. Various techniques have been used for nerve localisation, from landmark techniques to neurostimulation. Since the early 2000s, ultrasound guidance has developed and is now widely used to perform both peripheral nerve blocks and neuraxial anaesthesia. Numerous articles have been published to compare ultrasound guidance with other techniques, and some recent systematic literature reviews aimed at summarising the evidence for upper and lower limb blocks, truncal blocks and neuraxial blocks have also been published.[11,14,15] Although there are still conflicting results concerning the superiority of ultrasound guidance versus other the techniques, many guidelines recommend the use of ultrasound guidance in preference to other techniques (landmark or neurostimulation) to improve the efficacy and safety of regional anaesthesia procedures.[11–13,16–18]

We have considered the use of ultrasound compared with any other technique for performing any type of regional anaesthesia (peripheral nerve blocks, truncal blocks, neuraxial blocks) with or without a catheter, with or without general anaesthesia, in adult patients undergoing elective surgery. In the case of concomitant use of neurostimulation during ultrasound guidance, this was considered to be ultrasound guided.

The grading of recommendations is shown in bold type.

Upper limb blocks

Should ultrasound-guidance be used in patients requiring anaesthesia or analgesia in the distribution of an interscalene brachial plexus block?

Four hundred and seventy-nine abstracts were screened for relevance; 20 articles were selected for analysis and only 10[19–28] were finally included to inform the current guideline. We analysed the advantages/disadvantages of the use of USG when compared with other techniques of interscalene brachial plexus block (BPB) as depicted in Fig. 1.

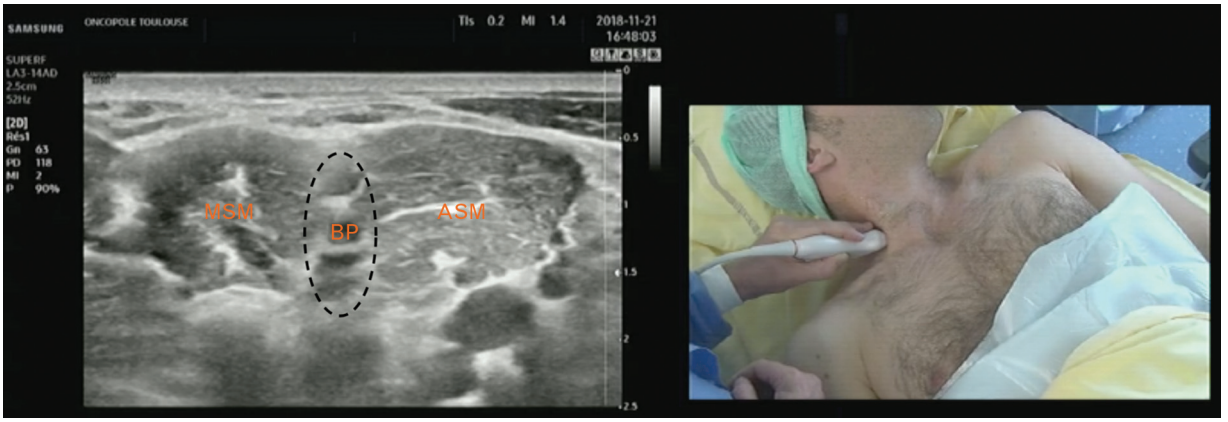
Adequacy of anaesthesia for intended surgery

Nine RCTs[19–22,24–28] with a total of 744 participants reported on the adequacy of anaesthesia for the intended surgery. The success rate was high in both the USG and the comparator groups: 98.9 (95% CI, 97.2 to 99.7)% and 95.7 (95% CI, 93 to 97.4)% respectively. In order to include data from three RCTs where there was complete success in both groups,[20,22,24] we conducted a random-effects meta-analysis to estimate the difference in risk (risk difference, 95% CI) of failure of block between USG and other techniques. This failed to demonstrate a reduced risk of failure with USG: risk difference, 0.03 (−0.01 to 0.06). A high degree of heterogeneity ($I^2 = 59\%$) cautions against drawing any firm conclusions from these data.

Adequacy of postoperative analgesia

Adequacy of postoperative analgesia was assessed using a 0 to 10 numerical rating scale (NRS) pain score in four studies,[19,24,25,27] but the data could not be evaluated, or reported no differences in NRS scores between the groups.

Fig. 1 Interscalene block. Ultrasonography of the interscalene area. Position of the probe (right) with the corresponding scan (left). ASM, anterior scalene muscle; BP, brachial plexus; MSM, middle scalene muscle.



Time to perform and achieve nerve block

Four RCTs assessed the time to perform the block,[19,22,26,27] whereas time to achieve an effective block was assessed in six studies.[19–21,24,26,27] Unsurprisingly, the level of heterogeneity for both of these outcome variables ($I^2 = 97$ and 96%) precluded combining data from the relevant studies for analysis.

Dose of local anaesthetic required

One RCT reported that the minimal effective anaesthetic volume ($MEAV_{50}$) providing effective analgesia in 50% of patients was reduced when using USG compared with any other technique.[23]

Incidence of complications

We considered eight RCTs (1016 patients) reporting complications of interscalene block (nerve damage, systemic local anaesthetic toxicity, phrenic palsy, vascular puncture, Horner's syndrome and paraesthesia). The total incidence of complications (95% CI) in the USG group was 4.35 (2.9 to 6.4)% and in the comparator group it was 11.5 (9.1 to 14.4)%. In order to include several studies where there were no complications in either group, we attempted a random-effects meta-analysis of the risk difference for any complication and individual complications. The high level of heterogeneity ($I^2 = 80\%$) renders this overall analysis of the incidence of any complication unreliable. Subgroup analyses of individual complications failed to show any risk difference between the groups.

Patient discomfort during procedure

No RCT or any other selected study reported patient discomfort during procedure.

Patient satisfaction with the procedure

The number of patients satisfied with the procedure was reported in three RTCs.[22,24,27] Our analysis revealed that there was no difference in the number of patients satisfied, with an OR (95% CI) of 3.03 (0.33 to 28). There was considerable heterogeneity among studies ($I^2 = 84\%$) in this random-effects model.

Needle passes

Two RCTs reported the number of needle passes when performing the block.[22,23] For one of them, a significant reduction in the number of needle passes was reported when USG was used but the effect size could not be estimated as only median values were provided.[22] The other study also reported a reduction in the number of needle passes when using USG.[23]

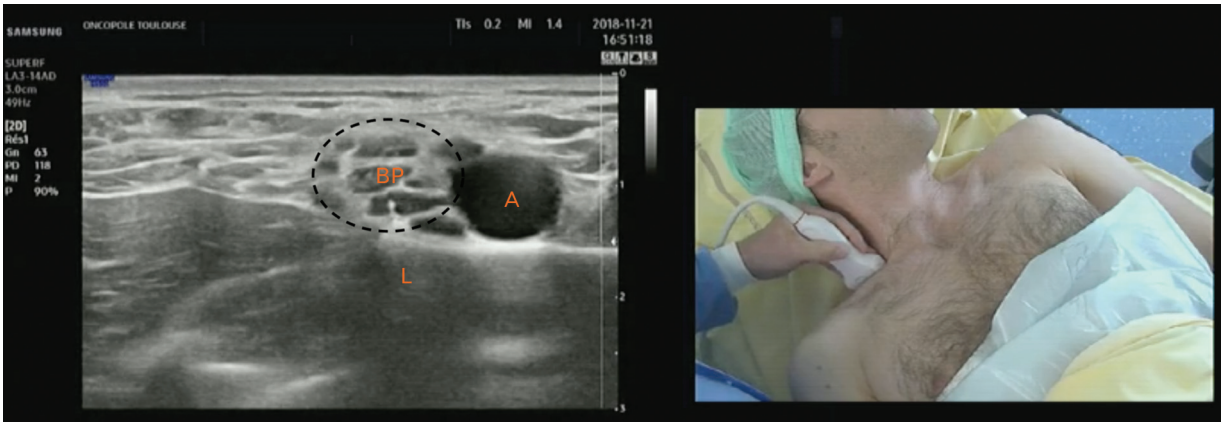
Recommendations

(1) The quality of evidence on which to base recommendations is generally weak, with data from only small studies with considerable heterogeneity.
(2) We suggest that USG is used for interscalene BPB because of its theoretical advantages, its high success rates, and evidence that it requires fewer needle passes and lower volumes of local anaesthetic agent. There is evidence that USG does not increase harm and it may be associated with a reduced rate of complications (**2C**).
(3) We suggest that whatever technique is used for interscalene BPB, the minimum success rate compatible with expert practice is 95% and the maximum total incidence of complication should be no more than 7% (**2C**).

Should ultrasound-guidance be used in patients requiring anaesthesia or analgesia in the distribution of a supraclavicular brachial plexus block?

Four hundred and fifty abstracts were screened for relevance; 15 articles were selected for analysis but only 6 of them were finally included to inform the current guideline.[29–34] We analysed the advantages/disadvantages of the use of USG when compared with other techniques of supraclavicular block (Fig. 2).

Fig. 2 Supraclavicular brachial plexus block. Ultrasonography of the supraclavicular area. Position of the probe (right) with the corresponding scan (left). A, artery; BP, brachial plexus; L, lung.



Adequacy of anaesthesia for intended surgery

Only two RCTs[29,30] with a total of 120 participants reported on the adequacy of anaesthesia for the intended surgery. The success rate (95% CI) was 95 (85.8 to 98.8)% in the USG and 81.2 (69.9 to 89.6)% in the comparator groups. We conducted a random-effects meta-analysis to estimate the difference in risk of failure of block between USG and other techniques. This demonstrated a reduced risk of failure (95% CI) with USG, risk difference 0.14 (0.03 to 0.25), with no heterogeneity ($I^2 = 0\%$).

Adequacy of postoperative analgesia

No RCT compared the adequacy of postoperative analgesia when USG was used in comparison to any other technique. A retrospective study performed in 104 patients receiving USG supraclavicular block for upper limb surgery showed a high rate of adequate postoperative analgesia (85.6%).[31]

Time to perform block

Our analysis of two RCTs[29,30] revealed that USG compared with any other technique results in a shorter time to perform the block, with a weighted mean difference (WMD, 95% CI) of −1.29 (−1.69 to −0.89) minutes (random-effects model, $I^2 = 0\%$). The clinical relevance of the difference in time to perform the block is limited.

Time to achieve effective block

Our analysis on two RCTs[29,30] found that in one study there was no difference in the time to achieve an effective block, whereas in the other, USG achieved a faster effective block. There was too much heterogeneity in the studies ($I^2 = 98\%$) to report a combined analysis or draw reliable conclusions on this outcome.

Dose of local anaesthetic required

No RCT reported the dose of local anaesthetic required for USG supraclavicular block compared with any other technique.

Incidence of complications

The incidence of complications (vascular puncture and pneumothorax) was only reported in one RCT that included 60 participants.[30] There were no complications in the USG group (95% CI, 0 to 13.5)% but one patient in the comparator group had a vascular puncture whereas another developed a pneumothorax: the incidence (95% CI) of either complication was 6.7 (0.8 to 22.4)%. The outcome of 510 consecutive patients receiving an USG supraclavicular block for upper limb surgery was reported in a prospective study:[33] this showed a low complication rate (no pneumothorax, 1% symptomatic hemidiaphragm paresis, 1% Horner's syndrome, 0.4% unintended vascular puncture and 0.4% transient paraesthesia).

Patient discomfort during procedure

No RCT or any other selected study reported patient discomfort during the procedure.

Patient satisfaction with the procedure

No RCT reported patient satisfaction with the procedure when USG was used in comparison to any other technique. One observational study reported a high percentage of patient satisfaction (96.7%) when USG was used for supraclavicular block.[34]

Needle passes

No RCT reported the number of needle-passes when performing supraclavicular block.

Recommendations

(1) The quality of evidence on which to base recommendations is generally weak, with data from only a few small RCTs.
(2) We recommend that USG is used for supraclavicular BPB because of its theoretical advantages and evidence for its reduced risk of inadequate block. There is evidence that USG does not increase harm and it may be associated with a reduced rate of complications, the incidence of which is low (**1C**).
(3) We suggest that whatever technique is used for supraclavicular BPB, the minimum success rate compatible with expert practice is 86% and the total incidence of pneumothorax or vascular puncture should be no more than 1% (**2C**).

Should ultrasound-guidance be used in patients requiring anaesthesia or analgesia in the distribution of an infraclavicular brachial plexus block?

Two hundred and ninety-one abstracts were screened for relevance; 22 articles were selected for analysis and 8 of them were finally included to inform the current guideline.[35–42] We analysed the different advantages/disadvantages of the use of USG when compared with other techniques of infraclavicular block.

Adequacy of anaesthesia for intended surgery

We analysed eight RCTs[35–42] (664 patients) where the adequacy of anaesthesia for the intended surgery was reported. The success rate (95% CI) was 90.4 (86.8 to 93.2)% in the USG and 82.5 (78.1 to 86.2)% in the comparator groups. We conducted a random-effects meta-analysis to estimate the difference in risk of failure of block between USG and other techniques. This demonstrated a reduced risk of failure with USG: risk difference (95% CI), 0.1 (0.02 to 0.19), but with a substantial degree of heterogeneity ($I^2 = 66\%$) cautioning the reliability of this analysis.

Adequacy of postoperative analgesia

One RCT reported the adequacy of postoperative analgesia when USG was compared with neurostimulation for

the placement of an infraclavicular catheter. There was no difference between the techniques in 0 to 10 VAS pain scores at day 1: the mean difference (95% CI) in scores was −0.23 (−1.01 to 0.55).[36]

Time to perform block

Six RCTs[36–38,40–42] reported the time to perform the block. The considerable heterogeneity among studies ($I^2 = 94\%$) precluded a combined analysis but the differences between USG and other techniques were generally not large enough to be clinically important.

Time to achieve effective block

Six RCTs[36–38,40–42] reported the time to achieve an effective block when USG infraclavicular block was used compared with neurostimulation. The data from two RCTs[37,42] were excluded from the meta-analysis as they presented data as median and interquartile ranges: it was felt that modifying this data to include it in the meta-anlaysis would overestimate the size of the effect. For the four remaining studies, a random-effects analysis showed no difference between the techniques with a WMD (95% CI) of −0.82 (−2.11 to 0.46) minutes ($I^2 = 0\%$).

Dose of local anaesthetic required

No RCT reported the dose of local anaesthetic required for USG infraclavicular block compared with any other technique.

Incidence of complications

We evaluated six RCTs[35–37,39–41] (581 patients) that reported the incidence of one or more complications of USG infraclavicular block compared with other techniques. We utilised a random-effects model to estimate the risk difference as there were no events for either technique for several of the outcomes (phrenic nerve palsy, inadvertent spinal or epidural injection,[41] pneumothorax[37,41]). However, the high level of heterogeneity ($I^2 = 77\%$) precluded presentation of comparison of overall complications.

Three RCTs[36,37,41] included the incidence of nerve damage in their secondary outcomes but only one event occurred in these three studies. Three RCTs[35,37,41] included the incidence of systemic local anaesthetic toxicity in their secondary outcomes but again only one event occurred in these studies. Our assessment of five RCTs[35,37,39–41] that reported the incidence of vascular puncture and four RCTs[35,37,40,41] that reported the incidence of paraesthesia as secondary outcomes revealed, in each case, a high level of heterogeneity ($I^2 = 84$ and 92%, respectively) that precluded further evaluation. We noted, however, that the overall incidence (95% CI) of vascular puncture from a total of 187 participants in the USG group was 0.5 (0 to 3.3)% and from the total of 184 participants in the comparator group it was 14.7 (10.2 to 20.6)%.

Patient discomfort during procedure

Patient discomfort during the procedure was reported in one RCT[38] using a 0 to 10 NRS pain score: there was no difference when USG infraclavicular block was compared with neurostimulation: the mean difference (95% CI) was −0.20 (−0.74 to 0.34).

Patient satisfaction with the procedure

No RCT reported patient satisfaction with the procedure as a secondary outcome.

Recommendations

(1) The quality of evidence on which to base recommendations is generally weak, with data from only small RCTs with a high degree of heterogeneity.
(2) We recommend that USG is used for infraclavicular BPB because of its theoretical advantages and possible evidence for a reduced risk of inadequate block. There is evidence that USG does not increase harm and is associated with a reduced rate of vascular puncture (**1C**).
(3) We suggest that whatever technique is used for infraclavicular BPB, the minimum success rate compatible with expert practice is 86% and the maximum incidence of vascular puncture should be no more than 4% (**2C**).

Should ultrasound-guidance be used in patients requiring anaesthesia or analgesia in the distribution of an axillary brachial plexus block?

Five hundred and twenty-six abstracts were screened for relevance; 31 articles were selected for analysis and 13[43–55] articles were finally included to inform the current guideline. We analysed the advantages/disadvantages of USG when compared with other techniques for axillary BPB (Fig. 3). There are, however, some question marks about the competence of the operators in these studies as, in some cases, the procedures were performed by a mixture of experienced anaesthetists, residents,[45] trainees[43] and surgeons.[54] This may have provided bias in the results and downgraded the quality of evidence of the corresponding outcomes.

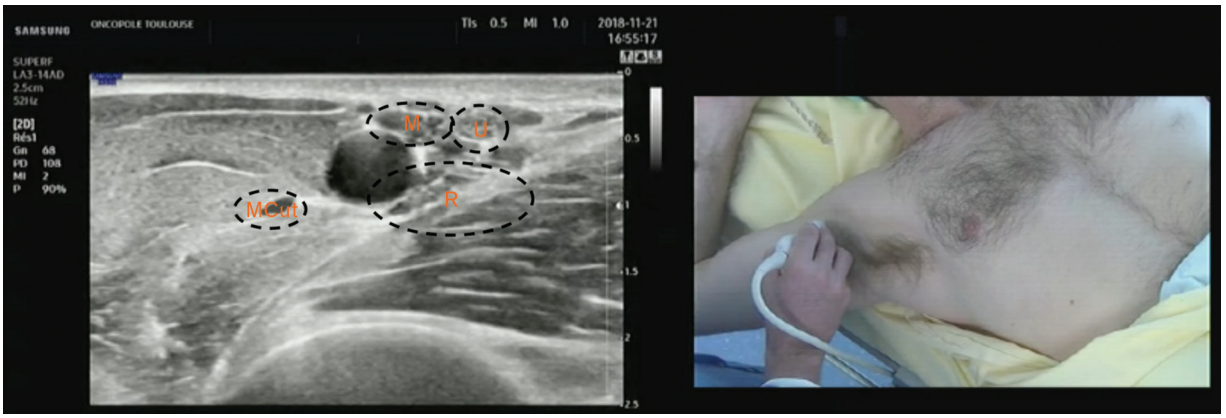
Adequacy of anaesthesia for intended surgery

We analysed 10 RCTs[43–46,49–51,53–55] (664 patents) that reported on the adequacy of anaesthesia for the intended surgery. The success rate (95% CI) was 90.2 (87 to 92.7)% in the USG and 82.4 (78.6 to 85.6)% in the comparator groups. We conducted a random-effects meta-analysis to estimate the difference in risk of failure of block between USG and other techniques. This found no difference in the risk of failure with USG: risk difference (95% CI), 0.06 (−0.01 to 0.13), but a substantial degree of heterogeneity ($I^2 = 67\%$) cautions against reliance on this analysis of effect size.

Adequacy of postoperative analgesia

Only one RCT[43] reported adequacy of postoperative analgesia when USG axillary BPB was used compared with

Fig. 3 Axillary brachial plexus block. Ultrasonography of the axillary area. Position of the probe (right) with the corresponding scan (left). A, artery; M, median nerve; MCut, musculocutaneous nerve; R, radial nerve; U, ulnar nerve.



neurostimulation. There was no difference in the median [10th to 90th percentiles] 0 to 10 NRS pain scores in post-anesthesia care unit (PACU), 2 [0 to 3] versus 2 [1 to 6], $P = 0.12$.

Time to perform block

Our analysis of nine RCTs[43,45,46,49–51,53–55] revealed a high degree of heterogeneity among studies ($I^2 = 92\%$) precluding further analysis.

Time to achieve effective block

Our analysis of four RCTs[44,50,53,54] revealed a high degree of heterogeneity among studies ($I^2 = 90\%$) precluding further analysis.

Dose of local anaesthetic required

No RCT compared the dose of local anaesthetic required when USG axillary BPB was used compared with any other techniques.

Incidence of complications

We evaluated nine RCTs[44–46,49–51,53–55] (736 patients) that reported the incidence of one or more complications of USG axillary block compared with other techniques. We used a random-effects model for the risk difference and found a marginal reduction in the risk of any complication with USG: risk difference (95% CI), −0.03 (−0.06 to −0.00), but the substantial degree of heterogeneity ($I^2 = 66\%$) cautions against reliance on this analysis of effect size. Additional caution is required about the quality of evidence because of concerns about the competence of the operators in some studies: this is illustrated by a higher than expected incidence of vascular puncture when using USG.

The incidence of nerve damage was a secondary outcome in five RCTs,[44,45,51,54,55] but only two events were reported in the comparator group (landmark technique) of a single study.[54] The incidence of local anaesthetic systemic toxicity was a secondary outcome of one RCT but no events occurred in either group.[55] The incidence of vascular puncture was a secondary outcome of eight RCTs[45,46,49–51,53–55] that included a total of 677 participants. The incidence (95% CI) of vascular puncture was 3.9 (2.2 to 6.6)% in the USG and 13.2 (10 to 17.3)% in the comparator groups. However, we are unable to reliably estimate the effect size using a random-effects analysis of the risk difference because of the high heterogeneity ($I^2 = 87\%$). Our random-effects analysis of five RCTs[45,46,49,50,53] revealed no difference in the risk of paraesthesia when USG axillary BPB was used compared with any other technique: risk difference (95% CI), −0.05 (−0.12 to 0.02).

Patient discomfort or pain during procedure

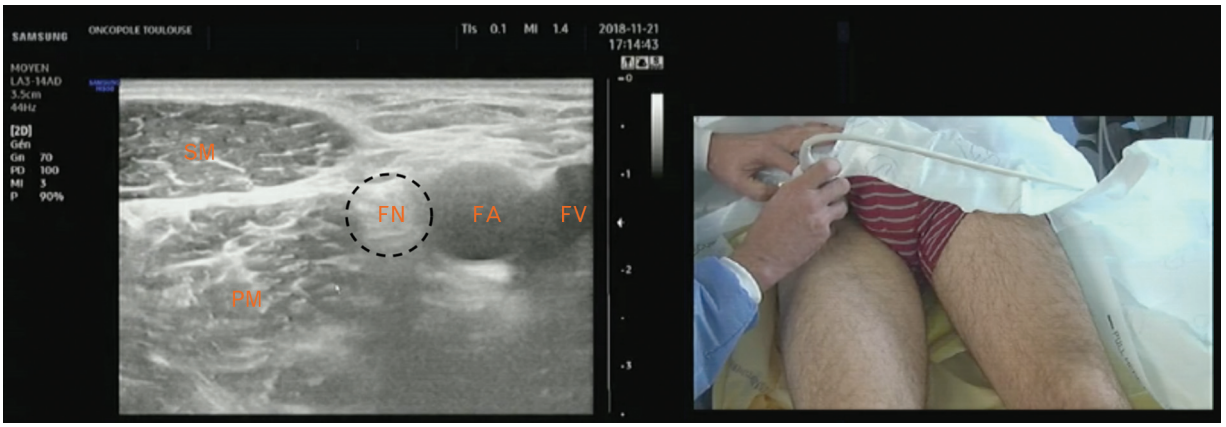
Patient discomfort during the procedure was reported using 0 to 10 NRS pain scores in three RCTs[44,50,54] but the effect size was not estimable in two of them (no differences in NRS pain scores were observed)[44,54] as standard deviations were not provided. The remaining RCT showed no difference in NRS scores between groups.

The incidence of pain during the procedure was a secondary outcome of three RCTs that included a total of 338 patients.[43–45] The incidence (95% CI) of pain was 8.9 (5.4 to 14.2)% in the USG and 25.4 (19.4 to 32.5)% in the comparator groups. A random-effects model for the risk difference confirmed a reduction in the risk of pain with USG: risk difference (95% CI), −0.15 (−0.22 to −0.08). Again, these data may not be reliable because of the competence of the operators in some studies.

Patient satisfaction with the procedure

Our analysis on three RCTs[43,44,50] revealed no difference in the percentage of patients satisfied with the procedure when USG axillary BPB was used compared with

Fig. 4 Femoral nerve block. Ultrasonography of the femoral area. Position of the probe (right) with the corresponding scan (left). FA, femoral artery; FN, femoral nerve; FV, femoral vein; PM, psoas muscle; SM, sartorius muscle.



neurostimulation using a random-effects model: OR (95% CI), 0.97 (0.28 to 3.41), $I^2 = 33\%$.

Recommendations

(1) The quality of evidence on which to base recommendations is generally weak, with RCTs that have a high degree of heterogeneity.
(2) We recommend that USG is used for axillary BPB because of its theoretical advantages and possible evidence for a reduced risk of inadequate block. There is evidence that USG does not increase harm and is associated with a possible reduced rate of vascular puncture and a reduced incidence of pain during the procedure (**1C**).
(3) We suggest that whatever technique is used for axillary BPB, the minimum success rate compatible with expert practice is 87% and the maximum incidence of vascular puncture should be no more than 7% (**2C**).

Lower limb blocks

Should ultrasound-guidance be used in patients requiring anaesthesia or analgesia in the distribution of the femoral nerve or for fascia iliaca block?

Seven-hundred and five abstracts were screened for relevance; 14 articles were selected for analysis of which five, reporting on a total of 392 participants, were included to inform the current guideline.[56–60] Figure 4 shows the ultrasonography of the femoral area. Three RCTs compared the insertion of femoral nerve catheters using ultrasound with nerve stimulation versus nerve stimulation alone.[56,59,60] One RCT compared the dose of local anaesthetic required for single shot femoral nerve block with ultrasound guidance versus nerve stimulator guidance.[57] The final study compared the efficacy of single shot fascia iliaca block with ultrasound guidance versus a loss of resistance landmark technique.[58]

Adequacy of anaesthesia for intended surgery

None of the catheter studies had this as its primary outcome, although two reported on the efficacy of the block before surgery.[56,58] Inadequate blocks were either repeated or analgesia was provided using alternative approaches. In the fascia iliaca study, the adequacy of block was low in both groups: 82.5 (95% CI, 67.7 to 91.6)% of patients had a complete sensory block in the ultrasound group compared with 47.5 (95% CI, 32.9 to 62.5)% in the loss of resistance group.[58]

Adequacy of postoperative analgesia

Adequacy of postoperative analgesia during mobilisation at 48 h was assessed using a VAS in one study.[56] This reported median and interquartile ranges of 14.5 [11.0 to 23.1] mm versus 28.5 [21.0 to 43.5] mm for the ultrasound and neurostimulation groups respectively: although this is reported as a statistically significant difference, the clinical relevance is debatable. As regards postoperative analgesia, this study also reported a statistically significant difference in the dose of local anaesthetic used via a patient-controlled administration through a femoral catheter (primary outcome) and oral morphine consumption in the first 48 h after surgery. Again the size of these differences (7.5 mg levobupivacaine and one 20 mg morphine tablet over 48 h) is of doubtful clinical relevance.[56]

Time to perform block

Performance time for insertion of a femoral catheter was the primary endpoint in two studies[59,60] and a secondary endpoint in another.[56] Two RCTs reported median [10th to 90th percentiles] which meant that the mean (95% CI) were not estimable for the combination of data.[59,60] Both studies found it was quicker to place the catheter in the ultrasound group: Li *et al.*, 9.0 (95% CI, 6.0 to 22.8) min versus 13.5 (95% CI, 6.0 to 35.9) min, $P = 0.024$,[59] and Mariano Loland *et al.* 5.0 (95% CI, 3.9 to 10.0) min versus 8.5 (95% CI, 4.8 to 30.0) min, $P = 0.012$.[60] Unlike in these

two studies,[59,60] Aveline *et al.*[56] included preparation of the ultrasound probes in the performance time and found a longer performance time in the ultrasound group: mean difference 3 (95% CI, 1.5 to 4.5) min. The clinical relevance of the differences in reported performance time is minimal.

Time to achieve effective block

Aveline *et al.*[56] reported a shorter median [IQR] time to achieve effective block using ultrasound: 11 [6 to 17] min compared with 16 [11 to 23] min for neurostimulation but this difference is of minimal clinical relevance.

Dose of local anaesthetic required

One RCT reported that the minimum anaesthetic volume providing effective analgesia in 50% of patients ($MEAV_{50}$) was reduced when using USG: 15 (95% CI, 7 to 23) ml compared with 26 (95% CI, 19 to 33) ml using nerve stimulation.[57]

Incidence of complications

On the basis of two studies with a total of 160, patients the incidence (95% CI) of vascular puncture was 1.2 (0.1 to 7.4)% in the USG and 11.2 (5.8 to 20.2)% in the comparator groups but, using a random-effects analysis, we were unable to demonstrate that the use of ultrasound was associated with significantly fewer vascular punctures: risk difference (95% CI), −0.11 (−0.2 to 0.02), $I^2 = 45\%$.[59,60] One study reported the incidence of paraesthesia during the block and the incidence of postoperative nausea and vomiting (PONV): no differences were found between ultrasound and comparator groups.[56]

Patient discomfort during procedure

Two studies reported reduced patient discomfort during the procedure in the ultrasound group, although the clinical relevance of the differences is doubtful.[56,60] Mariano *et al.*[60] reported a median [10th to 90th percentile] discomfort score of 0.5 [0.0 to 3.1] in the ultrasound group versus 2.5 [0.0 to 7.6] in the comparator group, $P = 0.015$. Aveline found a mean difference (95% CI) of −1.4 (−2.3 to −0.5).[56]

Patient satisfaction with the procedure

None of the studies reported patient satisfaction data.

Recommendations

(1) The quality of evidence on which to base recommendations is generally weak, with data from only a few, small, clinically heterogeneous RCTs.
(2) We recommend that USG is used for femoral nerve block because of its theoretical advantages and evidence for a reduced dose of local anaesthetic to produce an effective block. There is evidence that USG does not increase harm and is associated with a possible reduced rate of vascular puncture (**1B**).
(3) We suggest that whatever technique is used for femoral nerve block, the maximum incidence of vascular puncture should be no more than 7.5% (**2C**).

Should ultrasound-guidance be used in patients requiring anaesthesia or analgesia in the distribution of a subgluteal sciatic nerve block?

Seven hundred and seventy-one abstracts were screened for relevance; 18 articles were selected for analysis and 12 of them were finally included to inform the current guideline.[61–72] Among these, only one RCT[63] including a total of 60 patients was related to subgluteal sciatic nerve block, all the others being related to popliteal sciatic nerve block. These remaining RCTs were merged with those retrieved for the analysis of popliteal sciatic nerve block.[61,62,64–72]

Adequacy of anaesthesia for intended surgery

No RCT assessed the adequacy of anaesthesia for intended surgery when USG subgluteal sciatic nerve block was used compared with other techniques.

Adequacy of postoperative analgesia

No RCT assessed the adequacy of anaesthesia for intended surgery when USG subgluteal sciatic nerve block was used compared with other techniques.

Time to perform block

One RCT reported no difference in the time to perform block when USG is used compared with neurostimulation, with a median [range] duration of 3 [1 to 20] versus 4 [1 to 20] min, respectively ($P > 0.05$).[63]

Time to achieve effective block

No RCT assessed the time to achieve effective block when USG subgluteal sciatic nerve block was used compared with other techniques.

Dose of local anaesthetic required

One RCT reported that the $MEAV_{50}$ (95% CI) was reduced when using USG: mean volume 12 (10 to 13) ml compared with using nerve stimulation 19 (15 to 23) ml.[63]

Incidence of complications

One RCT reported no severe side effects or neurological complications in either group after subgluteal sciatic nerve block performed with USG or neurostimulation.[63] However, the effect size was not estimable from the study data. No difference was observed in the number of vascular punctures, with a median [range] of 0 [0 to 1] in the USG group compared with 0 [0 to 1] in the neurostimulation group ($P = 0.305$).

Patient discomfort during procedure

One RCT reported similar patient discomfort during the procedure when USG subgluteal sciatic nerve block was

used compared with neurostimulation: median [range] 0 to 10 NRS pain scores were 5 [0 to 9] versus 3 [0 to 8], respectively ($P > 0.05$).[63]

Patient satisfaction with the procedure

No RCT studied patient satisfaction when USG subgluteal sciatic nerve block was used compared with other techniques.

Needle passes

One RCT reported a similar number of needle passes when USG subgluteal sciatic nerve block was used compared with neurostimulation: median [range] number of needle passes was 3 [0 to 9] versus 3 [0 to 15], respectively ($P = 0.851$).[63]

Recommendations

(1) The quality of evidence on which to base recommendations is weak, with data from only one small RCT, designed to assess the dose of local anaesthetic required.
(2) We suggest that USG is used for subgluteal sciatic nerve block because of its theoretical advantages and evidence for a reduced dose of local anaesthetic to produce an effective block. There is evidence that USG does not increase harm (**2B**).

Should ultrasound-guidance be used in patients requiring anaesthesia or analgesia in the distribution of a sciatic popliteal nerve block?

Three hundreds and sixty-five articles were screened for relevance; 14 articles were selected for analysis and only 11 of them were finally included to inform the current guideline.[61,62,64–72] These RCTs were merged with those retrieved from our literature search strategy concerning the use of USG subgluteal sciatic nerve block but which actually concerned popliteal sciatic nerve block.[73,74] Therefore, a total number of 13 RCTs was finally included to inform the current guideline.[61,62,64–74] Among these studies, five reported the use of peripheral nerve catheters[61,67–69,73] and one of these was conducted in obese patients[66] with a BMI of more than 30 kg m^{-2}. We analysed the advantages/disadvantages of the use of USG when compared with other techniques for popliteal sciatic nerve block, with subgroup analyses for catheter studies whenever possible. Figure 5 illustrates the ultrasonography of the popliteal area.

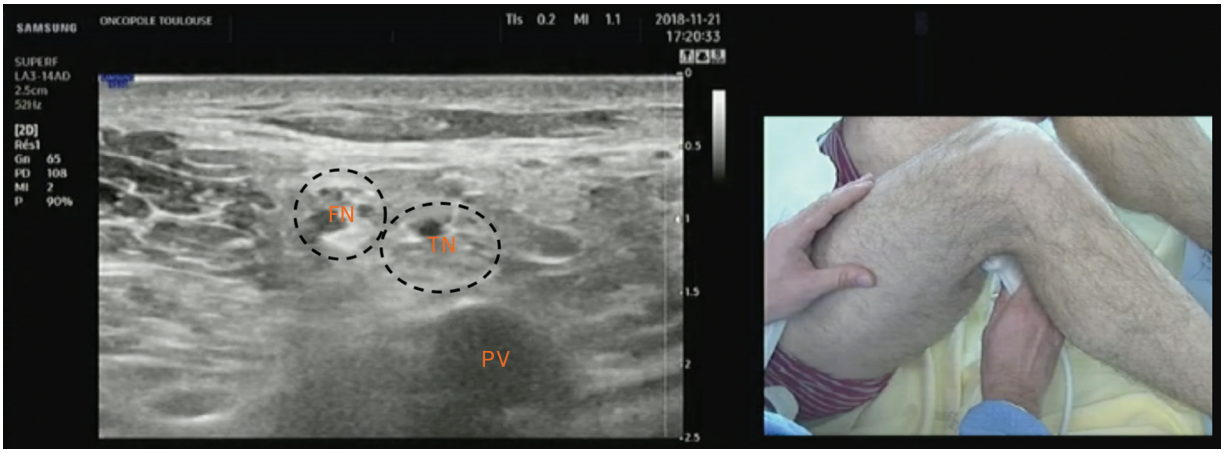
Adequacy of anaesthesia for intended surgery

The adequacy of anaesthesia for the intended surgery was reported in 11 RCTs.[61,62,64,65,67,68,70–74] with a total of 751 participants. The success rate (95% CI) was 93.2 (90.2 to 95.4)% in the USG and 73.4 (68.6 to 77.6)% in the comparator groups. We conducted a random-effects meta-analysis to estimate the difference in risk of failure of block between USG and other techniques but a high level of heterogeneity ($I^2 = 87\%$) precludes interpretation of the effect size. In subgroup analysis, there was the same level of heterogeneity for single-shot studies [62,64,65,70,72,74] whereas for catheter studies, we found no difference in the risk of failure with USG: risk difference (95% CI), 0.03 (−0.06 to 0.12), $I^2 = 50\%$).[61,73]

Adequacy of postoperative analgesia

The adequacy of postoperative analgesia was reported in five RCTs.[61,67–69,73] A combined effect size could not be estimated becasause data were summarised using median [IQR] or as mean without SD. However, none of the differences reported in the individual studies were clinically relevant. One RCT reported less morphine consumption at 48 h postoperatively when USG was used to insert a sciatic popliteal catheter in comparison with neurostimulation[61] but, from the data provided, we were

Fig. 5 Popliteal sciatic nerve block. Ultrasonography of the popliteal area. Position of the probe (right) with the corresponding scan (left). FN, fibular nerve; TN, tibial nerve; PV, popliteal vessels.



unable to verify that this clinically marginal difference was statistically significant.

Time to perform block

The time to perform the block was reported in nine RCTs.[62,64–66,68–70,73,74] The combined effect size is not presented because of the extent of heterogeneity found on random-effects analysis ($I^2 = 98\%$). The reported times to perform the blocks were clinically similar between groups in the individual studies. However, in obese patients, a significant difference in procedural time in favour of USG was found when compared with nerve stimulation:[66] 206 ± 40 versus 577 ± 57 s, with a 95% CI for the difference in times of 329 to 412 s.

The time to achieve an effective block was reported in four RCTs concerning single-shot studies.[62,66,72,74] In one RCT, no difference was observed in block onset time when USG was used compared with neurostimulation, but the effect size was not estimable as standard deviations were not provided.[74] In another study, although means (95% CIs) were reported, the data were clearly skewed.[72] A random-effects meta-analysis of the two remaining studies found a shorter time to achieve an effective block with USG: WMD (95% CI), −4.18 (−8.28 to −0.08) min ($I^2 = 24\%$) but this difference is of minimal clinical importance.

Dose of local anaesthetic required

Two RCTs reported the dose of local anaesthetic required to perform popliteal sciatic nerve block, one concerning a single-shot block[74] and the other[67] concerning catheter placement, but methodological flaws (high risk of bias and lack of equipoise,[67] confounding, inappropriate data handling and analyses[74]) prevent interpretation of the data.

Complications

We evaluated eight RCTs,[61,62,64,68–71,74] with a total of 461 patients, that reported the incidence of one or more complications (nerve damage, systemic local anaesthetic toxicity, vascular puncture and paraesthesia) of USG popliteal sciatic nerve block compared with other techniques. We used a random-effects model for the risk difference and found no difference in the risk of any complication with USG: risk difference (95% CI), −0.03 (−0.06 to 0.00), $I^2 = 54\%$. The incidence of nerve damage was a secondary outcome in six RCTs,[61,63,64,70,71] and a random-effects model found no difference in risk between the groups: risk difference (95% CI), −0.00 (−0.03 to 0.03), $I^2 = 0\%$. One RCT[74] reported local anaesthetic systemic toxicity as a secondary outcome, but there was only one event in either group. The incidence of vascular puncture was a secondary outcome of five RCTs[61,62,68,69,74] that included a total of 279 participants. The incidence (95% CI) of vascular puncture was 0% (0 to 3.1)% in the USG and 9.7 (5.6 to 16.0)% in the comparator groups. However, we are unable to reliably estimate the effect size using a random-effects analysis of the risk difference because of the high heterogeneity ($I^2 = 86\%$). Our random-effects analysis of three RCTs[61,62,71] reporting paraesthesia revealed high heterogeneity ($I^2 = 86\%$), precluding effect size estimation. One RCT reported the incidence of PONV, showing no difference in risk between the groups on day 0: risk difference (95% CI), −0.11 (−0.34 to 0.11).[67]

Patient discomfort during procedure

Four RCTs reported 0 to 10 NRS pain scores during the procedure as a secondary outcome.[62,66,68,69] The data are unsuitable for combined effect size estimates and there is no consistent clinically relevant difference in this outcome between ultrasound and comparator groups.

Patient satisfaction with the procedure

Patient satisfaction with the procedure was reported on satisfaction scales in four RCTs.[61,65,66,73] The data are unsuitable for combined effect size estimates and there is no consistent clinically relevant difference in this outcome between ultrasound and comparator groups.

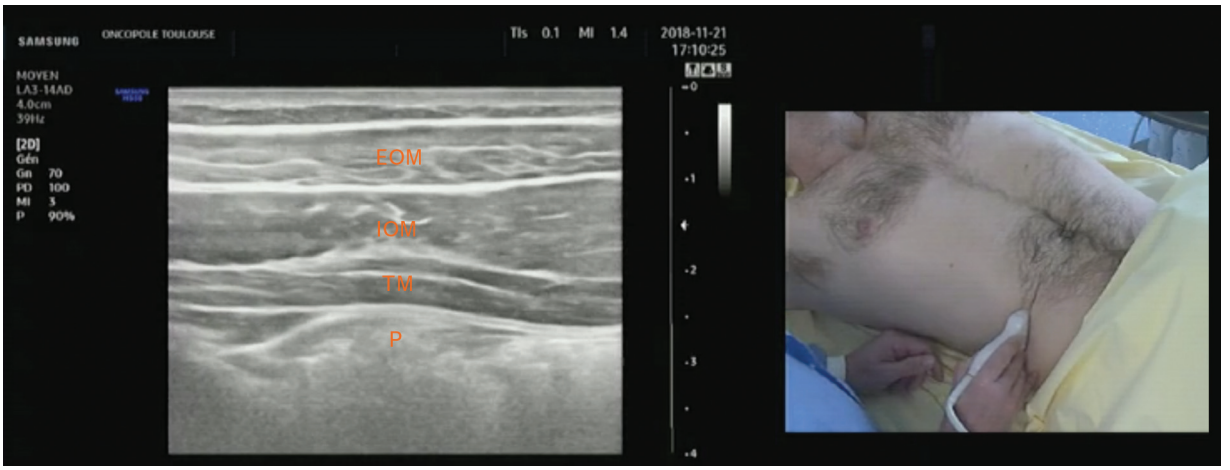
Needle passes

Three RCTs reported the number of needle passes required to perform single shot popliteal sciatic nerve blocks[62,64,65] and one RCT for popliteal catheter placement.[61] Two studies[64,65] of single shot blocks found no difference in the number of needle passes between the groups. One study of single shot blocks reported fewer needle passes with USG: median [range], 1 [1 to 2] versus 2 [1 to 4], $P = 0.001$).[62] The catheter placement study also reported fewer needle passes: median [range], 1 [1 to 6] versus 2 [1 to 10], $P = 0.0005$.[61] The data are unsuitable for combined effect size estimates.

Recommendations

(1) The quality of evidence on which to base recommendations is generally weak, from only a few small RCTs that have a high degree of heterogeneity and some methodological problems.
(2) We recommend that USG is used for popliteal sciatic nerve block because of its theoretical advantages and possible evidence for a reduced risk of inadequate block. There is evidence that USG does not increase harm and is associated with a possible reduced rate of vascular puncture and reduced procedural time in obese patients (**1C**).
(3) We suggest that whatever technique is used for popliteal sciatic nerve block, the minimum success rate compatible with expert practice is 90% and the maximum incidence of vascular puncture should be no more than 3% (**2C**).

Fig. 6 Transversus abdominis plane block. Ultrasonography of the abdominal wall area. Position of the probe (right) with the corresponding scan (left). EOM, external oblique muscle; IOM, internal oblique muscle; P, peritoneum; TM, transversus abdominus muscle.



Abdominal and thoracic truncal blocks

Should ultrasound-guided nonneuraxial regional techniques of the trunk (e.g. transversus abdominis plane or pectoral blocks) compared with either systemic analgesia, neuraxial or paravertebral regional anaesthesia be used in patients requiring postoperative analgesia of the trunk?

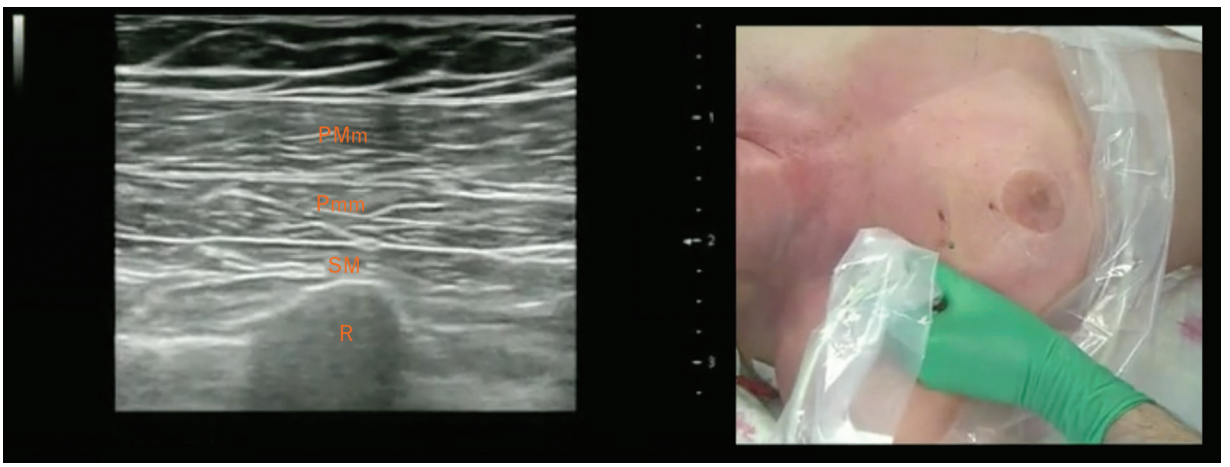
A total number of 2611 abstracts were screened for relevance; 93 articles were selected for analysis and 90 of them were finally included to inform the current guideline.[75–164] Among these, 78 RCTs concerned transversus abdominis plane (TAP) block,[75–82,84,86–91,93,94,96–110,112–115,117,120,121,123–130,132–159,162–164] 4 concerned rectus sheath block,[75,85,111,118] 5 concerned iliohypogastric–ilioinguinal (IHII) nerve block,[83,92,131,160,161] 2 concerned pectoral block[95,122] and 1 concerned serratus plane block.[116] Figure 6 shows ultrasonography of the abdominal wall area whereas Figure 7 demonstrates the ultrasonographic findings of the pectoral area.

Quality of analgesia

Transversus abdominis plane block

The quality of analgesia based on morphine consumption in PACU was assessed in 17 RCTs: USG TAP block was compared with site infiltration, standard care, placebo or spinal morphine.[75–77,94,96,103–105,108,110,112,117,124,127,135,138,139,145,147,163] A random-effects model for the mean difference in morphine consumption revealed considerable heterogeneity among these studies ($I^2 = 96\%$ overall, with $I^2 = 90–97\%$ for subgroup analyses), which precludes a combined effect-size estimate. Examination of individual studies suggests that any reduction in PACU

Fig. 7 Pectoral block. Ultrasonography of the pectoral area. Position of the probe (right) with the corresponding scan. Pmm, pectoralis minor muscle; PMm, pectoralis major muscle; R, rib; SM, serratus anterior muscle.



morphine consumption associated with TAP blocks is unlikely to be clinically important.

The quality of analgesia based on 24 h morphine consumption was assessed in 46 RCTs: USG TAP block was used compared with site infiltration, standard care, placebo, continuous wound infiltration, epidural analgesia and spinal morphine.[75–77,82,84,86–89,94,96,99,101–110,114,120,121,124–127,133,135,137,143,144,146,149–158,162–164]

However, there was considerable heterogeneity among these studies ($I^2 = 95\%$ overall, with $I^2 = 91–97\%$ for subgroup analyses), which precludes a combined effect-size estimate. Examination of individual studies suggests that any reduction in 24 h morphine consumption when TAP block is compared with wound infiltration, continuous wound infusion, epidural anaesthesia or spinal morphine is unlikely to be clinically important. There are insufficient good-quality data to draw conclusions about the effect of TAP blocks on 24 h morphine consumption when compared with placebo/standard care.

The quality of analgesia based on NRS pain scores in PACU was assessed in 44 RCTs: USG TAP block was compared with site infiltration, standard care, placebo, paravertebral block, epidural analgesia and spinal morphine.[77,81,86,90,96,98,104,108,114,115,117,119,120,123–128,132–137,140–142,144–146,148–151,153,154,156–159,162–164] A random-effects model for the mean difference in NRS pain scores revealed considerable heterogeneity among these studies ($I^2 = 97\%$ overall, with $I^2 = 86–95\%$ for subgroup analyses), which precludes a combined effect-size estimate. Examination of individual studies suggests that any differences in PACU NRS pain scores associated with TAP blocks are unlikely to be clinically important.

The quality of analgesia was assessed using NRS pain scores at 24 h in 58 RCTs: USG TAP block was compared with site infiltration, standard care, placebo, non-USG TAP block, paravertebral block, continuous wound infusion, epidural analgesia and spinal morphine.[48,53,55,64,67,71,75,77,78,80,81,84–88,92,93,97,98,101,102,104,105,110–125,127–133,135,136,138,140–143,145,146,148,153,154,156,157,162,163]

A random-effects model for the mean difference in NRS pain scores revealed considerable heterogeneity among these studies ($I^2 = 91\%$ overall, with $I^2 = 90–95\%$ for subgroup analyses), which precludes a combined effect-size estimate. Examination of individual studies suggests that any differences in 24 h NRS pain scores associated with TAP blocks are unlikely to be clinically important.

Rectus sheath block

The quality of analgesia assessed with NRS or VAS pain scores in PACU was reported when using USG rectus sheath block compared with other techniques in three RCTs.[85,111,118] In one of them, the effect size was not estimable as only figures were provided.[111] Data presentation was incompatible with a combined analysis in two RCTs.[85,118] In one RCT,[85] there was a higher median [IQR] VAS pain score following return of consciousness in the control group 7 [6 to 9] cm versus the USG rectus sheath block group 3 [3.5 to 5] cm ($P = 0.001$), but the intra-operative analgesic regimen was suboptimal. There was no evidence of a clinically important difference in PACU pain scores in the other RCTs. The quality of analgesia assessed with NRS pain scores at 24 h was reported when using USG rectus sheath block compared with other techniques in one RCT[118] but the effect size was not estimable. Two RCTs compared morphine consumption in PACU and at 24 h when ultrasound rectus sheath block was compared with other techniques.[85,111] The results of a random-effects meta-analysis are not presented because of considerable heterogeneity between the studies ($I^2 = 96\%$). Neither study found a clinically relevant difference in morphine consumption in PACU or at 24 h despite suboptimal intra-operative analgesic regimens.

Iliohypogastric–ilioinguinal nerve block

The quality of analgesia after inguinal hernia repair when using USG IHII nerve block compared with other techniques excluding TAP blocks was assessed with NRS pain scores in PACU in four RCTs [83,92,131,161] and with NRS pain scores at 24 h in four RCTs.[83,92,160,161] Examination of individual studies suggests that any differences in PACU or 24 h NRS pain scores associated with USG IHII nerve block compared with other techniques excluding TAP blocks is unlikely to be clinically important. Our random-effects meta-analysis of two RCTs[83,160] did not demonstrate a difference in 24 h morphine consumption, with a WMD (95% CI) of −2.05 (−10.62 to 6.51) mg, $I^2 = 71\%$. Although these data need to be treated with caution because of the heterogeneity, neither study suggests that there is likely to be a clinically important difference in 24 h morphine consumption.

Pectoral block

In one RCT,[122] there was no clinically important difference in VAS pain scores or 24 h morphine consumption associated with the use of a USG PECs block compared with a thoracic paravertebral block after breast surgery.

Serratus plane block

One RCT[116] reported the use of USG serratus plane block compared with thoracic paravertebral block. There was no difference noted in the NRS pain scores (in PACU, or at 24 h) nor a difference in 24 h morphine consumption.

Incidence of complications

Transversus abdominis plane block

One or more of systemic local anaesthetic toxicity, nerve damage, pneumothorax, dural puncture, and haematoma were included in the secondary outcomes of 10 RCTs.[75,76,80,94,112,130,136,149,150,153] However, the effect

size could only be calculated for the incidence of haematoma as none of the other complications occurred. In the five RCTs reporting the occurrence of haematoma,[80,94,130,149,153] we used a random-effects model for the risk difference, which found no difference in the risk of haematoma with USG TAP block versus systemic or neuraxial analgesia: risk difference (95% CI) −0.01 (−0.02 to 0.01), $I^2 = 0\%$. Concerning urinary retention, our analysis of three RCTs revealed no difference when USG TAP block was used in comparison with other techniques: risk difference (95% CI), 0.01 (0.01 to 0.08), $I^2 = 59\%$.[112,127,130] The incidence of PONV was reported in 48 RCTs.[75–78,82,84,86–90,96–98,100,102,103,105,106,110,112,113,115,120,121,123–127,129,130,134–136,138–140,146,147,150,152–156,158,163]

A random-effects model for the risk difference found a small reduction in the risk of PONV with USG TAP block versus systemic or neuraxial analgesia but a high level of heterogeneity indicates caution in the interpretation of this finding: risk difference (95% CI), −0.05 (−0.09 to −0.01), $I^2 = 70\%$.

Rectus sheath block

The incidence of complications (systemic local anaesthetic toxicity and haematoma) was a secondary outcome in two RCTS.[85,118] However, the effect size could not be calculated as no such events were observed. The incidence of PONV was reported in two RCTs,[85,111] but no events occurred in one of them.[111] In the other RCT, PONV in PACU, assessed on a 0 to 2 scale (0 = none, 1 = nausea, 2 = vomiting), was less in the rectus sheath block group than in the general anaesthesia group: median [IQR], 1 [1 to 1] versus 1 [1 to 3], $P = 0.027$.

Iliohypogastric–ilioinguinal nerve block

The incidence of nerve damage was reported in one RCT:[161] 1 of 16 patients receiving spinal anaesthesia experienced transient radicular irritation syndrome occurred compared with none of 16 patients in the USG IHII nerve block group. The incidence of PONV was reported in two RCTs,[92,161] but no events occurred in one of them.[92] In the other RCT, 1 of 16 patients receiving spinal anaesthesia developed PONV compared with none of 16 patients in the USG IHII nerve block group.[161] The incidence or urinary retention was reported in two 2 RCTs.[131,161] A random-effects model for the risk difference found a reduction in the risk of urinary retention with USG IHII nerve block compared with spinal anaesthesia after inguinal hernia repair: risk difference (95% CI), −0.13 (−0.23 to −0.04), $I^2 = 0\%$. No other complications were reported.

Pectoral block

The incidence of complications (systemic local anaesthetic toxicity, dural puncture, vascular puncture and pneumothorax) were secondary outcomes in one RCT but the effect size could not be estimated as no events occurred in any patient group.[122]

Serratus plane block

No RCT included the incidence of systemic local anaesthetic toxicity, dural puncture, vascular puncture or pneumothorax in their secondary outcomes. One RCT reported the incidence of PONV when USG serratus plane block was compared with thoracic epidural analgesia, with only a single case from each group of 20 patients.[116]

Time in PACU

Transversus abdominis plane block

Nine RCTs[93,96,97,102,105,140,144,146,155] reported the PACU stay when USG TAP block was used compared with any other method. Eight studies[93,96,97,102,103,104,140,144] reported data suitable for inclusion in a random-effects meta-analysis of the mean difference but a high level of heterogeneity ($I^2 = 96\%$) makes the effect size estimate unreliable

Rectus sheath block

No RCT reported the time in PACU when rectus sheath block was used compared with spinal anaesthesia.

Iliohypogastric–ilioinguinal nerve block

Three RCTs reported the time in PACU when IHII block was used compared with spinal anaesthesia.[131,160,161] The effect size was not estimable in one RCT[161] and in another,[131] the data were unsuitable for combined analysis as they were presented as median and range. The studies did not suggest a consistent effect on time in PACU with IHII block compared with spinal anaesthesia.

Pectoral block

No RCT reported the time in PACU when PECs block was used compared with spinal anaesthesia.

Serratus plane block

No RCT reported the time in PACU when serratus plane block was used compared with other techniques.

Time to postoperative mobilisation

Transversus abdominis plane block

Eight RCTs[96,112,143,144,148,155,162,164] reported the time to postoperative mobilisation when USG TAP block was used compared with any other method. One of these[143] presented data in a format unsuited for inclusion. A random-effects analysis of the remaining seven studies found a reduced time to mobilisation when using USG TAP block but the high level of heterogeneity indicates caution in the interpretation of this finding: WMD (95% CI), −2.05 (−3.9 to −0.29) hours, $I^2 = 72\%$.

Rectus sheath block

No RCT reported the time to postoperative mobilisation when rectus sheath block was used compared with any other technique.

Iliohypogastric–ilioinguinal nerve block

Two RCTs[131,160] reported the time to mobilisation when USG IHII nerve block was compared with spinal anaesthesia. For inguinal hernia repair, Mokini *et al.*[131] reported a significantly shorter time to mobilisation with USG IHII block compared with spinal anaesthesia, but there is an error in the median [range] data presented that precludes verification. Vallejo *et al.*[160] found no difference in mobilisation times following Caesarean delivery under spinal anaesthesia when USG IHII block was compared with intrathecal morphine.

Pectoral block

No RCT reported the time to postoperative mobilisation when PECs block was used compared with spinal anaesthesia.

Serratus plane block

No RCT reported the time to postoperative mobilisation when serratus plane block was used compared with other techniques.

Time to discharge

Transversus abdominis plane block

Of 13 RCTs[76,77,89,93,99,100,106,108,140,143,158,159,163] that reported time to discharge following USG TAP block compared with any other technique, 6 had data suitable for inclusion in a random-effects meta-analysis.[100,106,108,158,159,163] There was no difference in time to discharge: WMD (95% CI), −0.31 (−0.73 to 0.11) days, $I^2 = 76\%$. This estimate of effect size should be treated with caution because of the high heterogeneity. In addition, examination of the individual studies suggest it is unlikely that there is a clinically important reduction in time to discharge when USG TAP block used.

Rectus sheath block

No RCT reported the time to discharge when rectus sheath block was used compared with systemic analgesia.

Iliohypogastric–ilioinguinal nerve block

The time to discharge was a secondary outcome of two RCTs[92,161] where USG IHII was compared with other methods. The effect size was not estimable in one of these[161] and in the other study of inguinal hernia repair,[92] in which USG IHII nerve block was compared with a landmark technique, the difference (median [range]) was not clinically important: 21 [6 to 25] hours versus 24 (14 to 26] hours, respectively.

Pectoral block

No RCT reported the time in PACU when PECs block was used compared with spinal anaesthesia.

Serratus plane block

No RCT reported the time to discharge when serratus plane block was used compared with other techniques.

Patient satisfaction

Transversus abdominis plane block

Our random-effects meta-analysis of the risk difference from the 10 RCTs[82,88,89,100,113,128–130,149,154] reporting the percentage of patients satisfied with the procedure when USG TAP block was used compared with other methods, revealed high heterogeneity ($I^2 = 77\%$). However, 10 RCTs compared patient satisfaction using a 0 to 10 NRS[81,87,91,105,145,147,148,153,156,162] and 4 of these[81,105,145,147] included data suitable for a random-effects meta-analysis: this demonstrated no difference in patient satisfaction: WMD (95% CI), 0.20 (−0.52 to 0.92), $I^2 = 53\%$.

Rectus sheath block

One RCT reported patient satisfaction with a 0 to 10 NRS when USG rectus sheath block was compared with systemic analgesia,[118] with no difference between the groups.

Iliohypogastric–ilioinguinal nerve block

Patient satisfaction on a 0 to 10 NRS was a secondary outcome of three RCTs where USG IHII nerve block was compared with spinal anaesthesia.[92,160,161] A combined analysis was not undertaken because of the nature of the data. There was no consistent effect to suggest there was a clinically important difference in patient satisfaction when USG IHII nerve block was compared with spinal anaesthesia.

Pectoral block

One RCT reported the percentage of patients satisfied with the technique when USG PECs block was used compared with spinal thoracic block: there was no difference between the techniques.[95]

Serratus plane block

No RCT reported patient satisfaction when serratus plane block was used compared with other techniques.

Recommendations

Transversus abdominis plane block

(1) The quality of evidence on which to base recommendations is generally weak, with mostly small RCTs that have a high degree of heterogeneity.
(2) We are unable to make any recommendations about the use of USG TAP block on the basis of improved analgesia, reduced morphine consumption, incidence of the majority of complications, time to hospital discharge or patient satisfaction, although there is no evidence to suggest it is inferior to alternative methods of analgesia.
(3) We cannot exclude the possibility that USG TAP block has advantages for specific patient groups and there is a possibility that it may be associated with a reduced incidence of PONV and shorter postoperative mobilisation times.

Rectus sheath block

(A) The quality of evidence on which to base recommendations is weak, with only a few small RCTs, some of which have methodological problems.
(B) We are unable to make any recommendations about the use of USG rectus sheath block on the basis of improved analgesia, reduced morphine consumption, incidence of complications, postoperative mobilisation times, time to hospital discharge or patient satisfaction, although there is no evidence to suggest it is inferior to alternative methods of analgesia.
(C) We cannot exclude the possibility that USG rectus sheath block has advantages for specific patient groups.

Iliohypogastric–ilioinguinal nerve block

(1) The quality of evidence on which to base recommendations is generally weak, with only a few, mostly small RCTs that have a high degree of heterogeneity.
(2) We recommend the use of USG IHII block over spinal anaesthesia for inguinal hernia repair as the analgesia appears not to be inferior, there is a reduced incidence of urinary retention and it eliminates the risk of spinal cord and spinal nerve injury associated with spinal anaesthesia (**1C**).
(3) We are unable to make any recommendations about the use of USG IHII block for other comparisons on the basis of improved analgesia, reduced morphine consumption, incidence of complications, postoperative mobilisation times, time to hospital discharge or patient satisfaction, although there is no evidence to suggest it is inferior to alternative methods of analgesia.

Pectoral block

(1) The quality of evidence on which to base recommendations is weak, with only a few small RCTs.
(2) We are unable to make any recommendations about the use of USG PECs block.

Serratus plane block

(1) The quality of evidence on which to base recommendations is weak, with only few small RCTs.
(2) We are unable to make any recommendations about the use of USG serratus plane block.

Neuraxial blocks

Should ultrasound guidance be used to identify the intended intervertebral space prior to neuraxial anaesthesia

Studies conducted prior to the time window of our literature search had demonstrated that the use of surface landmarks to identify specific intervertebral spaces were inaccurate and possibly inferior to the use of ultrasound.[165] Subsequent research has demonstrated that anatomical landmark techniques and ultrasound are not concordant.[166–169]

Should ultrasound-guidance be used in patients requiring anaesthesia or analgesia for paravertebral block?

Four hundred and eight abstracts were screened for relevance; 13 articles were selected for analysis and only 2 of them[170,171] were finally included to inform the current guideline. We analysed the advantages and disadvantages of USG compared with a landmark technique for paravertebral block. Figure 8 shows the ultrasonography of the paravertebral area.

Adequacy of anaesthesia for intended surgery

One RCT,[170] that included a total of 72 patients, compared the adequacy of anaesthesia for breast surgery when USG was used for paravertebral block compared with an anatomical landmark technique. The success rate (95% CI) was 90.4 (80.9 to 99.4)% in the USG and 72.2 (55.9 to 84.3)% in the comparator groups. With the low success rate in the anatomical landmark group, we are not confident that this study demonstrates the superiority of the ultrasound technique as opposed to a suboptimal

Fig. 8 Paravertebral block. Ultrasonography of the paravertebral area. Position of the probe (left) with the corresponding scan (right). L, lung; PVS, paravertebral space; TP, transverse process.

choice of landmark technique or lack of expertise in using it (lack of equipoise).

Adequacy of postoperative analgesia

One RCT[170] compared the adequacy of postoperative analgesia when USG was used for paravertebral block compared with anatomical landmark technique during breast surgery but there are concerns about the equipoise of this study.

Time to perform block

No RCT or any other selected study reported time to perform paravertebral block when USG was used for paravertebral block.

Time to achieve effective block

No RCT or any other selected study reported time to achieve effective block when USG was used.

Dose of local anaesthetic

No RCT compared the dose of local anaesthetic when USG was used. One case series performed in 20 women undergoing breast surgery reported the use of only 12 ml of 0.75% ropivacaine injected at the T3 and T6 levels with successful blockade.[171]

Incidence of complications

One RCT[170] of breast surgery reported the incidence of complications when USG was used for paravertebral block compared with an anatomical landmark technique. No difference between the techniques was observed in the incidence of pleural puncture or vascular puncture.

Patient discomfort

No RCT or any other selected study reported patient discomfort when USG was used for paravertebral block.

Patient satisfaction

No RCT or any other selected study reported patient satisfaction when USG was used for paravertebral block.

Recommendations

(1) The quality of evidence on which to base recommendations is weak, with only one small observational study and one small randomised controlled trial with methodological concerns.
(2) We recommend the use of preprocedural ultrasound scanning to provide better accuracy in using the intended paravertebral space (**1B**).
(3) We are unable to make any other recommendations about the use of USG for paravertebral block.

Should ultrasound preprocedural assessment be used in patients requiring epidural analgesia?

In total, 1622 abstracts were screened for relevance, 6 articles were selected for analysis and 5 were finally included to inform the current guideline.[172–176] We analysed the advantages/disadvantages of the use of preprocedural ultrasound scanning when compared with landmark techniques for epidural analgesia. One RCT[172] assessed ultrasound preprocedural scanning for hip arthroplasty postoperative epidural analgesia. Three RCTs assessed ultrasound preprocedural scanning for combined spinal-epidural analgesia for obstetric anaesthesia or analgesia:[173,174,176] one study[173] was for vaginal delivery, one[176] was performed in obese patients, and one[174] for elective Caesarean delivery. One RCT[175] assessed ultrasound preprocedural scanning for epidural placement by residents for labour analgesia. These different types of epidural anaesthesia may have provided some bias in the results, which has been included in the final analysis.

Adequacy of epidural anaesthesia

Our random-effects analysis of the risk difference for success on five RCTs[172–176] when preprocedural ultrasound scanning for epidural anaesthesia was performed compared with palpation techniques demonstrated heterogeneity ($I^2 = 86\%$) incompatible with reporting an effect size. In four RCTs of combined spinal–epidural anaesthesia, adequacy of anaesthesia was defined as a successful dural puncture at the first attempt but different criteria were used to define a successful first attempt.[173–176] In one study,[175] the operators were trainee anaesthetists whereas in another the patients were obese.[176] Furthermore, the data from one study were internally inconsistent.[173]

Time to perform epidural anaesthesia

Our random-effects analysis of the mean difference for the time to perform the procedure in two RCTs[173,176] demonstrated heterogeneity ($I^2 = 86\%$) incompatible with reporting an effect size, although each demonstrated a statistically significant but clinically unimportant shorter procedure time with the palpation technique. One RCT[174] was not included in the analysis as it did not include the preprocedural ultrasound time in the results.

Incidence of complications

The incidence of complications (inadvertent dural puncture, vascular puncture and nerve damage) was reported in four RCTs,[173–176] and a random-effects model for the risk difference found no difference when ultrasound preprocedural scanning was performed for epidural anaesthesia compared with palpation technique: risk difference (95% CI), −0.00 (−0.01 to 0.01), $I^2 = 0\%$. In subgroup analysis, there was no difference for either inadvertent dural puncture[173–176] (risk difference (95% CI), 0.00 (−0.01 to 0.01), $I^2 = 0\%$) or vascular puncture [risk difference (95% CI), −0.00 (−0.05 to 0.04), $I^2 = 0\%$]. In the one study that included nerve damage as a secondary outcome there were no events.[176] No study

reported the incidence of local anaesthetic toxicity or epidural haematoma.

Patient discomfort during procedure

No RCT assessed patient discomfort during epidural placement when preprocedural ultrasound scanning was performed.

Patient satisfaction with procedure

One RCT[174] assessed patient satisfaction with the procedure on a 0 to 5 NRS scale: the median [range] satisfaction scores were 4 [3 to 5] in both groups.

Number of skin punctures

Three RCTs[173–175] reported the number of skin punctures when preprocedural ultrasound scanning was performed for epidural anaesthesia compared with a landmark and palpation technique. The data from one study were internally inconsistent.[173] One study found no difference in the number of skin punctures with a median [range] of 1 [1 to 3] in both groups.[174] Another study found a significantly reduced number of skin punctures when trainees used preprocedural ultrasound compared with a palpation technique: median [range], 1 [1 to 6] and 2 [1 to 6], P less than 0.01.[175]

Procedural and postprocedural back pain

Two RCTs[174,176] reported the incidence of postprocedural back pain after epidural anaesthesia with preprocedural ultrasound scanning compared with a landmark technique. A random-effects analysis of the risk difference found there was no difference in the incidence of procedural back pain when ultrasound preprocedural scanning was performed compared with landmark: risk difference (95% CI), 0.01 (−0.05 to 0.06), $I^2 = 0\%$)

Recommendations

(1) The quality of evidence on which to base recommendations is generally weak, with only a few RCTs that have a high degree of heterogeneity.
(2) We recommend the use of preprocedural ultrasound scanning to provide better accuracy in identifying the intended intervertebral space (**1C**).
(3) We are unable to make any recommendations about the use of preprocedural ultrasound scanning for other comparisons on the basis of improved success, incidence of complications, patient discomfort, number of skin punctures, postprocedural back pain or patient satisfaction, although there is no evidence to suggest it is inferior to landmark/palpation techniques.
(4) We suggest any increase in time to perform epidural anaesthesia with the use of preprocedural ultrasound scanning is not clinically important (**2C**).
(5) We recommend the use of preprocedural ultrasound scanning for epidural anaesthesia by anaesthetists in training to reduce the number of skin punctures (**1B**).

Should ultrasound preprocedural assessment be used in patients requiring spinal anaesthesia?

In total, 2478 abstracts were screened for relevance, 35 articles were screened for analysis and 8 were finally included to inform the current guideline.[177–184] Among these, three RCTs constituted obese patients.[179,180,183] We analysed the advantages/disadvantages of the use of preprocedural ultrasound scanning when compared with landmark techniques for spinal anaesthesia.

Adequacy of anaesthesia for intended surgery

Our random-effects analysis of the risk difference for better success of spinal anaesthesia with preprocedural ultrasound scanning on six RCTs[177–179,181–183] demonstrated heterogeneity ($I^2 = 94\%$) incompatible with reporting an effect size. A similar degree of heterogeneity was found for nonobese ($I^2 = 95\%$)[177,178,181–183] and obese ($I^2 = 91\%$)[179,183] patients. In one RCT of obese patients, adequacy of anaesthesia was defined as successful dural puncture on first attempt.[179]

Time to perform spinal anaesthesia

Our random-effects analyses found heterogeneity to be too high to estimate an effect size for any difference in the time to perform spinal anaesthesia either excluding the time to perform the preprocedural scanning ($I^2 = 88\%$, six RCTs[177–180,182–184]) or including it ($I^2 = 95\%$, three RCTs[177,179,181]). Examination of the individual studies suggest that any differences are likely to be clinically unimportant.

Incidence of complications

The incidence of complications (vascular puncture and paraesthesia) was reported in three RCTs.[182–184] There was no difference in a random-effects analysis with preprocedural ultrasound scanning compared with landmark techniques for either the overall risk difference (risk difference (95% CI), 01 (−0.04 to 0.06), $I^2 = 39\%$), or for vascular puncture, [risk difference (95% CI), −0.00 (−0.04 to 0.04), $I^2 = 0\%$][182–184] or paraesthesia [risk difference (95% CI), −0.0 (−0.17 to 0.17), $I^2 = 75\%$].

Patient discomfort

No RCT reported patient discomfort when USG was used for spinal anaesthesia.

Patient satisfaction

One RCT[178] reported no difference in patient satisfaction assessed on a 0 to 10 NRS scale, when preprocedural ultrasound scanning was performed compared with landmark technique, although the data presentation and analysis were inappropriate for the type of data. Two RCTs[177,182] reported the number of patients satisfied or

very satisfied, but a random-effects analysis of the risk difference revealed heterogeneity too high ($I^2 = 89\%$) to determine an effect size.

Postprocedural back pain

One RCT[178] assessed postprocedural back pain on a 0 to 10 NRS, and reported no difference between ultrasound preprocedural ultrasound scanning compared with the landmark technique, although the data presentation and analysis were inappropriate for the type of data. Another RCT[183] compared the incidence of postprocedural back pain between ultrasound preprocedural scanning or the landmark technique in nonobese or obese obstetric patients: nonobese (0 versus 4%) and obese (0 versus 12%). These differences were not statistically different.

Number of skin punctures

The number of skin punctures was reported in three RCTs,[178,179,181] although the data were not suitable for a combined analysis. For one study of obese patients presenting for lower limb orthopaedic surgery, there were fewer skin punctures in the ultrasound group than in the landmark group: median [IQR] 1 [1 to 2] versus 1 [1 to 4], $P < 0.001$, although differences in baseline characteristics may have confounded this result.[179]

Recommendations

(1) The quality of evidence on which to base recommendations is generally weak, with a few RCTs that have a high degree of heterogeneity.
(2) We recommend the use of preprocedural ultrasound scanning to provide better accuracy in identifying the intended intervertebral space (**1C**).
(3) We are unable to make any recommendations about the use of preprocedural ultrasound scanning for other comparisons on the basis of improved success, incidence of complications, number of skin punctures, postprocedural back pain or patient satisfaction, although there is no evidence to suggest it is inferior to landmark/palpation techniques.
(4) We suggest any increase in time to perform spinal anaesthesia with the use of preprocedural ultrasound scanning is not clinically important (**2C**).

Training in ultrasound-guidance for regional anaesthesia

How should peri-operative ultrasound training be conducted?

As discussed in the accompanying guideline on the use of ultrasound guidance for vascular access (ref PERSEUS Vascular), in the near future we can expect that all medical graduates will have received some training in point-of-care ultrasound (POCUS). Hopefully, this will translate into faster acquisition of basic ultrasound competencies.[185,186] The current need, however, is to accommodate the requirements of trainee anaesthetists who are POCUS 'novices' as well as those of clinicians who are already performing procedures by ultrasound-guidance but who require their competency to be certified. In order to satisfy these various needs, a structured, competency-based approach to training is of the upmost importance.

The aim of this section is to provide recommendations and guidance on training anaesthetists in USG regional anaesthesia, including assessment of proficiency. In developing this guideline, 68 articles on ultrasound education were screened although only 24 met our inclusion criteria, illustrating the paucity of high-quality evidence. Most of the articles and studies analysed were based on a single-centre experience in the training of ultrasound-guided procedures. Consequently, we used the RAND appropriateness adaptation of the Delphi process with an online rating system to generate consensus between the members of the Taskforce. All results from the Consensus are available in Appendix 5, http://links.lww.com/EJA/A430.

How to structure ultrasound training?

All the authors and experts agree that in order to gain some proficiency before a graduated introduction to learning in the clinical setting, ultrasound training should begin with the acquisition of suitable classroom-based knowledge and practical activities (lectures, video demonstrations,[66] one-to-one sessions,[187] e-learning tools and simulated practice).[188,189] Some argue that cadaver model-based training, combining human anatomy and skills improvement, should also be considered as a promising teaching tool:[190,191] but no amount of simulated training can replace a clinical teaching session with an experienced anaesthesiologist.[192] However, a randomised prospective study by Niazi *et al.* demonstrated that even 1 h of simulation-based training combined with conventional training could make a significant difference, compared with conventional training alone.[193] In summary, proper training requires a structured training programme, clinical learning opportunities and an appropriate patient and teacher.[194,195]

What are the main components of training of ultrasound-guided procedures?

Generic knowledge and skills

As with the accompanying guideline on ultrasound-guided vascular access (ref PERSEUS vascular), we recommend that an anaesthetist practicing USG regional anaesthesia should have a good grasp of the general principles of ultrasound (physics of ultrasound, knobology, image optimisation and interpretation) and ultrasound assessment, and of both normal and variant anatomy. Training should also include techniques for the correct visualisation of the needle tip, both in-plane and out-of-plane, although we suggest that an in-plane technique should be the method of choice in order to

maximise the needle tip visualisation especially for the correct local anaesthetic spread.

Knowledge and skills specific for ultrasound-guided regional anaesthesia

There was strong consensus that at the completion of their training the practitioner, in addition to achieving the generic objectives, should be able to demonstrate:

(1) Knowledge of the sectional and ultrasonic anatomy of the brachial plexus and its branches, the sciatic nerve and its branches, the femoral nerve and its branches, the vertebral column and epidural space, the paravertebral space, and anatomy relevant to truncal blocks. This includes identification of vascular, muscular, fascial, bone, pleural, vertebral and paravertebral structures.
(2) That they can recognise relevant variant anatomy using ultrasound, such as anatomical relations of nerves, branching of nerves, abnormal nerve morphology, perineural blood vessels.
(3) Supplementary techniques to confirm needle tip location.
(4) Knowledge of perineural catheter techniques.

Laboratory and simulation-based training

This should include the scanning of healthy volunteers for learning ultrasound anatomy and procedural practice on inanimate simulators (phantoms). We recommend that simulation practice on inanimate models should be structured in steps of increasing difficulty. The main objective is to develop both operator confidence with image-mediated rather than eye-guided hand motion, and co-ordination between the hands working in different ways: the nondominant hand holding the probe to obtain the best ultrasound scan of nerves or epidural space, and the dominant hand performing the needle insertion.

We suggest a six-step approach as follows:

(1) Step 1: probe orientation and correct imaging acquisition.
(2) Step 2: hand stabilisation, evaluation of the structures in terms of depth and needle course.
(3) Step 3: static visualisation of the needle and its tip.
(4) Step 4: dynamic visualisation of the needle and its tip without a phantom target.
(5) Step 5: techniques of ultrasound-guided nerve or epidural block.
(6) Step 6: complete simulation of the procedure including field preparation.
    (a) Step 6a: ultrasound visualisation of the local anaesthetic spread.
    (b) Step 6b: visualisation of the correct placement of the catheter for epidural anaesthesia/analgesia and for continuous peripheral nerve block.

It should be borne in mind that a greater learning capacity in younger people is likely to translate into novices being faster in acquiring proper skills in ultrasound-guided procedures.[187] The ultrasound training of specialist anaesthesiologists with lots of experience may, on the other hand be quite challenging and rather complicated. For example, the informally trained or self-taught colleague may have gaps in their knowledge, or have acquired bad habits, or both. This problem was analysed by Mariano *et al.*[196] who concluded that a 1-day standardised course of ultrasound-guided regional anaesthesia procedures may be sufficient for the experienced anaesthesiologist to acquire appropriate skills, but the practical implementation of these over the following 12 months was not demonstrated.

Competency assessment for ultrasound-guided regional anaesthesia procedures

On the basis of our Delphi process, the task force members decided that after laboratory and simulation training, the trainees should pass a theoretical examination before commencing clinical training. After an adequate clinical training including supervised procedures performed on patients, the trainee must complete every step of the final assessment in order to obtain certification of proficiency. Ideally, the final assessment of practical competency should include an audit of performance indicators from logbook data, and direct assessment by an expert assessor using a global rating scale (GRS). Some authors suggest reviewing video recordings of trainees performing peripheral nerve blocks in order to make a decision about their competency easier and more objective.[197] This could also be a useful learning tool for identifying errors and problems during the course of training.

Recommendations with strong consensus

(1) Before attempting their first directly supervised attempt for each ultrasound-guided regional anaesthesia procedure, the practitioner should have observed five ultrasound-guided procedures of that type and performed five ultrasound scans on patients scheduled for that ultrasound-guided procedure.
(2) The practitioner undergoing training in ultrasound-guided regional anaesthesia should maintain a logbook that documents every procedure they perform. In addition to the level of supervision, this should contain at a minimum the information required to complete 'Performance indicators for ultrasound-guided regional anaesthesia procedures' (see below).
(3) For each ultrasound-guided regional anaesthesia procedure, the practitioner should be directly observed for at least five ultrasound-guided procedures of that type before they perform the procedure with distant supervision.
(4) For each ultrasound-guided regional anaesthesia procedure, the practitioner should be signed off as

competent for that procedure by an expert trainer using a global rating scale before they perform the procedure with distant supervision.
(5) To be eligible for completion of competency-based training in ultrasound-guided regional anaesthesia, cumulative summated outcomes for key performance indicators should be within the tolerance limits of expert practice standards.
(6) Maintenance of competence in ultrasound-guided regional anaesthesia will require cumulative summated outcomes for key performance indicators to be within the tolerance limits of expert practice standards.
(7) Maintenance of competence in ultrasound-guided regional anaesthesia will require evidence of regular continuing professional development activities relevant to ultrasound-guided regional anaesthesia.
(8) Maintenance of competence in ultrasound-guided regional anaesthesia should be based on performance indicators only and not number of procedures.

The following are useful performance indicators for ultrasound-guided regional anaesthesia:

(1) successful block rate (no supplementation),
(2) rate of conversion to unplanned general anaesthesia,
(3) completion of procedure within 30 min,
(4) total procedural time,
(5) incidence of major complications,
(6) incidence of all complications,
(7) patient's satisfaction.

We recognise that it may be difficult for a trainee to achieve the required experience if they are based in a smaller hospital and these recommendations may have implications for the organisation of anaesthesia-training programmes. However, the Taskforce was in agreement that regular practice and performance are essential for the acquisition of competence with complex medical interventions. In this respect, it is our view that training in USG regional anaesthesia is a specialist undertaking that may not be possible in every hospital, similar to other specialist areas of anaesthetic practice, such as neuroanaesthesia, cardiac anaesthesia, paediatric anaesthesia, and so forth.

Who can become a trainer?

As already mentioned above, not only the infrastructure but also the learner and teacher themselves have a huge impact on the educational processes. Through our Delphi consensus, we decided that a trainer/instructor should be a certified anaesthesiologist who engenders a position of trust in the learning partnership by meeting the following criteria:

(1) be active in clinical practice
(2) have competence in what he/she teaches
(3) have knowledge of best practice and guidelines
(4) have experience and motivation in education and training

The instructor/supervisor should be a certified practitioner who is active in clinical practice and can demonstrate competency, knowledge of best practice, and clinical excellence through participation in academic activities within the field of peri-operative ultrasound.

Recommendations with strong consensus

An expert trainer in ultrasound-guided regional anaesthesia must be able to demonstrate:

(1) One year of independent practice in ultrasound-guided regional anaesthesia following completion of competency-based training, or
(2) Continuous independent practice in ultrasound-guided regional anaesthesia for at least 3 years and which began before the introduction of competency-based training ('Grandfather' clause)
(3) Cumulative summated outcomes for key performance indicators to be within the tolerance limits of expert practice standards
(4) Evidence of regular continuing professional development activities relevant to ultrasound-guided regional anaesthesia and education/training
(5) Maintenance of competence in ultrasound-guided regional anaesthesia should be based on performance indicators only and not number of procedures.

There was debate as regards the required minimum annual number of procedures but we recognise that requiring a minimum annual number of procedures may preclude some experienced anaesthesiologists from being recognised as an expert trainer. We consider that performance indicators should be taken into account more than a defined number of procedures performed per year.

Should the landmark-based technique also be included in ultrasound training?

For at least 20 years before ultrasound-guided procedures came into regular anaesthetic practice, the main technique for major peripheral nerve blocks was nerve stimulator-guided regional anaesthesia, which may now be considered as less relevant or important.[198,199] Various training programmes are still trying to reach a consensus on whether peripheral nerve stimulator (PNS)-guided techniques should be included in training, given the increasing use of UGRA.[200] Having in mind that PNS-guided techniques proved to be an unreliable indicator of both needle-nerve proximity and intraneural needle placement, ultrasound-guided regional anaesthesia is going to become the method of choice even in less developed countries.[201,202] However, PNS-guided techniques may be beneficial in some circumstances when ultrasound use is unavailable.[203] The use of ultrasound in

neuraxial blocks is also increasing, with an increasing number of publications demonstrating positive results: it is included in a variety of protocols for neuraxial blocks especially for parturients.[204] Ideally, learners should be exposed to both USG and non-USG techniques during their training. Gaining sufficient competency in landmark techniques may take significantly more time and achieving clinical competency in both USG and non-USG techniques might be difficult. Whatever the case, USG techniques should take priority.

Final remarks

The results from this extensive review of the literature on ultrasound-guided regional anaesthesia for peripheral nerve and neuraxial blocks aim to guide anaesthesiologists in their daily practice to choose the best technique in terms of better outcomes for the patient, improved success and cost/effectiveness of the procedure. The use of USG regional anaesthesia is considered well tolerated and effective for some nerve blocks when compared with alternative techniques but there are certain areas where a lack of robust data precludes useful comparison, such as truncal blocks (e.g. PEC, quadratus lumborum block). The new frontiers for further research are represented by the use of USG during epidural or spinal analgesia/anaesthesia as, in these cases, the evidence for the value of the use of ultrasound is limited to the preprocedure identification of the anatomy (e.g. the appropriate interspace, the depth of the epidural or spinal space, and some idea of the needle angle).[205] Other areas for improvement are represented by a cost/effectiveness evaluation of USG regional anaesthesia in the Enhanced Recovery After Surgery (ERAS) protocols as part of a multimodal approach to improve patient outcomes and reduce healthcare-related costs.

Ultrasound-guided regional anaesthesia can be considered an essential part of the curriculum for the anaesthesiologist, and the aim of this guideline is to provide a defined training and certification path that can be adopted by institutional or National boards to verify the competency of trainees to perform procedures unsupervised, and to verify the suitability of trainers according to an objective evaluation. Our recommendations will require considerable changes to some training programmes, and it will be necessary for these to be phased in before compliance becomes mandatory.

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