Ultrasound imaging for lumbar punctures and epidural catheterisations: systematic review and meta-analysis

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CRD summary
This generally well-conducted review concluded that ultrasound imaging could reduce the risk of a failed or traumatic lumbar puncture or epidural catheterisation. Limitations in the quality of the evidence, and uncertainty around the reliability and generalisability of the pooled estimates, mean that the authors' conclusions seem too strong.

Authors' objectives
To determine whether or not ultrasound imaging could reduce the risk of failure in lumbar puncture or epidural catheterisation, compared with standard palpation, and whether or not it could reduce the number of traumatic procedures, insertion attempts, and needle redirections.

Searching
MEDLINE, EMBASE and Cochrane Central Register of Controlled Trials (CENTRAL) were searched, without language restrictions, for articles from inception to May 2012; search terms were reported. Reference lists of retrieved articles and reviews were searched.

Study selection
Randomised or quasi-randomised trials that compared ultrasound imaging (to identify a location before the procedure or real-time scanning) with no imaging, for patients undergoing a lumbar puncture or epidural catheterisation, were eligible for inclusion. Trials had to report one or more of: the incidence of failed or traumatic procedures, the number of insertion attempts, the number of needle redirections, or the time taken to perform the procedure (definitions provided). Trials of procedures involving the peripheral nerves, or the caudal, paravertebral, radicular, or plexus regions, were excluded.

Most of the included trials used ultrasound to landmark before the procedure. Manual palpation, loss of resistance, or both were used for all control patients. All trials, except one, were of adults, and the settings were operating rooms, emergency departments or maternity wards.

Two independent reviewers selected trials for the review; disagreements were resolved by consensus.

Assessment of study quality
Two reviewers independently assessed trial quality, using a modified version of the Checklist to Evaluate a Report of a Nonpharmacological Trial (CLEAR NPT), covering sequence generation, allocation concealment, blinding, outcome reporting, and performance of operators.

Data extraction
Two reviewers independently extracted the data to calculate risk ratios, for binary outcomes, and mean differences, for continuous outcomes. Trial authors were contacted for missing data.

Methods of synthesis
Pooled risk ratios and weighted mean differences, with 95% confidence intervals, were calculated using random-effects models. Absolute risk reductions were calculated, and used to produce the number needed to treat. The authors assumed that: the mean was approximated by the median; the range was six standard deviations; and the interquartile range was 1.35 standard deviations. Where no measure of dispersion was reported, the outcome was not included in the synthesis.

For rare events, sensitivity analysis was conducted using the Peto method. Heterogeneity was assessed using \( I^2 \). Subgroup analyses were conducted to investigate the type of procedure, specialty and experience of the operator, risk profile of the population, and whether the same operator was assigned to both groups. Publication bias was investigated, using a funnel plot, where at least 10 trials were available. The trim-and-fill method was used where asymmetry was
Results of the review
Fourteen randomised controlled trials (RCTs) were included in the review (1,334 patients; range 20 to 370). Nine trials used ultrasound imaging for epidural catheterisation, and five used it for lumbar puncture. Six trials reported adequate sequence generation, 13 had adequate allocation concealment, one reported adequate blinding, 13 had adequate outcome reporting, 10 reported adequate experience and skill of the operators, and three reported using the same operator for both arms of the trial.

Ultrasound imaging significantly reduced the risk of a failed procedure (RR 0.21, 95% CI 0.10 to 0.43; NNT 16; I²=0; 12 RCTs), and a traumatic procedure (RR 0.27, 95% CI 0.11 to 0.67; NNT 17; I²=0; five RCTs), and the number of insertion attempts (WMD -0.44, 95% CI -0.64 to -0.24; I²=73%; eight RCTs) and needle redirections (WMD -1.00, 95% CI -1.24 to -0.75; I²=69%; eight RCTs).

The only subgroup analysis to significantly impact on the overall results was the benefit of ultrasound imaging in reducing the mean number of insertion attempts, which was significantly larger for lumbar puncture, than for epidural catheterisation. Funnel plots showed possible publication bias, but the trim-and-fill method was not used to investigate it.

Authors' conclusions
Ultrasound imaging could reduce the risk of a failed or traumatic lumbar puncture or epidural catheterisation, and the number of needle insertions and redirections.

CRD commentary
The review addressed a clear research question, with reproducible inclusion criteria. Relevant sources were searched, without language restrictions. There were no limits on publication status, but no specific search for unpublished trials was reported, and some relevant trials may have been missed. Each stage of the review was conducted by two people, reducing the risk of error and bias. Appropriate criteria were used to assess trials quality, and the results were published in full; only one of the RCTs was free from any of the biases assessed.

The trials differed clinically, and some analyses showed substantial statistical variation. One forest plot was presented for an analysis with an I² of zero; the included RCTs were generally small with imprecise point estimates, making the I² value unreliable. The sources of variation were investigated, but there were few trials in many of the subgroup analyses, and the I² results were not reported, so it was unclear whether the variability was reduced.

This was a generally well-conducted review, but the limitations in the quality of the evidence, and the uncertainty around the reliability and generalisability of the pooled estimates, mean that the authors' conclusions seem too strong.

Implications of the review for practice and research
Practice: The authors stated that clinicians working in settings where these procedures were commonly performed (obstetric anaesthesia and emergency medicine), or where failure was associated with particularly negative consequences (paediatric oncology), should consider using ultrasound imaging.

Research: The authors stated that future research should: determine the best way to use ultrasound imaging for lumbar puncture or epidural catheterisation in clinical practice; and investigate whether ultrasound should be used for patients who were expected to have difficult procedures, or after a failed procedure, due to the low event rates. They suggested that high-quality pragmatic randomised controlled trials should address these questions, and the cost-effectiveness of ultrasound should be investigated.

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This is a critical abstract of a systematic review that meets the criteria for inclusion on DARE. Each critical abstract contains a brief summary of the review methods, results and conclusions followed by a detailed critical assessment on the reliability of the review and the conclusions drawn.