Performing lumbar punctures for suspected CNS infections: experience and practice of trainee doctors

Lumbar punctures are essential in the management of suspected CNS infections. However, despite clear guidelines their use can be haphazard. This survey investigated the training, knowledge and experience of UK doctors in training in relation to lumbar punctures.

The lumbar puncture is an essential investigation in the management of several neurological emergencies, including suspected CNS infections. The results of CSF analysis are pivotal in the management (Heyderman et al, 2003; Chaudhuri et al, 2008; National Institute for Health and Care Excellence, 2010, 2013; Kneen et al, 2012; Solomon et al, 2012). CSF can be sent for many types of analysis including looking for evidence of CNS inflammation by cell counts and biochemical tests, bacterial culture or antigen tests, polymerase chain reaction techniques for specific pathogens, investigating antimicrobial sensitivities, further specific investigations for less common infections, testing for antibodies associated with autoimmune or paraneoplastic encephalitis and looking for malignant infiltration.

Timely and appropriate lumbar punctures and complete CSF testing are critical in the investigation of suspected CNS infections. However, despite the usefulness of CSF analysis, the practice of performing lumbar punctures has declined over recent years even though there is clear guidance about lumbar puncture safety (Kneen et al, 2002a, 2010; Kelly et al, 2012). Even when a decision is made to undertake a lumbar puncture there are often delays as a result of inappropriate neuroimaging, particularly in adult practice, and CSF is often not sent for standard investigations, with biochemical tests and viral polymerase chain reaction most often omitted (Bell et al, 2009; Kneen et al, 2010; Michael et al, 2010).

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While previous studies have identified problems with undertaking lumbar punctures it is not clear why they occur and to what extent current guidance is being followed. The authors therefore surveyed UK-based trainee doctors to evaluate current practices related to performing lumbar punctures.

Methods

An online semi-structured questionnaire was sent to eighteen postgraduate deaneries in the UK deaneries via email and they were invited to send the questionnaire to their current trainee doctors in adult medicine, paediatrics, general practice and the foundation years. The questionnaire consisted of 21 questions enquiring about knowledge and performance of lumbar punctures including sample collection, performing a lumbar puncture after treatment has been commenced and what they do when CSF cannot be obtained (*Appendix 1* – available online). The questionnaire was piloted among a representative group and subsequently refined. Trainees were given 3 months, until the end of July 2013, to complete the questionnaire. For the purposes of this survey, senior trainees are considered to be those of ST year 3 and above.

Free-text answers were grouped to allow examination of the answers in specific themes. When more than one theme or key word was noted within one answer, the response received two codes; thereby these results were not exclusive. The results were analysed using SPSS 20 (SPSS Chicago, IL). Correlations were calculated using the Pearson correlation coefficient.

To aid comparison for a question which asked about volume of CSF taken, all answers provided in drops were converted to millilitres based on the formula 1 drop = 0.06 ml (McIntyre, 2007). The number of bottles of CSF was calculated to include glucose, so when respondents stated 'three bottles plus separate glucose', this was recoded as four bottles.

The survey formed part of a National Institute for Health Research-funded programme grant on 'understanding and improving the outcome of encephalitis', which includes a cluster randomized control trial of a multifaceted intervention package to improve the management of encephalitis (Backman et al, 2015).

Results

A total of 658 responses were received; 642 (98%) were from eight deaneries, with the other 16 coming from a further eight deaneries which had not been invited to send out the questionnaire, so the respondents must have received the link via friends or colleagues. Nine deaneries declined sending the questionnaire link out to their trainees and one did not respond to the request. Three of the deaneries reported detailed information about the trainees to whom the survey was sent, allowing denominators to be calculated: for those three deaneries the response rates were 23%, 32% and 36%. The remaining deaneries did not forward details of how many and which trainees they forwarded the link to, thus preventing accurate response rates being calculated. Twenty-two questionnaires were excluded: 16 contained no answers, three were completed by consultants and for two the training grade was unclear. The remaining 636 respondents were in the following training grades: FY (100; 16%), ST years 1 and 2 (147; 23%), and ST year 3 and above (389; 61%). It seems likely that more paediatric trainees responded as 373 (57%) had paediatric experience at ST year 3 or above. However, there was equal representation at all training grades for respondents with both adult and paediatric experience.

Lumbar puncture training

Of the respondents, 573 (90%) reported that they had received practical training on how to perform a lumbar puncture. From 386 respondents who had included free-text answers, 318 (82%) had observed a senior, 89 (23%) recalled attending a specific organized teaching event, 58 (15%) had been supervised during a lumbar puncture attempt, 19 (5%) had received training on the ward as doctors, and 15 (4%) at medical school.

Just over a quarter of trainees, 108 (28%) of 636, reported practising on a mannequin, 109 (17%) watched a training video, 67 (11%) of whom had watched the video before their first lumbar puncture (*Figure 1*).

Trainees were asked how many lumbar punctures they had observed before performing one: 502 (78%) had observed fewer than five, 135 (21%) had observed 5–10, and 6 (1%) had seen more than 10. Trainees were asked to record their confidence level on a scale of 1 (not confident) to 10 (most confident) in performing a lumbar puncture. There was a positive correlation between the grade of the junior doctors and the level of confidence in deciding when to do a lumbar puncture (correlation coefficient r=0.938, P<0.001 (*Figure 2*)), and also between confidence and the number of lumbar punctures performed, both supervised and unsupervised (r=0.987, P<0.001 (*Figure 3*)).

Knowledge of performance of lumbar puncture and sample collection

Trainees were asked to record the number of bottles in which they collect CSF, and the average total volume of CSF taken: 326 (51.3%) collected four bottles, 227 (35.7%) collected three bottles, and 83 (13%) more than four bottles. Following conversion from drops, in 314/574 (55%) answers, the mean total volume of CSF the trainees stated they would take was 7.5 ml (standard deviation 5.26) for all trainees. The volume taken differed according to seniority, with a mean volume of 6.08 ml (standard deviation 1.34) for doctors from FY1 to ST2, and 2.48 ml (standard deviation 3.00) for doctors between ST3 and ST8 or specialist registrar levels (P<0.001).

Measurement of the CSF opening pressure did not often happen, despite 474 (77%) of 616 participants being aware that it is part of standard practice: 118 (19%) reported 'never' measuring opening pressure, 249 (41%) 'rarely', 123 (20%) 'sometimes', and 51 (8%) 'usually'; only 71 (12%) reported 'always' measuring opening pressure. A difference between junior and senior trainees was also seen in relation to measuring CSF opening pressure. Of junior trainees 67/228 (29%) reported always measuring an opening pressure, 34/228 (15%) reported usually, 35/228 (15%) reported sometimes, 53/228 (23%) reported rarely and 39/228 (17%) reported never measuring opening pressure. Of senior trainees 4/384 (1%) reported always measuring an opening pressure, 18/384 (5%) reported usually, 89/384 (23%) reported sometimes, 195/384 (51%) reported rarely and 78/384 (20%) reported never measuring opening pressure. Fisher exact test between the groups was 0 (P<0.01).

Figure 1. The different methods of lumbar puncture training reported as percentages according to the grade of the doctor. FY = foundation year; SpR = specialist registrar; ST = specialty trainee.

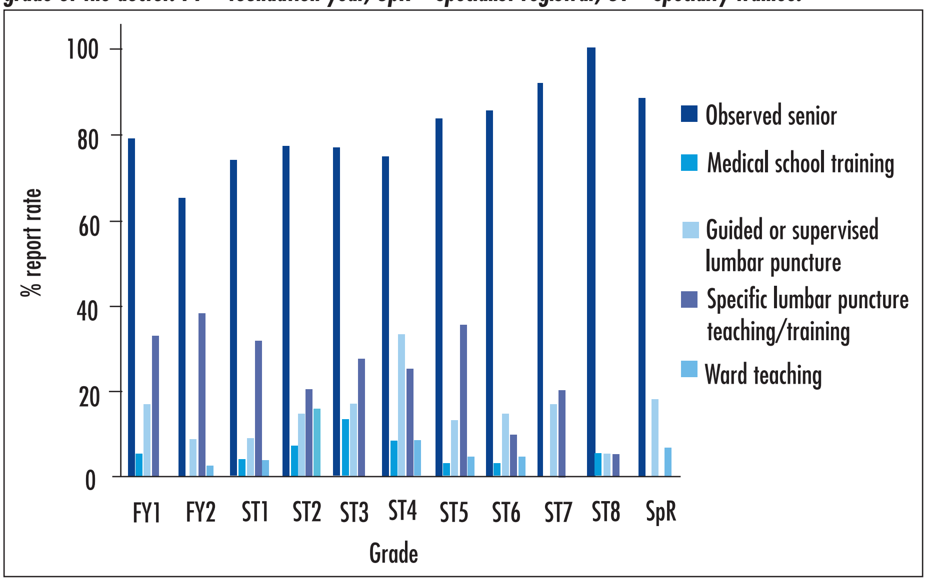


Figure 2. Confidence of medical trainees in making a decision to perform a lumbar puncture by grade of training using the Likert scale. CT = core trainee; FY = foundation year; SpR = specialist registrar; ST = specialty trainee.

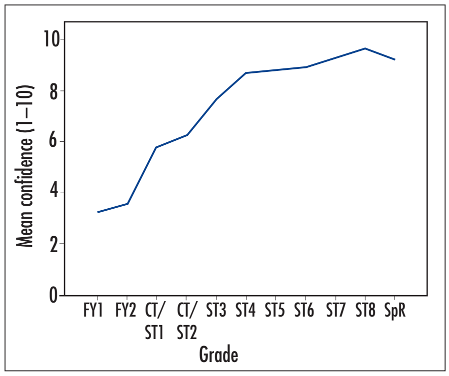
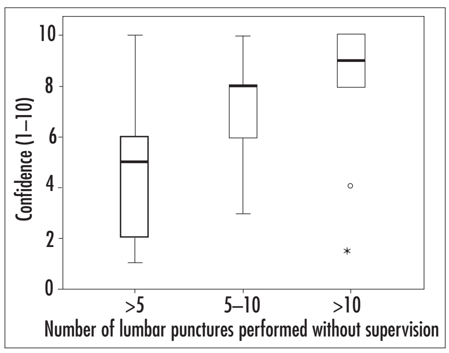


Figure 3. Box and whisker plot demonstrating confidence and number of lumbar punctures performed without supervision of UK-based trainee doctors (r=0.987, P<0.01). ° and * are outliers.



Performing a lumbar puncture after treatment has been started

When asked if trainees would undertake a lumbar puncture after initiating treatment, 523 (85%) of 613 said yes, 76 (13%) were unsure, and 14 (2%) said no. Free-text information for this question was received from 280 trainees; 111 (40%) described lumbar punctures to be useful for diagnostic reasons, 93 (33%) said that cell counts could be useful and 58 (21%) commented specifically that polymerase chain reaction could still be tested. The remaining 18 (6%) responses were statements of why they would delay the lumbar puncture. When asked specifically whether respondents thought performing herpes simplex virus polymerase chain reaction was still useful after treatment with aciclovir had been started, 617 replied, of which 457 (74%) said yes, 130 (21%) said no and the remaining 30 (5%) were unsure.

When CSF cannot be obtained

When questioned about how many attempts trainees would usually take to obtain CSF, 67 (11%) of 596 stated one attempt, 328 (55%) two attempts, 196 (33%) three attempts, four (0.8%) would make four attempts and one (0.2%) stated 10.

There were 56 free-text answers. They highlighted that 16 trainees had interpreted this question as how many attempts they usually take when performing lumbar punctures, and 40 had interpreted it as how many attempts they would perform if they were unsuccessful before abandoning the procedure.

Trainees were asked about what they usually do if they are unable to perform the lumbar puncture successfully; 578 (91%) of 637 replied. The majority, 407 (70%), reported that they would ask an available colleague; 317 (91%) of 350 trainees in their first 6 years said they would do this, compared to 114 (50%) of 228 more senior trainees (*P*<0.001); in contrast, 114/228 (50%) of the more senior trainees said they would leave the procedure until the next day, compared with just 33/350 (9%) of trainees in their first 6 years. Asking an anaesthetist to assist was stated by 24 (4%) of the 578 respondents. When asked specifically if an emergency anaesthetist was available in their hospital 194 (45%) of 374 trainees said they were. There were 41 free-text answers in relation to this question; 35 people reported their next step would be to ask the consultant or senior doctor on call, three would arrange radiology-guided lumbar puncture, and three would ask an anaesthetist for help.

Challenges faced when performing a lumbar puncture

Finding lumbar puncture equipment

Just over half of the trainees, 342 (55%) of 621, said it was usually easy to find the equipment needed for a lumbar puncture, 148 (24%) found it sometimes easy, 72 (12%) rarely easy, 44 (7%) always easy and 15 (2%) never easy. Of 385 who also supplied free-text information describing what was difficult to find, 177 (46%) said appropriate lumbar puncture needles, 115 (30%) manometers, 40 (10%) suitable assistance, 32 (8%) each for sterile field, gloves or gown and the spray on dressing, 28 (7%) the cleaning product and 15 (4.5%) the sample bottles.

Other issues faced

Respondents were asked to choose from a list what their 'overall biggest problem' was, when performing a lumbar puncture; 320 (55%) of 583 gave more than one answer, giving a total of 981 responses. Reasons chosen included: a lack of appropriately trained nursing staff to assist (383 (39%) of 981), the ward being too busy (232; 24%), inability to find all the equipment (179; 18%), lack of confidence (91; 10%), inability to find a supervisor (73; 7%) and waiting for imaging reports (23; 2%).

In the free-text answers, 30 (43%) of 69 described problems holding the patient when performing the lumbar puncture, 13 (19%) problems with general anaesthesia, eight (12%) had time issues (including getting other staff members to assist, finding all equipment or too many other patients to see), eight (12%) had consent and language barrier issues, and five (7%) had technical problems in performing the lumbar puncture. Several comments given in free-text answers gave insight to this question, listed in *Table 1*.

Discussion

It has previously been demonstrated that only about a half of patients with suspected CNS infections (and no contraindications) have a lumbar puncture performed, and that even when undertaken there are often significant unnecessary delays and the standard CSF investigations are not always requested (particularly glucose and viral polymerase chain reaction) (Bell et al, 2009; Kneen et al, 2010). There are often delays in lumbar puncture for inappropriate imaging, particularly in adult practice (Bell et al, 2009; Michael et al, 2010). Guidelines for the management of patients with meningitis and encephalitis indicate when the procedure should be performed and what tests should be requested (Begg et al, 1999;

Table 1. Free-text answers describing some of the problems experienced by UK-based medical trainee doctors when performing lumbar punctures

'The key to a good paediatric lumbar puncture is having an experienced and confident nurse hold the baby. Such a nurse isn't always available'
'Finding a person who knows how to hold the patient and is free to do so'
'Neurology unit obviously very well equipped; acute medical unit, very poorly equipped'
'Manometers are scarce, usually perform lumbar punctures without. If needed have to be taxied sometimes from the tertiary hospital'
'Sometimes in A&E there is no specific kit available for the paediatric age group'
'The kit is only available in our MAU so on a busy on call it is frustrating to have to go there from A&E to get the equipment. Also it is locked away from doctors! You then have to get one of the nurses to open the cupboard with fingerprint technology'
'I worked in New Zealand for a year and we had a whole pack with everything in including sterile collection bottles; so much better. I struggle to get everything together here'

A&E = accident and emergency; MAU = medical admission unit.

National Institute for Health and Care Excellence, 2010; Kneen et al, 2012; Solomon et al, 2012; Public Health England, 2014). Most emergency lumbar punctures are performed by trainee doctors. The current study was undertaken to understand some of the reasons why lumbar punctures are not always performed when indicated. The principal findings of this study were that significant proportions of trainee doctors reported not having received structured training on performing lumbar punctures and that trainees faced many challenges when attempting to perform lumbar punctures including inability to find all the equipment or suitable assistance and time pressures.

There were four main limitations to this study. First, fewer than half the deaneries sent the questionnaire out at all, but also it appears that the paediatric leads were more likely to send the questionnaire out as 57% of the respondents had a significant amount of paediatric experience. The reason for this is not clear, but it is possible that paediatricians regard this as an important issue as febrile illnesses are the most likely reason children present as a medical emergency (Armon et al, 2001). Second, the inability to obtain the exact denominator for the study means that the authors could not calculate an overall response rate. Third, there were flaws in the questionnaire design: when interpreting the responses, it became apparent that one of the questions was too leading, one led to ambiguous responses and one allowed multiple responses (a block to stop this could have been applied). Fourth, there may be biases introduced by the trainees that responded: recall bias is possible and trainees may not remember specific lumbar puncture training, especially as training takes a long time and this could underestimate training rates given from the earlier years of training. Another possible bias would be that those trainees who were dissatisfied with their training or who had encountered specific problems with doing lumbar punctures may have been more likely to respond which could overestimate the problems described here.

Training issues

The majority of trainees reported observation of lumbar punctures as their method of training with just over a quarter reporting the use of mannequins and less than a fifth watching a specific lumbar puncture training video. This is somewhat surprising since junior doctors are now required to demonstrate how competencies, including lumbar puncture, are acquired and also as studies have shown that lumbar puncture mannequin training improves knowledge and confidence (General Medical Council, 2010; Uppal et al, 2011; White et al, 2012). One quarter of the trainees had observed fewer than five lumbar punctures before doing them without supervision. Confidence improved significantly for trainees who had seen between five and ten lumbar punctures, but there was little additional gain in seeing more than ten. Confidence was also increased by the time trainees became more senior.

The theoretical knowledge of the trainees about number of bottles and the volume of CSF to collect was good. Two thirds said they would collect at least three bottles plus a separate glucose bottle and the average volume of CSF trainees said they would take was 7.5 ml over all training grades. Interestingly, the less experienced trainees stated that they would take more CSF than the senior trainees. The reason for this is unclear; possibly the junior trainees are more aware of the importance of taking a larger volume of CSF than senior trainees following recent training or, conversely, perhaps by the time trainees become senior and are actually doing more lumbar punctures, they reduce the volume because of concern about perceived safety. Other reasons may include senior trainees performing lumbar punctures on more difficult cases or being under more time constraints while supervising a busy acute take for example.

Despite more than three quarters of those surveyed being aware that measuring the opening pressure was part of standard practice, 60% said they never or rarely do it. The difference according to seniority for obtaining opening pressures may follow similar reasons to why the more senior trainees report taking smaller CSF samples. The reason for this was not specifically asked but it is likely to be related to the more general and logistical problems encountered with doing lumbar punctures (see below). The majority (85%) of trainees were also aware that performing a lumbar puncture after starting treatment of a CNS infection was still useful. However, a quarter were unaware or unsure that polymerase chain reaction can still demonstrate herpes simplex virus DNA up to 10 days after treatment with aciclovir (Kneen et al, 2012; Solomon et al, 2012). This may explain why this investigation is frequently not sent on CSF obtained from children with suspected CNS infections; most children are treated with empirical antibiotics and aciclovir, even if there is no clear indication for prescribing aciclovir (Kelly et al, 2012). Therefore this appears to be an area of knowledge which could be improved with more training.

Organizational issues

Trainees faced many challenges in performing lumbar punctures. When struggling to obtain CSF, junior trainees said they were likely to get help from a senior, whereas senior trainees would abandon the procedure and try again the next day, as presumably there was no one available who they felt they could ask for help. Difficulty finding all the equipment was a common problem. It has been demonstrated that a lumbar puncture pack containing the bottles and a flow chart to guide investigations increased the proportion of patients having the appropriate investigations performed; in addition there was a trend towards identification of a wider number of pathogens (Michael et al, 2013). Other simple measures may help, e.g. programming the hospital computer system to allow a multiple order set for lumbar puncture investigations. A lack of trained assistance, in particular nursing staff, was also reported as an important issue. In addition, many trainees commented that they were generally too busy when on call, as documented in the Royal College of Physicians' (2013) report 'Hospital Workforce – for the future?'.

Conclusions

Trainee doctors generally had a good knowledge of how to undertake a lumbar puncture, including the volume of CSF and which bottles are needed. However, the major difficulties reported were challenges faced with finding the equipment needed, and problems in getting appropriate assistance. It is possible that the management of patients with suspected CNS infections could be improved by addressing the issues identified here. To investigate this, the authors are currently undertaking a cluster randomized controlled trial of a tailored intervention package to promote improved investigation and treatment of suspected encephalitis (Backman et al, 2015). **BJHM**

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Ethics statement: The NIHR programme 'Understanding and improving the outcomes of viral encephalitis' was ethically approved by the NRES Committee East Midlands – Nottingham 1. This survey was part of a service evaluation of professional doctors and was completely anonymous.

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Extra data may be available by emailing the corresponding author and the questionnaire used is available as supplementary material on the website.

Statement of contribution: This study was conceived by Dr R Kneen and Dr S Defres, and designed by Dr R Backman, Dr R Kneen and Dr S Defres. Data were acquired by Dr R Backman and Dr S Defres, and interpreted and analysed by Dr S Defres, Dr J Mayer and Dr R Kneen. The article was drafted and revised by Dr S Defres, Dr J Mayer and Dr R Kneen. All authors read and approved the final manuscript.

A number of other people also helped with this survey: Professor Tom Solomon with conception and design, Dr Anu Goenka with data acquisition and both they and Dr Benedict Michael and Professor Robbie Foy helped with drafting and reviewing the final manuscript.

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KEY POINTS

- No studies have explored the training junior doctors receive or challenges they face in relation to performing lumbar punctures for suspected CNS infections; in particular why there may be unnecessary delays, why the standard tests are not always requested and sometimes not done at all.
- A total of 658 doctors in training, from all grades, responded to the questionnaire. Although 90% of trainee doctors reported receiving practical lumbar puncture training only 28% used a mannequin. Confidence in decision making was related to number of lumbar punctures performed and also timing of lumbar punctures.
- Difficulty obtaining all the necessary equipment for performing a lumbar puncture is a frequent problem as is finding an appropriately trained assistant.
- Around a quarter of respondents either thought performing a herpes simplex virus polymerase chain reaction after treatment had commenced was not useful (21%) or were unsure (5%), although herpes simplex virus polymerase chain reaction can remain positive for up to 10 days after starting treatment.

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