# Diagnostic and therapeutic lumbar puncture performed safely and efficiently with a thin blunt needle

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## ABSTRACT

**INTRODUCTION:** The risk of postdural puncture headache following lumbar puncture can be reduced by choosing a blunt spinal needle or by using a smaller needle diameter. Reports indicate that lumbar puncture practiced outside of the anaesthetic discipline does not adhere to the current level of evidence. To examine the practice among haematologists in Denmark, we performed a national survey. In addition, we analysed the flow rate of a blunt 27-gauge (0.4 mm) spinal needle typically used for spinal anaesthesia by timing the tap duration of a diagnostic lumbar puncture.

**MATERIAL AND METHODS:** An online survey was emailed to all twelve haematology departments in Denmark with questions regarding needle type and technique. A total of 64 patients undergoing lumbar puncture with a 27-gauge spinal needle (sitting position) had their sampling of 6 ml cerebrospinal fluid timed with a stopwatch.

**RESULTS:** Eleven sites participated. Only three (27%) reported routine use of blunt needles. Five (45%) departments used a large calibre needle (18-20 gauge; 1.2-0.9 mm), while the remaining six (55%) used smaller calibre needles (≥ 22-gauge; ≤ 0.7 mm). The mean sampling time was 11 min. 59 sec., which corresponds to a flow rate of 30 ml/h.

**CONCLUSION:** There is strong evidence in favour of the use of blunt spinal needles to reduce the risk of postdural puncture headache. In general, lumbar puncture practice among the haematologists in Denmark does not adhere to the literature's recommendations. The risk of headache may further be reduced by using a thin needle, even if this prolongs sampling time.

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Lumbar dural puncture (LP) is performed daily by physicians from many disciplines. Among haematologists, the purpose is paraclinical testing of the cerebrospinal fluid (CSF) and administration of intrathecal cytotoxic drugs.

Postdural puncture headache (PDPH) is one of the most common sequels to LP [1]. The condition is not life-threatening, but it can imply serious morbidity. Even though most resolve spontaneously within a few days [2], this excruciating condition [3] may protract for a week or even more [2] which results in prolonged immobilisation and hospitalisation and also causes extra work at departments and even readmission.

The incidence of PDPH can be reduced by using a "pencil-point" blunt needle (BN) instead of a traditional cutting needle (CN) [1, 3-7] and/or by choosing a smaller needle diameter [1, 5, 8]. However, practice outside of the anaesthetic discipline does not adhere to the literature's recommendations [1, 3, 9, 10].

We conducted a nationwide survey of LP practice in haematology departments in Denmark. In addition, we analysed the flow rate of a 27-gauge (G) (0.4 mm) BN typically used for spinal anaesthesia by timing the duration of an LP tap.

It is postulated by many that CSF collection with a needle calibre smaller than 22-G (0.7 mm) takes an unreasonably long time [1, 5] and is thus not feasible. Here, we report the results and discuss the results of practice.

## MATERIAL AND METHODS

### I: national survey regarding lumbar puncture practice at the haematology departments of Denmark

A survey was created using the Mamut Online Survey and distributed to all 12 Danish haematology wards in March 2012. It was emailed to a professor or senior physician of the ward, who was free to pass the email on to a colleague.

The questions referred to needle type, technique, positioning of the patient, paraclinical testing of the CSF and estimated quantity of lumbar punctures and blood patches per year.

All questions were written in Danish in a multiple-choice fashion. Submission was only possible once the entire questionnaire had been answered. The respondents knew that the results would be published anonymously.

### II: Duration of cerebrospinal fluid sampling

In a cohort of patients seen at the Department of Haematology, Rigshospitalet, for diagnostic LP with a blunt 27-G Pencan needle over a 10-month period in 2011, the sampling of CSF was timed with a stopwatch. Only patients in the sitting position were included. Six test tubes filled with 1 ml (20 droplets) of CSF were collected per patient (**Figure 1**). Aspiration was not allowed.

*Trial registration:* not relevant.

ORIGINAL ARTICLE

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FIGURE 1

Duration of sampling 6 ml of cerebrospinal fluid (N = 64).

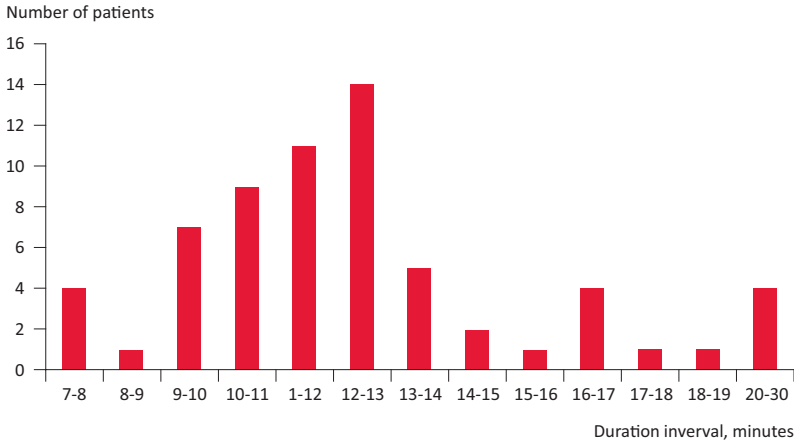
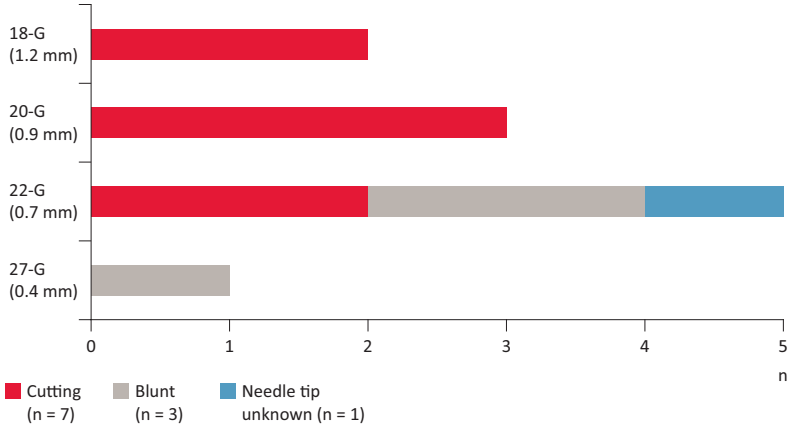



FIGURE 2

Needle size and type of needle tip (N = 11).




G = gauge.

## RESULTS

### I: national survey regarding lumbar puncture practice at the haematology departments of Denmark

Data from eleven of all 12 invited sites were collected in April 2012. One department declined to participate since LP was a rare procedure. The respondents provided their name in the survey or confirmed the participation in a follow-up correspondence.

The results of the survey showed that different needle types were preferred. Only three (27%) reported routine use of BN. Five (45%) departments used a large-calibre needle (18-20-G; 1.2-0.9 mm), while the remaining six (55%) used smaller calibre needles, ≥ 22-G (≤ 0.7 mm) (**Figure 2**). No department reported using a 25-G (0.5 mm) needle.

In **Table 1** the various procedure-related differences are presented.

Some major differences were that three of 11 departments reported that they also have medical students employed to perform LP. One department specified that a special team of students performed this procedure full-time (Table 1).

At five of the departments, patients would either be positioned in the sitting or in the lateral recumbent position. Local anaesthetics were used routinely in only three departments (Table 1).

Aspiration of CSF was allowed in two departments (Table 1). In case of unsuccessful puncture, the department of anaesthesiology was often approached (Table 1).

Measurements of protein, glucose and cell count in the CSF was routinely carried out in all departments, while paraclinical tests such as histology, microbiology and flow cytometry were performed less frequently (Table 1). In total: five departments (45%) collected five tubes, three departments (27%) collected two tubes and the remaining departments collected one, three and four tubes, respectively.

Eight respondents (73%) applied routine bed rest after diagnostic LP. However, all respondents reported routine bed rest after application of intrathecal cytotoxic drugs with a mean duration of 60 min. (range 30-120 min.) (Table 1).

Additionally, there was a clear variation in the frequency of the estimated number of performed LPs per year and a very low annual incidence of reported blood patches (Table 1).

### II: Duration of cerebrospinal fluid sampling

A total of 64 patients had the sampling of 6 ml CSF with a 27-G-needle measured by an observer during the procedure (Figure 1).

The median duration of sampling was 11 min. 59 sec., equalling a flow rate of 30 ml/h (interquartile range 10 min. 27 sec.-13 min. 17 sec.). A sensitivity analysis based on the exclusion of the four outliers lasting more than 20 min. resulted in a change of the median duration to 11 min. 53 sec., while the mean duration was reduced to 11 min. 52 sec. (standard deviation (SD) 2 min. 17 sec.) from 12 min. 45 sec. (SD 4 min. 16 sec.).

## DISCUSSION

This is the first national survey to examine a clinical procedure in haematology in Denmark and the first study to report on the duration of a fixed CSF sampling using a Pencan 27-G needle in patients.

Across the clinical specialities, procedures such as vascular catheterization, pleural drainage or even temperature measurement continuously evolve and are

evaluated in order to optimize practice. Different techniques may then be preferred at different departments. One purpose of this survey was to report differences in the performance of LP which may be relevant to complications like PDPH.

PDPH characteristically worsens after sitting or standing up, and abates after resuming the recumbent position [1, 3]. This orthostatic component is in line with the pathophysiological theory of PDPH, which states that the headache is caused by CSF leakage from the hole produced when the spinal needle traverses the dura [1, 7, 8]. In contrast to earlier assumptions that a BN will produce less damage by separating rather than cutting the dural fibres, eletron microscopic studies have revealed that a BN tears and disrupts the fibres as opposed to the clean cut semilunar "tin lid" opening created by a CN, see **Figure 3**. In addition, the cross-sectional area of the holes produced by two needle types appears to be similar [12]. How this finding is associated with reduced PDPH incidence remains unknown [3, 12].

In a meta-analysis of 38 trials with a total of 8,184 patients, the risk of PDPH was significantly decreased by applying BN instead of CN [3].

A subgroup analysis within the neurology population established a number needed to treat of six corresponding to one patient potentially avoiding PDPH for every six patients undergoing a LP with a BN instead of a CN [3].

Diagnostic LP with a 22-G needle in neurology patients has shown a significant decrease in PDPH incidence from 36% to 3% [6] and from 24% to 12% [7] when a BN is used instead of a CN. A similar comparison has been reported in a haematology setting, demonstrating a reduction in PDPH from 30% to 4% [4]. The result presented in the present study shows that three departments use the BN routinely (Figure 2). Therefore, the risk of PDPH may vary within the Danish departments of haematology.

A higher success rate with the application of local anaesthetic prior to LP has been demonstrated in a paediatric study [13]. In theory, a local anaesthetic reduces the number of LP attempts, since it prevents a reflective extension of the spine caused by the pain of the traversing lumbar needle, and hereby keeps the spine in ventral flexion. This expands the interspace between two adjacent spinal processes and laminae, allowing the optimal passageway for the needle. Only three departments used local anaesthetics routinely (Table 1). Some may argue that this may conceal the anatomical hallmarks, or may increase the risk of bleeding in thrombocytopenic patients. However, the use of an introducer before a small diameter needle makes necessary the use of a local anaesthetic.

Our finding that only a minority of departments use

**TABLE 1**

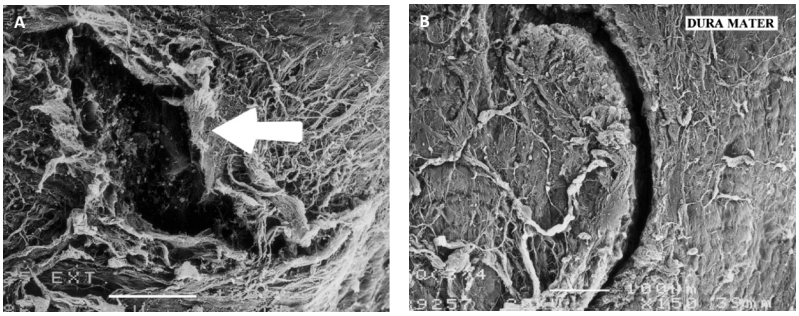
Results of reported information from the survey [11] to departments of haematology (N = 11).

| | n (%) |
|---|---|
| **Procedure** | |
| *Person taking the sample*[a] | |
| Consultant, or senior physician | 10 (91) |
| Staff specialist | 11 (100) |
| Junior doctor | 10 (91) |
| Medical student employed at the department | 3 (27) |
| *Positioning of the patient during the procedure* | |
| Sitting | 4 (36) |
| Lateral recumbent | 2 (18) |
| Equally valid | 5 (45) |
| *Routine use of local anaesthetic?* | |
| Yes | 3 (27) |
| No | 6 (55) |
| Optional | 2 (18) |
| *Is cerebrospinal fluid occasionally aspirated with a syringe?* | |
| Yes | 2 (18) |
| No | 9 (82) |
| *Assistance in case of unsuccessful lumbar puncture on the ward* | |
| Department of anaesthesiology | 6 (55) |
| Department of anaesthesiology or neurology | 1 (9) |
| Department of radiology (X-ray guided) | 1 (9) |
| Depends on the problem in hand | 3 (27) |
| *Routine choice of paraclinical testing of the cerebrospinal fluid*[a] | |
| Pathology department[b] (histology) | 9 (82) |
| Marker analysis[b] (flow cytometry) | 6 (55) |
| Microscopy and culturing | 7 (64) |
| Biochemistry (protein, glucose, cell count) | 11(100) |
| Stored | 6 (55) |
| **Post-procedure positioning** | |
| *Duration of bed rest after lumbar puncture, min.* | |
| 0 | 3 (27) |
| 30 | 3 (27) |
| 60 | 3 (27) |
| 120 | 2 (18) |
| *Duration of bed rest after intrathecal cytotoxic drugs, min.* | |
| 30 | 2 (18) |
| 60 | 8 (73) |
| 120 | 1 (9) |
| **Estimations** | |
| *Lumbar punctures, n/yr* | |
| < 25 | 3 (27) |
| 25-75 | 5 (45) |
| > 75 | 3 (27) |
| *Blood patches, n/yr* | |
| 0 | 4 (36) |
| 1-2 | 6 (55) |
| < 5 | 1 (9) |
| 5-10 | 0 |
| > 10 | 0 |

a) Multiple selections allowed.
b) One department reported having the pathology department performing the flow cytometry in addition to the pathology examination.

FIGURE 3

Dural lesions produced by 25-gauge blunt (**A**) and cutting needle (**B**). Dural surface observed from the epidural space. Note the "flaps" of collagen fibres at the borders of the lesions in A (arrow). Scanning electron microscopy [12]. Reproduced with permission.




a BN is in line with international practice [1, 3, 10].

A survey in Denmark in disciplines outside of anaesthesia conducted in 1997 [14] showed that the use of BN was known by many departments. However, the response rate on this specific question was only 50%. Today, only a minority of Danish neurologists use a BN [9].

In a recent paper, the assertions that the BN is difficult to use and has a low flow rate were both rejected. A review including a meta-analysis of spinal anaesthesia actually showed greater operator difficulty with the CN [3], and a comparison of flow rate between these two needle types of *same* calibre revealed similar flow rates, if not greater rates when using the BN [3, 15].

A cost comparison analysis in a recently published paper indicates that the BN is associated with 26 USD cost savings per patient when both the cost of the procedure and the costs associated with the treatment of PDPH are considered [16].

Information on the applied needle tip was not precisely reported by all respondents (Figure 2). The current Danish Medical Society guideline on LP recommends choosing a needle calibre of approx. 0.5-0.9 mm (i.e. 25-20-G), but does not reflect on tip design as a means to reduce the risk of PDPH and thus needs to be updated [17]. An appropriate implementation of the routine use of BN would require supervision by skilled colleagues, most likely anaesthesiologists. Moreover, it should be integrated as part of medical training. Both training and maintenance of skills in LP are necessary to be able to perform this procedure correctly, as is the case for any invasive procedure.

Needle diameter is a separate risk factor for developing PDPH, and a decreasing incidence of PDPH is associated with a smaller CN calibre, e.g. a 20-40% decrease is achieved by using a 20-G to 22-G needle [5]. Despite this apparent advantage, concerns have been raised against the use of a needle diameter smaller than 22-G due to possible prolongation of the CSF tap-time, and some may argue these needles are less rigid and thus harder to use [1, 15]. However, we found a median flow of 30 ml/h with the blunt 27-G Pencan needle. If this flow rate were to be applied to the routine number of collected test tubes, (Table 1), the mean sampling duration would be 2-10 min., given that each tube is filled with 1 ml of CSF. This indicates that a more restricted or individual use of specific tests may speed up sampling time. Implementation of small-calibre BN may reduce the risk of PDPH and still be efficient for clinical purposes (Figure 1).

Figure 1 showed four measurements lasting 20-30 min., which thus eliminated the Gaussian distribution. These four outliers might have been due to displacement of the needle during the procedure; obstruction of the needle opening by a nerve root [18] or unintentional timing of an LP performed in the lateral recumbent position. The latter hypothesis is supported by a sensitivity analysis which excluded four patients from the overall analyses. This median flow rate would be markedly slower than that of a 20-G needle [15]. In patients who are in the lateral recumbent position, the correspondingly lower hydrostatic pressure may protract the sampling time. In such circumstance, or when large amounts of CSF is needed, the use of a 20-22-G BN is justified to speed up the tap-time [19].

Meanwhile, two studies [8, 19] have suggested an apparently safe procedure to speed up the collection of CSF; i.e. applying a negative pressure with a syringe during LP.

This has been discouraged by some [18], since it theoretically may precipitate haemorrhage, though no evidence for the latter has been provided. This technique involves a risk of displacement of the needle causing a subsequent flow loss. However, this risk is already imminent for the haematology patient receiving intrathecal cytostatics where manipulation with the needle hub is required anyway. Prior to injecting the cytostatics, the clinician may check the position of the needle by aspirating CSF into the syringe with cytostatics. Only two departments (18%) occasionally used aspiration (Table 1) during LP. More studies are needed to ascertain whether this is a safe procedure.

Treatment options of PDPH remain sparse. Eight (73%) respondents of this survey had routine bed rest after LP, even though there is no evidence to support that bed rest following an LP reduces the occurrence of PDPH [5, 20]. The same redundant practice of bed rest was described in the Danish survey conducted in 1997 [14].

Whether patient position plays a role in the circulation of intrathecal medications in the CSF needs to be explored [20].

Beyond the issues of cost and patient inconvenience, termination of PDPH by blood patch may not always be a safe procedure for the severely immunocompromised haematology patient due to the potential risk of epidural abscess [2] or of introducing blast cells into the CNS and thereby spread the disease. However, the risk of dissemination remains unknown [21].

There are limitations to this study. Firstly, due to strong evidence against cutting and large-bore needles, we did not perform similar flow studies with other needle types. Secondly, as acknowledged, the majority of the respondents were senior staff members. This may imply selection bias.

In conclusion, the majority of departments reported using a CN despite the apparent evidence favouring BN and clear indication of a reduced risk of PDHP. A further reduction can be achieved by using a thinner needle, even if this increases sampling time. We measured a flow-rate of 30 ml/h with the blunt 27-G needle. The LP practice clearly varies between Danish haematology departments Our study indicates that shared inter-speciality guidelines could be developed in order to unify and optimize LP as a safe and efficient procedure.

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