

Evidence-Based Practice Recommendations to Prevent/Manage Post-Lumbar Puncture Headaches in Pediatric Patients Receiving Intrathecal Chemotherapy

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Abstract

Post-lumbar puncture headaches (PLPHs) are a known complication of lumbar puncture procedures. Children undergoing treatment for cancer often undergo multiple lumbar punctures, placing them at increased risk for PLPHs. There are currently no guidelines for the prevention or management of PLPHs in children. A team was therefore assembled to conduct a systematic review of the evidence in relationship to PLPHs in the pediatric population. Clinical questions were developed and used to guide the literature review. Twenty-four articles were deemed appropriate for use and were evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) criteria. Based on the review of evidence, strong recommendations are made for the use of smaller needle sizes and for the use of pencil point needles during lumbar puncture procedures. Weak recommendations are made for needle orientation and positioning following the procedure as well as for interventions used to treat PLPHs once they occur. There is a need for additional, pediatric-specific studies to further examine the issue of PLPH prevention and treatment.

Keywords

pediatric, lumbar puncture, headache, treatment, prevention

Introduction

Scientific advancements in the field of pediatric oncology have led to a dramatic rise in the number of childhood cancer survivors in the United States over the past 50 years (O'Leary, Krailo, Anderson, & Reaman, 2008). This improved survival rate, due in part to studies completed during the 1970s, proved that central nervous system (CNS) disease could be controlled through the administration of intrathecal chemotherapy to patients with acute lymphoblastic leukemia (ALL) (Nesbit et al., 1982). Today, CNS therapy continues to be an important component of treatment for children and adolescents diagnosed with acute lymphoblastic leukemia, acute myeloid leukemia (AML), and non-Hodgkin lymphoma (NHL).

Recent Children's Oncology Group (COG) high-risk, acute lymphoblastic leukemia protocols include as many as 27 lumbar punctures with intrathecal chemotherapy administration throughout treatment. This CNS-directed therapy is not without risk. Post-lumbar puncture headaches (PLPHs) are a debilitating side effect and one of

the most commonly reported procedural complications (Chi-Yan Lee, Sennett, & Erickson, 2007; Sudlow & Warlow, 2006; Turnbull & Shepherd, 2003). Post-lumbar puncture headaches, also referred to as postdural puncture headaches, were first described in 1898 by Dr August Bier (Chi-Yan Lee et al., 2007; Turnbull & Shepherd, 2003). By definition, a PLPH is a headache that develops within 5 days of a lumbar puncture, worsens within 15 minutes of assuming an upright position, and improves within 15 minutes of resuming a recumbent position (Olsen et al., 2004). Other identifiable characteristics of PLPHs include the following: nausea, vomiting, ache or stiffness of the neck, photophobia,

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diplopia, blurred vision, tinnitus, vertigo, ataxia, hearing loss, and hyperacusis (sensitivity to certain sounds) (Ahmed, Jayawarna, & Jude, 2006; Bezov, Lipton, & Ashina, 2010; Olsen et al., 2004). To date, the underlying pathophysiology of PLPHs remains relatively unclear. General consensus is that a hole created in the dura by the introduction of a needle leads to persistent leakage of cerebral spinal fluid (CSF), which results in decreased intracranial pressure and subsequent pain when patients are in the upright position (Ahmed et al., 2006; Chi-Yan Lee et al., 2007; Lavi et al., 2010).

The incidence of PLPHs in adults has been reported as high as 36% following diagnostic and therapeutic lumbar punctures (Lavi et al., 2006). Studies in the pediatric oncology population report an 8% to 14% incidence in PLPHs following diagnostic or therapeutic lumbar punctures (Keidan et al., 2005; Ramamoorthy, Geiduschek, Bratton, Miser, & Miser, 1998). Despite these incidence rates, there is a lack of evidence-based guidelines for prevention and management of PLPHs in pediatrics. The scope and purpose of this project was to perform a systematic review of all existing evidence related to the prevention and management of PLPHs in children and young adults and to develop practice recommendations for the prevention and management of PLPHs in pediatric oncology patients.

Evidence-Based Development Methods

Evidence-Based Project Review Team

This evidence-based practice project was submitted to the COG Nursing Discipline in response to a call for proposals under the COG Nursing Evidence-Based Practice Initiative, which was guided by the Nursing Discipline's blueprint (Landier, Leonard, & Ruccione, 2013). The goal of this initiative was to develop evidence-based tools to guide clinicians in aspects of care not typically broached in COG protocols but that are pertinent to the delivery of quality care. After a competitive review process, the PLPH proposal was selected for development. The evidence-based review team consisted of 3 nurses from the Children's Hospital of Wisconsin (2 outpatient oncology nurse practitioners and an outpatient oncology registered nurse) along with a PhD prepared nurse researcher who served as the project mentor. All team members received training on the evidence-based review process through webcasts and other written material. A more detailed description of the rigorous evidence-based process conducted for this study can be found within the introductory article of this journal. With regard to stakeholder involvement, the initial concept and the final manuscript were reviewed by COG leadership and the COG Committee Chairs with oversight related to the topic area.

Question Development

Prior to beginning the evidence-based review, clinical questions were developed per the method outlined by Fineout-Overholt and Johnston (2005) using the PICOT (Population, Intervention, Comparison, Outcome, Time) format. The following PICOT questions were used to guide the literature search for this project:

Prevention:

1. In pediatric oncology patients receiving intrathecal chemotherapy (P), how does hydration, needle type (design and size), and position of the patient during and after the procedure (I) affect the development of post-lumbar puncture headache (O) within 1 week of the procedure?

Treatment:

1. In pediatric oncology patients with post-lumbar puncture headaches (P), how do pharmacologic interventions (narcotics, non-narcotic medications, caffeine) (I) affect the duration and severity of post-lumbar puncture headaches (O)?
2. In pediatric oncology patients with post-lumbar puncture headaches (P), how do nonpharmacologic interventions (bed rest, positioning, fluids, blood patch) (I) affect the duration and severity of post-lumbar puncture headaches (O)?

Literature Search Strategy

For this evidence-based project, a professional medical librarian assisted in searching the electronic databases of Scopus, CINAHL, Ovid Medline, and Cochrane for literature published between 1993 and 2013. Additional databases included The National Guideline Clearing House, American Academy of Neurology, and Google Scholar. Key search terms included spinal injection, spinal puncture, epidural anesthesia, caudal anesthesia, spinal anesthesia, intrathecal chemotherapy, lumbar puncture, headache, postdural puncture headache, post-lumbar puncture headache, water, fluids, fluid therapy, hydration, patient positioning, positioning, needle, bed rest, blood patch, epidural blood patch, drug therapy, pharmacologic, narcotic, non-narcotic, analgesic, medication, and caffeine. Articles used in the review consisted of meta-analyses, systematic reviews, research studies, and case studies. Basic review articles were excluded. In addition, obstetric patients, non-human subject research, and non-English language publications were excluded.

Using these key search terms, 1488 articles were initially identified. The 3 team members at Children's Hospital of Wisconsin met to collectively review the articles and apply the inclusion/exclusion criteria (Figure 1).

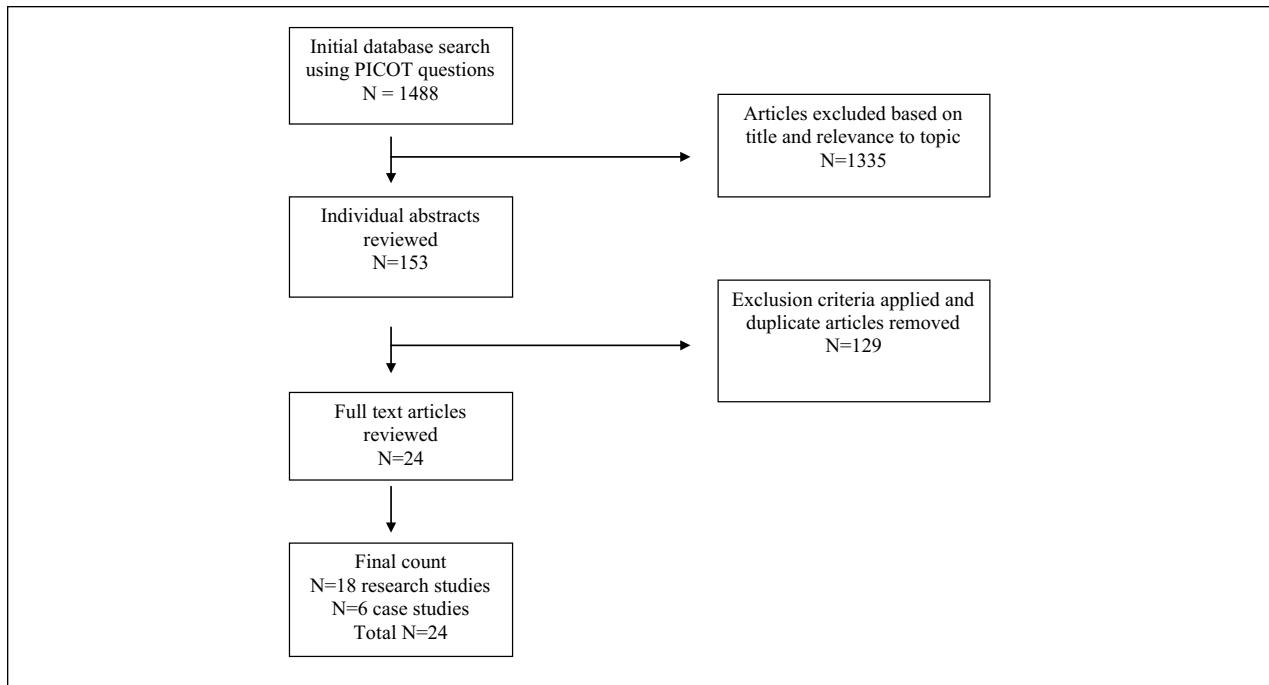


Figure 1. Evidence search strategy.

Titles were reviewed and included based on relevance to the topic, yielding a total of 153 articles. Due to a lack of literature specific to the pediatric oncology population, studies with any pediatric patients undergoing lumbar puncture were included, even if the median age was that of an adult. Articles containing only adult patients were excluded as recommendations for the management and prevention of PLPHs in adults already exist. The initial search was limited to articles published within the past 10 years, 2003 to 2013, but was expanded to include the past 20 years, 1993 to 2013, secondary to a low yield of initial articles. Duplicate articles were removed, leaving 24 articles for inclusion in this evidence-based guideline.

Review Approach

All authors independently reviewed each of the publications selected for inclusion. An appraisal of evidence was cumulated into a matrix table that included article title, authors, purpose, design and variables, subjects, measurements, and results. For each article, the matrix tables were compared and discussed and points of disagreement resolved, ending with a consensus regarding the level of evidence and strength of recommendation using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach (Guyatt et al., 2008). The GRADE criteria were selected for use as they provide a transparent method for scoring the quality of evidence and the strength of associated recommendations for patient management.

Evidence Review

The final 24 articles retained for this review consisted of 18 research studies and 6 case studies. Of the 18 research studies, only 11 were exclusively pediatric in nature and only 2 were specific to pediatric oncology. Despite the presence of guidelines for the prevention and management of PLPHs in adults, no clinical guidelines were found for PLPHs in pediatrics. The included articles for this review were grouped together based on the PICOT question that they addressed, as summarized below.

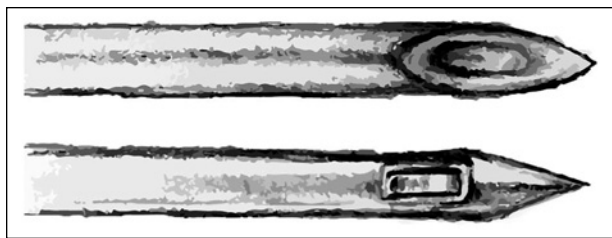
Needle Size

The size of the needle used to perform lumbar puncture may vary based on purpose for the procedure and provider preference. Needle size theoretically influences the risk of developing a PLPH due to the diameter of the needle and the resulting hole left in the dura. Table 1 displays the 5 studies that assessed the size (gauge) of the needle used during a lumbar puncture and the prevalence of PLPHs. Three studies supported the use of a smaller size needle (Hammond, Wang, Bhulani, McArthur, & Levy, 2011; Kokki, Turunen, Heikkinen, Reinikainen, & Laisalmi, 2005; Shah & Bhosale, 2010). One study demonstrated statistical significance in favor of using smaller size (higher gauge) needles (Shah & Bhosale, 2010). Two additional studies supported the use of smaller size needles but were not statistically significant (Hammond et al., 2011; Kokki et al., 2005). Only 1 study, conducted by

Table 1. Summary of Articles Examining Needle Size.

First Author, Year	Subjects; Design	Needle Size	Findings	Grade of Evidence
Ebinger, 2004a	N = 112, ages 2-16 years; prospective, observational study	19G, 20G, 22G	No significant difference in rate of headache in relationship to gauge. Not statistically significant.	Low
Kokki, 2005	N = 303, ages 9 months-17 years; randomized study	26G Atraucan, 27G Whitacre	Decreased incidence of PLPH with 27G (4%) vs 26G (5%). Not statistically significant.	High
Lowery, 2008	N = 99, ages 2-17 years; prospective, descriptive study	22G Quincke, 25G Pencan	No significant difference in incidence of PLPH between 22G and 25G ($P = .8$).	Low
Shah, 2010	N = 800, ages 16-40 years; randomized study	25G Quincke, 27G Quincke, 25G Whitacre, 27G Whitacre	The incidence of spinal headache was 14% (25G Quincke), 7% (27G Quincke), 1% (25G Whitacre), and 0.5% (27G Whitacre) ($P = .0001$).	High
Hammond, 2011	N = 187, ages 15-88 years; prospective study	20G Quincke, 22G Quincke, 22G Sprotte	Decreased PLPH with 22 Sprotte (19%) compared to the 20 Quincke (32%). No difference between 20 Quincke and 22 Quincke (both 32%). Not statistically significant.	Low

Abbreviation: PLPH, post-lumbar puncture headache.

**Figure 2.** Needle types.

Top = cutting point needle; bottom = pencil point needle. Illustrations by Aimee D. Ermel, Eugene and Ruth Roberts Academy Student, City of Hope.

Lowery and Oliver (2008), assessed 2 needle sizes specifically in pediatric oncology patients in relation to PLPHs, but no statistically significant difference was noted between the sizes.

Needle Design

Figure 2 displays the 2 most common types of spinal needles used to perform a lumbar puncture, which are cutting point and pencil point needles. Cutting point needles, such as Quincke and Atraucan, have an obliquely sliced tip that cuts through the dura. In contrast, pencil point needles, such as Whitacre and Sprotte, are thought to penetrate and then separate the dural fibers, resulting in a less traumatic hole.

Table 2 displays the 7 articles that examined the design of the needle used to perform the lumbar puncture and the prevalence of PLPH. Three articles showed statistical significance supporting the use of pencil point

needles to decrease the incidence of PLPH (Apiliogullari, Duman, Gok, & Akillioglu, 2010; Hammond et al., 2011; Shah & Bhosale, 2010). Three additional research articles supported the trend of decreased PLPH rates with the use of pencil point needles but were not statistically significant (Kokki, Heikkinen, Turunen, Vanamo, & Hendolin, 2000; Kokki, Hendolin, & Turunen, 1998; Kokki, Salonvaara, Herrgård, & Riikonen, 1999). Only 1 prospective study assessed needle design specifically in pediatric oncology patients receiving intrathecal chemotherapy, and this study found no statistical significance between needle types and incidence of PLPHs (Hashem, Heydarian, Gharavi, & Khoshnod, 2012).

Orientation of Needle Bevel

Direction of the bevel either parallel or perpendicular to the long access of the spinal column is thought to influence the risk of developing a PLPH. Anatomically, the dural fibers run in a longitudinal fashion. Inserting the bevel parallel with the dural fibers may decrease the incidence of PLPH due to fewer dural fibers being cut (Mihic, 1986). Three articles were found that assessed the orientation of the lumbar puncture needle to the long access of the spine and the prevalence of PLPHs (Amorim, Gomes De Barros, & Valença, 2012; Ebinger, Kosel, Pietz, & Rating, 2004a; Hashem et al., 2012). A cross-sectional study with 640 patients, 8 to 65 years of age, found that bevel orientation perpendicular to the long access of the spinal column was significantly associated with increased PLPHs ($P = .03$) (Amorim et al., 2012). Two additional studies examined this issue but found no significant

Table 2. Summary of Articles Examining Needle Design.

First Author, Year	Subjects; Design	Needle Design	Findings	Grade of Evidence
Kokki, 1998	N = 200, ages 2 -128 months; randomized study	25G Quincke (C), 26G Atraucan (C), 25G Whitacre (P), 24G Sprotte (P)	Overall, 10 patients developed PLPHs: 3 with pencil point needles and 7 with cutting needles. Not statistically significant.	Moderate
Kokki, 1999	N = 57, ages 8 months-15 years; randomized study	22G Quincke (C), 22G Whitacre (P)	11 patients (12%) developed PLPHs: 7 (15%) with cutting needles and 4 (9%) with pencil point needles ($P = .42$).	Low
Kokki, 2000	N = 215, ages 1-18 years; randomized study	25-27 gauge, pencil point or cutting point needles	8 patients (4%) developed PLPHs: 2 with pencil point needles and 6 with cutting point needles. No statistical significance.	Moderate
Apiliogullari, 2010	N = 414, ages 2-17 years; retrospective study	26G Atraucan (C), 27G Pencan (P)	Pencil point needles had fewer PLPHs (0.4%) than cutting point needles (4.5%) ($P = .005$).	Low
Shah, 2010	N = 800, ages 16-40 years; randomized study	25G Quincke (C), 27G Quincke (C), 25G Whitacre (P), 27G Whitacre (P)	Fewer PLPHs with pencil point needles. 14% (25G Quincke), 7% (27G Quincke), 1% (25G Whitacre), 0.5% (27G Whitacre) ($P = .0001$).	High
Hammond, 2011	N = 187, ages 15-88 years; prospective study	20G Quincke (C), 22G Quincke (C), 22G Sprotte (P)	Decreased risk of PLPH with 22G Sprotte (19%) vs 20G Quincke (32%). 4-fold increase in odds of PLPH with 22G Quincke vs 22G Sprotte ($P = .014$).	Low
Hashem, 2012	N = 280, younger than 15 years	Lumbar puncture needle vs syringe needle	No significance between needle types and incidences of PLPH ($P = .46$).	Low

Abbreviations: C, cutting point needle; P, pencil point needle; PLPH, post-lumbar puncture headache.

difference in the prevalence of PLPH in relation to the bevel orientation (Ebinger et al., 2004a; Hashem et al., 2012). The prospective, observational study by Ebinger et al. (2004a) included 112 subjects (ages 2-16 years) and reported no significant difference in the rate of headache in relationship to the orientation of the needle bevel ($P = .435$). Likewise, a prospective study by Hashem et al. (2012) found no difference in the rate of headache in relationship to bevel orientation ($P = .52$) in 280 subjects all younger than 15 years.

Position of Patient After Lumbar Puncture

Bed rest following lumbar puncture is a common practice at many facilities, either as the result of sedation for the procedure or secondary to provider preference. Two randomized, prospective studies were identified that assessed position of the patient following a lumbar puncture and the prevalence of PLPHs (Ebinger, Kosel, Pietz, & Rating, 2004b; Tejavaniya, Sithinamsuwan, Sithinamsuwan, Nidhinandana, & Suwantamee, 2006). Ebinger et al. (2004b) reported significantly more PLPHs in patients ages 2 to 17 years who were randomized to 24 hours of bed rest as compared to free mobility ($P = .018$). Another study conducted by Tejavaniya et al. (2006) found bed rest to be of no benefit in decreasing

the incidence of PLPHs between 2 groups of patients: those who remained recumbent for 6 hours versus those who ambulated within 1 hour of the lumbar puncture. Position of the patient during a lumbar puncture (sitting vs lateral decubitus) was included in the literature search, but no pediatric literature was found.

Interventions for PLPH

Four articles were found that contained information related to interventions for PLPH. One of these, a nonrandomized pilot study, found no statistical significance for the use of frovatriptan, an antimigraine medication, in reducing the duration of PLPHs (Bussone et al., 2007). Three case reports assessed other interventions including tramadol, oral and intravenous hydration, caffeine, ibuprofen, and acetaminophen (Liley, Manoharan, & Upadhyay, 2003; Raiger, Naithani, Gupta, & Pareek, 2012; Stephenson, Varness, Schroeder, & Ford, 2012). One case study found these interventions to be ineffective and the patient required an epidural blood patch to relieve the PLPH (Liley et al., 2003). There is no statistically significant evidence for use of these interventions in managing PLPHs in pediatric patients. Prophylactic hydration (preprocedure and postprocedure) was also included in the literature search, but no pediatric literature was found.

Table 3. Summary of Articles Examining Blood Patch.

First Author, Year	Subjects; Design	Intervention	Findings	Grade of Evidence
Roy, 1995	N = 1, age 7 years; case study	EBP	Resolved PLPH	Very low
Cassady, 2000	N = 1, age 11 years; case study	EBP	Resolved PLPH	Very low
Ylonen, 2002b	N = 42, ages 13-18 years; retrospective chart review	EBP	The first EBP successfully relieved headache in 37/40 patients (93%).	Very low
Ylonen, 2002a	N = 7, ages 6-12 years; retrospective chart review	EBP	EBP gave some relief of symptoms in every child.	Very low
Liley, 2003	N = 1, age 11 years; case study	Hydration, recumbent position, oral caffeine, EBP	Conservative therapy failed; EBP resolved PLPH.	Very low
Van Kooten, 2008	N = 42, mean age 36, all patients \geq 18 years; randomized study	EBP vs conservative treatment of 24 hr bed rest, fluid intake of 2 liters	Patients with PLPH randomization. 24 h after intervention, headache occurred in 58% of EBP and 90% of conservative treatment ($P = .03$).	Moderate
Kara, 2012	N = 1, age 10 years; case study	Bed rest, IVF, oral paracetamol, epidural saline patch	Epidural saline patch resolved PLPH	Very low
Kokki, 2012	N = 42, ages 3-18 years; retrospective chart review	EBP	90% of patients (37/41) had complete relief of symptoms.	Very low

Abbreviations: EBP, epidural blood patch; IVF, intravenous fluids; PLPH, post-lumbar puncture headache.

Epidural Blood Patch

An epidural blood patch is an injection of autologous blood into the epidural space at the same vertebral interspace as the suspected CSF leak. In this procedure, the injected blood will clot at the site of the leak and prevent further leakage (Sudlow & Warlow, 2006; Turnbull & Shepherd, 2003). Table 3 displays 8 articles that were identified on the use of epidural blood patches in treating PLPHs in pediatric patients. There were 4 research articles and 4 case studies. Only 1 research study, a randomized controlled trial, demonstrated statistical significance for the use of a blood patch to decreased duration of PLPHs (Van Kooten, Oedit, Bakker, & Dippel, 2008). In this study, patients presented with PLPHs and were randomized to an epidural blood patch or 24 hours of bed rest and adequate fluid intake. The percentage of patients with persistent headache after an epidural blood patch was decreased when compared to patients receiving conservative treatment ($P = .03$). An additional 3 retrospective chart review studies reported that the use of an epidural blood patch was effective in relieving PLPHs in a high percentage of patients (Kokki, Sjövall, & Kokki, 2012; Ylonen & Kokki, 2002a, 2002b). Four case studies also supported this trend (Cassady, Lederhaas, Turk, & Shanks, 2000; Kara et al., 2012; Liley et al., 2003; Roy, Vischoff, & Lavoie, 1995).

Overall Summary of Recommendations

As described in the introduction article of this journal issue, recommendation statements were developed from the synthesized evidence and labeled as strong or weak. The strength of each recommendation was determined by the desirable and undesirable effects of the evidence and made independently of the quality level of the evidence (Andrews et al., 2013). Based on the available evidence, the following recommendations are made for the prevention and treatment of PLPHs. Table 4 provides an overview of these recommendations.

Recommendation 1

There is a strong recommendation, based on an overall moderate quality of evidence, for the use of smaller size (higher gauge) spinal needles for performing lumbar punctures in pediatric patients to prevent PLPHs, when clinically applicable. Needle sizes ranged from 19 to 27 gauge in the articles reviewed, making it difficult to recommend a standard needle size. Patient weight and body characteristics, need for intrathecal chemotherapy, and experience of the provider performing the procedure need to be considered when choosing the appropriate needle size.

Table 4. Summary of Recommendations and Overall Quality of Evidence.

Recommendations to Prevent/Manage PLPHs	Grade of Recommendation	Overall Quality of Evidence
Needle size: smaller size (higher gauge)	Strong	Moderate
Needle design: pencil point	Strong	Moderate
Needle orientation: needle parallel to the long access	Weak	Low
Positioning: extended bed rest is of no benefit for preventing PLPHs	Weak	Low
Interventions: caffeine, hydration, frovatriptan, ibuprofen, and tramadol do not influence duration of PLPHs	Weak	Very low
Epidural blood patch is of benefit in managing PLPHs	Weak	Very low

Abbreviation: PLPH, post-lumbar puncture headache.

Recommendation 2

There is a strong recommendation, based on an overall moderate quality of evidence, for the use of pencil point needles in pediatric patients undergoing lumbar puncture to prevent PLPHs, when clinically applicable. Patients at risk for PLPHs, such as a prior history of PLPHs, should be considered for pencil point needle use with subsequent lumbar punctures.

Recommendation 3

There is a weak recommendation, based on an overall low quality of evidence, that bevel orientation of the lumbar puncture needle parallel to the long access should be used to decrease the incidence of PLPHs. In theory, placing the bevel of the spinal needle parallel to the long access of the spine causes less trauma to the dural fibers.

Recommendation 4

There is a weak recommendation, based on an overall low quality of evidence, against the use of extended bed rest following lumbar puncture to prevent PLPHs. The 2 studies that examined bed rest following the lumbar puncture used exceptionally long periods of bed rest (6-24 hours). No studies were identified that examined shorter periods of bed rest in pediatric patients, which may be more comparable to modern day practices. Therefore, there is insufficient evidence to make a recommendation regarding shorter periods of bed rest (60 minutes) immediately following a lumbar puncture.

Recommendation 5

There is a weak recommendation, based on an overall very low quality of evidence, against the use of caffeine, oral and intravenous hydration, frovatriptan, ibuprofen, and tramadol to reduce the duration of PLPHs. Limited studies are present in the pediatric population; of those reviewed, there was no evidence to support the

effectiveness of these agents in decreasing the duration of PLPHs.

Recommendation 6

There is a weak recommendation, based on an overall very low quality of evidence, for the use of epidural blood patch in managing PLPHs in pediatric patients. Of the articles reviewed, no adverse events were reported in association with the epidural blood patch.

Conclusion

These recommendations are based on evidence primarily from the general pediatric population. Careful consideration is needed when applying the recommendations specifically to pediatric oncology. For example, bed rest following the instillation of intrathecal chemotherapy may be indicated for reasons other than the prevention of PLPHs. It is the practice at some institutions for patients to lie flat or in Trendelenburg position for a defined period of time to theoretically facilitate the distribution of intrathecal chemotherapy throughout the CNS. It was not within the scope of this current project to evaluate the evidence related to patient positioning for intrathecal chemotherapy distribution; only the evidence related to patient positioning and PLPHs was reviewed to answer the PICOT question.

Careful consideration must also be applied prior to the use of epidural blood patches to manage PLPHs in pediatric oncology patients. Remission status should be evaluated and factored into the decision of using an epidural blood patch. In theory, using epidural blood patches in patients with leukemia could cause neoplastic seeding into the CNS (Bucklin, Tinker, & Smith, 1999). In addition, epidural blood patches are usually not considered for patients with suspected infection or those with bleeding risks.

Limited evidence was found that specifically related to the pediatric population with regard to PLPHs. To address this important clinical issue, further research is recommended on PLPHs in pediatrics and specifically in pediatric oncology patients. Within this review, only 2

articles were specific to pediatric oncology (Hashem et al., 2012; Lowery & Oliver, 2008). Future studies should include well-designed clinical trials assessing needle size and design specific to pediatric patients receiving intrathecal chemotherapy. In addition, multi-institutional, randomized, controlled trials designed to evaluate treatment strategies or interventions to reduce the duration of PLPHs in pediatric patients with cancer would be beneficial in affecting practice by reducing pain and enhancing quality of life in patients with PLPHs.

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