Cost comparison between the atraumatic and cutting lumbar puncture needles

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ABSTRACT

Objective: The aim of this study was to determine which type of spinal needle is preferred from a cost perspective, taking into account costs of the spinal needle and treatment of postlumbar puncture headache.

Methods: A decision-analytic model was created to determine the cost of diagnostic lumbar punctures using atraumatic and cutting needles. We assumed a health care system perspective and based the analysis on the treatment of a patient facing event probabilities derived from prior studies. The economic outcome measure was the difference in estimated costs between the 2 needles. One-way and probabilistic sensitivity analyses tested the robustness of the model.

Results: Lumbar puncture performed with the atraumatic needle is associated with an average cost savings of \$26.07 per patient. Average total health care costs are \$166.08 with the atraumatic needle, compared to \$192.15 with the cutting needle. There is 94% certainty that the atraumatic needle is cost-saving compared to the cutting needle based on probabilistic sensitivity analysis. Use of the atraumatic needle over the cutting needle by neurologists alone may result in \$10.4 million in cost savings to the US health care system per year.

Conclusion: The atraumatic spinal needle is associated with an overall cost savings to the US health care system. The balance of costs and benefits favors the use of the atraumatic needle over the cutting needle for diagnostic lumbar puncture. *Neurology*® 2012;78:109-113

Every year approximately 400,000 diagnostic lumbar punctures are performed by neurologists in the United States.¹ Recent studies have shown that the “atraumatic,” pencil-point Sprotte spinal needle is associated with a lower incidence of postlumbar puncture headache compared to the conventional “cutting” Quincke needle.^{2,3} Although the use of the atraumatic needle is standard practice among anesthesiologists for spinal anesthesia, only 2% of neurologists routinely use atraumatic needles. The most common reasons given by neurologists for not using the atraumatic needle are nonavailability and expense.⁴ There have been no formal decision-analytic studies evaluating the costs associated with the use of each of these spinal needles.⁵ The goal of this study was to determine whether the atraumatic or the cutting spinal needle is preferred from a cost perspective, taking into account the initial procedural costs and the costs associated with treatment of postlumbar puncture headache.

METHODS Model overview. A decision-analytic model was created (TreeAge Software, Inc.) to determine the costs of diagnostic lumbar punctures with the atraumatic and cutting spinal needles (figure 1). In the analysis, we estimated average health care costs of each alternative from the time of the lumbar puncture to the resolution of postlumbar puncture headache. Not experiencing a postlumbar puncture headache and resolution of postlumbar puncture headache are the absorbing states after which the patient is excluded from the model. No further costs incurred by the absorbing states are included in the analysis.

Input parameters. Model input parameters were drawn from published literature (table). The base case is a patient who is 40 years old with a neurologic indication for a diagnostic lumbar puncture. This is the mean age of the patients who were enrolled in a randomized, double-blind study comparing the atraumatic needle (22-gauge Sprotte) to the cutting spinal needle (22-gauge Quincke).² The probability of postlumbar puncture headache associated with the cutting needle was obtained from this study. The probability of postlumbar puncture headache associated with the atraumatic needle was obtained using the odds ratio and confidence

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Study funding: Supported by the NIH (NINDS, K23 NS051372).

Disclosure: Author disclosures are provided at the end of the article.

Figure 1 Decision-analytic tree

A patient enters the model when undergoing an outpatient diagnostic lumbar puncture (LP). If successful insertion is not obtained using the atraumatic needle, the cutting needle is then used. If successful insertion is not obtained using the cutting needle, the patient undergoes a lumbar puncture under fluoroscopy using the cutting needle. If there is a postlumbar puncture headache (PLPHA), the patient is treated with conservative medical management (bed rest, hydration, over-the-counter medication), aggressive medical management (emergency department visit, IV fluids), aggressive invasive treatment (epidural blood patch [EBP]), or surgery to repair the dural leak, until the PLPHA resolves. Square nodes represent decision nodes. Circle nodes represent chance nodes. Triangular nodes represent terminal absorbing states in the model.

interval from a meta-analysis of randomized controlled trials.⁶ Probabilities of successful needle insertion were based on published values.⁷ The probabilities associated with recovery from postlumbar puncture headache after conservative medical management (bed rest, hydration, and over-the-counter medications), aggressive medical management (emergency department visit, IV medications), conventional invasive treatment (epidural blood patch), and aggressive invasive treatment (surgical repair of spinal dural leak) were obtained from published literature.⁸⁻¹⁰

All costs reflect published estimates inflated to 2011 dollars using the medical care component of the Consumer Price Index. The cost of diagnostic lumbar puncture was based on a nationwide US estimate of Medicare cost (current procedural terminology or CPT code 62270). Reports from neurologists who use the atraumatic needle indicate that they typically obtain a lumbar puncture tray containing the cutting needle and add to it a single atraumatic needle. This is partially due to lack of availability of diagnostic lumbar puncture kits that contain the atraumatic needle, but also provides a backup cutting needle in case of insertion failure with the atraumatic needle.⁴ Published literature provided the cost of the atraumatic spinal needle, including the introducer that accompanies the needle.¹¹ Lumbar puncture under fluoroscopy and epidural blood patch costs were determined from Medicare reimbursement rates (CPT codes 62270, 76005,

62273). The costs incurred by the health care system for patients with postlumbar puncture headache were estimated as follows. The cost of conservative medical management (bed rest, hydration, over-the-counter medication) was assumed to be zero. The cost of aggressive medical management (emergency department visit, IV medication) was estimated based on published literature examining the direct medical costs of migraines.¹² The cost of surgery to repair a spinal dural leak was estimated based on published literature examining inpatient care costs of migraines and Medicare reimbursement rates for imaging to identify the location of the leak (CT myelography) and surgical repair of the leak (CPT codes 62284, 72265, 72132, 63707, 63709).¹² The analysis was conducted from the health care perspective; thus indirect and societal economic costs such as loss of work productivity were not included.

Outcome assessment. The economic outcome measure of the model was the difference in estimated health care costs between the 2 procedure alternatives. Annual cost savings to the health care system was determined based on estimates of the number of lumbar punctures performed by neurologists yearly.

Sensitivity analysis. Deterministic one-way sensitivity analyses were performed to test the robustness of the model. Parametric

Table Probabilities and costs used in the decision-analytic model

Model input	Cutting needle	Atraumatic needle	Reference
Probability of			
Insertion success	0.979	0.837	7
PLPHA	0.244	0.085	2, 6
Recovery from PLPHA with conservative therapy in 4 d	0.53		8
Recovery from PLPHA with aggressive medical therapy in 4 d	0.19		8
Recovery from PLPHA with epidural blood patch	0.84		9
Recovery from PLPHA with surgical repair of CSF leak	1.0		10
Cost (2011 USD)^a			
Atraumatic needle	15.49		11
LP under fluoroscopy	153.70		CPT 62270, 76005
Diagnostic LP in the outpatient or ambulatory setting, hospital or private practice	116.38		CPT code 62270
Conservative management of PLPHA (bed rest, hydration, over-the-counter medication)	0		—
Aggressive medical management of PLPHA (ED visit, IV medication)	293.16		12
Epidural blood patch	137.59		CPT code 62273
Aggressive invasive treatment (inpatient admission, imaging, surgical repair of spinal dural leak)	11,159.12		12, CPT codes 62284, 72265, 72132, 63707, 63709

Abbreviations: CPT = current procedural terminology; ED = emergency department; LP = lumbar puncture; PLPHA = postlumbar puncture headache.

^a All costs were converted to 2011 dollars using the medical care component of the Consumer Price Index.

ters varied and analyzed included all probabilities and costs listed in the table. Plausible ranges were obtained from the literature or by varying estimates up to 20% in each direction.

Since parameters are unlikely to change in isolation, all parameters were also varied simultaneously in a probabilistic sensitivity analysis (Monte Carlo simulation). Costs were varied assuming a normal distribution. Probabilities were varied assuming a β distribution. The analysis was run 1,000 times to capture stability in the results.

RESULTS Base case analysis. For the base case scenario, lumbar puncture performed with the standard cutting needle cost \$192.15. Use of the atraumatic needle is associated with a cost of \$166.08. The atraumatic needle is thus associated with \$26.07 in cost savings per procedure, which translates into an estimated \$10.4 million in savings to the health care system per year.

Sensitivity analysis. One-way sensitivity analyses indicate that the study results are robust. All model parameters were varied and those with the highest relative effect on the cost difference between the 2 needle types are illustrated in the tornado diagram in figure 2. The difference in cost is most sensitive to the probability of success of epidural blood patch for the treatment of postlumbar puncture headache. At the upper bound of the range of probabilities of epidural blood patch success, the cost difference between the 2 needles was minimal. The difference in

cost was relatively insensitive to varying other model parameters. The cost associated with the atraumatic needle was never greater than the cost associated with the cutting needle.

Results of the probabilistic sensitivity analysis showed that in 94% of simulation runs, the atraumatic needle was less costly than the cutting needle and is therefore the preferred strategy. The cutting needle was the cost-saving option in only 6% of stimulation runs.

DISCUSSION Our results indicate that use of the atraumatic spinal needle for diagnostic lumbar puncture is cost-saving compared to the standard cutting needle when both the cost of the procedure and the costs associated with treatment of postlumbar puncture headache are considered.

Even though lumbar puncture is a routine procedure for neurologists, the overwhelming majority of literature on the subject of spinal needle types is found in the anesthesia literature. Only 2% of neurologists use the atraumatic spinal needle and half of neurologists are unaware of the existence of this type of needle. Among neurologists who are aware of atraumatic needles, expense was often given as the reason for not using them.⁴ Neurologists may have greatly overestimated the costs associated with using the atraumatic needle. Although use of the atrau-

Figure 2 One-way sensitivity analyses: effect of parameter variation on the cost difference between the atraumatic and cutting needles

All model parameters were varied and those with the highest relative effect on the cost difference between the 2 needle types are displayed. Dark-shaded bars represent the lower bound of variable range. Light-shaded bars represent the upper bound. The first number listed after the variable name is the base case value. Numbers listed in parentheses indicate the range over which the value was varied in the sensitivity analysis. The base case cost difference is \$26.07. PLPHA = postlumbal puncture headache.

matic needle adds approximately \$15 to the price of a standard lumbar puncture tray, our study demonstrates that when considering their efficacy in preventing postlumbar puncture headache, the atraumatic needle is associated with \$26.07 cost savings per patient.

The estimated cost savings on a per-patient basis may seem small and therefore inconsequential. Nevertheless, wider adoption of the atraumatic needle should be advocated for several reasons. First, since lumbar puncture is a common procedure, the small cost savings per procedure translates into significant annual savings to the overall US health care system. When only lumbar punctures performed by neurologists are considered, use of the atraumatic needle may result in \$10.4 million in cost savings to the US health care system per year. The cost savings would be higher if lumbar punctures performed by other specialists, such as emergency department physicians, general medicine physicians, pediatricians, and radiologists, were also considered. Second, use of the atraumatic needle not only reduces morbidity from postlumbar puncture headaches, but may also reduce the incidence of subdural hematomas, subdural fluid collections, and seizures, at times resulting in death, which have been described as a result of CSF leakage following lumbar puncture.³ If these conditions were also taken into account, the cost savings associated with the atraumatic needle would have been even

greater. Third, our estimate that the atraumatic needle is more expensive than the cutting needle is based on the assumption that the atraumatic needle cannot be purchased as part of a prepackaged lumbar puncture tray. We therefore assumed that, in order to perform a lumbar puncture with an atraumatic needle, a separately sold single atraumatic needle would be used in addition to a prepackaged lumbar puncture tray with a cutting needle. When competitively priced lumbar puncture trays containing the atraumatic needle become available, the cost savings associated with the use of the atraumatic needle will increase. Assuming no price difference between the atraumatic and cutting needle, the health care cost savings with the use of the atraumatic needle increases from \$26.07 to \$41.87 per procedure. Finally, we conducted this study from the health care system perspective as opposed to a societal perspective. Thus, our model does not account for the costs associated with lost work productivity when patients are disabled from postlumbar puncture headache. If a societal perspective had been chosen and costs of lost work productivity associated with postlumbar puncture headache had been included, the cost savings associated with the use of the atraumatic needle would have been greater.

As is typical for most economic analyses, we used best estimates from previously published data for our input parameters. By using high-quality cost data

from the literature and inflating the costs to 2011 dollars, we have attempted to closely approximate current actual costs. We used current procedural terminology codes to obtain Medicare reimbursement rates for procedures and imaging. It is possible that these best estimates overestimate or underestimate the true value of any of the model parameters. Studies that reassess current actual costs of lumbar puncture, fluoroscopy, epidural blood patch, surgery, clinic visits, emergency department visits, and hospitalization would provide valuable data for future cost studies of lumbar puncture needle alternatives. It is, however, unlikely that the conclusions of our study would change based on data derived from such studies. The robustness of our results is supported by the probabilistic sensitivity analysis which demonstrates that the atraumatic needle is the cost-saving strategy with 94% probability.

Robustness of the study results is also demonstrated by the one-way sensitivity analyses. Lumbar puncture performed with the atraumatic needle remained the least expensive option even at the extremes of the sensitivity analyses for each of the model parameters. For example, while the atraumatic needle is associated with a higher rate of insertion failure, it is unlikely that the rate of insertion failure would be high enough to offset the cost savings. Although there are no studies examining the rate of successful insertion of the atraumatic needle in the hands of experienced neurologists, inexperienced house staff trained to perform lumbar punctures using the atraumatic needle obtained a successful insertion 84% of the time.⁷ Our sensitivity analysis shows that even at a probability of successful insertion of 67%, the atraumatic needle remains the cost-saving alternative. Similarly, sensitivity analysis shows that over the entire range of postlumbar puncture headache probabilities (0.19–0.29), the atraumatic needle is cost-saving from a health care system perspective. Only patients at very low risk (<15%) of postlumbar puncture headache have no economic benefit from the atraumatic needle. Such low probabilities may be seen in very young and elderly patients. However, in this setting the atraumatic needle remains preferred as the benefits in terms of reduced morbidity would likely outweigh the marginally higher cost.

The atraumatic spinal needle is associated with lower incidence of postlumbar puncture headache and an overall cost savings to the US health care system. The balance of costs and benefits clearly favors

the use of the atraumatic needle over the cutting needle for diagnostic lumbar puncture.

AUTHOR CONTRIBUTIONS

Dr. Tung participated in the design and conceptualization of the study, analysis and interpretation of the data, and drafting and revising the manuscript. Dr. So participated in revising the manuscript. Dr. Lansberg participated in the design and conceptualization of the study, analysis and interpretation of the data, and drafting and revising the manuscript.

DISCLOSURE

Dr. Tung reports no disclosures. Dr. So performs neurodiagnostic tests (10% effort) and lumbar punctures (<5% effort) in his clinical practice; is co-founder of and holds stock in Satoris, Inc.; receives publishing royalties for *Occupational & Environmental Medicine* (Appleton & Lange, 2007) and from UpToDate, Inc.; receives research support from the NIH/NIEHS; and serves as consultant in medical-legal cases, with none to date involving lumbar puncture. Dr. Lansberg receives research support from the NIH/NINDS and has served as a medical-legal consultant.

Received May 23, 2011. Accepted in final form August 31, 2011.

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