Published April 15, 2009 as 10.3174/ajnr.A1594

ORIGINAL RESEARCH

Are C1–2 Punctures for Routine Cervical Myelography below the Standard of Care?

D.M. Yousem
S.K. Gujar

BACKGROUND AND PURPOSE: Recently, the performance of C1–2 punctures for cervical myelography was challenged in a medicolegal proceeding as being below the standard of care. We sought to examine current neuroradiologic practices and opinions on the technique.

MATERIALS AND METHODS: An 11-question survey was sent to 120 program directors of neuroradiology via e-mail links regarding cervical myelography using a C1–2 puncture. Reminders were sent during a 2-month period before data were finalized.

RESULTS: Eighty-five of 120 (71%) surveys were returned. In the previous year, 14.3% (12/85) of institutions had not performed a C1–2 puncture. Thirty-eight percent (32/85) had performed ≥6 in the same period. Seventy-nine percent (54/68 responding) favored a lumbar approach to cervical myelography, with 6% (4/68) having a predilection for a C1–2 puncture. Ninety-five percent (76/80 responding) thought that performing a C1–2 puncture for cervical myelography reflected the standard of care. Every institution except 1 had staff with expertise to perform C1–2 punctures, and 73% of the institutions teach their fellows the procedure. Ninety-three percent (78/84) of programs would perform a C1–2 puncture for thoracolumbar pathology if MR imaging was contraindicated and there was a contraindication such as a local wound infection precluding a lumbar puncture. Indications for a C1-2 approach included severe lumbar spinal stenosis, infection in the lumbar region, upper limit of the block to be delineated, technical issues preventing lumbar puncture, and the best assessment of the cervical region for myelographic films.

CONCLUSIONS: C1–2 puncture for cervical myelography, though currently not the most frequently performed method at most institutions, continues to be practiced and is considered within the standard of care by most neuroradiology programs across the country.

With the advent of MR imaging, the frequency of the performance of myelography for the evaluation of degenerative spine disease has decreased. The initial evaluation of patients with back pain, if imaging is pursued, may be plain films and/or MR imaging of the spine. Myelography, being an invasive procedure with associated well-defined risks, is generally reserved for patients who have contraindications to MR imaging, equivocal findings on MR imaging studies, or failed MR imaging because of metallic hardware in the spinal column, which renders MR imaging suboptimal. Nonetheless, before intervention, some surgeons prefer CT myelography studies of the cervical spine because of the exaggeration of foraminal stenosis that may plague gradient-echo axial MR imaging scans obtained through the cervical region.

Cervical myelography with postmyelography CT has the advantage of high resolution, excellent depiction of bony stenosis, and outstanding visualization of the cervical spinal nerve roots. Two techniques are commonly used for performing cervical myelography: 1) lumbar puncture and iodinated contrast injection with manipulation of the contrast column superiorly to the cervical region, or 2) lateral C1–2 puncture with injection of contrast. The advantages of the local C1–2 instillation of contrast material include absence of dilution of contrast leading potentially to better quality myelographic images of the cervical spine, easier manipulation of the contrast to avoid intracranial spillage, optional use of the supine or prone position for patient comfort, and a potential reduction in the concentration and volume of contrast material needed for good-quality imaging.[1-5] The disadvantages of the direct C1–2 cervical puncture technique include the potential for spinal cord puncture and/or injection and injury to the local nerves and arteries, factors that are much less likely when performing a lumbar puncture.[6-10]

As part of a recent settlement negotiation of a medicolegal case, the plaintiff's attorneys argued that performance of a C1–2 puncture for cervical myelography was below the level of the standard of care. In medicolegal terms, "standard of care" is defined as what a reasonable and prudent practitioner in a given community would do in a similar circumstance. In assessing standard of care, consideration is given to both the local practice within a community and the national medical standard. In some instances, the training of the physician is considered in the assessments of standard of care (eg, a subspecialty certified neuroradiologist may be held to a different standard than a general radiologist or a neurologist looking at an MR imaging study of the brain).

To assess current practices with regard to the performance of cervical myelography, a survey of neuroradiology fellowship programs and the executive committee of the American Society of Neuroradiology was performed. We hypothesized that cervical (C1–2) puncture for cervical myelography was still considered a reasonable practice that radiologists could perform for routine myelographic CT assessment of the cervical spine.

Materials and Methods

For 2 months, an 11-question survey was sent to 120 neuroradiologists on the e-mail list of program directors and executive committee members of the American Society of Neuroradiology. The call for

Received January 23, 2009; accepted after revision February 19.

From the Johns Hopkins Medical Institutions, Baltimore, Md.

Please address correspondence to David M. Yousem, MD, MBA, Director of Neuroradiology, Johns Hopkins Medical Institutions, 600 N Wolfe St, Phipps B-112, Baltimore, MD 21287; e-mail: dyousem1@jhu.edu

Indicates article with supplemental on-line table.

DOI 10.3174/ajnr.A1594

SPINE

ORIGINAL RESEARCH

survey completion was sent 6 times during the 2-month period, restricting the reminders to those individuals who had not completed the survey. Because the survey was based on individuals' e-mail addresses, each individual could complete the survey only 1 time.

Because the study was considered a quality-assurance module and was limited to a Web survey, an institutional review board waiver for the study and for informed consent was obtained.

The results of the survey were collated from the SurveyMonkey Website (*www.surveymonkey.com*), and the comments were reviewed for each question.

The questions asked in the survey are listed in the on-line Appendix. Comments from the final open-ended question and all results may be retrieved from tinyurl.com/6zurts.

Results

Eighty-five individuals responded to the survey, representing a response rate of 70.8% (85/120). Because of the nature of questions being asked, some questions were skipped by respondents, such that the maximum number of individuals responding to any question was 84, with the minimum number of respondents being 59 for the final question, which was open-ended (on-line Appendix).

Twelve of the 85 (14.1%) individuals responding reported that their programs perform <1 C1–2 puncture approach to cervical myelography on average per year. Most programs, 66 of 84 (78.6%) responding, averaged between 1 and 25 C1–2 punctures per year, with the most common response, by 40 (47.6%) individuals, being an average between 1 and 5. Six individuals responded that their programs performed >25 C1–2 punctures per year.

Fifty-four of 68 (79.4%) individuals responding said that their practice was to favor a lumbar puncture for the intrathecal instillation of contrast for cervical myelography. Only 1 respondent stated that C1–2 punctures are almost always performed for cervical myelography, and 13 (19.1%) programs split between the faculty favoring a cervical approach ($n = 3$) or making a best judgment between a lumbar and cervical puncture after assessing the patient ($n = 10$).

Fifty-four of 62 (87.1%) individuals responding said that <10% of their cervical myelograms were performed via a lateral C1–2 puncture. The percentages indicated for the remaining 8 programs responding were split between 11% and 25% ($n = 3$), 26% and 50% ($n = 2$), 51%–75% ($n = 2$), and >75% ($n = 1$).

C1–2 punctures to obtain CSF (ie, not for myelography) were performed in the past year by 52 of 83 (62.7%) programs responding.

In patients with contraindications to MR imaging, C1–2 punctures were reported as being performed in 51 of 84 (60.7%) programs surveyed to show the upper extent of a myelographic block. Seventy-eight of 84 (92.9%) respondents stated that they would perform a C1–2 puncture for myelography to evaluate the thoracic or lumbar spine if there was a contraindication to a lumbar approach, such as a local infection or recent postoperative state. In those instances in which MR imaging is contraindicated and a lumbar access is not successful (due to degenerative changes), 71 of 77 (92.2%) program directors indicated that they would perform a C1–2 puncture for myelography.

Eighty-three of 84 (98.8%) survey respondents stated that there was a person trained to perform C1–2 punctures within their division, and 59 of 81 (72.8%) program directors stated that they train their fellows and/or residents to perform C1–2 punctures.

Only 4 of 80 (5%) individuals responding thought that performing a C1–2 puncture (as the primary approach) for cervical myelography in a patient with a contraindication for MR imaging was below the standard of care.

The final question was opened-ended and allowed any comments for individuals to provide conditions under which their neuroradiology team would perform a C1–2 puncture. Once again, the common indications listed by the respondents included the additional indications: those patients in whom lumbar access was not available either due to severe degenerative changes or local infection; those patients who have low conus medullaris or tethered spinal cords; patients with a complete myelographic block in the thoracic spine; and those patients who could not assume a prone position, in which case a C1–2 puncture could be performed in the supine position.

Discussion

Despite widespread use of MR imaging for the screening evaluation of the spine for neck and back pain, there are instances in which cervical myelography provides important information to the clinical team. This is largely for those individuals who have postoperative metallic instrumentation that leads to ferromagnetic artifacts on MR imaging or who have other contraindications for MR imaging. For that reason, trainees must be taught and the radiologists must remain adept at performing spinal punctures for intrathecal instillation of myelographic contrast media.

The preference for a lumbar puncture approach for the instillation of iodinated contrast for cervical myelography lies in the impression that this is a safer technique because the puncture is performed below the expected termination of the conus medullaris of the spinal cord. The potential complications of cervical myelography have been enumerated in many articles dating to the 1980s[3,4,6,7] and most recently in 2008.[10] In this latest study, Chin et al[10] reviewed 637 patients who underwent myelographic evaluation for cervical spondylosis, of whom 544 had a C1–2 puncture. Adverse reactions to cervical punctures were present in 25 of the 544 patients and included (in decreasing order) pain (28%), anxiety (24%), headaches (8%), difficulty assuming head positioning (8%), neck spasms (4%), lightheadedness (4%), right-arm pain (4%), and tingling in the triceps (4%).[10]

The overall rate of adverse reactions with a cervical puncture (4.9%) was slightly higher than that of a lumbar puncture approach (3/89, 3.4%) but did not assume statistical significance. The rate of conversion from a cervical puncture to a lumbar puncture was 7%, compared with a lumbar-to-cervical-puncture conversion rate of 4.3%.[10] More patients undergoing cervical puncture stated that in comparison with the lumbar puncture, they would not undergo the procedure again, largely due to the pain of the procedure and nausea.[10] Only 1 patient of the 637 had a major complication, which was a CSF leak after a cervical puncture. Chin et al[10] concluded that lumbar punctures are to be favored over cervical punctures for cervical CT myelography.

Although the article of Chin et al[10] did not report any neu-

rologic deficits from complications of C1–2 puncture myelography, other studies have done so. Robertson and Smith[8] in 1990 surveyed neuroradiologists performing cervical myelography and found that cervical hyperextension beyond the safe limit for an excessive period of time leading to myelopathic symptoms occurred in 0.023% of patients. This resulted in acute respiratory arrest in 1 patient, permanent quadriparesis in 4 patients, and transient quadriparesis in 3 patients. Skalpe and Amundsen[1] and Skalpe[5] have suggested that one should not keep the neck hyperextended for >15 minutes, to avoid complications related to patient positioning.

Arterial puncture of the vertebral artery or posterior inferior cerebellar artery and direct puncture of the spinal cord were also reported by Robertson and Smith.[8] In a review of 164 vertebral arteriograms, Katoh et al[9] identified only 3 patients in whom the vertebral artery was superimposed over the posterior one third of the spinal canal at C1–2, where it may be in the path of a standard C1–2 myelographic puncture. In 113/164 (71%) patients the vertebral arteries were located anterior to the spinal canal at C1–2; in 45 (26%) patients the vertebral artery was superimposed over the anterior one third of the C1–2 spinal canal, and in another 3 patients it was superimposed over the middle one third of the spinal canal.[9]

Katoh et al[9] also reported 3 patients with spinal cord puncture, of whom 1 had a persistent neurologic deficit on long-term follow-up. Of 5 patients with direct cord punctures, Robertson and Smith[8] reported that 1 died, 1 had a persistent neurologic deficit, and 3 had no sequelae. Eight of 16 patients who had contrast inadvertently injected into the spinal cord had persistent neurologic deficits, whereas the other 8 recovered fully. Other studies have reported anecdotally on the presumed benefit of urgent steroid administration for patients in whom the spinal cord has been punctured or injected. Servo and Laasonen[7] have suggested that the volume of contrast injected into the cord is the overriding factor as to whether patients become symptomatic.

The risks of lumbar puncture include the possibility of puncturing a low-lying conus or injuring a low origin of the artery of Adamkiewicz. The other potential risks inherent in myelography (bleeding, hematoma, contrast medium and anesthetic allergy, pain, injury to penetrating nerves, and infection) are common to both a lumbar and cervical approach.

What then are the benefits that could justify favoring a C1–2 puncture for cervical myelography? The direct instillation of contrast locally could be advantageous for the following reasons: 1) improved quality of cervical myelogram films, 2) reduction in intracranial penetration of contrast, 3) decreased concentration and volume of contrast medium required due to absence of dilutional effects, 4) decreased risk of entrapment of contrast by degenerative changes of the upper lumbar spine or thoracic spine blocking flow, 5) decreased risk to individuals with low-lying conus/tethered cord and/or histories of myelomeningoceles, and 6) reduced rate of headaches as reported by Skalpe and Amundsen,[1] Skalpe and Nakstad,[4] and Skalpe.[5]

Is cervical myelography via a C1–2 puncture below the level of the standard of care nationwide? The survey respondents overwhelmingly by 95% said this is not the case. More than 90% said that under certain circumstances, they would readily convert to cervical puncture as the means to study the upper spine. Do the benefits of a C1–2 approach outweigh the potential risks? This survey suggests that the practice of cervical myelography is currently dominated by a lumbar approach.

However, at least 1 individual responding to the survey believed strongly that the best-in-practice cervical myelogram technique was via a cervical approach, opining: "Doing a cervical myelogram via lateral C1–2 puncture is a higher skilled and higher standard approach to myelography. It became important with the advent of water soluble contrast around 1980 or so, as pictures would not be good with water soluble [contrast] because of dilution if injected from a lumbar approach. The choice of lumbar-versus-cervical approach should depend on patient cooperation, physical condition, etc. The most difficult cases (coma, difficult to position prone, and others) should best be done with lateral C1–2 (which could be done supine or prone) since there is little problem to manage patients in that position. Lateral C1–2 is safe, as long as there is care to monitor 2 aspects: 1) lateral imaging to verify that the needle goes across in the posterior one third of the bony AP [anteroposterior] diameter of the canal, 2) care to ensure that head doesn't drift to [the] oblique neck, which will make lateral imaging fallacious and allow the needle to get to the cord (Allan Fox, Sunnybrook, Canada; August 4, 2008).

Because 62% of respondents answered that they perform <5 C1–2 punctures each year, 1 issue to be addressed is the volume of cases needed to train fellows in the technique or for radiologists to maintain skills. The question is whether the neuroradiology community should do even fewer procedures by restricting routine cervical examinations to a lumbar approach and risk inexperience when one must do a C1–2 puncture in the instances cited in the article, or should one advocate performing C1–2 punctures preferentially to ensure that trainees are comfortable with the technique and that existing radiologists maintain their skills? This may also be an instance in which having appropriate simulation models may be useful for developing and maintaining skills. Having a local expert who has the most experience and comfort with the procedure may be an alternative approach (as with other infrequently performed studies such as sialography or pediatric neuroangiography).

Conclusions

Although in current practice, cervical myelography is widely performed via a lumbar puncture approach with manipulation of the contrast column superiorly, most neuroradiology fellowship programs responding to the survey teach the lateral C1–2 puncture technique to their trainees, perform cervical punctures when the lumbar approach is contraindicated or not feasible, and have adequate personnel to meet the requirements of the procedure. Ninety-five percent (76/80) of survey respondents thought that C1–2 punctures for cervical myelography are within the standard of care, even if only a minority performs them routinely for cervical myelography.

Acknowledgments

We thank Angelo Artemakis and the American Society of Neuroradiology for access to e-mail addresses, design of the survey, and SurveyMonkey privileges.

References

1. Skalpe IO, Amundsen P. **Thoracic and cervical myelography with metrizamide: clinical experiences with a water-soluble, non-ionic contrast medium.** *Radiology* 1975;116:101–06
2. Orrison WW, Eldevik OP, Sackett JF. **Lateral C1–2 puncture for cervical myelography. Part III. Historical, anatomic, and technical considerations.** *Radiology* 1983;146:401–08
3. Orrison WW, Sackett JF, Amundsen P. **Lateral C1–2 puncture for cervical myelography. Part II. Recognition of improper injection of contrast material.** *Radiology* 1983;146:395–400
4. Skalpe IO, Nakstad P. **Myelography with iohexol (Omnipaque): a clinical report with special reference to the adverse effects.** *Neuroradiology* 1988;30:169–74
5. Skalpe IO. **Cervical myelography.** *Radiology* 1990;177:590–91
6. Johansen JG, Orrison WW, Amundsen. **Lateral C1–2 puncture for cervical myelography. Part I. Report of a complication.** *Radiology* 1983;146:391–93
7. Servo A, Laasonen EM. **Accidental introduction of contrast medium into the cervical spinal cord: a case report.** *Neuroradiology* 1985;27:80–82
8. Robertson HJ, Smith RD. **Cervical myelography: survey of modes of practice and major complications.** *Radiology* 1990;174:79–83
9. Katoh Y, Itoh T, Tsuji H, et al. **Complications of lateral C1–2 puncture myelography.** *Spine* 1990;15:1085–87
10. Chin KR, Eiszner JR, Huang JL, et al. **Myelographic evaluation of cervical spondylosis: patient tolerance and complications.** *J Spinal Disord Tech* 2008; 21:334–37