

How Are We Handling Fluoroscopy-Guided Lumbar Puncture Requests? A Nationwide Survey of Practice Trends

T.J. Richards, J.C. Durieux, and A.P. Nayate



ABSTRACT

BACKGROUND AND PURPOSE: Referrals to perform fluoroscopy-guided lumbar punctures by neuroradiologists have increased. The purpose of our study was to determine the management of fluoroscopy-guided lumbar puncture referrals in different practice settings.

MATERIALS AND METHODS: We sent an online questionnaire to neuroradiologists and radiology trainees between May and June 2020 to survey their handling of fluoroscopy-guided lumbar puncture requests, preprocedural work-up, and the use of physician extenders/trainees to perform fluoroscopy-guided lumbar punctures, among other questions. Categories were compared using ORs.

RESULTS: Of the 123 US respondents, 81.3% were in combined academic and 18.7% in combined private practice groups. Regarding fluoroscopy-guided lumbar puncture referrals, 27.6% of respondents did not require a bedside lumbar puncture attempt before a fluoroscopy-guided lumbar puncture. Of private practice, 95.7%, and of academic respondents, 85.0%, were often asked to perform fluoroscopy-guided lumbar punctures by clinicians because of the clinician's lack of procedural competence. Of those, 74.8% stated that they always or sometimes agreed to the request. 41.5% of respondents stated that they would always comply with patients' requests for a fluoroscopy-guided lumbar puncture without a bedside lumbar puncture attempt, a 5.26 times higher likelihood (95% CI, 2.04–14.29) for private practice respondents. To perform fluoroscopy-guided lumbar punctures, 32.0% of academic respondents and 47.8% of private practice respondents use physician extenders. 75.0% of academic respondents reported that trainees perform >50% of their fluoroscopy-guided lumbar punctures.

CONCLUSIONS: This survey demonstrates that many academic and private practice neuroradiologists engage in practices that may promote an increase in fluoroscopy-guided lumbar puncture referrals including not requiring a non-image-guided lumbar puncture attempt, complying with clinicians' requests for a fluoroscopy-guided lumbar puncture due to lack of competence in performing lumbar punctures, and fulfilling patient requests for fluoroscopy-guided lumbar punctures.

ABBREVIATIONS: FGLP = fluoroscopy-guided lumbar puncture; LP = lumbar puncture

During the past few decades, there has been a large shift in the lumbar puncture (LP) volume to radiologists, and now radiologists are the primary performers of LPs in both Medicare inpatients and outpatients.¹ Performing LP under image guidance, usually using fluoroscopy, allows the radiologist to directly visualize the needle, which is especially useful in challenging

cases, including patients with extensive spinal hardware, scoliosis, or morbid obesity, among others. These advantages likely play a large role in the increased rates of referrals to radiology for fluoroscopy-guided lumbar punctures (FGLPs), but we believe other factors also contribute, including the time required of the patient's primary clinical provider, poor monetary reimbursement, incomplete mastery of the LP technique by the provider, and disruption of the provider's workflow.^{2,3} Performing FGLPs also creates difficulty for radiologists, including disrupting the flow of the normal workday, which is of growing concern especially because the diagnostic imaging workload continues to increase.⁴ In addition, performing emergent after-hours FGLPs is often medically necessary and can further challenge radiology departments because after-hours radiology technologists and FGLP operators are required. Many academic radiology departments rely

Received June 3, 2022; accepted after revision September 26.

From the Department of Radiology and Imaging Sciences (T.J.R.), University of Utah School of Medicine, Salt Lake City, Utah; and Department of Radiology (J.C.D., A.P.N.), University Hospitals Cleveland Medical Center, University Hospitals, Cleveland, Ohio.

Please address correspondence to Ameya Nayate, MD, Department of Radiology, UH, 11100 Euclid Ave, BSH 5056, Cleveland, OH 44106; e-mail: Ameya.Nayate@UHhospitals.org; @UHneurorads

Indicates article with online supplemental data.

<http://dx.doi.org/10.3174/ajnr.A7684>

on trainees (residents/fellows) to perform FGLPs, while other practices, both academic and private, rely on assistance from physician extenders (such as physician assistants and nurse practitioners). To our knowledge, there is not much information available on the use of trainees or physician extenders in academic or nonacademic groups.

LPs are considered a moderate-risk procedure due to the low incidence of complications, and there are societal recommendations for preprocedural work-up before performing LPs.^{5,6} However, in our experience, there is institutional variability on obtaining pre-LP head imaging and laboratory values.

The purpose of this investigation was to survey US and international neuroradiologist FGLP practices, including handling requests from providers, preprocedural work-up, and use of physician extenders and trainees to perform FGLPs.

MATERIALS AND METHODS

The study was approved by the University Hospitals Cleveland Medical Center institutional review board. The link to participate in a voluntary online survey was included in a monthly newsletter (May 2020) for members of the American Society of Neuroradiology. Due to an initial low response rate, a brief description of our aims (Online Supplemental Data) and the link to the survey were also e-mailed to a LISTSERV for neuroradiology section chiefs and neuroradiology fellowship directors of academic practices in the United States. Also, given the initial low response rate of private practice radiologists and to obtain a comparison nonacademic group, the survey invitation was also e-mailed to neuroradiology fellowship alumni (practicing in the United States and internationally in varying types of practices) of both the first and last authors. The survey was launched on May 7, 2020, and was closed on June 30, 2020. The survey included responses from both practicing board-certified radiologists and current radiology trainees (distinction between neuroradiology fellow or radiology resident was not made) both within the United States and internationally. Except for the initial e-mail, no further contact occurred between the authors and the survey respondents. There was no reward for completing the survey and no provided incentive to answer questions in a particular manner.

The survey (Online Supplemental Data) included 13 questions, and responses were collected electronically using an online survey tool that allows viewing of the responses by the owner of the survey (first author). Other than respondents' answers to the type of practice setting in which they worked and their geographic location, no identifiable data about the respondents, including the respondent's name, e-mail, or practice/hospital name, were obtained. Data were exported from the online survey manager for advanced statistical analysis.

Subgroup analysis was performed evaluating responses on the basis of practice type, practice location, and the use of physician extenders and trainees for performing FGLPs. To simplify analysis by practice type, we grouped together respondents that identified as "academic" and "hybrid academic and private practice," single respondents that identified as "other: hospital-based and academic," and 3 trainee respondents grouped together under "combined academic." Respondents who identified as "private practice" or "hospital-based radiology practice" were grouped together under "combined private practice." "Hospital-

based radiology practice" was grouped with the combined private practice group on the basis of our experience that many of these practices essentially function as a private practice (ie, limited academic and teaching responsibilities) and that only 2 of 7 respondents within this group stated that trainees perform FGLPs in their practice. Unadjusted ORs and 95% confidence intervals were calculated to quantify responses by practice type. *P* values < .05 were considered statistically significant.

RESULTS

Respondents

The survey was distributed to 7028 American Society of Neuroradiology members as a part of their May 2020 e-newsletter, and 2734 individuals opened the e-mails. An invitation to take the survey was also sent to 44 neuroradiology fellowship directors, 82 neuroradiology section chiefs, and 78 neuroradiology fellowship alumni of the first and last authors for a total of 7232 invited individuals. There were a total of 131 responses for a response rate of 1.8%.

Of the respondents, 6.1% (*n* = 8) were from outside the United States. Given that the low number of responses was unlikely to accurately reflect FGLP practices outside the United States, these responses were excluded from analysis but were included in the Online Supplemental Data. Of the remaining 123 responses limited to the United States, 81.3% (*n* = 100) were in the combined academic group, which included 89 respondents (72.4% of total) identifying as an academic practice; 10 respondents, as "hybrid academic/private" practice (8.1%); and 1 respondent, as "trainee" (0.8%). Of respondents, 18.7% (*n* = 23) were in the combined private practice group, including 16 as "private" practice (13.0%) and 7 as "hospital-based private" practice (5.7%). Of respondents, 84.6% (*n* = 104) interpreted only neuroradiology studies in adults and/or pediatric patients, 11.4% (*n* = 14) interpreted a mixture of neuroradiology and non-neuroradiology studies, and only 1.6% (*n* = 2) of respondents interpreted mostly non-neuroradiology studies. Of those that chose academic for practice, 3 respondents (2.4%) chose trainee for the type of studies read.

The highest number of respondents were from the Northeast at 36 (29.3%), and lowest, from the Southwest at 12 (9.8%) (Fig 1 shows depiction of geographic locations and the geographic distribution of US respondents). Of the combined private practice respondents, 52.2% (*n* = 12) were from the West. Respondents in the United States were from 31 of the 50 states, and 4 respondents were from the District of Columbia.

FGLP Operators

Trainees. The subgroup of the combined academic group that described their practice as academic had the highest overall proportion of FGLPs performed by trainees, with 80.9% indicating that trainees performed at least half of the FGLPs. For those who identified with practicing in an academic private practice hybrid, only 20.0% (*n* = 2) responded that trainees perform at least half of their FGLPs, but 80.0% stated that trainees do perform FGLPs at their institution. In the combined private practice group, 8.7% (*n* = 2) stated that trainees perform FGLPs at their practice; both of these respondents were in the hospital-based practice group. Figure 2 shows a comparison of FGLPs

performed by trainees and physician extenders in the combined-academic-versus-combined-private practice groups.

Physician Extenders. The combined private practice group had more respondents state that physician extenders perform any FGLPs at their institution compared to the academic group (47.8% compared with 32.0%, respectively). Private practice radiologists are 4.54 times (95% CI, 1.20–16.67) more likely to have

all or nearly all (75%–100%) FGLPs performed by physician extenders compared with academic practice radiologists.

Regional Variation. By region, the Northeast had the lowest use of physician extenders performing FGLPs, with only 33.3% stating that physician extenders performed any FGLPs, while the Midwest had the highest at 42.9%. The West had the highest percentage of respondents stating that physician extenders performed at least half of the FGLPs (27.6%).

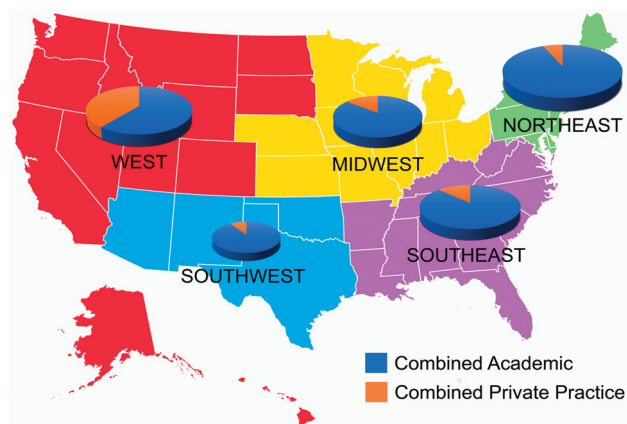


FIG 1. US map demonstrating the regional divisions for subgroup analysis. This pie chart demonstrates the proportion of respondents in the combined academic group (blue) compared with the combined private practice group (orange). The size of the pie chart is scaled according to the proportion of the total respondents from each region.

Bedside Lumbar Puncture Attempt Requirements. Compared with private practice, respondents from an academic type of practice were 5.99 times (95% CI, 2.35–16.01 times) more likely to require a bedside LP attempt before an FGLP. In practices in which neither physician extenders nor trainees performed FGLPs, only 25% required a bedside attempt. When asked about possible reasons that a patient could skip undergoing a bedside LP and go directly to FGLP, the 2 most common reasons were morbid obesity in which the bony landmarks (81.3%) cannot be palpated and surgical wound or infection limiting access (75.6%). Figure 3 shows additional responses.

Clinician Requests Due to Lack of LP Competency

Of combined private practices, 95.7% and 85.0% of combined academic respondents were often asked to perform FGLPs by clinicians because the clinician did not feel competent performing LPs. Of those, combined private practice respondents more commonly stated that they would either “always” or “sometimes” oblige this request compared with combined academic respondents (86.3%

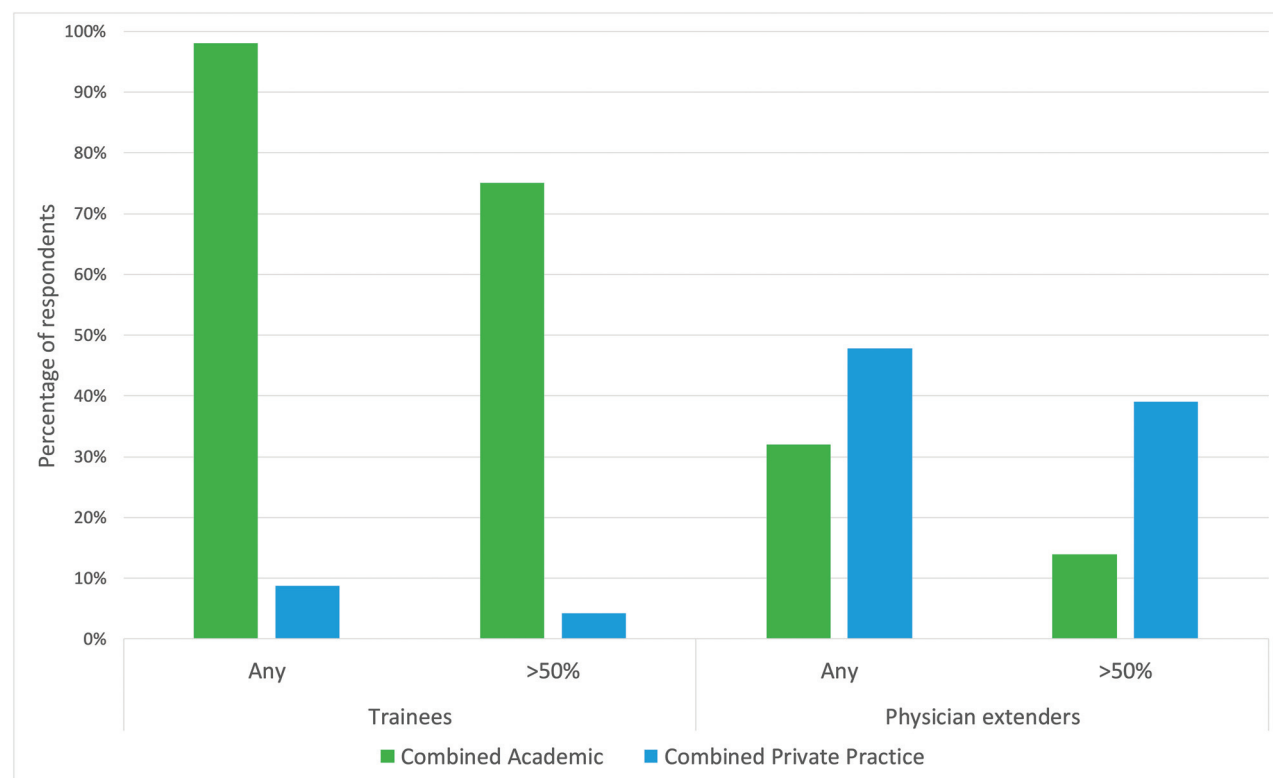


FIG 2. Column graph demonstrating the percentage of FGLPs performed by trainees and physician extenders according to the survey respondents in the combined academic compared with private practice groups.

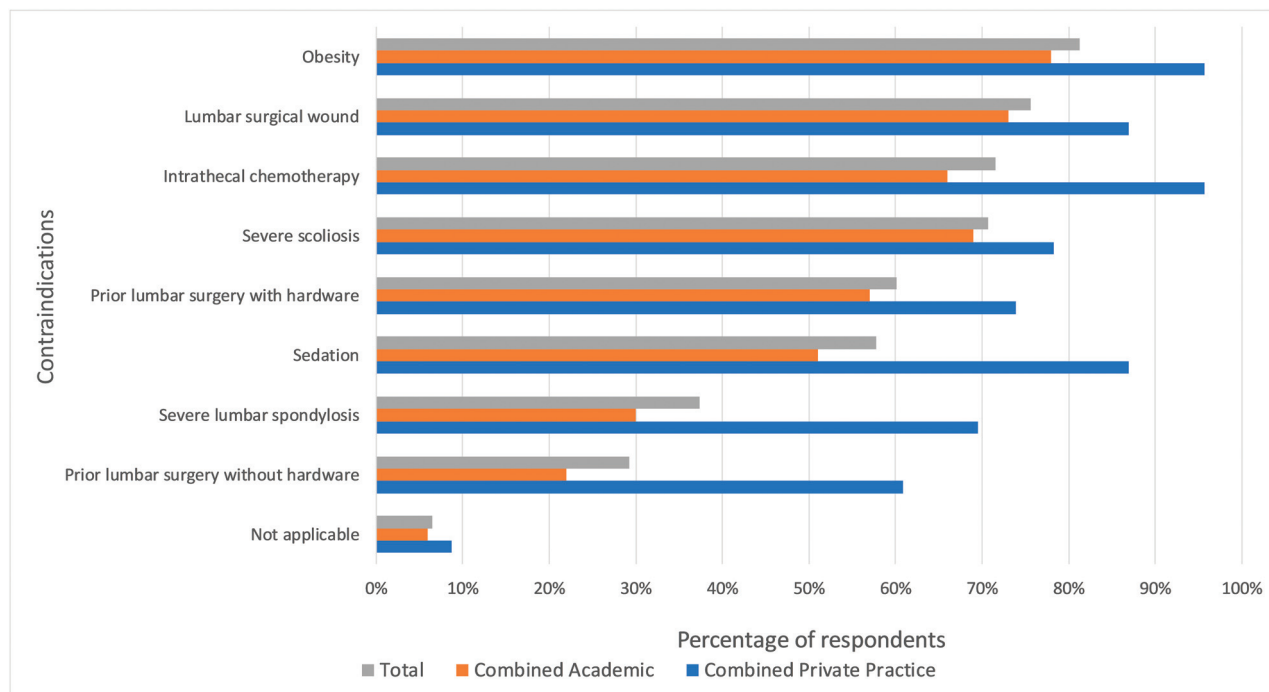


FIG 3. Bar graph demonstrating the percentage of respondents that chose each possible contraindication to a bedside LP and having the patient go directly to a FGLP according to all respondents, combined academic, and combined private practice groups.

compared with 71.8%, respectively). The Online Supplemental Data give additional FGLP practice requirements.

Patient FGLP Requests. Overall, 41.5% ($n = 51$) of respondents stated that they would always accommodate a patient request for FGLP before a bedside attempt. Compared with respondents from an academic-type practice, private practice radiologists were 5.26 times (95% CI, 2.04–14.29 times) more likely to accommodate a patient's request for FGLP. The subgroup in which physician extenders performed at least half of the FGLPs had the highest percentage of refusing this patient request, at 13.0%.

Outpatient FGLP Requests. When an outpatient is referred for an FGLP, none of the combined private practice groups stated that they always required a bedside LP attempt compared with 13.0% of the combined academic group.

Laboratory and Imaging Requirements. Pre-FGLP coagulation test requirements were very similar between the combined private practice and academic groups, with 39.0% and 39.1% (respectively) always checking preprocedural coagulation test results and platelet counts. Of the respondents that did not require all patients to get coagulation tests before an FGLP, most checked these labs in patients with an increased risk of coagulopathy (92.0%). Figure 4 shows additional details.

Of all respondents, most (82.9%) stated that patients are required to get a CT of the head before an FGLP only if there is high suspicion of increased intracranial pressure and CSF is being removed. More respondents in the combined private practice group always required head imaging compared with the combined

academic group (17.4% compared with 8.0%, respectively). Figure 5 shows response data for additional head imaging requirements.

After-Hours Emergent FGLPs. Overall, 83.7% of respondents (78.3% of the combined private practice group and 85.0% of the combined academic group) stated that they performed emergency FGLPs after regular work hours. The subgroup with the lowest proportion that performed emergent after-hours FGLPs was respondents (both academic and private practice) where neither physician extenders nor trainees performed any FGLPs. In this subgroup, only 66.7% performed emergent FGLPs.

DISCUSSION

This article presents the only published survey on FGLP practice trends among neuroradiologists across the United States. The survey evaluated expectations for bedside LP attempts before FGLP as well as exceptions to this expectation, including patient and referring clinician requests and complicating patient factors including surgical hardware or variant anatomy. The survey also investigated the primary operators of FGLPs, preoperative imaging and laboratory requirements, and the availability of FGLPs performed as an emergent after-hours procedure.

Bedside LP Attempt Requirements

Most respondents (72.4%) stated that they required a bedside LP attempt by a clinician for inpatients before referral for an FGLP. Respondents who stated that this was their standard practice were approximately 6 times more likely to come from an academic-type practice compared with a private-type practice. When clinicians requested a radiologist to perform an FGLP without a bedside LP attempt due to lack of competence in performing bedside LPs, only

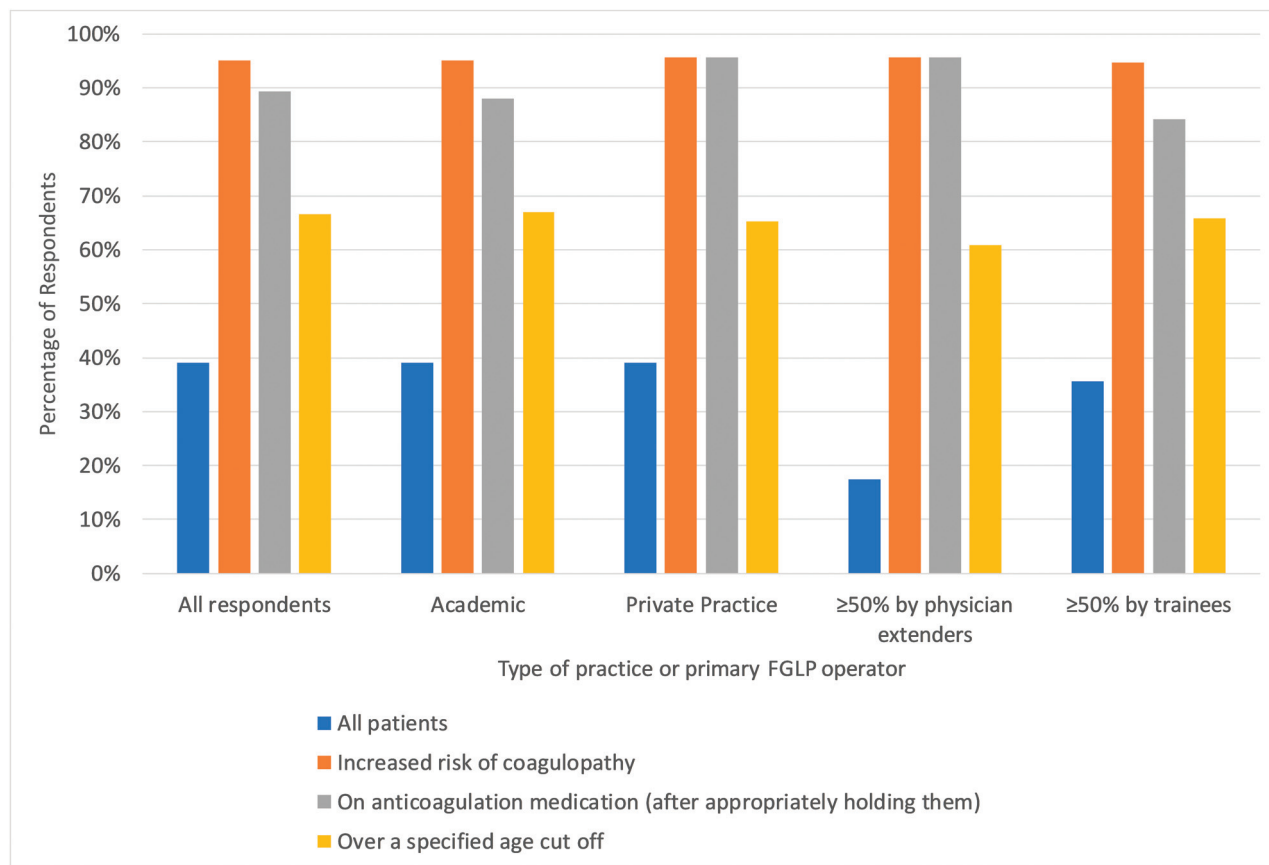


FIG 4. Column graph demonstrating the percentage of all respondents and each major subgroup of respondents that checked coagulation test results and platelet counts in each patient situation. Of note, the respondents that checked laboratory values in all patients were added to each of the other responses, given that if a respondent checked laboratory values in all patients, they would also check them in each of the additional situations.

25.2% of respondents typically refused. Furthermore, when patients requested going directly to FGLP, private practice respondents were approximately 5.3 times more likely to always accommodate the request compared with academic respondents. We believe the dramatic differences between the responses by private practice–versus-academic radiologists are at least partially related to the different practice models. Overall, the high proportion of survey respondents who appease patients and hospitalists with these requests demonstrates the shift in both radiology and medicine as a whole toward a service industry targeted toward patient satisfaction. Despite this shift, it is important to balance the desire to please the patient and referring clinician with doing what is best for the patient and using costs and resources responsibly. FGLPs potentially add unnecessary ionizing radiation and have added cost compared with bedside LPs. Furthermore, FGLPs can be disruptive to both trainees in academic practices and radiologists.^{7,8}

Performing FGLPs on outpatients without a bedside attempt also appears to be common practice, with only 10.6% of respondent indicating that they always require a bedside attempt before performing an FGLP on outpatients. FGLPs have a high success rate, and we suspect that FGLPs are requested by outpatient clinicians to potentially decrease the inconvenience of a longer procedure and possibly requiring a return for a second attempt if the bedside LP is unsuccessful.

Procedural hesitancy is especially of concern because many clinicians do not feel competent in performing LPs.^{3,9} For the internal medicine physician, this problem is, in part, related to their performing fewer bedside LPs¹⁰ and bedside LP procedural skills are no longer considered necessary for certification by the Board of Internal Medicine.¹¹ While it is important to appease the referring clinicians and patients, it is also important for radiologists to be good stewards of medical resources and limit unnecessary exposure of patients to ionizing radiation.

Use of Trainees and Physician Extenders to Perform FGLPs

Our survey demonstrates that trainees perform most FGLPs in academic practices. Only 32.0% of the combined academic group use physician extenders to perform FGLPs, and 14.0% stated that physician extenders perform greater than half of the FGLPs. While radiology trainees need to learn to perform FGLPs as part of their clinical training and they provide no added cost to the radiology department for performing this service, it is important to not overburden trainees with performing a superfluous number of FGLPs to avoid impacting their diagnostic neuroradiology training. Richards et al⁸ reported that for each FGLP performed by a radiology resident, there was a predictable and significant decrease in the number of diagnostic cross-sectional neuroradiology studies that they read in a day. Increased use of physician

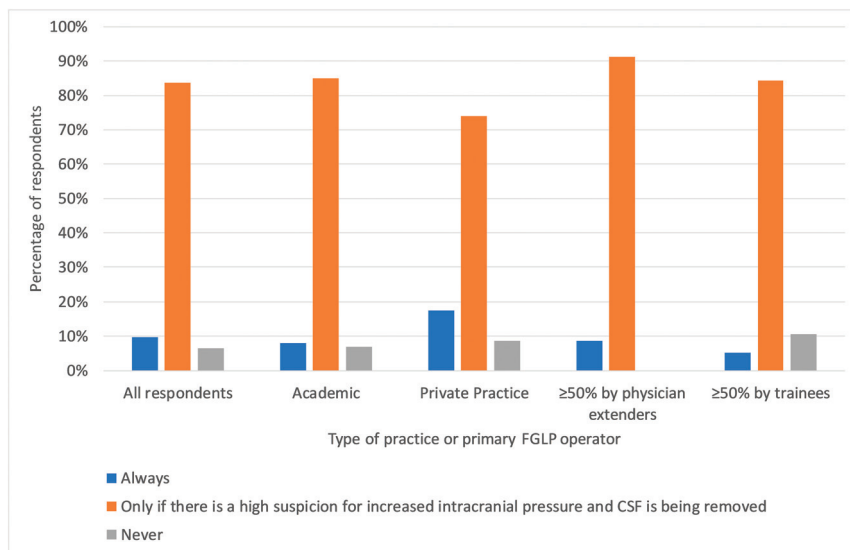


FIG 5. Column graph demonstrating the percentage of all respondents and each major subgroup of respondents that required head imaging in each patient situation.

extenders in academic centers may help relieve some of the burden on trainees of performing increasing number of FGLPs.

Coagulation Test and Head Imaging

Guidelines for when coagulation tests and platelet counts should be checked are controversial and, in our experience, often variable among neuroradiologists, even within the same practice. The updated Society of Interventional Radiology guidelines for periprocedural bleeding risk in 2012 recommended checking platelet counts and international normalized ratios in all patients before procedures with a moderate bleeding risk such as FGLPs, but ultimately the decision was left to the clinician's judgment.⁵ Despite this recommendation, only 39.0% of respondents stated that they check these tests on all patients before FGLP, but most respondents checked them in patients with a high risk of bleeding or those on anticoagulation medications.

In contrast to laboratory requirements, there is a high level of consensus among our survey respondents regarding preprocedural head imaging, with most stating that patients should get a CT of the head before an FGLP only if there is high suspicion for increased intracranial pressure and CSF is being removed, with a minority requiring CT head studies on all patients before performing FGLPs. Most interesting, despite essentially all available society guidelines^{12,13} recommending head CT before diagnostic LP under certain clinical criteria, 6.6% stated that they never require a preprocedural head CT.

Emergent After-Hours FGLPs

There are several indications for which lumbar punctures may be considered emergent or very urgent as part of the patient's essential medical care.^{14,15} Of the survey respondents, 83.7% stated that they perform emergent FGLPs after hours. The subgroup that performed the lowest proportion of emergent FGLPs was the group in which neither physician extenders nor trainees performed any of

their FGLPs. Although the reasons are probably multifactorial, this finding is logical from a financial perspective, given that compensating attending radiologists to cover FGLPs overnight is an expensive means of covering this service and in many cases may not be affordable.

Indications for FGLP without Bedside Attempt

Morbid obesity, severe scoliosis or congenitally altered anatomy, and prior lumbar surgery with hardware were some of the most frequent reasons that respondents did not require a bedside LP attempt before referral for FGLP. These findings are logical and pertain to the inability or high likelihood of the clinician not being certain of the lumbar level or exact location at which the needle is entering the spinal canal due to anatomic issues related to increased

flank adiposity from obesity, altered anatomic landmarks due to spinal curvature, congenital issues, or prior lumbar surgery with hardware. Knowledge of the lumbar level where the spinal needle is entering the thecal sac is important because entering the spinal canal at or above the level of the conus medullaris increases the risk of spinal cord injury. Most interesting, most respondents stated that performing LPs for intrathecal chemotherapy administration and patients requiring sedation or general anesthesia were reasons for which a prior bedside LP was not required. We believe these responses are congruent with the mission of many radiology departments, which is to provide aid to our referring clinicians in the diagnosis and treatment of patients.

Our study has multiple limitations that should be considered when interpreting our results. First, with survey research, there is a chance of self-reporting and recall bias. Second, our findings are based on a relatively small sample size compared with the larger population of neuroradiologists across the country, and more of our respondents practiced in an academic group than in a private practice group. However, we had respondents from all the major geographic sections of the country and statistical power to demonstrate differences between private and academic groups. Also, while sending the e-mail to the neuroradiology fellowship alumni of 2 of the authors could introduce regional bias, the alumni were from different parts of the country and from different types of practices. Third, there is a possibility that multiple respondents from the same institution participated in our survey. There were 7/131 (5%) completed surveys in which the answers were exactly the same as in another survey from the same state. It is possible that either the same person filled out the survey more than once or the respondents were from the same practice and handled FGLPs referrals in the same manner. If the potentially duplicated entries were deleted, we still had very similar results (not presented). Furthermore, recall bias may have also increased the rate of duplicate entries and, therefore, present bias toward

larger institutions and practices and to respondents with more of a vested interest in the results. Finally, the survey was limited to neuroradiologists; however, in some practices, FGLPs are considered a general procedure and performed by many non-neuroradiologists. FGLP practices by other radiologists may vary and would not be captured by this survey.

CONCLUSIONS

This survey demonstrates that many academic and private practice neuroradiologists in the United States engage in practices that may promote an increase in FGLP referrals, including not requiring a non-image-guided LP attempt, complying with requests by clinicians to perform an FGLP due to lack of competence in performing LPs, and fulfilling requests by patients to perform an FGLP without a prior bedside attempt. In general, private practice groups were more lenient in requiring a non-image-guided LP compared with academic groups. Some of our findings are consistent with a known national trend toward reliance on radiology to perform LPs, including most radiologists stating that they were asked by clinicians to perform FGLPs without a prior bedside attempt because the clinician did not feel competent performing LPs. However, radiologists also play a role in this trend because most radiologists stated that they would oblige clinicians' requests to perform a FGLP if the clinician did not feel competent performing a bedside LP and would often perform FGLPs without a prior bedside LP attempt if the patient requested it. The survey also demonstrated a lack of consensus on preprocedural laboratory requirements and reasons to forgo a bedside LP attempt before FGLP referral among radiology practices. We hope that this information can help promote further studies on developing evidence-based guidelines for best FGLP practices.

ACKNOWLEDGMENTS

The authors would like to thank Dr Lubdha Shah, MD, for her feedback on the survey.

Disclosure forms provided by the authors are available with the full text and PDF of this article at www.ajnr.org.

REFERENCES

1. Johnson DR, Waid MD, Rula EY, et al. **Comparison of radiologists and other specialists in the performance of lumbar puncture procedures over time.** *AJNR Am J Neuroradiol* 2021;42:1174–81 [CrossRef Medline](#)
2. Allard M, Jelovac I, Léger PT. **Treatment and referral decisions under different physician payment mechanisms.** *J Health Econ* 2011;30:880–93 [CrossRef Medline](#)
3. Vaisman A, Cram P. **Procedural competence among faculty in academic health centers: challenges and future directions.** *Acad Med J Med* 2017;92:31–34 [CrossRef Medline](#)
4. Smith-Bindman R, Kwan ML, Marlow EC, et al. **Trends in use of medical imaging in US health care systems and in Ontario, Canada, 2000–2016.** *JAMA* 2019;322:843–56 [CrossRef Medline](#)
5. Patel IJ, Davidson JC, Nikolic B, et al; Standards of Practice Committee, with Cardiovascular and Interventional Radiological Society of Europe (CIRSE) Endorsement. **Consensus guidelines for periprocedural management of coagulation status and hemostasis risk in percutaneous image-guided interventions.** *J Vasc Interv Radiol* 2012;23:727–36 [CrossRef Medline](#)
6. Malloy PC, Grassi CJ, Kundu S, et al; Standards of Practice Committee with Cardiovascular and Interventional Radiological Society of Europe (CIRSE) Endorsement. **Consensus guidelines for periprocedural management of coagulation status and hemostasis risk in percutaneous image-guided interventions.** *J Vasc Interv Radiol* 2009;20:S240–49 [CrossRef Medline](#)
7. Schemmel A, Lee M, Hanley T, et al. **Radiology workflow disruptors: a detailed analysis.** *J Am Coll Radiol* 2016;13:1210–14 [CrossRef Medline](#)
8. Richards TJ, Schmitt JE, Wolansky LJ, et al. **Radiology performed fluoroscopy-guided lumbar punctures decrease volume of diagnostic study interpretation: impact on resident training and potential solutions.** *J Clin Imaging Sci* 2021;11:39 [CrossRef Medline](#)
9. Mourad M, Kohlwes J, Maselli J, et al; MERN Group. **Supervising the supervisor: procedural training and supervision in internal medicine residency.** *J Gen Intern Med* 2010;25:351–56 [CrossRef Medline](#)
10. Wigton RS, Alguire P; American College of Physicians. **The declining number and variety of procedures done by general internists: a resurvey of members of the American College of Physicians.** *Ann Intern Med* 2007;146:355–60 [CrossRef Medline](#)
11. Duffy FD, Holmboe ES. **What procedures should internists do?** *Ann Intern Med* 2007;146:392–93 [CrossRef Medline](#)
12. Dodd KC, Emsley HCA, Desborough MJR, et al. **Periprocedural antithrombotic management for lumbar puncture: Association of British Neurologists clinical guideline.** *Pract Neurol* 2018;18:436–46 [CrossRef Medline](#)
13. The American College of Radiology. **ACR-ASNR-SPR practice parameter for the performance of myelography and cisternography.** 2019. <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Myelog-Cisternog.pdf>. Accessed March 1, 2022
14. Glimåker M, Johansson B, Grindborg Ö, et al. **Adult bacterial meningitis: earlier treatment and improved outcome following guideline revision promoting prompt lumbar puncture.** *Clin Infect Dis* 2015;60:1162–69 [CrossRef Medline](#)
15. Evans RW, Friedman DI. **Expert opinion: the management of pseudo-tumor cerebri during pregnancy.** *Headache* 2000;40:495–97 [CrossRef Medline](#)