Declines in the Number of Lumbar Punctures Performed at United States Children's Hospitals, 2009-2019

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Objective To evaluate trends in lumbar puncture (LP) performance among US children's hospitals to assess how these trends may impact pediatric resident trainee exposure to LP.

Study design We quantified LPs for emergency department (ED) and inpatient encounters at 29 US children's hospitals from 2009 to 2019. LP was defined by either a LP procedure code or cerebrospinal fluid culture billing code. Temporal trends and hospital variation in LP were assessed using logistic regression analysis.

Results A total of 215 030 LPs were performed during the study period (0.8% of all encounters). Twenty six thousand and five hundred twenty three and 16 696 LPs were performed in the 2009 and 2018 academic years, respectively (overall 37.1% reduction, per-year OR, 0.935; 95% CI, 0.922-0.948; $P < .001$), and the rate of LP decreased from 10.9 per 1000 hospital encounters to 6.0 per 1000 hospital encounters over the same period.

Conclusions LP rates have declined across US children's hospitals over the past decade, potentially resulting in reduced clinical exposure for pediatric resident trainees. Improved procedural simulation during residency may augment the clinical experience. *(J Pediatr 2021;231:87-93)*.

See editorial, p 32 and related article, p 94

Given its prevalence, the Accreditation Council for Graduate Medical Education (ACGME) identifies lumbar puncture (LP) as a core procedural skill in which pediatric residents must demonstrate competency by the completion of training.[1] Many interns have not performed an unsimulated LP by the start of their residency.[2-4] Residency programs must navigate this responsibility alongside new duty hour restrictions, increased attending supervision with more frequent in-house attending coverage during overnight hours, and a growing workforce of nurse practitioners, physician assistants, and emergency medicine and hospitalist fellows, all of whom compete for procedural exposure with pediatric residents.[5,6] In an effort to ensure sufficient training in LP, simulation has been used with variable success in facilitating trainee procedural confidence and competence.[7,8] Effective training for physicians who will routinely perform LPs throughout their careers is critically important. Previous studies have demonstrated that relative procedural inexperience is associated with an increased risk for traumatic LP, which promotes diagnostic uncertainty, potentially increasing rates of hospitalization and antibiotic use.[9-11]

With the widespread implementation of conjugate vaccination, the prevalence of bacterial meningitis has declined significantly.[12-17] These trends, in addition to recent evidence suggesting that LP may be safely avoided in some patients with common clinical presentations, such as febrile seizure and fever in infants, have the potential to further limit LP procedural exposure.[18-21] There have been documented declines in LP performance for each of these common pediatric diagnoses.[16,22]

We sought to evaluate temporal trends in LP performance at US children's hospitals over a 10-year period, assess for hospital-level variation, and estimate how these trends may impact pediatric resident exposure to LP. We hypothesized that there has been a substantial decline in LP performance nationwide over the past decade resulting in reduced potential for clinical exposure to LP during pediatric residency training.

ACGME	Accreditation Council for Graduate Medical Education
APR-DRG	All Patients Refined Diagnosis Related Group
ED	Emergency Department
LP	Lumbar puncture
NICU	Neonatal intensive care unit
PHIS	Pediatric Health Information System

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Methods

For this study, we obtained data from the Pediatric Health Information System (PHIS), an administrative database that contains ED, inpatient, observation, and ambulatory surgery encounter-level data from 52 not-for-profit tertiary care pediatric hospitals in the US. Data from 29 of these hospitals were included in this study. Each hospital included is an academic center affiliated with an ACGME-accredited pediatric residency training program. These hospitals are affiliated with the Children's Hospital Association. The Children's Hospital Association and participating hospitals are responsible for ensuring data quality and reliability. Portions of the data submission and data quality processes for the PHIS database are managed by Truven Health Analytics. For external benchmarking, participating hospitals provide discharge and encounter data including demographics, such as age, sex, race and ethnicity, diagnoses, and procedures. Most hospitals also submit data on resource use (eg, imaging, laboratory, and pharmaceuticals) into PHIS. At the time of data submission, data are deidentified and subjected to validity and reliability checks before inclusion in the database. Data for the primary pediatric residency program affiliated with each PHIS hospital were obtained through the National Resident Matching Program.[18] Twenty-three hospitals were excluded from analysis due to data quality issues or for absent or incomplete ED, inpatient, and residency data for the entire study period.

LP

We evaluated the count and per-encounter rate of LP performance among pediatric ED and inpatient encounters for children aged 0-18 years between July 1, 2009, and June 30, 2019. We defined LP by the presence of an LP procedure code or clinical transaction classification code for cerebrospinal fluid culture (**Table I**; available at www.jpeds.com).[17,19,22] We excluded encounters for patients with current or previous oncologic and severe neurologic comorbidities using a previously defined classification system, as well as encounters among children with cerebrospinal fluid ventricular shunts.[20] Patients with these underlying diagnoses were excluded, given that pediatric subspecialists, such as oncologists, interventional radiologists, neurosurgeons, and neurologists, are more likely than pediatric residents to perform LPs in these patients.

Statistical Analyses

Descriptive statistics, including median with IQR and count with proportion, were used to characterize hospital and patient-level covariates. Hospitals were characterized by geographic region, payer mix, and ED and inpatient volumes. Patient-level variables were age, sex, race/ethnicity, geographic region, and payer mix. Encounters with LP were categorized by disposition as follows: discharged from the ED, admitted to an inpatient service (including a pediatric intensive care unit), or admitted to a neonatal intensive care unit (NICU). An LP was considered performed in the ED if the patient was subsequently discharged from the ED or if the LP was performed on the first day of the clinical encounter, whereas those performed after day 1 were attributed to the inpatient setting. LPs were attributed to the NICU if the patient's date of birth was the same as the date of admission for the encounter. All-Patient Refined Diagnosis Related Groups (APR-DRGs) were used to assess temporal trends in LP performance by disease specific indication.

To examine trends in LP and the potential impact to resident LP exposure over time, we estimated a set of logistic regression models with LP utilization as the dependent variable and academic year as the independent variable, using robust standard errors clustered on hospital to account for intrahospital correlation. To determine the proportion of study hospitals with a statistically significant change in LP rate during the study period, we performed a logistic regression comparing the rates of LPs at the beginning and end of the 10-year period, using a Bonferroni-style correction. To quantify the estimated maximum number of resident LPs performed annually, we attributed all LPs to pediatric resident trainees. The annual LP incidence at each hospital was divided by the total number of pediatric residents at each program in a given year. Residents counted toward the total number based on ACGME data if they were enrolled in their pediatric residency program's categorical, primary care, or integrated research track. Residents enrolled in combined programs, such as medicine and pediatrics and pediatric neurology were excluded from the study given differences in their training programs. LP rates were calculated for each individual hospital by year. Hospital-level variation in LP rates was assessed by estimating a logistic regression model with LP utilization as the dependent variable and unique hospital indicators as the independent variables and testing the null hypothesis that LP odds were equal across all hospitals using a Wald test. Data analyses were conducted using STATA SE version 16.0 (StataCorp). Tests were considered significant with a 2-sided $\alpha < 0.05$. The logistic regression comparing hospital-level LP rates in 2009 vs 2018 used an adjusted α value of 0.002 for the 29 study hospitals. The study hospitals' Institutional Review Boards approved this study and waived informed consent.

Results

During the 10-year study period, a total of 215 030 LPs were included in the analysis (0.8% of all hospital encounters) (**Table II**). The median age of patients in the cohort who underwent LP was 1.5 months (IQR, 0.6-15.6 months). Infants aged ≤3 months accounted for 5.9% of all hospital encounters but 64.6% of all LPs. There were no appreciable differences in the hospital characteristics for encounters where LP was performed compared with all encounters (**Table II**).

A total of 26 523 and 16 696 LPs were performed in the 2009 and 2018 academic year, respectively (an overall

Table II. Patient and hospital characteristics

Characteristics	All ED and inpatient visits (N = 26 463 925)	Visits with LP (N = 215 030)
Patient level		
Age group, n (%)		
0-≤3 mo	1 580 086 (6)	138 952 (65%)
>3 mo-≤1 y	3 050 169 (12)	18 858 (9%)
>1-5 y	9 129 441 (40)	18 283 (8%)
6-18 y	12 316 290 (42)	38 937 (18%)
Age, y, median (IQR)	4.6 (1.5-10.3)	0.1 (0.1-1.3)
Male sex, n (%)	13 991 997 (52)	116 709 (54)
Race/ethnicity, n (%)		
Non-Hispanic white	9 136 958 (35)	95 843 (45)
Non-Hispanic black	6 705 666 (25)	36 979 (17)
Hispanic	5 308 998 (20)	41 105 (19)
Asian	517 857 (2)	5238 (2)
Other	1 360 428 (5)	11 266 (5)
Payor, n (%)		
Government	16 420 469 (62)	123 514 (57)
Private	7 997 933 (30)	79 445 (37)
Other	1 798 832 (7)	9363 (4)
Hospital level		
Geographic region, n (%)		
Northeast	2 390 831 (9)	20 724 (10)
South	11 461 600 (43)	111 632 (52)
Midwest	7 626 605 (29)	43 365 (20)
West	4 984 889 (19)	39 309 (18)

Values reported as count (percentage) or median (interquartile range). Percentage reflects the proportion of total patients or visits in a given subset of the variable.

37.1% reduction; per-year OR, 0.935; 95% CI, 0.922-0.948; $P < .001$) (**Figure 1**). The rate of LP decreased from 10.9 per 1000 hospital encounters to 6 per 1000 over the same period (45.0% reduction). Assuming that each LP was performed by a pediatric resident, the estimated maximum number of LPs per pediatric resident per year decreased from 13.2 LPs in 2009 to 7.3 LPs in 2018 (overall 44.7% reduction; per-year OR, 0.939; 95% CI, 0.938-0.940; $P < .001$). LPs were most commonly performed in the ED (82.3%), followed by the inpatient setting (9.8%) and the NICU (7.9%) (**Figure 2**).

The most common APR-DRGs among children with LPs included fever (13.7% of LPs in the study cohort), seizure (6.9%), kidney and urinary tract infection (5.7%), meningitis (5.2%), and infection of the upper respiratory tract (4.8%). During the study period, LPs were reduced by 56.2% for encounters with fever, 46.1% for seizures, 32.2% for kidney and urinary tract infections, 9.9% for meningitis, and 60.6% for infections of the upper respiratory tract.

LP performance varied across hospitals during the study period, with a median of 669 LPs annually (range, 267-1591; $P < .001$). During the study period, we observed declines in LP rates for 28 of the 29 hospitals in the cohort, with a median reduction of 44.1% (IQR, 34.2%-56.3%) (**Figure 3**). At 26 of these hospitals (89.6%), the reduction in LP rates over the 10-year period was statistically significant ($P < .002$).

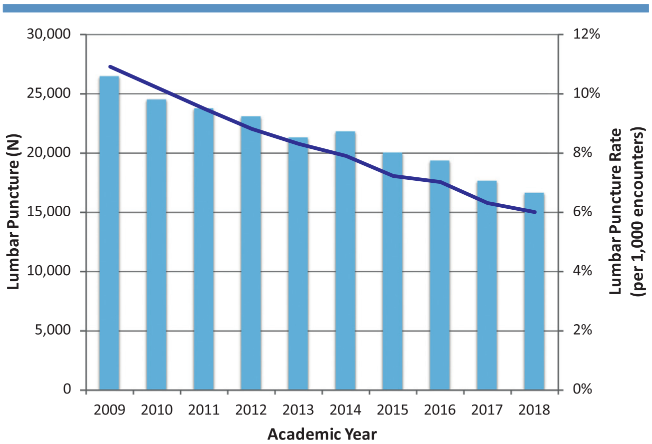

Figure 1. Trends in overall LPs by academic year. The columns show LP incidence over time. Test for linear trend: OR, 0.935; 95% CI, 0.922-0.948; $P < .001$. The line represents LPs per 1000 encounters over time.

Discussion

Across US children's hospitals, the performance of LPs has decreased by 37% over the past decade. In 2018, assuming that all LPs were attributed to pediatric residents, the estimated maximum number of LPs per pediatric resident per year was 7, a 45% reduction from 2009. In practice, this number is likely a significant overestimate without taking into account the number of LPs performed by other providers, many of whom are emergency medicine residents who also require competency in LP as part of their training.[21]

The decline in LP performance is likely attributed to changing patient demographics and practice guidelines. In the era of widespread vaccination, application of new risk stratification algorithms recommend fewer children undergo LP to evaluate for bacterial meningitis.[12-15,23,24] These findings have facilitated changes in the management of febrile young infants, with 1 study illustrating that less than one-half of these patients now undergo LP, given application of this low-risk criteria.[18,25] In addition, the past decade has seen a declining LP rate for patients with first simple febrile seizures, given mounting evidence of the exceedingly low risk of bacterial meningitis in these patients.[16,26,27] In response to these findings, the American Academy of Pediatrics changed their clinical practice guidelines for simple febrile seizures and recommend against routine LP for vaccinated children without signs and symptoms of meningitis or pretreatment with antibiotics.[28]

The ACGME recognizes LP as a core procedural skill, charging residency programs with the task of ensuring procedural competence for all pediatric resident trainees. Procedural competence is defined by the trainee's ability to successfully perform the procedure; articulate procedural indications, contraindications, complications, and postprocedural

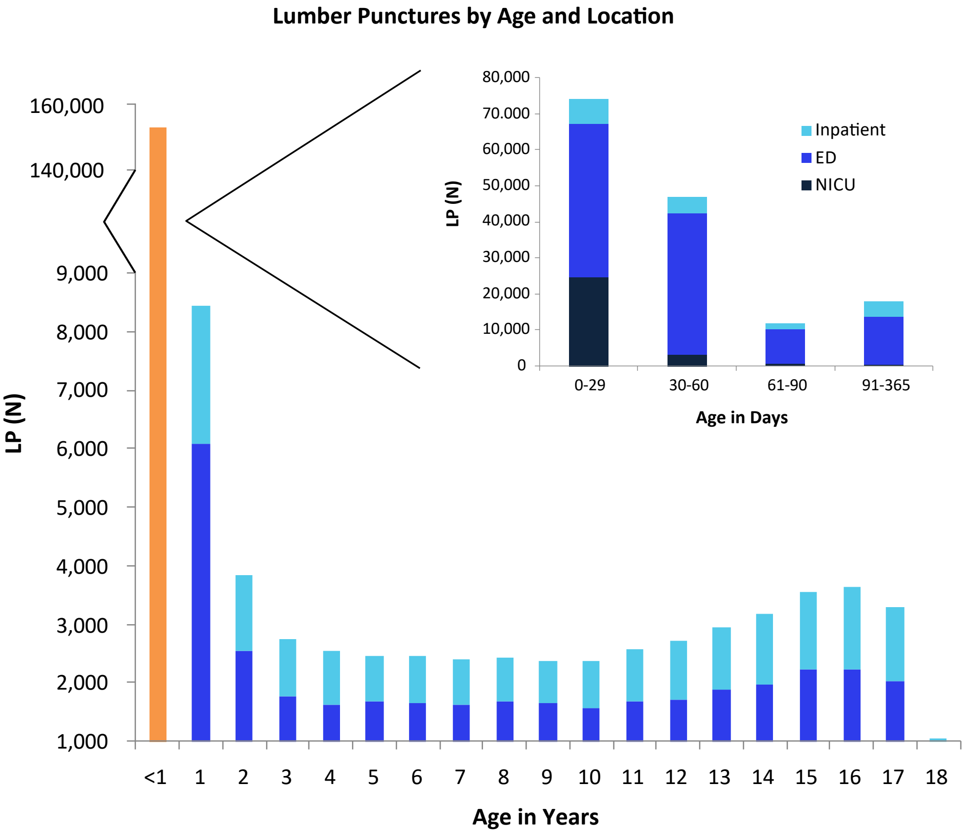

Figure 2. LPs stratified by patient age and location of procedure: NICU, ED, or inpatient.

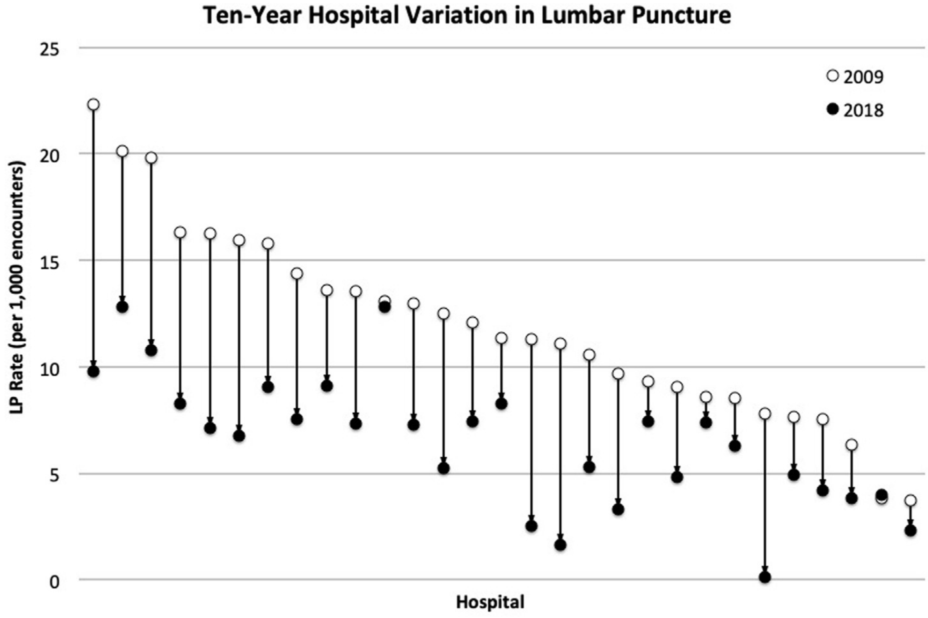

Figure 3. Ten-year hospital variation in LPs. Shown is the LP rate per 1000 encounters by hospital in the 2009 and 2018 academic years, with arrows demonstrating percent change over the study period. Hospitals experienced a median LP reduction of 44.1% (IQR, 34.2%-56.3%).

management; and appropriately interpret procedure results.[1] Without standardized guidelines for procedural numbers and methods for assessment, residency programs are tasked with developing their own approach to define competence.

Although increased procedural numbers do not necessarily indicate procedural competence, trainees must still have sufficient clinical exposure to acquire the technical skill.[29,30] To our knowledge, there have been no published studies that suggest a minimum number of LPs to achieve competency. One single-center investigation reported that one-half of graduating pediatric residents performed ≤10 LPs during training.[31] A second single-center study demonstrated that the maximum number of LPs performed by a single emergency medicine resident during training was 25.[32] Our study supports these studies and the previous finding that critical procedures in children are performed infrequently compared with adults.[33] It is expected that with different clinical procedures, varying amounts of exposure will be required to achieve competency. Studies have shown that only 10 ultrasounds may be required to achieve competency in the focused assessment with sonography in trauma, whereas competency in intubation may require more than 200 attempts.[34,35] Although there is currently no minimal recommended number for achieving competency in LP, previous studies demonstrating that more than one-third of resident LPs are traumatic support the idea that current exposure to LP does not facilitate competence for all trainees.[9]

Our findings illustrate that there is reduced clinical exposure to LP over the past decade, calling into question whether there is sufficient clinical exposure to LP in pediatric residency training to ensure competency for all graduating pediatric residents. If LP is felt to be an important skill in which all pediatric residents must become competent before graduation, residency programs must quantify resident exposure to LP and develop a standardized measure to assess procedural competence before completion of training. Given the reduced clinical exposure to LP in pediatric training programs across the country, the ACGME must work with residency programs to identify opportunities for increased exposure to LP either in the clinical setting or through simulation. Although some studies assessing the impact of simulation-based training on procedural competence have been promising, less than one-third of pediatric residency programs have formal simulation training for LP.[31,36] Simulation that emphasizes distributed practice and just-in-time and just-in-place training before the clinical procedure has the potential to facilitate competency. This model has been successful in teaching central line dressing changes and cardiac compressions, but the success of distributed practice and just-in-time and just-in-place training for LP training has been mixed.[7,37-42] Kessler et al demonstrated that the addition of just-in-time and just-in-place practice to intern simulation training for LP improved process measures, such as use of appropriate analgesia and stylet technique, but ultimately did not improve success rates.[40] Although this type of simulation may ultimately prove to be most effective for teaching LP, the ideal frequency and distribution of formal simulated practice with refresher learning at the time of the clinical procedure remains to be determined.

Alternatively, given our findings demonstrating declines in LP over time, the ACGME may consider reevaluating whether LP should remain a core competency for all pediatric residency trainees. Residency programs may instead opt to maximize clinical opportunities for LP for those residents pursuing pediatric subspecialties where mastery of LP will be important, including critical care, emergency medicine, hospital medicine, neonatology, and neurology. We identified that the majority of LPs are performed in the ED and in young infants. These findings are important for understanding the clinical setting and patient demographics for which LP is most common, thereby allowing residents who must master this skill for their future careers to seek out LP in these settings.

There are several notable limitations to our study. PHIS does not uniformly indicate the individual performing the LP, so we were not able to assess how many of these LPs were performed by pediatric residents or other healthcare professionals, including residents in other specialties, as well as fellows, nurse practitioners, and physician assistants. By using the PHIS database, we evaluated only freestanding children's hospitals. Thus, our findings might not be broadly generalizable to non-freestanding children's hospitals, where LPs are performed less frequently, and as a result, pediatric trainee exposure may be much lower.[43] Alternatively, there may be fewer healthcare professionals at non-freestanding children's hospitals allowing for pediatric resident trainees to have increased procedural exposure. Twenty-three hospitals were excluded from the study for data quality issues or incomplete data. We performed a secondary analysis using available data for these 23 excluded hospitals and found that, similar to LP rates in our study hospitals, the rates of LP decreased from 16.4 per 1000 hospital encounters to 5.4 per 1000 over the study period (overall reduction, per-year OR, 0.875; 95% CI, 0.840-0.913; $P < .001$). In some residency programs included in this study, residents rotate through other community hospitals and EDs in addition to their training at the primary children's hospital. We were not able to capture encounters at these non–PHIS-participating hospitals, which may provide residents with additional opportunities for LP. However, we believe that the numbers of LPs performed by residents are instead overestimated in this study. In keeping with the practices at our institution, we excluded LPs performed in operating rooms and subspecialty clinics and in patients with underlying diagnoses for whom subspecialists are more likely to perform the LP. It is possible that in other institutions, residents may perform some of these LPs. In the PHIS database, the setting for LP is not specified. Therefore, we attributed all LPs performed for inpatient admissions on hospital encounter day 1 to the ED and all those after to the inpatient setting. It is possible that LPs attributed to the ED may be overestimated as a result. Finally, we classified diagnoses associated with LP performance using APR-DRGs assigned at the ED visit or hospitalization. As a result, these diagnoses might not reflect the primary indication for LP, which in most cases was to evaluate for meningitis in the setting of fever and signs or symptoms suggestive of central nervous system infection.

Pediatric residency programs must assess whether there are sufficient clinical opportunities to achieve competence during a 3-year training program. If competence in LP is a required skill for pediatric trainees, residency programs must quantify resident LP performance, assess for procedural competence, and identify alternative approaches to learn this procedure given declines in clinical exposure over time. ■

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Data Statement

Data sharing statement available at www.jpeds.com.

References

1. Accreditation Council for Graduate Medical Education (ACGME). ACGME program requirements for graduate medical education in pediatrics impact statement. http://www.acgme.org/Portals/0/PDFs/archive/320_pediatrics_Impact.pdf. Accessed August 9, 2020.
2. Cartwright MS, Reynolds PS, Rodriguez ZM, Breyer WA, Cruz JM. Lumbar puncture experience among medical school graduates: the need for formal procedural skills training. Med Educ 2005;39:437.
3. Lammers RL, Temple KJ, Wagner MJ, Ray D. Competence of new emergency medicine residents in the performance of lumbar punctures. Acad Emerg Med 2005;12:622-8.
4. Pruden CM, Kerrey BT, Mittiga M, del Rey JG. Procedural readiness of pediatric interns: defining novice performance through simulation. J Grad Med Educ 2010;2:513-7.
5. Gozzo YF, Cummings CL, Chapman RL, Bizzarro MJ, Mercurio MR. Who is performing medical procedures in the neonatal intensive care unit? J Perinatol 2011;31:206-11.
6. Nadel FM, Lavelle JM, Fein JA, Giardino AP, Decker JM, Durbin DR. Assessing pediatric senior residents' training in resuscitation: fund of knowledge, technical skills, and perception of confidence. Pediatr Emerg Care 2000;16:73-6.
7. Gaies MG, Morris SA, Hafler JP, Graham DA, Capraro AJ, Zhou J, et al. Reforming procedural skills training for pediatric residents: a randomized, interventional trial. Pediatrics 2009;124:610-9.
8. Vozenilek J, Huff JS, Reznek M, Gordon JA. See one, do one, teach one: advanced technology in medical education. Acad Emerg Med 2004;11:1149-54.
9. Nigrovic LE, Kuppermann N, Neuman MI. Risk factors for traumatic or unsuccessful lumbar punctures in children. Ann Emerg Med 2007;49:762-71.
10. Howard SC, Gajjar AJ, Cheng C, Kritchevsky SB, Somes GW, Harrison PL, et al. Risk factors for traumatic and bloody lumbar puncture in children with acute lymphoblastic leukemia. JAMA 2002;288:2001-7.
11. Mazor SS, McNulty JE, Roosevelt GE. Interpretation of traumatic lumbar punctures: who can go home? Pediatrics 2003;111:525-8.
12. Hsu HE, Shutt KA, Moore MR, Beall BW, Bennett NM, Craig AS, et al. Effect of pneumococcal conjugate vaccine on pneumococcal meningitis. N Engl J Med 2009;360:244-56.
13. Thigpen MC, Whitney CG, Messonnier NE, Zell ER, Lynfield R, Hadley JL, et al. Bacterial meningitis in the United States, 1998-2007. N Engl J Med 2011;364:2016-25.
14. Khatami A, Pollard AJ. The epidemiology of meningococcal disease and the impact of vaccines. Expert Rev Vaccines 2010;9:285-98.
15. Kaplan SL, Mason EO Jr, Wald ER, Schutze GE, Bradley JS, Tan TQ, et al. Decrease of invasive pneumococcal infections in children among 8 children's hospitals in the United States after the introduction of the 7-valent pneumococcal conjugate vaccine. Pediatrics 2004;113(3 Pt 1):443-9.
16. Kimia AA, Capraro AJ, Hummel D, Johnston P, Harper MB. Utility of lumbar puncture for first simple febrile seizure among children 6 to 18 months of age. Pediatrics 2009;123:6-12.
17. Nigrovic LE, Fine AM, Monuteaux MC, Shah SS, Neuman MI. Trends in the management of viral meningitis at United States children's hospitals. Pediatrics 2013;131:670-6.
18. National Resident Matching Program. The Match. NRMP Program Results 2007-2018 Main Residency Match. https://www.nrmp.org/wp-content/uploads/2018/04/Main-Match-Result-and-Data-2018.pdf. Accessed May 5, 2020.
19. Aronson PL, Thurm C, Williams DJ, Nigrovic LE, Alpern ER, Tieder JS, et al. Association of clinical practice guidelines with emergency department management of febrile infants ≤56 days of age. J Hosp Med 2015;10:358-65.
20. Feudtner C, Feinstein JA, Zhong W, Hall M, Dai D. Pediatric complex chronic conditions classification system version 2: updated for ICD-10 and complex medical technology dependence and transplantation. BMC Pediatr 2014;14:199.
21. Accreditation Council for Graduate Medical Education (ACGME). ACGME program requirements for graduate medical education in emergency medicine. https://www.acgme.org/What-We-Do/Accreditation/Common-Program-Requirements. Accessed August 9, 2020.
22. Aronson PL, Thurm C, Alpern ER, Alessandrini EA, Williams DJ, Shah SS, et al. Variation in care of the febrile young infant <90 days in US pediatric emergency departments. Pediatrics 2014;134:667-77.
23. Aronson PL, Shabanova V, Shapiro ED, Wang ME, Nigrovic LE, Pruitt CM, et al. A prediction model to identify febrile infants ≤60 days at low risk of invasive bacterial infection. Pediatrics 2019;144:e20183604.
24. Mintegi S, Bressan S, Gomez B, Da Dalt L, Blázquez D, Olaciregui I, et al. Accuracy of a sequential approach to identify young febrile infants at low risk for invasive bacterial infection. Emerg Med J 2014;31(e1):e19-24.
25. Woll C, Neuman MI, Aronson PL. Management of the febrile young infant: update for the 21st century. Pediatr Emerg Care 2017;33:748-53.
26. Trainor JL, Hampers LC, Krug SE, Listernick R. Children with first-time simple febrile seizures are at low risk of serious bacterial illness. Acad Emerg Med 2001;8:781-7.
27. Shaked O, Garcia Peña BM, Linares MYR, Baker RL. Simple febrile seizures: are the AAP guidelines regarding lumbar puncture being followed? Pediatr Emerg Care 2009;25:8-11.
28. Subcommittee on Febrile Seizures; American Academy of Pediatrics. Neurodiagnostic evaluation of the child with a simple febrile seizure. Pediatrics 2011;127:389-94.
29. Lenchus JD, Carvalho CM, Ferreri K, Sanko JS, Arheart KL, Fitzpatrick M, et al. Filling the void: defining invasive bedside procedural competency for internal medicine residents. J Grad Med Educ 2013;5:605-12.
30. Sawyer T, French H, Ades A, Johnston L. Neonatal-perinatal medicine fellow procedural experience and competency determination: results of a national survey. J Perinatol 2016;36:570-4.
31. McMillan HJ, Writer H, Moreau KA, Eady K, Sell E, Lobos AT, et al. Lumbar puncture simulation in pediatric residency training: improving procedural competence and decreasing anxiety. BMC Med Educ 2016;16:198.
32. Bucher JT, Bryczkowski C, Wei G, Riggs RL, Kotwal A, Sumner B, et al. Procedure rates performed by emergency medicine residents: a retrospective review. Int J Emerg Med 2018;11:7.
33. Cabalatungan SN, Thode HC Jr, Singer AJ. Emergency medicine physicians infrequently perform pediatric critical procedures: a national perspective. Clin Exp Emerg Med 2020;7:52-60.

34. Shackford SR, Rogers FB, Osler TM, Trabulsy ME, Clauss DW, Vane DW. Focused abdominal sonogram for trauma: the learning curve of nonradiologist clinicians in detecting hemoperitoneum. J Trauma 1999;46:553-62 [discussion: 562-4].
35. Bernhard M, Mohr S, Weigand MA, Martin E, Walther A. Developing the skill of endotracheal intubation: implication for emergency medicine. Acta Anaesthesiol Scand 2012;56:164-71.
36. Gaies MG, Landrigan CP, Hafler JP, Sandora TJ. Assessing procedural skills training in pediatric residency programs. Pediatrics 2007;120:715-22.
37. Niles D, Sutton RM, Donoghue A, Kalsi MS, Roberts K, Boyle L, et al. “Rolling Refreshers”: a novel approach to maintain CPR psychomotor skill competence. Resuscitation 2009;80:909-12.
38. Scholtz AK, Monachino AM, Nishisaki A, Nadkarni VM, Lengetti E. Central venous catheter dress rehearsals: translating simulation training to patient care and outcomes. Simul Healthc 2013;8:341-9.
39. Sutton RM, Niles D, Meaney PA, Aplenc R, French B, Abella BS, et al. Low-dose, high-frequency CPR training improves skill retention of in-hospital pediatric providers. Pediatrics 2011;128:e145-51.
40. Kessler D, Pusic M, Chang TP, Fein DM, Grossman D, Mehta R, et al. Impact of just-in-time and just-in-place simulation on intern success with infant lumbar puncture. Pediatrics 2015;135:e1237-46.
41. Kessler DO, Arteaga G, Ching K, Haubner L, Kamdar G, Krantz A, et al. Interns’ success with clinical procedures in infants after simulation training. Pediatrics 2013;131:e811-20.
42. Barsuk JH, Cohen ER, Caprio T, McGaghie WC, Simuni T, Wayne DB. Simulation-based education with mastery learning improves residents’ lumbar puncture skills. Neurology 2012;79:132-7.
43. Patrick SW, Schumacher RE, Davis MM. Variation in lumbar punctures for early- onset neonatal sepsis: a nationally representative serial cross-sectional analysis, 2003-2009. BMC Pediatr 2012;12:134.

50 Years Ago in *The Journal of Pediatrics*

Familial Russell-Silver Syndrome

Fuleihan DS, Der Kaloustian VM, Najjar SM. The Russell–Silver syndrome: report of three siblings. J Pediatr 1971;78:654-7.

In 1971 Fuleihman et al reported 3 siblings (2 male) with clinical features of Russell–Silver syndrome. These features included low birth weight, short stature with craniofacial disproportion, triangular facies, high forehead, café au lait macules, and clinodactyly. Despite the parents’ consanguineous relationship, an autosomal-dominant inheritance for Russell–Silver syndrome in this family appeared to be likely, as the mother of the siblings had short stature and facial features consistent with Russell–Silver syndrome.

We know now that Russell–Silver syndrome may be caused by uniparental maternal disomy for chromosome 7 and hypomethylation of the imprinting center (ICR, H19/IGF2:IGBMR) in 11p15.5 regulating the expression of imprinted genes H19 and IGF2.[1] Most cases of Russell–Silver syndrome occur sporadically. What molecular mechanisms would account for a 50% transmission risk for Russell–Silver syndrome to parental offspring? Maternal microdeletions and microduplications involving chromosome 7, chromosome abnormalities including unbalanced translocations involving 11p15.5, maternal microduplications including *CDKN1C*, and paternal microdeletions involving 11p15.5 are associated with Russell–Silver syndrome. CDKN1C is a maternally expressed cyclin-dependent kinase inhibitor that represses cell proliferation. Pathogenic *CDKN1C* variants inherited from female probands, *IGF2* pathogenic variants inherited from male probands, and *PLAG1* and *HMGA2* variants inherited from either parent are associated with the occurrence of Russell–Silver syndrome.[2] Although less likely, 3M syndrome, associated with severe short stature, macrocephaly, triangular facies, and skeletal features, is in the differential diagnosis for the case reported by Fuleihman et al. Inheritance is autosomal recessive, which can be observed in a consanguineous mating in which one partner is clinically affected with 3M syndrome and the other partner is a carrier for 3M syndrome.

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References

1. Azzi S, Salem J, Thibaud N, Chantot-Bastaraud S, Lieber E, Netchine I, et al. A prospective study validating a clinical scoring system and demonstrating phenotypical–genotypical correlations in Silver–Russell syndrome. J Med Genet 2015;52:446-53.
2. Habib WA, Brioude F, Edouard T, Bennett JT, Lienhardt-Roussie A, Tixier F, et al. Genetic disruption of the oncogenic HMGA2-PLAG1-IGF2 pathway causes fetal growth restriction. Genet Med 2018;20:250-8.

Table I. Codes defining LP

Code type	Code	Description
ICD-9	0331	Spinal tap
ICD-10	009U30Z	Drainage of spinal canal with drainage device, percutaneous approach
ICD-10	009U3ZX	Drainage of spinal canal, percutaneous approach, diagnostic
ICD-10	009U3ZZ	Drainage of spinal canal, percutaneous approach
CTC	3611101113	Aerobic cerebrospinal fluid culture
CTC	3611101213	Aerobic cerebrospinal fluid culture
CTC	3611103113	Aerobic cerebrospinal fluid culture

ICD-9, International Classification of Diseases, Ninth Revision; *ICD-10*, International Classification of Diseases, Tenth Revision; *CTC*, Clinical Transaction Classification Code.