

Perspectives on Starting a Pediatric Spinal Anesthesia Program

Authors:

Alina Lazar, MD

Department of Pediatric Anesthesiology
Ann & Robert H. Lurie Children's Hospital of Chicago
Northwestern University Feinberg School of Medicine, Chicago, Illinois
Email: allazar@luriechildrens.org

Alexander B Froysheter, MD

Department of Pediatric Anesthesiology
Ann & Robert H. Lurie Children's Hospital of Chicago
Northwestern University Feinberg School of Medicine, Chicago, Illinois
Email: afroysheter@luriechildrens.org

Ashlee E Holman, MD

Department of Anesthesiology
C.S. Mott Children's Hospital
University of Michigan Medicine, Ann Arbor, Michigan
Email: holmana@med.umich.edu

Emmett E Whitaker, MD

Department of Anesthesiology and Critical Care Medicine
John's Hopkins Health System, Baltimore, Maryland.
Email: emmett@jhmi.edu

Abstract

The use of spinal anesthesia as an alternative to general anesthesia for infants has seen a significant resurgence in recent years but achieving its successful implementation at an institutional level is not without challenges. This manuscript provides a structured approach to establishing a pediatric spinal anesthesia program, with emphasis on identifying implementation champions, careful preparation, stakeholder engagement, and quality control to ensure a successful and sustainable initiative. The key to success lies in creating an early blueprint for the process, with a focus on ensuring procedural success early on via thorough preparation and careful selection of patients within an initial pilot program. Successful expansion of the program depends on the implementation of robust staffing models, and proactive efforts to educate staff and maintain adherence to established protocols.

1. Introduction

Spinal anesthesia, while well-established in adults, presents unique challenges and opportunities when applied to children. While concerns about the impact of general anesthesia on brain development (1), have led to increased interest in spinal anesthesia (2, 3) they have lessened to a certain extent in recent years. Nonetheless, spinal anesthesia remains a valuable and enduring option, particularly for infants, where currently this technique is most commonly utilized and which is the focus of this manuscript. Its benefits, such as reduction in the risk of respiratory complications associated with airway instrumentation and administration of systemic anesthetics (4), a remarkably stable hemodynamic profile (5), excellent analgesic attributes (6), shorter intraoperative and postoperative times (3, 7), and high parent satisfaction, are increasingly recognized and appreciated in the field of pediatric anesthesiology.

While an increasingly number of institutions (7, 8, 9) have successfully implemented spinal anesthesia programs in recent years, establishing and maintaining such initiatives is fraught with

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: [10.1111/pan.15141](https://doi.org/10.1111/pan.15141)

challenges, and without careful management, they can easily lose momentum or fail to gain traction. Barriers to successful execution include inadequate recovery from early failures, inability to overcome negative staff and parent perceptions as a result of insufficient preparation and education, and failure to design reliable, sustainable processes and staffing models to ensure routine and dependable execution of the technique.

This manuscript outlines key considerations for the implementation of a spinal program rooted in the principles of innovation adoption (10) and based on our collective experiences in establishing and sustaining successful infant spinal anesthesia programs at 6 institutions totaling more than 3000 cases. It provides a structured framework for implementation (Figure 1) and outlines barriers and facilitators to a successful implementation process (Table 1). Emphasis is placed on detailed planning, ensuring safety, team building, and multidisciplinary collaboration.

2. Identifying Stakeholders in the Process and Developing an Institutional Spinal Anesthesia Protocol

The first step in development of an infant spinal anesthesia program is to identify stakeholders and their respective needs and perspectives (Table 2). As discussions with the stakeholders advance, management decisions should be incorporated into an easily accessible institutional protocol, which will be continuously refined and updated to reflect accumulated experience, process improvements, and other enhancements. This protocol will serve as a comprehensive reference for providers participating in the spinal anesthesia program.

Developing a thorough understanding of the theoretical and practical aspects of performing spinal anesthesia is critical prior to embarking on building a spinal anesthesia program. Numerous high-quality reviews on pediatric spinal anesthesia are available for reference. Attendance at local, regional, and national conferences offering workshops and educational sessions on pediatric spinal anesthesia can provide additional insights. Consulting with experts from institutions that frequently perform this technique can greatly enhance the development of expertise.

2.1. Leadership

Securing support from departmental leadership will enhance the program's credibility and increase acceptance among stakeholders. This can be achieved by highlighting the program's potential benefits, such as cost savings, improved efficiency, increased patient volume from families interested in the technique, enhanced patient safety, and greater parental satisfaction. (3, 7) A comprehensive plan that identifies stakeholders, anticipates challenges, and outlines potential solutions will showcase thorough preparation and serve as a valuable blueprint for the implementation process.

2.2. Surgeons

Identifying high-volume surgeon spinal champions from within the same specialty enhances communication and experience-sharing, builds strong departmental alignment, and secures buy-in – making future expansion to other specialties significantly easier. Pediatric urologists are particularly well-suited for this role, as urological procedures are among the most common surgeries in infancy. (11) Most urological procedures involve a surgical site below the umbilicus and typically last less than two hours, making them ideal targets for a pilot program. Reduced risk of anesthesia complications, significant reductions in operating room time, excellent analgesia, and increased parent satisfaction make spinal anesthesia attractive to surgeons; however, some surgeons may be hesitant to adopt an unfamiliar technique. In a survey on preferred anesthetic management for common pediatric urologic procedures, only 20% of responding pediatric urologists favored spinal anesthesia over general anesthesia, and roughly half did not think their anesthesia colleagues would be comfortable performing the technique. (12) The responders expressed concerns about potential operating room delays due to block placement, low success rates, limited anesthesia duration, and procedural disruptions from patient movement, crying, or coughing during surgery. These concerns are unfounded and disproved by data from institutions with

robust spinal anesthesia programs and significant experience with the technique. (13) Surgeons should be reassured that in experienced hands and in well-established programs the average time to induction of spinal anesthesia is less than 5 minutes (9) with success rates of 90-97%. (2, 14, 15, 16) Even in newly implemented spinal anesthesia programs, induction times have been reported between 9 minutes (8) and 13 minutes (17), with success rates ranging from 80% to 89%. (2, 8, 9) These findings indicate that rapid and reliable adoption of the technique is achievable. Patient movement under the drapes is limited, and in one study, only 2% of cases were converted to general anesthesia prior to incision due to lack of motor blockade. (2) In regard to surgical outcomes, secondary results from the General Anesthesia vs Spinal (GAS) study indicate no significant difference in complications between general anesthesia and spinal anesthesia for infants who underwent inguinal hernia repair. (18)

Initial discussions between surgeons and anesthesiologists should focus on identifying patients and procedures that are ideal candidates for spinal anesthesia (e.g., children < 12 months, procedures with less than 1.5-hour surgical duration). Other key elements for discussion include labeling suitable cases during the scheduling process, clarifying communication channels with the spinal program champions or anesthesia coordinators, enlisting the surgeons' support for spinal anesthesia during the preoperative discussion with parents, and optimal educational platforms for parents regarding anesthesia options.

2.3. Parents and Guardians

Parents may have limited awareness of spinal anesthesia as an option for their infant's surgery. Providing comprehensive information and support prior to surgery will mitigate the often-stressful process of selecting the appropriate anesthetic option for their child on the day of surgery. A supportive surgeon is a great resource to initiate the conversation about anesthetic options with parents. This conversation should occur as early as the initial surgical visit. Distribution of educational pamphlets may assist the surgeon with introducing families to the option of spinal anesthesia and will help prepare them for further discussion with the anesthesiologist. (8) (Appendix 1) Special attention should be focused on addressing the needs and concerns of minority groups and those with a lower socioeconomic status who may be more hesitant to accept the use of spinal anesthesia for their child. (19, 20) Ensuring that preoperative discussions about anesthetic technique options are conducted in an unbiased and culturally-sensitive manner is essential to providing equal informed access to spinal anesthesia for all pediatric patients.

2.4. Nursing Staff

Engagement of preoperative, intraoperative, and postoperative nursing staff and leadership through targeted discussion, educational presentations, and rounds is essential to raise awareness of the program, address misconceptions and opposition to challenging the status quo, detail staffing roles in the new process, establish workflows, and build enthusiasm and support for the program. Regular follow up with nursing leadership should occur to address new concerns and reinforce educational and training goals. Individualized in-OR debriefs during or after cases can help to highlight specific knowledge or skill gaps whilst reinforcing processes performed well. Virtual surveys (e.g., using QR codes) can serve as valuable tools during the implementation phase for gathering feedback, identifying areas for improvement, and even as an indirect reminder of new practices that are being instituted. For example, we found that administering a brief survey to the nurses caring for spinal anesthesia patients in Phase 1 recovery - focused on factors contributing to a PACU stay longer than 15 minutes—resulted in a reduction of PACU duration overtime (unpublished data). This outcome may be attributed to increased knowledge and familiarity with new processes, but also to the question-behavior effect, which refers to the influence of asking a question about a behavior on the subsequent performance of that behavior. (21) All feedback, whether positive or negative, should be accepted, reviewed, and acted upon to optimize program success.

2.5. Pharmacy

Intrathecal medications are high-risk drugs that carry a significant potential for error. Vials may have variable labels, leading to administration of incorrect concentrations, volumes, adjuncts, or medications. Dilutional errors can be made by even the most experienced providers. Enlisting the help of pharmacists in compounding and dispensing these medications will enhance safety and reduce waste. Pharmacy is, in general, busiest immediately before first-start cases, so scheduling spinal cases with a slight delay may provide additional time for medication preparation, especially if the preoperative administration of intranasal dexmedetomidine, which has a slower onset, is planned. (8)

2.6. Information Technology (IT) Specialists

IT specialists are instrumental in creating preoperative and postoperative order sets, macros for the documentation of spinal blocks, including intrathecal route, type, and concentration of spinal medications, automatic discontinuation of lumbar topical anesthetics after the placement of the spinal block, as well as integrating spinal anesthesia discharge education materials into the electronic medical record. Spinal team leaders can request privileges to label cases on the operating room status board as “spinal candidate” or “consented for spinal”, enhancing communication and preparedness.

3. Executing a Pilot Program

3.1. The Spinal Champion Team

A dedicated initial spinal anesthesia team consisting of 1-3 surgeons, anesthesiologists, and nurses is ideally positioned to quickly develop expertise, facilitate communication, troubleshoot problems, establish a workflow, and generate momentum.

3.2. Patient Selection

Selecting an appropriate initial patient for spinal anesthesia is crucial for success. Initial successes will foster quicker acceptance and sustained support for the program, whereas repeated failures and complications may demoralize the team and potentially result in abandoning the initiative. In our experience, healthy, term infants 4-6 months of age undergoing brief procedures (i.e., circumcision) are optimal candidates. In younger patients, the thecal sac is narrower and more difficult to access, whereas older patients are more vigorous and more difficult to restrain. (22)

The authors highly recommend contacting the families of prospective patients prior to the day of surgery to discuss spinal anesthesia as an anesthetic option. Many caregivers value having adequate time to consider the benefits and risks of spinal anesthesia as well as being able to discuss any concerns they may have in advance with the anesthesiologist and other members of their child’s care team (e.g., surgeon, pediatrician). Preoperative phone calls during the pilot period will enable anesthesiologists to better understand parental attitudes towards spinal anesthesia and will assist in refining their approach to education and consent. As the use of spinal anesthesia becomes more common, the approach to parental education may shift to relying more on preoperative distribution of well-designed written and/or video materials, reducing the need for time-intensive individual consultations.

3.3. Creating Optimal Conditions for Successful Spinal Block Placement

Use of preoperative sedation for appropriate patients is highly recommended during the initial pilot period to ensure optimal conditions during block placement. Premedication may help to ensure a calm baby who separates easily from parents, tolerates positioning and spinal injection, and quickly falls asleep after the block is placed. Older infants may move more vigorously during positioning and needle insertion, which can make the procedure more challenging and stressful for both the provider performing the spinal block as well as for those who are holding the infant. This patient group may also benefit from prophylactic premedication beyond the pilot period. Dexmedetomidine in modest doses has been proven

effective in improving the success of the block, is neuroprotective, and may extend the duration of the block. (8, 9) It has been widely used as a procedural sedative for imaging studies in children of all ages (23) and has been demonstrated to be safe, even in infants under 60 weeks postconceptional age, including those with preexisting oxygen requirements and a history of apnea. (24) However, additional studies are necessary to validate these findings in this specific age group. The administration of sedatives, including dexmedetomidine, to patients in this demographic should be approached with caution or deferred.

In all circumstances, optimizing the infant's comfort is a priority and includes bringing comfort items (e.g., pacifier, blanket) to the operating room and oral administration of Sweet-Ease (sucrose and purified water solution by Philips Healthcare, Andover, Mass.) during the block placement. Optimal holding is critical to the success of the procedure and should be done firmly but gently, focusing on stabilizing the infant's pelvis and preventing back-arching. A second assistant may be needed to stabilize an older infant's torso. Occasionally, as expertise with infant holding and comforting is developing, nitrous oxide may be briefly administered via face mask to create better conditions for spinal placement and reduce the need for repeated attempts. However, nitrous oxide is not without side effects and is becoming less commonly available in operating rooms due to growing concerns about its environmental impact.

Positioning the patient in lateral decubitus for spinal placement can reduce movement but may pose technical challenges due to a reduced interspinous distance and lower cerebrospinal fluid (CSF) pressure compared to the sitting position. This can result in a smaller intrathecal target and slower flow, particularly following an extended fasting period. (25)

Careful preparation and organization of all supplies necessary for the procedure requires forethought and planning. Readily available standardized and easily retrievable supplies (Figure 2, Figure 3) and materials to guide the process (i.e., checklists, protocol) will ensure that the technique is easy to adopt and implement while maintaining high standards of quality and safety.

Prior to bringing the patient into the operative theater, the room should be prepared for provision of both spinal anesthesia and general anesthesia as backup. The patient's correct dose of medication with or without adjuvants should be calculated and prepared in sterile fashion with a secondary back-up syringe immediately available should the primary syringe become contaminated or dropped. The electrosurgical grounding pad should be removed from its packaging, and blankets and towels for positioning and advanced equipment for securing intravenous access should be present. Reviews (26, 27, 28, 29) and guidelines from experienced institutions (Appendix 2) detailing the optimal execution of the procedure, as well as troubleshooting strategies for mitigating potential challenges (e.g., difficult IV access, managing an unhappy infant) and complications (e.g., failed spinal, high spinal) (16, 29, 30, 31) should be thoroughly reviewed and readily available.

3.4. Staff Education and Training

Early successes and positive experiences for all involved parties—surgeons, nursing staff, and anesthesiologists—are vital for the acceptance and sustained adoption of infant spinal anesthesia. Performing spinal blocks in awake or mildly sedated patients represents a significant paradigm shift for most pediatric institutions. Proactively setting expectations, demonstrating patient comfort and safety during the procedure, and actively eliciting and addressing staff feedback is essential during both early implementation and later maintenance of the program.

Education of preoperative nursing staff should include correct and timely application of the topical local anesthetic in the lumbar area, prompt administration of premedication if desired, and communication of expected time of onset for each medication so that optimal coordination can be achieved. As the program expands to include NICU and PICU patients, it will be essential to provide education to nursing staff in these areas as well. This should optimally incorporate written materials, given the relatively infrequent nature of these cases for each individual nurse. Child life specialists can be

invaluable in engaging and distracting older infants during separation from their parents, placement of the spinal block, and surgical procedure itself, if the child remains awake.

Thorough training of the operative staff and technicians is critical to ensure effective patient positioning, as well as efficient IV placement, site preparation, and surgical draping. It is crucial to emphasize the need for a quiet environment to prevent startling or waking the patient during surgery. Performing an early huddle with the operating room team and conducting the surgical time-out prior to performing the spinal block ensure clear communication, readiness, and efficiency across the entire team.

Training of post-operative care unit (PACU) nurses is crucial for quickly identifying potential complications, such as postoperative apnea in at-risk neonates and infants, and to ensure that patients are not kept in the unit longer than necessary. As more experience is accumulated, bypassing phase 1 recovery for infants who are fully awake at the end of surgery can be explored.

Identifying nursing champions is instrumental in promoting training among other nurses and assisting in the promotion of the program. Fostering expertise within this group through regular didactics, retreats, and group emails is highly recommended, as is actively seeking team member input to continuously refine and streamline processes.

3.5. Concluding the Pilot Program

The pilot program aims to rapidly develop expertise in a few spinal champions (32) while refining protocols and processes to achieve a stable, satisfactory success rate. Feasibility studies generally recommend sample sizes of 30 or fewer to reach saturation (33). At the conclusion of this phase, results should be presented to leadership and stakeholders—including surgeons, anesthesiologists, and nurses—through staff meetings or grand rounds. The report should encompass outcome measures such as success rates, process measures (e.g., anesthesia and operating room times, PACU stay duration, time to first oral intake), and balancing measures (e.g., turnover time). Including examples of situations where spinal anesthesia proved to be a superior option and highlighting parent testimonials will provide additional impact. This is an important opportunity, along with key milestones (e.g., completing 100 cases under spinal anesthesia), to celebrate successes and leverage them to energize the team and sponsors, building and sustaining momentum for the program.

4. Program Expansion

After a successful pilot program, the top priority of the spinal anesthesia champions should be training additional anesthesiologists to match the increased demand from surgeons, while maintaining or improving quality standards.

A comprehensive educational strategy should be developed to ensure that all individuals learning the technique achieve a high level of competence. This may include live or recorded lectures, videos demonstrating the setup and procedural technique, knowledge tests, easily available protocols and cognitive aids, and supervised practice on a simulator (Figure 4) until competence is achieved. It is essential to discuss non-routine situations with learners, including troubleshooting difficulties in block placement, accurately diagnosing, and managing incomplete blocks, addressing potential problems after block placement (such as patient movement, irritability, or hiccups), and handling complications like high or total spinal. Limiting the spinal team to individuals with expertise in regional anesthesia or a special interest in spinal anesthesia may accelerate the learning curve for these practitioners. However, training a broader group enhances the system's capacity to ensure consistent coverage for spinal cases at all times.

To promote a rapidly ascending learning curve, it is critical to ensure a robust and systematic exposure to cases. Proactively identifying potential cases and strategically assigning experienced providers to assist new learners fosters timely expertise development and reinforces the expectation that spinal anesthesia will be the default anesthetic option for specific cases. At Lurie Children's Hospital, a spinal anesthesia case schedule is created a month in advance by rotating spinal champions and updated weekly, using a live document accessible to the entire spinal anesthesia team. This document tracks tasks

such as contacting surgeons and families, assigning anesthesiologists based on training priorities, and communicating with operating room coordinators. Initially, at the University of Michigan, the anesthesiologist spinal champion reviewed the operating room schedule on a weekly basis, selecting cases and confirming spinal candidacy individually with each surgeon. Once spinal anesthesia became the default anesthetic option for select cases and was expected by surgeons, the surgery schedulers began booking cases under spinal anesthesia, with subsequent weekly schedule review and updating of anesthetic type by the anesthesiologist spinal champion if needed.

As the program matures and more anesthesiologists become comfortable with performing spinal anesthesia, daily staff assignments will require less hands-on input and engineering. Tagging cases as 'spinal anesthesia candidates' by surgery schedulers or spinal anesthesia champions can streamline coordination of case assignments and support the transition towards designating spinal anesthesia as the default option for specific cases.

As anesthesia expertise grows, use of spinal anesthesia can be extended to additional surgical specialties (e.g., general surgery, orthopedics), older patients, and even more complex or lengthy procedures (e.g., in combination with caudal catheters). Special attention should be given to expanding the use of infant spinal anesthesia to ambulatory surgical centers, where many of these qualifying cases are scheduled. (34) Expansion to other sites may involve rethinking spinal medication retrieval processes, adapting staff education to address local practice patterns, and ensuring that assigned anesthesia teams are fully capable of independently and reliably performing the procedure.

5. Quality Control and Program Sustainability

Spinal anesthesia in infants has a long track record of safety, but rare complications may occur. (5) These must be monitored, recorded, and managed effectively. Discharge instructions listing concerning symptoms (e.g., persistent lower extremity weakness, vomiting, poor oral intake, excessive fussiness, lethargy, depressed fontanelles, fever) and contact information for the anesthesia team should be given to parents prior to leaving the hospital. Maintaining open communication with surgeons will help to identify rare events. Additionally, postoperative checks or phone calls after discharge performed by designated nursing staff or other personnel can help detect complications and assess the level of parental satisfaction. Those conducting postoperative checks should be trained to specifically inquire about issues related to infant spinal anesthesia.

Formal outcome reviews, both prospective and retrospective, are important for quality control and research purposes. Tools like EPIC® SlicerDicer can be used by spinal anesthesia team leaders to monitor structural, process, and outcomes measures, and live reports can be generated by data analysts using electronic medical records.

Creating and participating in an infant spinal anesthesia program can be an important source of satisfaction, empowerment, professional pride, and team building and may even lead to decreased burnout. It also serves as a great opportunity to provide mentorship, collaborate with colleagues across various specialties and institutions, and advance professional growth. Most importantly, spinal anesthesia directly benefits the youngest and most vulnerable pediatric patients and their families by allowing them access to a simple and effective alternative to general anesthesia.

6. Conclusion

Pediatric anesthesia is a field that embraces innovation and continuously aims to enhance patient care. Successful implementation of changes in practice patterns necessitates a structured, systematic approach to identify potential challenges and formulate effective solutions. In this manuscript, we discussed several common obstacles and subsequent mitigation strategies in developing and maintaining an infant spinal anesthesia program. Engaging in well-informed discussions, starting with a small pilot program, managing expectations, and optimizing success rates from the start can address surgeon and staff hesitancy with accepting new, workflow-altering techniques. Coordinated efforts to identify

qualifying cases, engage with parents of prospective spinal candidates early in the perioperative process, and ensure appropriate anesthesia staffing models are essential for optimal case capture and accelerating expertise development. A robust and strategic process for provider education and mentoring is vital for long-term success and growth. Optimal patient positioning and ensuring comfort are crucial for achieving high success rates with spinal anesthesia, thereby increasing the technique's appeal and acceptability. Standardization of supplies, resources, and processes improves technique uptake and quality control. Additionally, active promotion of a successful program will spotlight direct benefits to the patient and the institution and will garner support from hesitant team members and leadership.

References

1. [FDA Drug Safety Communication](#) issued on 4-27-2017.
2. Whitaker EE, Wiemann BZ, Dajusta DG, et al. Spinal anesthesia for pediatric urological surgery: reducing the theoretic neurotoxic effects of general anesthesia. *J Pediatr Urol.* 2017;12(4):393-400.
3. Ing C, Sun LS, Friend AF, et al. Adverse events and resource utilization after spinal and general anesthesia in infants undergoing pyloromyotomy. *Reg Anesth Pain Med.* 2016;41(4):532-7.
4. Welborn LG, Rice LJ, Hannallah RS, et al. Postoperative apnea in former preterm infants: prospective comparison of spinal and general anesthesia. *Anesthesiology.* 1990;72(5):838-42.
5. Dohi S, Naito H, Takahashi T. Age-related changes in blood pressure and duration of motor block in spinal anesthesia. *Anesthesiol.* 1979;50(4):319-23.
6. Ebert KM, Jayanthi VR, Alpert SA, et al. Benefits of spinal anesthesia for urologic surgery in the youngest of patients. *J Pediatr Urol.* 2019;15(1):49.e1-49.e5.
7. Heydinger G, Roth C, Kidwell R, et al. A single center's experience with spinal anesthesia for pediatric patients undergoing surgical procedures. *J Pediatr Surg.* 2024;59(6):1148-53.
8. Cronin JA, Satterthwaite B, Robalino G, et al. Improving outcomes through implementation of an infant spinal anesthesia program for urologic surgery patients. *Pediatr Qual Saf.* 2023;8(3):e615.
9. Handlogten K, Warner L, Granberg C, et al. Implementation of a spinal anesthesia and sedation protocol that reliably prolongs infant spinal anesthesia: case series of 102 infants who received spinal anesthesia for urologic surgery. *Paediatr Anaesth.* 2020;30(12):1355-62.
10. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: systematic review and recommendations. *Milbank Q.* 2004;82(4):581-629.
11. Shi Y, Hu D, Rodgers EL, et al. Epidemiology of general anesthesia prior to age 3 in a population-based birth cohort. *Paediatr Anaesth.* 2018;28(6):513-9.
12. Rehfuess A, Bogaert G, Kogan BA. Spinal anesthesia in children: most pediatric urologists are not on board. *J Pediatr Urol.* 2019;15(3):263.e1-263.e5. doi:10.1016/j.jpuro.2019.02.020.
13. Holman A, Haydar B, Kraft K, et al. Infant spinal anesthesia: a safe, efficient, and worthwhile collaboration. *J Pediatr Urol.* 2019;15(5):583-4.
14. Eizaga Rebollar R, García Palacios MV, Morales Guerrero J, et al. Pediatric spinal anesthesia at a tertiary care hospital: Eleven years after. *Paediatr Anaesth.* 2022;32(5):617-24.
15. Kachko L, Simhi E, Tzeitlin E, et al. Spinal anesthesia in neonates and infants – a single-center experience of 505 cases. *Paediatr Anaesth.* 2007;17(7):647-53.
16. Williams RK, Adams DC, Aladjem EV, et al. The safety and efficacy of spinal anesthesia for surgery in infants: The Vermont Infant Spinal Registry. *Anesth Analg.* 2006;102:67-71.
17. Liu CA, Davis N, Kelleher CM. Application of an infant spinal anesthesia protocol in infants presenting for inguinal herniorrhaphy improves operating room and postanesthesia recovery unit utilization. *Paediatr Anaesth.* 2019;29(8):881-2.
18. Disma N, Withington D, McCann ME, et al. Surgical practice and outcome in 711 neonates and infants undergoing hernia repair in a large multicenter RCT: Secondary results from the GAS Study. *J Pediatr Surg.* 2018;53(9):1643-50.

19. Lo C, Ross PA, Le S, et al. Engaging parents in analgesia selection and racial/ethnic differences in analgesia given to pediatric patients undergoing urologic surgery. *Children*. 2020;7(12):277.
20. Baetzel AE, Holman A, Dobija N, et al. Racial disparities in pediatric anesthesia. *Anesthesiol Clin*. 2020;38(2):327-39.
21. Sprott DE, Spangenberg ER, Block LG, et al. The question-behavior effect: What we know and where we go from here. *Soc Infl*. 2006;1(2):128-37.
22. Baxter AL, Fisher RG, Burke BL, Goldblatt SS, Isaacman DJ, Lawson ML. Local anesthetic and stylet styles: factors associated with resident lumbar puncture success. *Pediatrics*. 2006;117(3):876-81.
23. Tervonen M, Pokka T, Kallio M, Peltoniemi O. Systematic review and meta-analysis found that intranasal dexmedetomidine was a safe and effective sedative drug during paediatric procedural sedation. *Acta Paediatr*. 2020 Oct;109(10):2008-2016.
24. Leister N, Yüce-tepe S, Ulrichs C, Pietsch S, Schink U, Kilian J, Menzel C, Trieschmann U. Dexmedetomidine as a sole sedative for procedural sedation in preterm and neonate infants: A retrospective analysis. *Paediatr Anaesth*. 2022 Aug;32(8):907-915.
25. Apiliogullari S, Duman A, Gok F, et al. The effects of 45-degree head-up tilt on the lumbar puncture success rate in children undergoing spinal anesthesia. *Paediatr Anaesth*. 2008;18(12):1178-82.
26. Trifa M, Tumin D, Whitaker EE, et al. Spinal anesthesia for surgery longer than 60 min in infants: experience from the first 2 years of a spinal anesthesia program. *J Anesth*. 2018;32(4):637-40.
27. Kokki H. Spinal anaesthesia in infants and children. *Best Pract Res Clin Anaesthesiol*. 2000;14(4):687-707.
28. Disma N, Clunies-Ross N, Chalkiadis GA. Is spinal anaesthesia in young infants really safer and better than general anaesthesia? *Curr Opin Anaesthesiol*. 2018;31(3):302-7.
29. Frawley G, Ingelmo P. Spinal anaesthesia in the neonate. *Best Pract Res Clin Anaesthesiol*. 2010;24(3):337-51.
30. Frawley G, Bell G, Disma N, et al. Predictors of failure of awake regional anesthesia for neonatal hernia repair: Data from the General Anesthesia Compared to Spinal Anesthesia Study—comparing apnea and neurodevelopmental outcomes. *Anesthesiology*. 2015;123(1):55-65.
31. Frawley G. Second infant spinal anesthetic: Incidence, dose modification, and adverse events after initial failure. *Paediatr Anaesth*. 2024;34(4):324-31.
32. Lew E, Allen JC Jr, Goy RWL, Ithnin F, Sng BL. Determining competence in performing obstetric combined spinal-epidural procedures in junior anesthesiology residents: results from a cumulative sum analysis. *Int J Obstet Anesth*. 2020;44:33-39.
33. Teresi JA, Yu X, Stewart AL, Hays RD. Guidelines for Designing and Evaluating Feasibility Pilot Studies. *Med Care*. 2022;60(1):95-103.
34. Heydinger G, Kim SS, Beltran RJ, et al. Ambulatory spinal anesthesia in infants $\leq$ six months of age: A retrospective review of outcomes and safety. *J Clin Anesth*. 2022;81:110920.

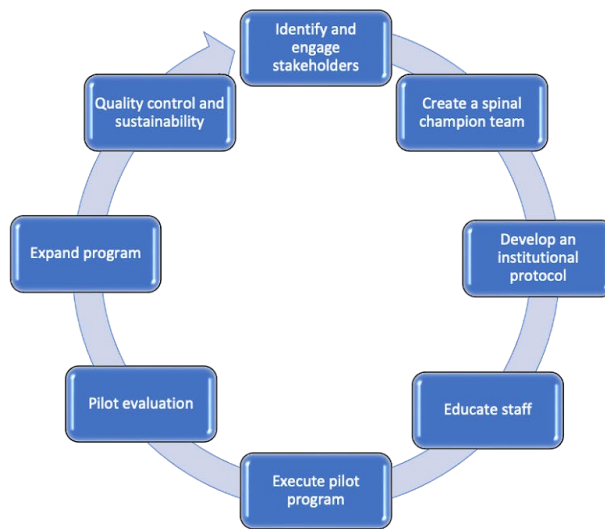


Figure 1. Process of developing a spinal anesthesia program

Table 1. Factors influencing the successful implementation of a spinal anesthesia program	
Barriers	Facilitators
CULTURAL	
• Staff resistance to change • Previous failures • Apprehension about liability • Staff uncertainty about benefits • Reduced institutional ability to implement changes • Hierarchical culture	• Organizational absorptive capacity for change and innovation (pre-existing regional anesthesia knowledge and skill, favorable surgeons' attitude towards regional anesthesia) • Social and professional connectivity, opportunities to network with experts from other institutions • Perception of positive impact (sharing testimonials from parents, surgeons, staff) • Recognizing and celebrating successes; maintaining a visible, real-time track record of achievements
TECHNICAL	
• Lack of expertise • Unstandardized, difficult to locate supplies	• Providing flexible training opportunities, using multiple learning strategies (written protocols, cognitive aids, didactic presentations, simulation, just-in-time learning, on-the-job training)
ORGANIZATIONAL	
• Lack of strong or effective cooperation and synergy between physicians/staff.	• Prior experience implementing innovations. • Strong channels of communication with other professional groups (pharmacy, informatics, supply chain)

• Ineffective communication across departmental boundaries	• Fostering team cohesion by creating dedicated channels of communication, providing easy access to live protocols and algorithms, and organizing regular meetings
STRATEGIC	
• Planning that does not cover all contingencies • Failure to seek or receive departmental and institutional support • Lack of focus on outcome measures (including balancing measures) • Inconsistent leadership • Inconsistent staff availability • Resource inadequacy (faculty turnover, burnout, dissatisfaction, work overload)	• Early and widespread involvement of staff at all levels in decision-making and creating a collective vision and goal for the program • Developing simple, reproducible workflows, standardized supplies, and detailed protocols for all contingencies • Ensuring consistent expert support to novice users • Working towards building the expectation that spinal anesthesia is the default anesthetic for all qualifying procedures and patients • Creating reliable mechanisms to capture all potential cases at each stage of implementation and ensuring appropriate staffing and support • Providing periodic updates on all outcome measures to all stakeholders through efficient data collection and review systems • Enhancing practitioner's sense of ownership (e.g., taking turns creating a spinal schedule and interfacing with surgeons and board runners) • Compensating additional administrative responsibilities • Engaging team members in academic projects derived from clinical work involving spinal anesthesia

Table 2. Stakeholders in the process of implementation of a spinal anesthesia program and their perspectives

Stakeholders	Perspectives
Parents and guardians	Unfamiliarity with the technique, concerns about baby's comfort and potential complications, interest in avoiding general anesthesia
Surgeons	Minimizing operating room delays, ensuring optimal surgical conditions, enhancing parent/guardian satisfaction, consistency in technique availability
Anesthesiologists	Optimizing patient's safety and comfort, performing a new technique in a high-stakes environment
Nursing	Ensuring patient comfort and safety, adapting to new routines and workflow
Leadership	Achieving cost savings, improving efficiency, enhancing patient safety, boosting parental satisfaction, and attracting families interested in the technique
Pharmacists	Ensuring the availability and safe administration of spinal medications
IT specialists	Developing appropriate order sets and spinal block documentation

NICU, PICU	Timely communication with anesthesiologists regarding case appropriateness and patient preparation
------------	--

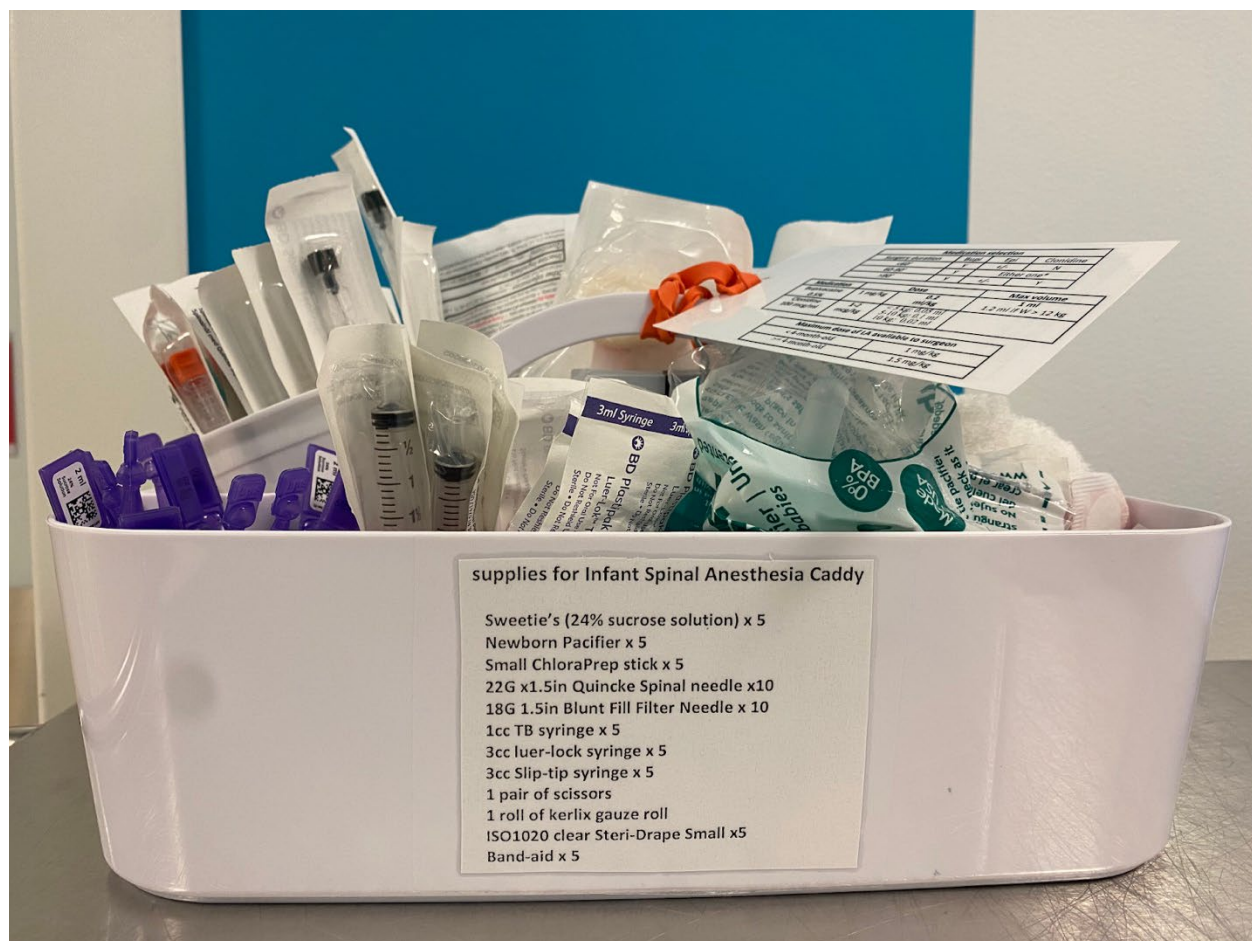


Figure 2. Spinal anesthesia caddy and cognitive aid



Figure 3. Commercial infant spinal anesthesia kit



Figure 4. Infant spinal block simulation mannequin developed at the University of Michigan (courtesy of

Dr. Ashlee Holman)