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Yearbook *of* Anesthesiology 13

Yearbook of Anesthesiology 13

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Editors
Mukul Chandra Kapoor
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Contents

1. Ultrasound for Airway Assessment 1
Riccardo Antolini, Stefano Falcetta, Andrea Carsetti

- Use of the Probe *3*
- Ultrasound Anatomy of the Upper Airway *3*
- Assessment of Difficult Airways Using Ultrasound *8*
- Confirmation of Endotracheal Intubation *9*
- Laryngeal Edema Assessment *10*
- Evaluation for Percutaneous Tracheostomy *11*
- Evaluation for Cricothyrotomy *11*
- Pediatric Patients *12*

2. Negative Pressure Pulmonary Edema 16
Niti Batra

- Pathophysiology *17*
- Clinical Features *20*
- Diagnosis *21*
- Investigations *24*
- Management *26*

3. Uncommonly Performed Regional Anesthesia Techniques 30
Deepak Pahwa

- Sphenopalatine Ganglion Block *31*
- Superior Trunk Block *33*
- Selective Trunk Block *36*
- Clavipectoral Fascial Plane Block *37*
- Medial Cutaneous Nerve of Forearm Block *39*
- Lateral Cutaneous Nerve of Forearm Block *41*
- Transversus Thoracic Plane Block/Parasternal Intercostal Plane Block *42*
- External Oblique Intercostal Plane Block *45*
- Genitofemoral Nerve Block *47*
- Pudendal Nerve Block *49*
- Sacral Multifidus Plane Block *51*
- Deep Posterior Gluteal Compartment Block *51*

4. Continuous Spinal Anesthesia 57
Pratibha Jain Shah, Anisha Nagaria

- Historical Background *59*
- Advantages *60*

- Indications *61*
- Contraindications *61*
- Equipment (Kit) Required *62*
- Technique of Continuous Spinal Anesthesia *64*
- Drugs to be Used *65*
- Problems/Complications *65*
- Continuous Spinal Anesthesia in Obstetrics *67*

5. The Impact of Perioperative Variables on Morbidity and Mortality of Elderly Hip Fractures 71
Ioana Pasca, Haad Arif, Gian Ignacio, Ashish Sinha

- Type of Fractures *72*
- Age and Sex *72*
- Frailty *73*
- Comorbidities *75*
- Kidney Disease *76*
- Chronic Obstructive Pulmonary Disease *77*
- Cognitive Impairment *77*
- Infection *78*
- Causes of Mortality *78*
- Postoperative Delirium *87*
- General versus Regional Anesthesia *88*
- Hypotension *88*

6. Anesthesia for Spine Surgeries 97
Balavenkatasubramanian Jagannathan, Vivekanandan Natarajan, Sathish Rajaselvam Parameswaran

- Preanesthetic Considerations and Assessment *98*
- Physiological Changes of Positioning in Spine Surgeries *101*
- Positioning—Anesthetic Considerations *101*
- Anesthetic Drugs *104*
- Anesthetic Equipment *106*
- Anesthetic Techniques *109*
- Anterior Approach for Thoracic Spine Surgeries *110*
- Complications and their Prevention *111*

7. Total Intravenous Anesthesia: Basic Principles and Practical Aspects 117
Gaurav Kakkar

- History *118*
- TIVA or TCI: What is the Difference? Or are They Identical? *119*
- Benefits of Total Intravenous Anesthesia *119*
- Disadvantages of Total Intravenous Anesthesia *120*
- Pharmacokinetics *121*

- Commonly Used Models *123*
- Commonly Used Terminologies *124*
- TIVA in Special Circumstances: Elderly/Pediatrics/Obese *125*
- Practical Aspects: Fifteen Rules for TIVA *125*
- Total Intravenous Anesthesia Outside the Operating Room *127*
- Total Intravenous Anesthesia in India *127*

8. The Contemporary Perioperative Management of Pheochromocytoma 130
A Kumar, Venkatesan Thiruvenkatarajan

- Etiology and Epidemiology *131*
- Clinical Features *131*
- Biochemical Investigations and Imaging *132*
- Preoperative Evaluation and Preparation *132*
- Pharmacological Preparation for Blood Pressure Control *133*
- Assessment and Optimization of Myocardial Function *135*
- Intravascular Volume Optimization *136*
- Surgical Approach *136*
- Anesthesia Management *137*
- Intraoperative Hemodynamic Response *142*
- Postoperative Management *144*
- Specific Scenarios *144*

9. Sedation for Healthcare Interventions: Should Anesthetists be Worried? 151
Harriette Beard, Anavi Prakash, Amit Prakash

- Sedation Outside the Operating Room *152*
- Patient Selection *155*
- Monitoring *155*
- Pharmacology *157*
- Recovery and Discharge *158*
- Training *159*
- Governance *160*

10. Space: The New Frontier for Nonoperating Room Anesthesia 162
Shagun Bhatia Shah, Rajiv Chawla, Uma Hariharan

- Stressors in the Space Milieu *164*
- Pathophysiological Effects on the Human Body *164*
- Logistic Issues *167*
- The Damage Control Philosophy *167*
- Surgical Considerations *168*
- Anesthetic Considerations *169*

- General Anesthesia *173*
- Cardiopulmonary Resuscitation in Space *176*
- Telemedicine Technology *176*
- Imaging Techniques *177*
- Aerospace Medicine Sieve *177*
- Future Directions *178*

11. Premedication in Pediatric Anesthesia 183
Dave Barrett, Shireen Edmends

- Psychological Factors *184*
- Extrinsic Factors *184*
- Choosing the Ideal Agent *184*
- Discussion of Common Agents *185*

12. Anesthesia for Robotic Surgeries in Children.....200
Neerja Bhardwaj, Ravi P Kanojia

- The Robotic System *202*
- Laparoscopic Surgery *204*
- Prerequisites for Robotic Procedures *208*
- Preoperative Assessment and Investigations *209*
- Monitoring *210*
- Anesthesia Management *210*
- Postoperative Management of Pain *212*
- Complications *212*

13. Hepatobiliary Disease and Anesthesia 216
Tejal Desai, Hesham Youssef, Achal Dhir

- Anatomy and Physiology *217*
- Liver Disease *219*
- Other System Involvement in Liver Disease *223*
- Scoring Systems *227*
- Patients with Hepatobiliary Disease Coming for Nonhepatic Surgery: Perioperative Risks *229*
- Patients with Hepatobiliary Disease Presenting for Nonhepatic Surgery: Preoperative Assessment *229*
- Preoperative Investigations *230*
- Anesthetic Management of Patients with Chronic Liver Disease *231*

14. Acute Kidney Disease and Anesthesia 241
Sophia TH Chew

- Definition of Acute Kidney Injury *242*
- Normal Physiology of the Kidneys *244*
- Pathophysiology of Acute Kidney Injury *244*

- Formation of Microvascular Thrombi *245*
- Risk Prediction Models *246*
- Perioperative Patient Management *251*
- Renal Replacement Therapy *254*
- Outcomes of Acute Kidney Injury and Acute Kidney Disease *254*
- Postoperative Monitoring and Management *255*

15. Perioperative Management and Anesthetic Implications of Drug Addiction and Substance Abuse 260
Puneet Khanna

- Screening for Substance Abuse *262*
- Opioid Use Disorders *262*
- Alcohol *263*
- Cannabis *264*
- Nicotine *264*
- Vaping Substances *264*

16. Anticoagulation and Regional Anesthesia 267
Eric King, Harsimran Kaur, Shalini Dhir

- Considerations before Regional Anesthesia for Patients on Anticoagulation *268*
- Complications *269*
- Common Anticoagulants *270*
- Management of Antithrombotic Therapy in Obstetric Patients *274*

17. Clinical Outcome Scoring in Intensive Care 279
Pallavi Ahluwalia

- Validation and Testing Model Performance *281*
- Outcome Prediction Scores Used in Healthcare *281*
- Organ Dysfunction Scores *286*
- Severity Assessment Based on Impact on Nurses' Workload *288*
- Single Organ or Disease-specific Scoring Systems *290*
- Do We have an Ideal Scoring System? *290*
- Why do We Need a Scoring System in ICU? *291*
- Problems of Using Severity of Illness Scores to Compare Outcomes between ICUs *291*

18. Extracorporeal Membrane Oxygenation Support in Intensive Care 296
Vivek Gupta, GS Wander

- What is Extracorporeal Membrane Oxygenation? *297*
- Progress of ECMO *297*
- Physiology *298*

- Indications and Patient Selection *301*
- Contraindications *303*
- Circuit Configuration and Design *304*
- Management Strategy during ECMO *305*
- Issues, Challenges, and Complications during ECMO *309*

19. Delirium in Intensive Care 318
Prathamesh Milind Patwardhan, Sandeep Lakhani

- Incidence and Prevalence *319*
- Risk Factors *319*
- Pathophysiology *320*
- Clinical Presentation *322*
- Diagnosis and Evaluation *323*
- Investigations *324*
- Prevention *325*
- Treatment *326*
- Way Forward *327*

20. Objective Pain Monitoring: A Gift from Artificial Intelligence 331
Rajesh Bhavsar, Laima M, Thomas Stroem

- Pain: Revisited *332*
- Objective Pain Monitoring: Overview *333*
- Artificial Intelligence *339*
- Nociception Level Index Monitor *342*
- Clinical Applicability *345*
- Validity *345*
- Pitfalls *346*

21. Methadone for Perioperative Pain 352
Skule Bakke, Rajesh Bhavsar, Thomas Stroem

- Methadone: An Interesting Alternative *354*
- History and Pharmacology of Methadone *354*
- Clinical Applicability: Previous Experience *356*
- Methadone: Major Concerns *357*
- Dose *359*
- Methadone Advantages *360*

22. Return to Intended Oncologic Therapy 366
Rajiv Chawla, Shagun Bhatia Shah, Uma Hariharan

- Cancer Treatment *368*
- Cancer Therapy Options *368*
- What is "Intended Therapy?" *369*

- Literature Review in RIOT: Equivocal Role of RIOT in Cancer Cure and Cancer Recurrence *373*
- Prospects *373*
- Limitations of Return to Intended Oncologic Therapy *385*

23. Nontechnical Skills in Anesthesiology 388
Pradeep Bhatia, Swati Chhabra

- History of Nontechnical Skills *389*
- Purpose of Nontechnical Skills *390*
- Application of Nontechnical Skills in Anesthesiology *390*
- Training in Nontechnical Skills *393*
- Measuring the Nontechnical Skills *394*
- Role of Organizations *394*
- Global Status of Training in Nontechnical Skills *396*
- Barriers to Effective Implementation of Nontechnical Skills *397*

24. Advanced Features in the Modern Anesthesia Workstation 400
Bharti Wadhwa, Kiran Mahendru

- New Features in Anesthesia Workstations *401*
- Enhanced Gas Delivery Systems *401*
- Drug Delivery Innovations *404*
- Remote Monitoring and Telemedicine *408*
- Integration of Digital Health Technologies *408*
- Ergonomic Designs and User Interfaces *409*
- Simulation and Training Solutions *410*

25. End of Life: Laws and Policies 413
Anjali Gera, Bimla Sharma

- Need for End-of-life Laws and Policies *414*
- Euthanasia *415*
- End-of-life Laws in Other Countries *416*
- The Legal Framework in India *417*
- Legal Evolution of Laws on End of Life *418*
- Law Commission of India Report *422*
- Recent Judgment *422*

Index 427

CHAPTER

4

Continuous Spinal Anesthesia

Pratibha Jain Shah, Anisha Nagaria

ABSTRACT

Continuous spinal anesthesia (CSA) is a reliable and versatile but underutilized centrineuraxial technique in which a small titrated amount of local anesthetic (LA) is injected into subarachnoid space through an indwelling catheter to achieve the height of block as per the surgical need with stable hemodynamic, to extend block duration for prolonged surgery and to provide post-operative analgesia. Most of the reviewed literature has pointed out the advantages of CSA over general anesthesia (GA), spinal and epidural anesthesia, and combined spinal-epidural, especially in high-risk elderly patients and after an accidental dural puncture in obstetric patients. Most complications associated with CSA, like meningitis, postdural puncture headache (PDPH), and neurological complications, are preventable. As mentioned in the chapter, one must weigh the advantages and disadvantages of CSA in a selected group of patients with specific indications. This technique will be needed more in the coming times because of the increasing age of surgical presentation and associated systemic illness. This chapter also covers the historical background, indications, contraindications, methodology, and precautions to avoid complications.

Keywords: Anesthesia techniques; Continuous spinal anesthesia; Single-shot spinal anesthesia; Intrathecal/spinal catheter; Epidural catheters; Microcatheters; Complications of continuous spinal anesthesia

KEY POINTS

- Continuous spinal anesthesia (CSA) is a well-established, reliable centrineuraxial technique in which a small titrated volume of local anesthetics (LAs) is injected intermittently through an intrathecal catheter to produce and maintain a desired level of sensory block to extend the duration of the blockade in case of prolonged surgeries and to provide postoperative analgesia.

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- It has an excellent success rate and provides good hemodynamic stability. Hence, safe for lower limb and abdominal surgery in high-risk, trauma, and elderly patients.
- Besides many advantages over single-shot spinal anesthesia (SSSA), epidural anesthesia, combined spinal–epidural anesthesia, and general anesthesia (GA), CSA is not so popular and underutilized by anesthesiologists due to technical reasons and false belief that it is associated with a high risk of postdural puncture headache (PDPH), meningitis, and neurological complications.
- To avoid curling and caudal displacement, the intrathecal catheter should not be advanced beyond 3 cm into subarachnoid space. It should be labeled appropriately to avoid any medication errors.
- Catheter insertion, manipulation, and drug injection should be done under strict asepsis, preferably by a single anesthesiologist or caregiver aware of the intrathecal catheter.
- Despite the high risk of PDPH in the obstetric population, CSA is considered in specific challenging situations such as previous spinal surgery, significant maternal cardiac disease, morbid obesity, difficult epidural catheter placement, difficult airway, and accidental dural puncture.
- With increasing high-risk surgical patients, CSA can be an asset to the anesthesiologist.

INTRODUCTION

Continuous spinal anesthesia is a type of regional anesthesia, where an intrathecally placed catheter allows injection of small titrated doses of LA to produce a well-controlled subarachnoid block. It provides better hemodynamic stability following sympathetic blockade associated with spinal anesthesia, unlike SSSA, where a fixed larger dose can result in an unpredictable block height and hemodynamic instability.[1-6] LA are usually injected intermittently in CSA; intermittent or fractionated spinal anesthesia could be a more appropriate word than CSA.[7] It is one of the most useful, versatile, and reliable centrineuraxial techniques available to provide analgesia and anesthesia in both obstetric and nonobstetric populations.[5,6] For many years, it was considered only for elderly patients with cardiac problems posted for lower abdominal and limb surgeries,[8] but nowadays it is also used in younger population too for various obstetric, gynecological, and urological procedures.[6,9-12] Though the use of CSA in the nonobstetric and obstetric population dates back almost a century and eight decades, respectively, the wider use and acceptance of this technique have been hampered primarily by limitations of the available equipment and associated complications, despite having plenty of inherent advantages.

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HISTORICAL BACKGROUND[1,2,4-6,7,9,11]

Continuous spinal anesthesia was first described in 1906 by Henry Percy Dean, a British surgeon, almost 7 years after the introduction of SSSA with cocaine in 1899 by August Bier. It involved intermittent injection of LA through a spinal needle left in the spinal canal throughout the operation. Its popularity and existence remained in a dilemma ever since.

After three decades, in 1940, William T. Lemmon, a Philadelphia surgeon, revived the technique, though it was cumbersome and very tricky. He performed a spinal tap in lateral position in 140 cesarean deliveries using a malleable 17–18G German silver needle (2.5–3.5″ long), which was connected to a flexible, rubber tubing with a stopcock to inject the LA as and when required. Then, the patient was positioned supine on a mattress and table, having a gap to accommodate the indwelling needle and rubber tubing **(Fig. 1)**. The same mattress was used by Hinebaugh and Lang (1944) to administer CSA for labor analgesia in over 50 cases. The usefulness of the CSA approach was constrained by the requirement to anchor needles in the subarachnoid area.

In 1944, Edward Tuohy of Mayo Clinic attempted to overcome this limitation by using a 15G Tuohy spinal needle that allowed easy passage of a 4G lacquered silk urethral catheter, injecting LA intermittently into subarachnoid space. Though continuous access was more manageable, inevitable PDPH secondary to the sizeable dural hole created by the 15G Tuohy needle hindered its widespread use. In 1950, Dripps reported paresthesia and a low success rate following CSA. The inherent drawbacks of CSA, such as technical problems, degree of trauma, and likelihood of cerebrospinal fluid (CSF) loss, put this technique into a long period of quiescence.

The technique of CSA was revisited 20 years later, following the development of 32G microcatheters by Hurley and Lambert in 1987 which

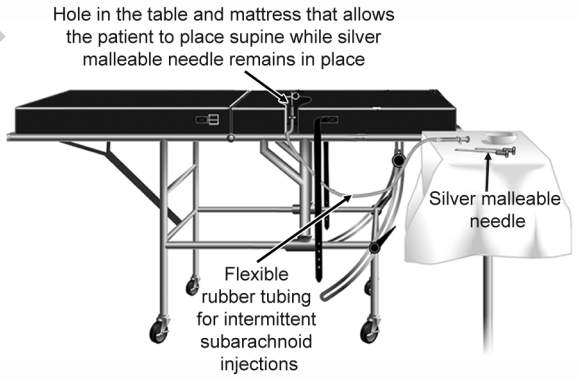

Fig. 1: Special table and mattress used by Lemmon for continuous spinal anesthesia in 1940.

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were passed through a 26G spinal needle. Since then, there has been a surge in enthusiasm for using CSA as these microcatheters and the smaller spinal needles required for their placement promised to decrease the incidence of PDPH to certain levels. Unfortunately, these catheters were challenging to manipulate and associated with a high failure rate because of kinking and breakage. A high incidence of cauda equina syndrome was reported with their use by Rigler et al. In 1992, the US Food and Drug Administration (FDA) banned using catheters over 24G size. In 2010, Palmer reported the successful administration of CSA in 300 parturients using a 28G catheter.

There have been many case reports on the successful conduct of anesthesia for abdominal and lower limb surgeries in high-risk elderly populations. However, inhibition of using CSA among anesthesiologists continued because of beliefs of high risk of PDPH, neurological damage, and meningitis.

ADVANTAGES

Continuous spinal anesthesia has definite advantages over single-shot spinal, epidural, continuous epidural, combined spinal epidural, unilateral spinal anesthesia, and sciatic nerve block **(Box 1)**.

- CSA provides reliable and excellent anesthesia because of a definite end point, i.e., free flow of CSF with minimal hemodynamic and respiratory disturbance, and the duration of anesthesia can be extended as per surgical need. Hence, it is helpful for prolonged surgical procedures in high-risk patients.[1,2,7,8,13,14]
- CSA provides better control over the height of the block with low incremental doses, extended duration of anesthesia, postoperative pain relief with better hemodynamic stability, and reduced risk of high or total spinal block compared to SSSA.[3,5,7,8,15-18]
- It avoids the use of multiple anesthetic agents used in GA, autonomic response to intubation and extubation, complications associated with GA,

BOX 1: Advantages of continuous spinal anesthesia.

- Reliable and well-established technique
- High success rate due to definite end point, i.e., free flow of cerebrospinal fluid
- Faster onset
- Better control over the height of the block
- Better cardiovascular and respiratory stability
- Provides extended duration of blockade in case of prolonged surgery
- Provision for postoperative analgesia
- Almost no risk of high and total spinal block
- Avoid the use of multiple anesthetic agents as in general anesthesia
- Relatively easier to perform
- Minimal side effect

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and positive pressure ventilation, especially postoperative respiratory and cognitive dysfunction, and provides prolonged postoperative analgesia. Therefore, it is a valuable and excellent alternative anesthesia technique to GA in high-risk patients, such as those with severe aortic stenosis or cardiomyopathy, respiratory diseases posted for noncardiac abdominal and lower limb surgeries.[7,8]

- Compared to epidural anesthesia, CSA is relatively easier to perform, has a faster onset, has a high success rate due to a definite end point (free flow of CSF) and excellent hemodynamic stability, provides adequate level and degree of anesthesia, prolonged duration of sensory blockade with small incremental doses, and dramatically reduces the risk of high spinal anesthesia and LA toxicity. Hence, CSA is a better option for emergency surgeries or patients with limited anesthesia time.[7,18-23]
- Besides lots of advantages of CSA over epidural anesthesia by using smaller anesthetic doses with rapid onset and motor and sensory blockade recovery with better cardiovascular stability, it also provides superior hemodynamic stability during the initial intraoperative period compared to combined spinal–epidural anesthesia.[24]

INDICATIONS

Existing literature suggested that CSA has been successfully used in various types of major high-risk and abdominal surgeries in high-risk patients. There are a number of situations and comorbidities in which CSA becomes an attractive option while weighing the relative risk of treatable side effect against many advantages of CSA, which are as follows:

- Major lower abdominal and lower limb surgeries in patients with severe cardiorespiratory diseases and trauma, where GA is relatively risky.[8,23]
- Labor analgesia and cesarean deliveries, especially in high-risk pregnancy, previous spinal surgery, significant cardiac disease, morbid obesity, difficult airway, and difficult epidural catheter placement.[12,24,25]
- After an accidental dural tap, CSA can provide anesthesia and postoperative analgesia, as it is known to decrease the incidence of PDPH and avoids undue risk of repeat dural punctures.[12,24-26]
- Postoperative pain relief through a patient-controlled analgesic pump. Ansbro et al. (1954) have reported the use of an intrathecal catheter for postoperative analgesia.[27-29]
- Pain relief in cancer patients through an intrathecal pump.[30]

CONTRAINDICATIONS

- *Absolute*: CSA is contraindicated in case of patient refusal, raised intracranial pressure, coagulopathy, blood dyscrasias, sepsis, and marked spinal deformity.

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- *Relative*: Mildly impaired coagulation (platelet count 80 × 10^9/L) and patients on anticoagulant therapy are relative contraindication due to the risk of spinal hematoma. The risk of spinal hematoma must be weighed against the benefits of avoiding GA in these patients.

EQUIPMENT (KIT) REQUIRED[1,3,7,9]

Continuous spinal anesthesia can be given through a standard epidural macrocatheter or specially designed spinal microcatheter sets. The only catheters available and frequently used to establish CSA are epidural catheters.[1]

- *Standard epidural macrocatheters sets*: These catheters (18G/20G/23G) are inserted into the subarachnoid space after a deliberate dural puncture with an epidural needle (16G/18G/20G), once free flow of CSF is achieved **(Fig. 2)**. These catheters are most commonly used for CSA because of their availability, easy insertion for those familiar with epidural insertion technique, unequivocal confirmation of correct catheter position by CSF aspiration, and better mixing of LAs. However, many experienced anesthesiologists still find deliberate dural punctures challenging to accept. We routinely use a 20G pediatric epidural needle with a 23G catheter for CSA in our tertiary care center.
- *Specially designed microcatheter sets* are available in various sizes as catheter-over-the-needle or catheter-through-needle sets.
  - *Catheter-over-the-needle set*: These sets (marketed as *Spinocath*) consist of a 22G catheter mounted on a 27G Quincke spinal needle or a 24G catheter mounted on a 29G Quincke spinal needle and an 18G epidural needle to access epidural space **(Fig. 3)**. The Quincke spinal needle is connected to a braided wire and has a fluid exit side hole within the catheter. Once the epidural needle is in place, a spinal needle with a mounted catheter is inserted and advanced to puncture

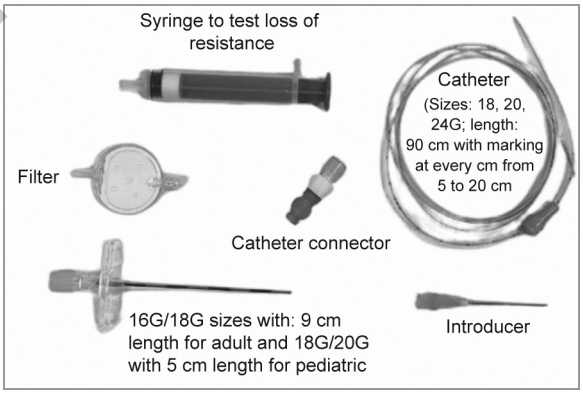

Fig. 2: Standard epidural set.

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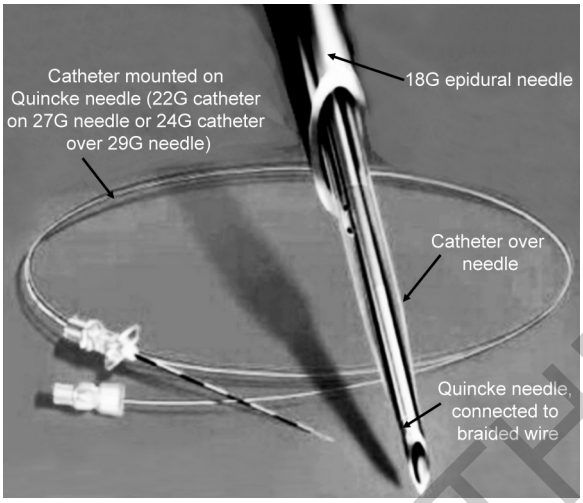

Fig. 3: Catheter over needle (Spinocath).

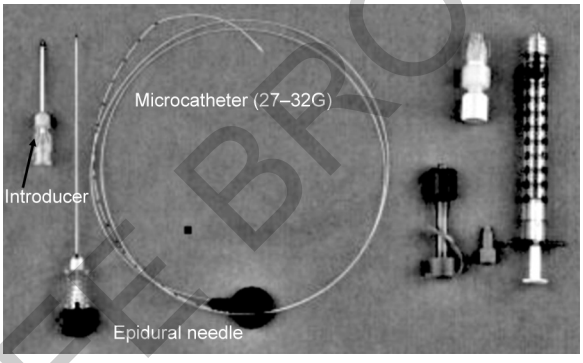

Fig. 4: Microcatheter through needle.

a dura and reach subarachnoid space. This is confirmed by getting CSF into the catheter, which comes through the exit side hole in the spinal needle. Then, braided wire is withdrawn to pull back the spinal needle while leaving the catheter within the subarachnoid space. After that epidural needle is withdrawn carefully, and the catheter is secured on the back using aseptic precautions. The main advantages of these sets are the definite end point of catheter placement and less risk of PDPH as a wide-bore catheter seals the hole made in the dura by the Quincke needle. However, published literature mentions that they are difficult to insert and require a definite skill.

- *Catheter-through-needle set*: These sets consist of microcatheters of varying sizes (25–32G), spinal needle, and introducer **(Fig. 4)**. Different manufacturers produce different types of needles and sizes of microcatheters; e.g., Pajunk IntraLong has 22G Sprotte needles

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with 25–32G catheters, Smith Medical makes 23G Crawford needles with 28G catheters and Kendell makes 22G Sprotte needles with 28G microcatheters. These catheters get kinked if force is applied during insertion. They may be difficult to insert despite the metal stylet introducer. Once inserted, it is not easy to aspirate CSF. CSF aspiration (an unequivocal end point of spinal catheter placement) is an impractical method for confirming the location of the microcatheter.

TECHNIQUE OF CONTINUOUS SPINAL ANESTHESIA

- Before proceeding with CSA, one should do a thorough pre-anesthetic check-up and consider any contraindications for CSA.
- Follow NPO guidelines, insert and secure large-bore cannula, and ensure availability of resuscitative equipment and emergency drugs. No premedication is required.
- Inside the operation room (OR), attach routine monitors. Invasive monitoring may be required in severely compromised surgical patients.
- Standard spinal anesthesia technique is followed for CSA. The lumen volume of the catheter and filter (dead space) should be measured (about 0.8–1.2 mL). This volume of normal saline is used to flush the intrathecal catheter after each aliquot to avoid an overdose of intrathecal LA. Under strict aseptic conditions, an epidural needle (in case of standard epidural macrocatheter set and catheter-over-needle set) and spinal needle (in case of microcatheter through needle set) is inserted, preferably through L3–L4 interspace. Free flow of CSF gives an unequivocal confirmation of correct needle placement.
- The catheter is threaded through the needle. Once it crosses the needle tip, advance it further 2–3 cm in the cephalad direction into the subarachnoid space and confirm the free flow of CSF.[1] Secure it in place and label it clearly to avoid confusion with the epidural catheter. Advancement of the catheter >3 cm increases the risk of malposition (caudally directed catheter) and coiling.[7] Caudally directed catheter lead to pooling of LAs in the sacral sac around cauda equina that has a potential risk of neurotoxic damage. Curled-up catheters can snare nerve roots at removal.
- The patient is positioned supine and small aliquots of preservative-free either mixture of iso- and hyperbaric or plain hyperbaric LAs (<1 mL) are injected through the subarachnoid catheter and flushed in with a small volume of saline (equal to dead space volume) to achieve the desired dermatomal block height as per surgical need.
- If the desired block height is not achieved in 10 minutes after the initial dose, inject the second aliquot of LA. Wait another 10 minutes and give third aliquot if desired block height still needs to be achieved. The procedure should be abandoned if there is no effect after three incremental doses.
- The patient's hemodynamics should be monitored every 5 minutes throughout the procedure.

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- To extend the duration of anesthesia, a small volume of LA, followed by a saline flush, can be injected to increase the block height.
- The catheter should preferably be removed at the end of surgery after giving an analgesic concentration of LA or opioid alone unless there is a pressing reason to keep it in place. This is to avoid confusion with the epidural catheter and catastrophe, as staff in the ward may not be familiar with these catheters.
- A strict sterile technique is mandatory during the catheter placement, manipulation, and drug injection to minimize the risk of infection.[6,31]
- Clear labeling of the catheter is essential to alert all caregivers about the location of the catheter to avoid mistaking it for an epidural catheter. The same anesthesiologist should preferably administer the aliquots.[6,31]

DRUGS TO BE USED

Any preservative-free preparation of LA can be injected through spinal catheters for CSA. Bupivacaine 0.5% and 0.25% are the most frequently used.[1] Adjuncts, like opioids, midazolam, and clonidine, can be added to enhance the quality of blockade and prolong the duration of analgesia. Plain isobaric solutions spread by diffusion and produce a block centered around the segment of catheter insertion in both caudad and cephalad directions. Hyperbaric solutions are spread by physical movement of the solution around the floor of the uneven dural sac. The spread is limited by lumbar lordosis and thoracic curve up to T10.[1,6,7] Some researchers have used hyperbaric preparation for the initial bolus and isobaric for top-ups. Others have used a mixture of both hyperbaric and isobaric while some have just used isobaric preparation. Isobaric preparation is preferred for CSA to achieve more controllable anesthesia without posture manipulation and to avoid pooling of 8% dextrose that may exert hyperosmolar pressure on neurons.

PROBLEMS/COMPLICATIONS[1,5,7]

Factors preventing frequent use of CSA are listed in **Box 2**. The issues are:

- *Technical problems*: Difficulty in inserting and manipulating the fine catheters through needle, injecting drugs due to high resistance offered

BOX 2: Problems and complications associated with continuous spinal anesthesia.

- Technical problems
- Breakage, kinking, curling and caudally directed catheter
- Hemodynamic instability with large volume of local anesthetic
- Postdural puncture headache
- Meningitis
- Neurological complications (cauda equina syndrome)
- Intrathecal hematoma/hemorrhage
- Medication errors

JAYPEE BROTHERS

by fine catheters and confirmation of correct catheter placement by CSF aspiration. Their incidence is approximately 20%.

- *Breakage/kinking of catheter*: It was more common with microcatheters, but can occur with macrocatheters. This can be minimized by slow removal of catheter with patient's back in flexed position and pulling the catheter as close to its insertion point as possible to avoid overstretching.
- *Hemodynamic instability*: This can cause hypotension and bradycardia, due to high level of block caused if large volume of LAs is given at frequent intervals. If small aliquots (<1 mL) are given at intervals to achieve adequate block height, no or transient hypotension follows CSA.
- *PDPH*: This is the common reason for the underutilization of CSA. The incidence of PDPH is directly proportional to the needle size and inversely proportional to patient age. The reported incidence of PDPH is quite low (<1% in the elderly population in Standl, 5.6% in Kumar and 1.5% in Lux studies). This low incidence of PDPH may be due to microcatheters, small-bore spinal needles, and an inflammatory reaction of the dura around the catheter that seals the hole at catheter removal. The reported incidence is high, around 29–33% in the obstetric population and young ambulatory patients.[2,4,7]
- Neurological complications such as *cauda equina syndrome*, although rare it is associated with the pooling of a large volume of hyperbaric LAs around the nerve roots secondary to microcatheters and caudally directed position. The high concentration of LAs causes direct LA toxicity and indirect nerve injury due to spinal cord ischemia. Accumulation of LAs may be avoided by threading only 3 cm of a catheter in subarachnoid space to prevent caudal displacement, injecting only <1 mL volume at any time, abandoning the technique if a total 3 mL of LA would not produce an adequate block, and avoiding administration of hyperbaric preparation.[1,7]
- *Infection*: Theoretically, drugs may spread directly via catheter into CSF and cause meningitis, but studies suggest a rare incidence of subclinical infection after 24–72 hours catheter in situ. This problem can be minimized by following strict aseptic precautions while placing and manipulating catheters and injecting drugs, avoiding frequent disconnection and reconnection, maintaining a closed system by continuous infusion, and using a bacterial filter.[7,11,31]
- *Intrathecal hemorrhage/hematoma* is rare with CSA and usually associated with heparin and urokinase use.[7]
- *Medication errors* can occur due to drug administration through incorrect routes or drug administration. Injecting a large epidural dose through catheters can lead to high spinal anesthesia, hypotension, and respiratory arrest. There are reports of intrathecal administration of labetalol and

JAYPEE BROTHERS

tranexamic acid instead of intravenous administration. This can be minimized by clearly labeling catheters, syringes, and infusion pumps, providing clear instructions, and educating the staff.[31]

- One article reported intraoperative coughing, discomfort, hypotension, and nausea and vomiting following CSA, but that was possible because of the high spinal blockade required for laparotomy and excessive bowel handling by the surgeon.[9]

CONTINUOUS SPINAL ANESTHESIA IN OBSTETRICS

Continuous spinal anesthesia provides excellent, reliable, and rapid neuraxial blockade for labor analgesia and anesthesia for cesarean section. However, it is not frequently used in obstetrics because of the high incidence of PDPH and technical issues compared to single-shot spinal, epidural, and combined spinal–epidural anesthesia. However, in particular circumstances, intentional CSA is preferred over other centrineuraxial techniques, such as previous spinal surgery, significant maternal cardiac disease, morbid obesity, difficult epidural catheter placement, difficult airway, and accidental dural puncture.[7,11,12,26] The risk of PDPH is significantly reduced when the catheter is inserted into the subarachnoid space following an accidental dural puncture and is left in situ for >24 hours. The mechanical barrier prevents CSF leak from the dural hole and promotes early inflammation at the puncture site[29,31] **(Table 1)**. A long study was done on 761 obstetric population by Cohn et al. which reported no severe complications such as meningitis,

TABLE 1: Clinical indications of continuous spinal anesthesia (CSA) in obstetric population with reason.[6]

Clinical indications	*Reason*
Previous spinal surgery	Difficult epidural placement—about 40% failure rate
Significant maternal cardiac disease	Cannot tolerate slight changes in hemodynamics and additional IV anesthetics. CSA provides excellent anesthesia with minimal hemodynamic changes with slow titration of LA
Morbid obesity	Higher rate of epidural catheter failure and unintentional dural puncture. CSA conveys protection against PDPH
Difficult epidural catheter placement	CSA avoids risk of further dural puncture, provides immediate analgesia, and reduces rate of PDPH for 24 hours
Difficult airway	Though somewhat controversial, CSA provides immediate reliable and flexible route to induce anesthesia safely without worrying about loss of airway

(IV: intravenous; LA: local anesthetic; PDPH: postdural puncture headache)

JAYPEE BROTHERS

TABLE 2: Suggested drugs for labor analgesia and anesthesia through continuous spinal catheter.[6,7,31]

Technique		*Drugs*
Labor analgesia	Intermittent bolus	Preservative-free plain bupivacaine 0.25%, 0.5–1 mL (1.75–2.5 mg) + fentanyl 15–20 µg as needed (roughly each 1–2 hours) or sufentanil 5.0 µg initial bolus, repeated as needed
	Continuous infusion	0.05–0.125% bupivacaine + fentanyl 2–5 µg/mL @ 0.5–3.0 mL/h and titrated to a T8–T11 sensory level Or sufentanil 2.5–5. 0 µg/h
	Patient-controlled intrathecal analgesia	0.125% bupivacaine + fentanyl 2 µg/mL @ 1–2 mL/h Bolus 1 mL; lockout 20–30 minutes
	Top-ups	Bupivacaine 0.25%, 0.5–1 mL (1.75–2.5 mg) +/– fentanyl 15–20 µg as needed (roughly each 1–2 hours) Or sufentanil 5.0 µg
Surgical anesthesia		Preservative-free 0.5% bupivacaine 5.0 mg (1 mL) + fentanyl 15 mg for the initial dose followed by 0.5 mL boluses of 0.5% bupivacaine (2.5 mg) every 5 minutes until the desired block height is obtained

arachnoiditis, cauda equina syndrome, spinal and epidural abscess, and hematoma during the 12-year follow-up.[6,32] No clinical trial has compared or studied a particular drug for labor analgesia or anesthesia. However, according to the available case reports and series, opioids alone or a combination of opioids with LA are suggested for labor analgesia and anesthesia **(Table 2)**.

CONCLUSION

Continuous spinal anesthesia is a reliable, flexible, and well-established technique that provides excellent analgesia and surgical anesthesia in nonobstetric and obstetric patients using standard epidural catheters (preferably pediatric epidural catheters 24G). Fear of PDPH, meningitis, and neurological complications are the primary reason for its infrequent use; however, the relative risk of these preventable and treatable side effects should be weighed against many advantages of this technique, especially in specific, challenging populations. With the increasing rate of high-risk surgical patients, CSA can be an asset for an anesthesiologist to conduct abdominal and lower limb surgeries without complications.

JAYPEE BROTHERS

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