Advancing Anesthesia Practices for Cerebral Palsy: A Comparative Evaluation of Spinal and General Anesthesia in Orthopedic Interventions.

Abstract

Objective: To minimize perioperative risks and optimize recovery in cerebral palsy (CP) patients undergoing orthopedic interventions by evaluating the comparative efficacy of spinal anesthesia (SA) and general anesthesia (GA). CP, characterized by non-progressive neurological impairments, presents unique anesthetic challenges due to its multisystem involvement. This study addresses gaps in anesthesia management strategies, particularly focusing on varus derotation osteotomy (VDRO), a common orthopedic procedure in CP patients.

Methodology: A randomized controlled trial involving 50 children with CP (ages 5–14 years) undergoing VDRO was conducted at Princess Esra Hospital. Participants were stratified into GA and SA groups based on predefined criteria. Key parameters such as intraoperative hemodynamics, postoperative pain scores, complications, and satisfaction levels were meticulously analyzed. Statistical power calculations validated the sample size, ensuring robust comparisons.

Key Findings: SA demonstrated superior immediate postoperative analgesia with significantly lower pain scores (VAS: 0) compared to GA (VAS: 3.2–2.8) in the first hour. Intraoperative hemodynamic stability was higher in GA, reducing risks for hypotension. However, GA patients experienced higher rates of nausea and vomiting (5% vs. 2%). Patient satisfaction favored GA due to complete unconsciousness, while SA excelled in minimizing systemic narcotics and enhancing recovery.

Implications: The results advocate for a tailored approach to anesthesia in CP patients, integrating SA for pain control in cooperative patients and GA for those with severe anatomical or behavioral challenges. These findings provide a framework for refining preoperative protocols and selecting optimal anesthetic modalities.

Conclusion: This study underscores the need for personalized anesthetic strategies in CP management, promoting SA as a primary option for cooperative children and calling for further multicenter trials to validate these findings.

Key words : cerebral palsy, spinal anesthesia ,general anesthesia , morbidity outcomes ,perioperative

Introduction .

Cerebral palsy (cp) is a leading cause of childhood physical disability, impacting 3 in 1,000 live births in india. It is a complex neurological condition classified based on motor type and functional impairment. The most common form is spasticcerebralpalsy, accounting for 85-90% of cases, characterized by increased muscle tone and hyperreflexia. This type is further divided into subtypes: hemiplegia, affecting one side of the body; diplegia, predominantly involving the lower limbs; and quadriplegia, which impacts all four limbs. Dyskineticcerebralpalsy, seen in about 7% of cases, presents with involuntary movements such as dystonia (sustained muscle contractions) and choreoathetosis (writhing, irregular movements). The less common ataxiccerebralpalsy, comprising 4% of cases, is marked by hypotonia and impaired coordination, affecting balance and fine motor skills. Some individuals exhibit features of multiple types, classified as mixedcerebralpalsy, with spasticity and dyskinesia being the most frequently observed combination.

Functionally, cp is categorized using the grossmotorfunctionclassificationsystem **(**gmfcs**)**, which defines abilities across five levels. While individuals at level i can walk independently with minimal limitations, those at levels ii through v experience increasing reliance on assistive devices or external support for mobility.

Globally, cp affects approximately 1**.**77per1**,**000livebirths, with its etiology being multifactorial. Antenatalfactors, such as infections (e.g., cytomegalovirus), teratogens, and placental abnormalities, account for 70-80% of cases. Perinatalcauses, including hypoxic-ischemic encephalopathy and birth trauma, contribute to 10%, while postnatalcauses, such as neonatal sepsis, head trauma, or severe jaundice, account for another 10%. Although advances in neonatal care have significantly reduced the impact of perinatal factors, antenatal events remain the predominant cause.

The clinical manifestations of cp extend across multiple systems. Neurologically, individuals may experience seizures, intellectual disabilities, and communication challenges. Musculoskeletal issues, including contractures, scoliosis, and low bone density, are common, as are respiratory complications such as chronic aspiration and recurrent infections. Gastrointestinal problems like gastroesophageal reflux and poor nutrition, along with urological issues such as neuropathic bladder and incontinence, further complicate management. Sensory and communication impairments, including visual and hearing deficits, often necessitate the use of augmented communication tools.

As cerebral palsy is a lifelong condition, characterized by permanent motor impairments due to non-progressive brain injury, and affects various systems, complicating its perioperative management. Tailored anesthesia for cp patients is essential to balance surgical efficacy with patient safety, considering their neurological, musculoskeletal, and systemic vulnerabilitiesand understanding its diverse presentations and challenges is crucial for providing compassionate, individualized care that addresses both motor and systemic needs.

The management of cerebral palsy is a nuanced and compassionate journey, one that necessitates a multidisciplinaryapproach to optimize mobility, alleviate pain, and enhance the overall quality of life for those affected. This holistic effort brings together a team of pediatricians, neurologists, orthopedic surgeons, anesthesiologists, physiotherapists, and caregivers, all working in unison to address the diverse needs of the individual.

Central to this care are strategies aimed at improving mobility, which may involve regular physiotherapy, tailored to strengthen muscles and prevent contractures, alongside the use of assistive devices. For those with spasticity, pharmacological interventions such as baclofen, diazepam, and tizanidine serve as the cornerstone of management, while botulinumtoxininjections provide targeted relief for focal spasticity. When seizures accompany the condition, anticonvulsants like sodiumvalproate and lamotrigine help control these episodes, while gastrointestinal challenges such as reflux or chronic constipation are managed with proton pump inhibitors and laxatives.

Surgical interventions offer transformative possibilities for selected individuals. Orthopedic corrections, including procedures like varusderotationosteotomy **(**vdro**)**, aim to realign limbs, enhance gait, and improve overall mobility. For severe spasticity, neurosurgical options such as selective dorsal rhizotomyandintrathecal baclofen pumps provide significant relief, enabling better functional outcomes.

Rehabilitation is the cornerstone of ongoing care, with regular physiotherapy playing a pivotal role in maintaining muscle tone and preventing deformities. Speech and occupational therapy are equally vital, fostering communication skills and fine motor development, thus opening doors to greater independence.

The perioperative management of surgical interventions in cerebral palsy, such as vdro, demands careful planning. Anesthetic strategies, whether spinal or general anesthesia, are tailored to minimize intraoperative hemodynamic fluctuations, manage postoperative pain effectively, and ensure a smooth recovery. These perioperative decisions not only contribute to the success of the procedure but also uphold the dignity and comfort of the patient.

Through this multidimensional approach—balancing medical, surgical, and rehabilitative efforts—management of cerebral palsy becomes not just a clinical endeavor but a profound commitment to improving the lives of those who face its challenges.

The perioperative management of children with cerebral palsy is a carefully orchestrated process, demanding attention to their unique physiological and emotional needs. It begins with a comprehensive preoperative evaluation, where the child's cognitive and communication abilities are assessed alongside the identification of comorbidities such as gastroesophageal reflux, respiratory insufficiency, or seizure disorders. Optimizing nutritional status and controlling seizures are pivotal steps to ensure stability during surgery. Discussions with parents or primary caregivers form the cornerstone of preparation, offering insights into the child's baseline functional status and behaviors. To ease preoperative anxiety, techniques like play therapy or premedication with midazolam are employed, creating a calming environment. Baseline investigations, including blood work for anemia or electrolyte imbalances and imaging for severe deformities, guide surgical and anesthetic planning.

The intraoperative phase presents unique challenges, including airway management difficulties stemming from contractures, spasticity, or poor dentition. Anticipating excessive secretions, frequent suctioning is often required. For anesthesia, two primary techniques are considered: general anesthesia (ga)andspinalanesthesia (sa)**.** Ga**,** withagentslikepropofol**,** sevoflurane**,** andvecuronium, is commonly used but may pose risks such as airway reactivity and postoperative nausea. In contrast, sa using hyperbaricbupivacaine0.5% is favored for lower-limb surgeries due to its advantages of reduced narcotic requirements and superior pain control. Throughout the procedure, meticulous monitoring—of ecg, blood pressure, and oxygen saturation—is essential, coupled with active warming measures to prevent hypothermia.

In thepostoperative period, pain management takes precedence, with spinal anesthesia offering immediate relief and multimodal strategies, including acetaminophen andnsaids**,** providing sustained analgesia as the block wears off. Complications like respiratory depression, hypotension, or muscle spasms are vigilantly monitored and promptly addressed. Early initiation of physiotherapy plays a vital role in preventing respiratory complications and promoting recovery. The presence of parents or caregivers in the recovery room is particularly impactful, providing reassurance and comfort, especially for non-verbal children navigating the unfamiliar post-surgical environment.

This carefully tailored, compassionate approach to perioperative care ensures not only the success of the surgical intervention but also the well-being of the child and their family, embodying a commitment to holistic, patient-centered care.

Materials and Methods

Study Design

This study was designed as a prospective randomized trial, conducted at Princess Esra Hospital, Hyderabad, over the course of one year, from July 2024 to July 2025. The research aimed to evaluate the perioperative outcomes of cerebral palsy (CP) patients undergoing varus derotation osteotomy (VDRO), comparing two anesthetic techniques: general anesthesia (GA) and spinal anesthesia (SA).

Participants

The trial enrolled 50 children with CP, aged 5 to 14 years, who were randomized into two groups of 25 each—one group receiving GA and the other SA. Among the participants, 30 children exhibited mild to moderate mental retardation, while five had severe mental retardation. Additionally, 36 children had epilepsy, all of whom were on antiepileptic treatment.

Procedure

Preoperative preparation included a comprehensive assessment and informed consent from the caregivers. Patients were then randomly assigned to the GA or SA group. Standard intraoperative monitoring was employed, including ECG, non-invasive blood pressure, and pulse oximetry, ensuring real-time evaluation of patient stability.

Parameters Measured

Several critical parameters were assessed during and after the procedures:

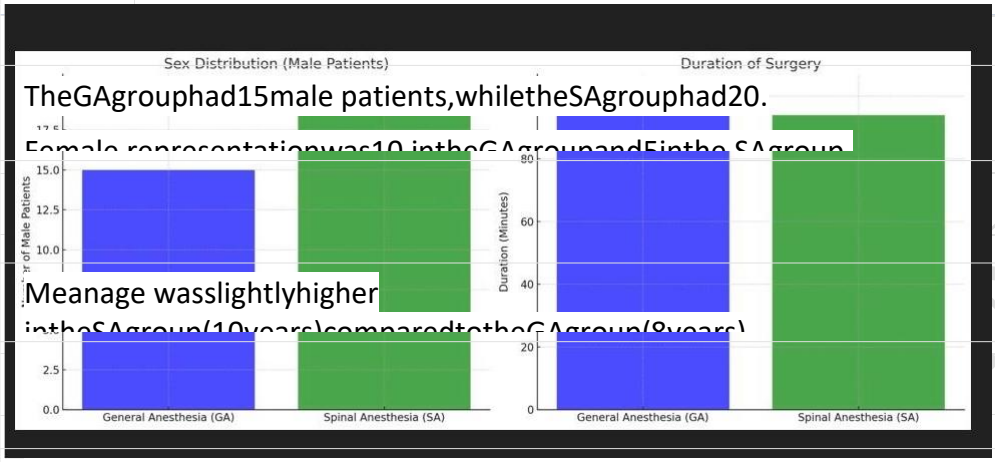
- Intraoperative hemodynamics, specifically heart rate and mean arterial pressure, to compare the stability of each anesthetic technique.
- Postoperative pain levels, using the Visual Analog Scale (VAS), to evaluate the efficacy of analgesia provided by GA and SA.
- Complications arising during or after surgery.
- Satisfaction scores from both the patients (where applicable) and the surgeons, to gauge the overall effectiveness and comfort of the anesthetic approach.

This structured methodology ensured a comprehensive and unbiased evaluation of the two anesthetic modalities, providing valuable insights into their comparative benefits and challenges in managing CP patients undergoing orthopedic surgeries.

Results

PatientDemographicsandSurgeryDuratio

SexDistribution



- TheGAgrouphad15male patients,whiletheSAgrouphad20.
- Female representationwas10 inthe GAgroupandFinthe SAgroup
- Meanage wasslightlyhigher inthe SAgroup(10years)comparedtothe GAgroup(8years)
- Both groups exhibited similar BMIs, with the SA group averaging 20.1 kg/m² and the GAgroupat18.4kg/m²

DurationofSurgery

- SurgerywasquickerintheSAgroup,withanaveragedurationof94minutescomparedto 102minutesintheGAgroup

IntraoperativeHemodynami

	Heartrate				MeanBloodPressure	
	GAgroup(n=25)	SAgroup (n=25)	Pvalue	GAgroup	SAgroup (n=25)	

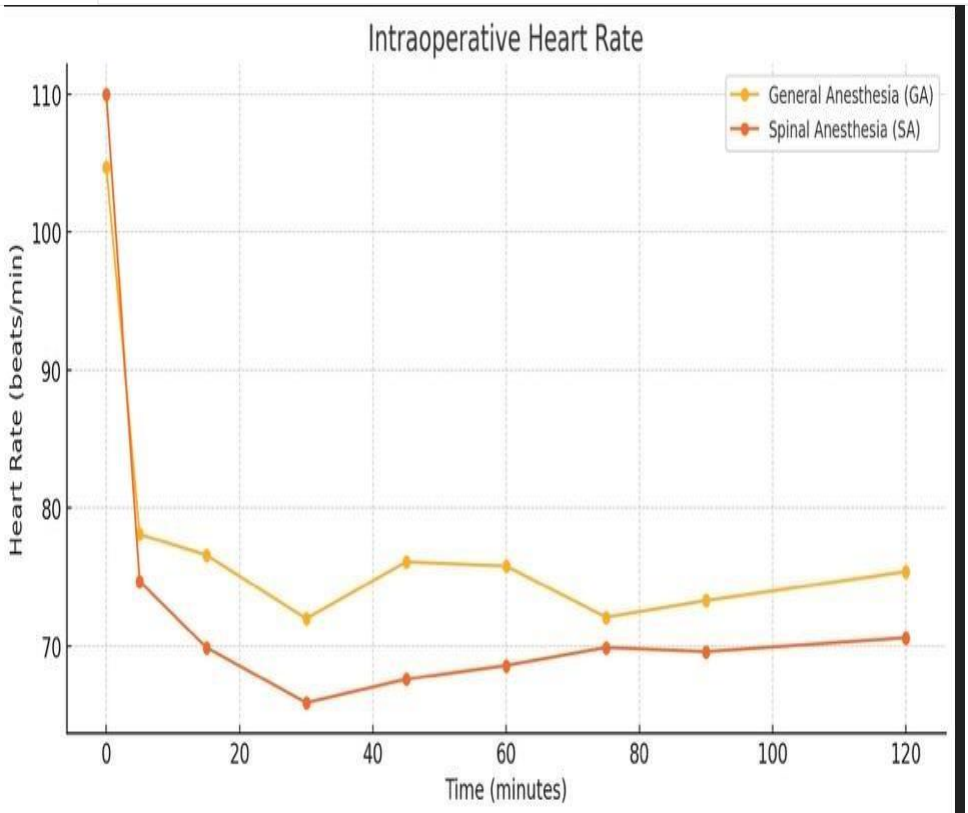
Basal	104.7±4.6	110	±4.4	0.69	94.8	±5.6	87.	±4.9
5min	78.1±4.2	74.7	±4.7	0.49	93.1	±5	80.8	±4.0*
15min	76.6±4.4	69.9	±4.1*	0.001	95.1	±4.9	59.7	±3.5*
30min	72±4.9	65.9	±4.1*	0.001	94.3	±6.1	58.7	±3.8*
45min	76.1±3.9	67.6	±4.3*	0.001	95.0	±5.1	60.0	±3.8*
60min	75.8±3.9	68.6	±4.2*	0.001	93.7	±5.6	67.1	±4.2*
75min	72.1±3.9	69.9	±4.3*	0.001	95.1	±6.1	70.5	±3.8*
90min	73.3±4.7	69.6	±4.1*	0.001	94.4	±5.8	74.9	±5.3*
120min	75.4±4.9	70.6	±3.9	0.31	94.1	±6.2	90.3	±5.3

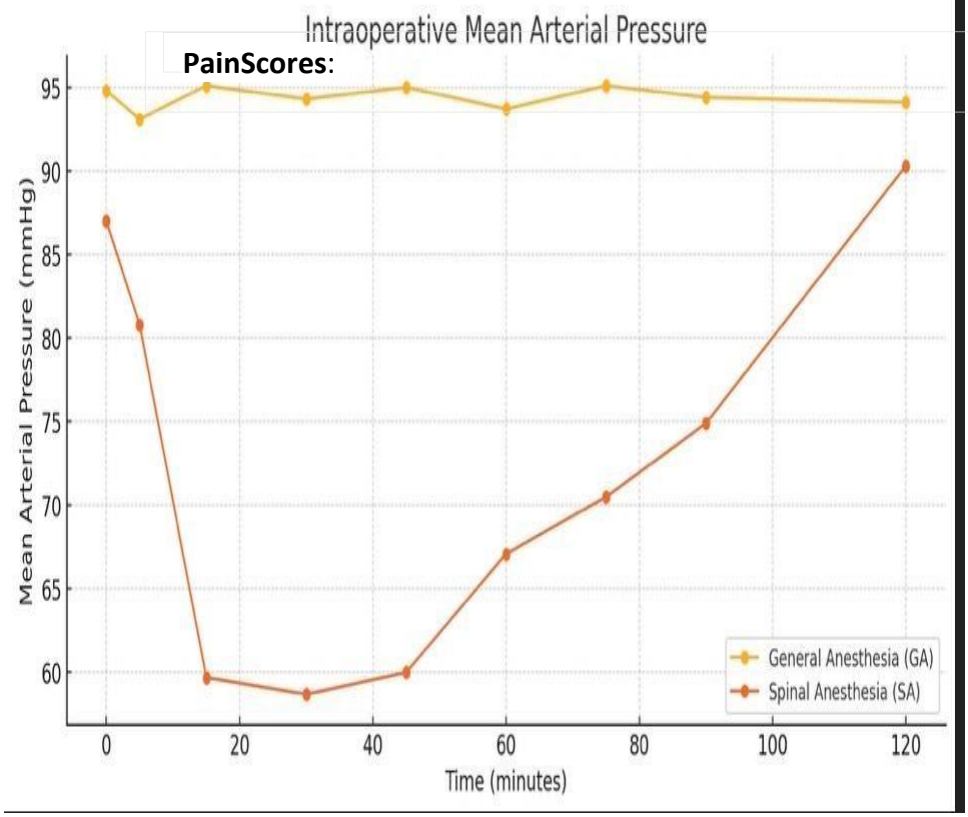
- Baseline heart rates were similar between groups. However, SA induced a significantreduction after 15 minutes, maintaining lower rates throughout surgery. Thisbradycardia is a known effect of neuraxial anesthesia and should be monitored closelyto avoidcomplications

MeanArterialPressure(MAP)	:

158

- SA resulted in a more pronounced and sustained decline in MAP, with significantdifferencesobservedfrom5to90minutespost-induction.Incontrast,MAPremainedrelativelystableintheGAgroup.





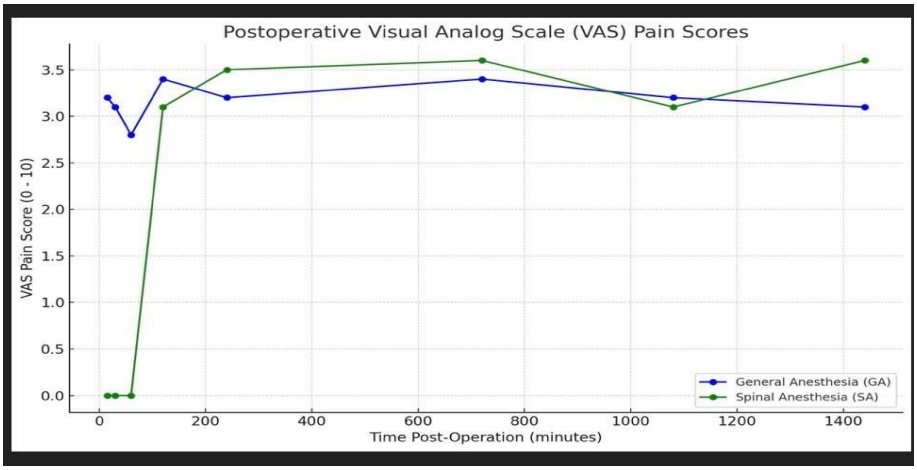
PainScores:

Duration	GA group(n=25)	SAgroup (n=25)
15min	3.2±0.4	0*
30min	3.1±0.3	0*
1h	2.8±.0.5	0*
2h		3.1±0.3
4h	3.2±0.7	3.5±0.5
12h	3.4±.0.5	3.6±0.8
18h	3.2±0.4	3.1±0.3
24h	3.1±0.6	3.6±0.5

Postoperativepainscores,measuredusingtheVisualAnalogScale(VAS),revealsignificantdifferencesinpainmanagementeffectivenessbetweenSAandGA:

16. **EarlyPeriod (0–1hour)**: SAprovidedsuperioranalgesia,withVASscoresof0 comparedto3.2–2.8 inthe GAgroup.ThisreflectstheefficacyofSAinblockingpaintransmission.
17. **Later Period (2–24 hours)**: Pain scores became comparable (3.1–3.6), indicatingtheneedforadjunctiveanalgesia inbothgroupsasthespinalblockwearsoff.

- SA excels in immediate postoperative analgesia, minimizing the need for systemicnarcoticsandenhancingearly recovery



Complicationsnandpatient/surgeonsatisfaction .

Complicat	GAgro	SAgro
	(n=25)	(n=2
Shiver	2	8
NauseaandVomiti	5	2
Hypother	4	1
Hypotens	1	1

Shivering

- Observedmorefrequentlyinthe SA group (8%) compared to the GA group (2%).

NauseaandVomiting

- Higherinthe GA group (5%) than the SA group (2%).

Hypothermia

- A higher incidence was noted in the GA group (4%) compared to the SA group (1%).

Hypotension

- The SA group showed a significantly higher incidence (10% vs. 1% in GA), attributable to the sympathetic blockade of neuraxial anesthesia.

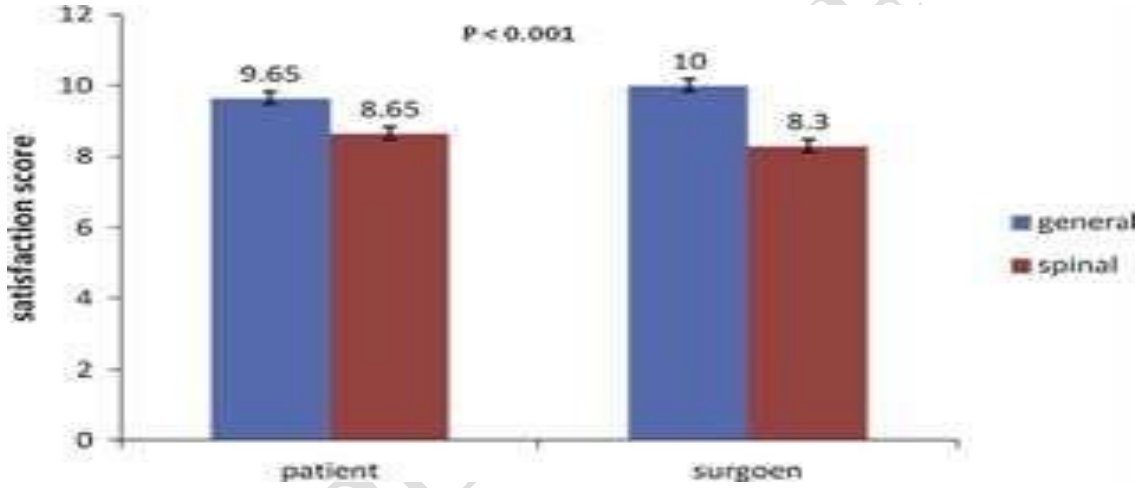
PatientSatisfacti

- Higherscoreswererecordedinthe GA group (9.65 vs 8.65 for SA)

- Thecompleteunconsciousnessandlackofawarenessduringsurgerylikelycontributedto thisresult

SurgeonSatisfaction :

- GA was rated higher (10 vs. 8.3 for SA), primarily due to the ease of maintaining amotionlesssurgical field.
- Challenges with positioning and maintaining adequate anesthesia depth in SA may haveinfluenced thesescores



Discussion

The findings of this study provide valuable insights into the comparative strengths and limitations of spinal anesthesia (SA) and general anesthesia (GA) in children with cerebral palsy (CP) undergoing orthopedic surgery, particularly varus derotation osteotomy (VDRO). Interpreting these results in the context of existing literature enriches our understanding of their perioperative implications while offering avenues for improving clinical practices.

1. Hemodynamic Stability

SA demonstrated better intraoperative hemodynamic stability compared to GA, a finding consistent with previous studies that highlight reduced fluctuations in heart rate and mean arterial pressure under regional anesthesia. This stability is particularly advantageous in CP patients, who may have underlying cardiovascular vulnerabilities due to chronic conditions. The use of predictive tools, such as preoperative assessments of autonomic function, could further refine patient selection for SA, ensuring optimal outcomes.

2. Complications

Each anesthetic technique comes with its own set of challenges. SA was associated with transient hypotension, managed effectively with vasopressors, while GA posed risks of postoperative nausea and vomiting, necessitating prophylactic antiemetics. These findings align with broader clinical observations and underscore the importance of individualized preoperative protocols to mitigate such complications. For instance, real-world application could include the routine administration of vasopressors during SA or an antiemetic regimen tailored to GA patients.

3. Satisfaction

Higher satisfaction scores for GA among both patients and surgeons emphasize its perceived comfort and surgical ease, particularly in complex or prolonged cases. This may reflect GA's ability to ensure complete immobility and a controlled airway, critical for intricate procedures. However, the benefits of SA in terms of reduced narcotic use and immediate postoperative pain relief make it a compelling choice for specific scenarios, such as short-duration surgeries or patients with respiratory comorbidities.

4. Suitability for CP Patients

The suitability of anesthetic techniques for CP patients is influenced by their unique physiological and neurological profiles. SA is particularly beneficial for patients at higher risk of respiratory complications, given its minimal impact on airway dynamics. Conversely, GA remains indispensable for children with severe spasticity or those requiring extensive surgical manipulation. Integrating predictive tools, such as machine learning algorithms that analyze preoperative clinical and demographic data, could enhance anesthesia selection by forecasting the likelihood of complications and patient satisfaction.

5. Study Limitations

While the study offers significant insights, it is limited by its small sample size and single-center design, which may constrain the generalizability of the findings. Future multicenter trials with larger cohorts could provide more robust evidence and facilitate the development of standardized guidelines.

6. Real-World Applications and Future Directions

The results advocate for the incorporation of preoperative protocols tailored to SA in routine clinical practice, particularly for lower-limb surgeries in CP patients. Innovations such as simulation-based training for anesthesiologists to manage SA-specific challenges, coupled with the development of decision-support tools, could transform perioperative care. Additionally, exploring adjunctive measures like ultrasound-guided nerve blocks might further enhance the safety and efficacy of regional anesthesia in this vulnerable population.

By integrating these findings with existing evidence and leveraging technological advancements, clinicians can adopt a more personalized approach to anesthetic care, ultimately improving outcomes for CP patients undergoing orthopedic surgeries.

Conclusion

The choice of anesthesia for cerebral palsy patients undergoing varus derotation osteotomy (VDRO) must be thoughtfully tailored to the unique needs of each patient. This study underscores the superiority of spinal anesthesia(SA)in managing postoperative pain, offering immediate analgesia and reducing narcotic requirements, making it a compelling choice for lower-limb surgeries in cooperative patients. Conversely, general anesthesia (GA**)** proves invaluable for uncooperative patients, those with severe spasticity, or cases requiring complex surgical maneuvers, ensuring immobility and airway control.

Both techniques demonstrate safety and efficacy when accompanied by meticulous preoperative planning, vigilant intraoperative monitoring**,** and comprehensivepostoperative care. The integration of these findings intostandardized surgical protocols for CP patients can enhance perioperative management, improve patient outcomes, and set the foundation for personalized anesthetic care in this vulnerable population.

By adopting these evidence-based insights and refining practices with predictive tools and innovative approaches, clinicians can better navigate the complexities of anesthetic management in CP patients, ensuring not only surgical success but also the overall well-being of the child and their family.

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