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A CONCEPTUAL REVIEW ARTICLE OF PERIBULBAR ANAESTHESIA IN OCULAR SURGERY

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ABSTRACT

Ophthalmic surgery is one of the most commonly performed procedures requiring anesthesia, with both local and general techniques available. Local ocular anesthesia is preferred for most intraocular surgeries due to its safety profile and the need for patient cooperation. Common methods include topical, sub-tenon's, peribulbar, and retrobulbar anesthesia, applied across procedures such as cataract, corneal, glaucoma, vitreoretinal, and strabismus surgeries. Peribulbar anesthesia involves injection outside the muscle cone and is widely used as an alternative to retrobulbar block. While retrobulbar anesthesia provides rapid analgesia and akinesia with smaller drug volumes, it carries higher risks, including scleral perforation and oculocardiac reflex stimulation. Peribulbar anesthesia aims to achieve comparable surgical conditions with a potentially improved safety profile.

KEYWORDS: Peribulbar, Extraconal, Anaesthesia, Lignocaine 2%, Bupivacaine0.5%.

INTRODUCTION

Ophthalmic surgery is among the most frequently performed surgical procedures requiring anaesthesia in developed countries and serves as an important model for understanding effective anaesthetic practice, particularly the use of local and regional nerve blocks. A wide range of anaesthetic techniques—including local, regional, and general anaesthesia—are employed in ophthalmology, with local anaesthesia being preferred for most procedures due to shorter operative times and reduced systemic risks. Common ophthalmic surgeries such as cataract extraction, corneal transplantation, glaucoma surgery, vitreoretinal procedures, and strabismus correction are routinely performed under local anaesthesia using topical, sub-Tenon's, peribulbar, or retrobulbar techniques. The primary objectives of ophthalmic anaesthesia are to ensure adequate pain control, patient cooperation, and ocular akinesia to provide optimal surgical conditions while minimizing intraoperative complications. Successful administration requires a thorough understanding of ocular anatomy and physiology, as local anaesthetic agents act on sensory nerves, extraocular muscles, and the ciliary ganglion within close proximity to the optic nerve. Peribulbar and topical techniques are most commonly used, often employing a combination of lignocaine, bupivacaine, and hyaluronidase. Despite their effectiveness, these techniques carry potential risks, including ocular, neurological, and rare systemic complications, underscoring the need for precision and expertise in ophthalmic anaesthesia.

MATERIAL AND METHOD

All literature related to ocular anaesthesia, peribulbar anaesthesia, anaesthetic drugs from various authentic books, various research paper and web search etc.

AIM

To study peribulbar anaesthesia in ocular surgeries.

OBJECTIVES

- To study details about peribulbar anaesthesia
- To study the action of anaesthetic drugs used in peribulbar.

REVIEW OF PERIBULBAR ANAESTHESIA

The term "peribulbar" is derived from two components:

1. "Peri-": A prefix of Greek origin, meaning "around" or "surrounding." It is commonly used in medical terminology to indicate something located around or near a specific structure.

2. "Bulbar": This comes from the Latin word bulbus, meaning "bulb" or "globe." In the context of ophthalmology, "bulbar" refers to the eyeball or the globe of the eye.

Thus, "peribulbar" refers to the space around the eyeball (the peribulbar space).

The term "anaesthesia" comes from the Greek words "an-" (meaning "without") and "aisthēsis" (meaning "sensation" or "perception").

Anatomy[5, 11]

- **Orbit**
  - Paired bony cavities at the front of the skull housing the eyeballs and associated structures
  - Truncated pyramidal shape; adult orbital volume ≈ 30 mL
  - Medial walls are parallel; lateral walls are perpendicular

- **Globe**
  - Spherical structure suspended in the anterosuperior orbit; volume ≈ 7 mL
  - Composed of three tunics: fibrous (cornea, sclera), vascular (iris, ciliary body, choroid), and neural (retina)
  - Axial length ≈ 24 mm (longer in myopia, shorter in hypermetropia)
  - Sclera is thinnest at the equator and muscle insertion sites
  - Myopic eyes may have posterior staphyloma, increasing perforation risk

- **Anterior and Posterior Segments**
  - Posterior segment contains vitreous, retina, macula, and optic nerve root
  - Anterior segment includes anterior and posterior chambers separated by the iris
- **Extraocular Muscles**
  - Four rectus and two oblique muscles control eye movement
  - Rectus muscles arise from the annulus of Zinn and form the retrobulbar cone
  - Optic nerve passes through this cone
- **Intraorbital Compartments**
  - Three spaces: intraocular, intraconal, and extraconal
  - No true membrane separates intraconal and extraconal spaces
  - Large-volume peribulbar blocks can achieve anesthesia similar to retrobulbar blocks
- **Innervation of the Orbit**
  - Sensory supply mainly from ophthalmic nerve (V1) via frontal and nasociliary branches
  - Infraorbital nerve (V2) supplies the orbital floor
  - Motor control: oculomotor (III), trochlear (IV), and abducens (VI) nerves
- **Anatomical Quadrants**
  - Globe divided into eight quadrants using three perpendicular planes
  - Orbital quadrants: superonasal, superotemporal, inferonasal, inferotemporal
  - Inferotemporal quadrant is least vascular and preferred for nerve blocks

Indications[3]

1. Cataract Surgery: Peribulbar anaesthesia is commonly used for cataract extraction, as it provides adequate pain relief, akinesia, and patient cooperation.
2. Retinal Surgery: Procedures such as retinal detachment repair, macular hole surgery, and vitrectomy can benefit from the anaesthesia provided by peribulbar blocks.
3. Glaucoma Surgery: Surgeries like trabeculectomy or tube shunt surgery may require peribulbar anaesthesia for effective pain management and muscle relaxation.
4. Strabismus Surgery: To minimize eye movement and ensure the surgeon's precision, peribulbar anaesthesia is used in the correction of strabismus.
5. Orbital Surgery: Peribulbar blocks are indicated for surgeries involving the orbit, such as tumor resection or repair of orbital fractures, as they provide anaesthesia to the eye and surrounding structures.
6. Pterygium Surgery: This involves removal of the pterygium and may require peribulbar anaesthesia for optimal analgesia and akinesia.
7. Corneal Surgery: Procedures like corneal transplantation benefit from the pain relief and muscle relaxation afforded by peribulbar anaesthesia.

Contraindications[3]

1. Allergy to Anaesthetic Agents: A known allergy to local anaesthetic drugs like lignocaine or bupivacaine would prevent the use of peribulbar anaesthesia.
2. Severe Orbital or Eyelid Infection: Infections such as cellulitis or abscesses in the orbit or eyelids are contraindications, as they may increase the risk of spreading the infection.
3. Uncontrolled Bleeding Disorders: Conditions such as hemophilia or thrombocytopenia can increase the risk of hemorrhage from the needle insertion, making peribulbar anaesthesia risky.
4. Globe Rupture or Severe Trauma: If the globe is ruptured or severely traumatized, the procedure could worsen the injury, leading to complications.
5. Severe Orbital Anatomy Abnormalities: Any anatomical abnormalities, such as severe exophthalmos, may complicate the placement of the needle and increase the risk of injury.
6. Inability to Cooperate: In patients who are unable to remain still or follow instructions, general anaesthesia might be more appropriate than peribulbar anaesthesia.
7. Pregnancy (Caution): Although peribulbar anaesthesia is generally considered safe in pregnancy, caution is advised, and it should be

avoided unless necessary due to potential risks to the fetus from the anaesthetic agents.

8. Allergic Reactions to Adjuvants: In some formulations, adjuvants like hyaluronidase may cause allergic reactions in certain patients, necessitating the use of alternative anaesthesia methods.

Procedure[14]

1. Preparation

- Patient Positioning: The patient is positioned supine, with the head slightly tilted backward and the eye to be anaesthetized in the upward position. This position helps expose the lower eyelid and facilitates the procedure.
- Sterilization: The skin around the eye, including the eyelid and periorbital region, is cleaned and sterilized using an antiseptic solution, such as iodine or chlorhexidine, to reduce the risk of infection.

2. Anatomical Landmarks Identification

- Limbus: The junction between the cornea and sclera, typically located near the equator of the globe, is used as a key landmark.
- Inferotemporal Quadrant: Inferior injection is given at the junction of the outer one third & inner two third of the lower orbital rim.
- Superonasal Quadrant: Superior injection is given usually nasally just above the medial canthus. The superior injection may be avoided till the time the inferior injection takes effect (3-5 min), to judge the necessity for the additional injection.

3. Injection Site Selection

- A needle is typically inserted at the inferotemporal region of the orbit, around 1–2 cm below the lower eyelid and lateral to the lateral canthus (outer corner of the eye).
- The needle should be directed medially and superiorly (towards the retrobulbar space) to avoid damage to the globe and other structures.

4. Needle Insertion

- A 25–27 gauge needle (typically 1.5 inches) is used for the procedure.
- The needle is gently inserted through the skin and soft tissue, advancing toward the periosteum (the bone surrounding the orbit), while ensuring that the needle tip stays away from the globe, optic nerve, and major blood vessels.
- The needle is carefully positioned around the muscular cone or peribulbar space, ensuring that the tip does not enter the deeper retrobulbar space.
- Aspirate: Before injecting the anaesthetic agent, the syringe is aspirated to ensure no blood return, which would indicate a blood vessel has been punctured.

5. Injection of Anaesthetic

- Anaesthetic agents: A mixture of 2% lignocaine and 0.5–0.75% bupivacaine with or without hyaluronidase (25 IU/mL) is commonly used. The mixture provides both rapid onset and prolonged duration of anaesthesia.
- A small volume (4–7 mL) of the anaesthetic mixture is injected into the peribulbar space. This ensures that the nerve endings of the eye and the extraocular muscles are blocked to provide both analgesia and akinesia (immobility).
- The solution is deposited progressively: 1 ml in the lid, 2-3 ml near the globe's equator, and 1-2 ml posterior to the equator.
- The injection is typically performed in two or three sites to ensure adequate distribution of the anaesthetic agent around the globe.

6. Assessment of Effect:

- 10-20 minutes of intermittent ocular compression is applied after the injection.
- After the injection, the patient's eyelid should be tested for ptosis (drooping) and immobility of the globe to assess the success of the block.
- The anaesthesia should take effect within a few minutes, with complete akinesia of the extraocular muscles and analgesia of the globe.

7. Post-procedure Monitoring:

- The patient is monitored for signs of complications, such as ocular perforation, retrobulbar hemorrhage, or ocular nerve injury, although these are rare.
- The anaesthesia typically lasts for 1–2 hours, but this may vary depending on the anaesthetic agents used.

Anaesthetic Drugs[13]

1. Lignocaine (Lidocaine)

- Action: Lignocaine is a local anaesthetic that works by blocking sodium channels in nerve cells, preventing the propagation of nerve impulses. This results in loss of sensation in the area where the drug is applied.
- Onset and Duration: It has a rapid onset (within 2-5 minutes) and provides a moderate duration of anaesthesia (30-60 minutes), making it effective for short to medium-duration procedures.

2. Bupivacaine

- Action: Bupivacaine is a long-acting local anaesthetic that also blocks sodium channels in nerve cells, preventing nerve impulse conduction and providing analgesia and akinesia (muscle paralysis).
- Onset and Duration: It has a slower onset (5-10 minutes) but provides a longer duration of action (up to 4-8 hours). This makes it useful for procedures that require prolonged anaesthesia.

3. Mepivacaine

- Action: Similar to lignocaine, mepivacaine is a local anaesthetic that blocks sodium channels in nerve fibers to inhibit nerve signal transmission, resulting in loss of sensation and muscle movement.
- Onset and Duration: Mepivacaine has an onset of action similar to lignocaine (2-5 minutes) and provides a moderate duration of anaesthesia (1-2 hours).

4. Procaine

- Action: Procaine, also a sodium channel blocker, provides local anaesthesia by inhibiting the transmission of nerve impulses in the area where it is injected.
- Onset and Duration: Procaine has a relatively slow onset and a shorter duration of action compared to lignocaine and bupivacaine (lasting about 30-60 minutes), so it is less commonly used in peribulbar blocks.

5. Hyaluronidase

- Action: Hyaluronidase is an enzyme that breaks down hyaluronic acid, a major component of the extracellular matrix. By degrading the hyaluronic acid, it increases tissue permeability, allowing for a faster spread of local anaesthetic agents and improving the overall effectiveness of the block.
- Use: It is often added to local anaesthetic mixtures to enhance the diffusion of the anaesthetic agents, facilitating a more uniform and quicker anaesthesia.

6. Adrenaline (Epinephrine)

- Action: Adrenaline is a vasoconstrictor that works by stimulating alpha-adrenergic receptors, causing the blood vessels to constrict. This reduces local blood flow, decreasing the absorption of the anaesthetic into the bloodstream and prolonging its action at the injection site.
- Use: While not always used in peribulbar blocks, adrenaline is sometimes added to local anaesthetics (such as lignocaine or bupivacaine) to extend the duration of anaesthesia and reduce bleeding during surgery. Caution is needed when used in the orbit due to the potential for increased intraocular pressure.

Pharmacodynamics[13]

Peribulbar anaesthesia involves deposition of the anaesthetic agent in the peribulbar space.

It targets the cranial nerves (III, IV, V, VI) and ciliary nerves to block sensation and movement.

Compared to retrobulbar anaesthesia (which is injected within the muscle cone), peribulbar anaesthesia has a more diffuse spread and involves larger volumes of anaesthetic.

Pharmacokinetics[13]

1. Absorption

- Drugs are injected into a vascular area, leading to partial systemic absorption.
- The rate of absorption depends on the vascularity of the injection site, dose, and use of vasoconstrictors (e.g., epinephrine).

2. Distribution

- Local anesthetics bind to plasma proteins (e.g., alpha-1 acid glycoprotein).
- Highly lipophilic agents (e.g., bupivacaine) exhibit extensive tissue distribution.

3. Metabolism

- Amide Local Anesthetics (e.g., lidocaine, bupivacaine, ropivacaine):
- Metabolized by hepatic enzymes (cytochrome P450).
- Clearance may be reduced in liver dysfunction.
- Ester Local Anesthetics (e.g., procaine, tetracaine):
- Hydrolyzed rapidly by plasma cholinesterases.
- Rarely used in peribulbar blocks due to systemic toxicity concerns.

4. Excretion

- Metabolites are eliminated via the kidneys.
- Renal impairment may lead to accumulation of metabolites, particularly for amide anesthetics.

Advantages:[3]

1. Reduced Risk of Complications: Lower risk of globe perforation, retrobulbar haemorrhage, or optic nerve damage compared to retrobulbar anaesthesia.
2. Wider Area of Anaesthesia: Blocks nerves outside the muscle cone, providing more comprehensive anaesthesia.
3. Safer for High-Risk Patients: Preferred in patients with axial myopia or compromised orbital anatomy due to reduced risk of intraocular damage.
4. Minimal Risk of Brainstem Anaesthesia: Unintended spread to the brainstem is rare compared to retrobulbar injections.

Recent Advances In Peribulbar Anaesthesia

1. Improved Techniques

- Ultrasound-Guided Injections: Allows precise localization of the injection site, minimizing complications and improving anaesthetic efficacy.
- Single Injection Techniques: Reduce patient discomfort by minimizing the number of needle passes.

2. Innovative Drug Combinations

- Use of adjuvants like clonidine or dexmedetomidine for prolonged anaesthesia and analgesia.
- Incorporation of hyaluronidase to enhance the spread of anaesthetic agents.

3. Safer Needle Designs: Blunt-tipped needles or cannulae reduce the risk of perforation or vascular injury.
4. Better Monitoring: Use of devices for real-time ocular pressure monitoring and imaging ensures patient safety.
5. Training and Simulation: Simulation-based training for ophthalmologists improves injection accuracy and reduces complications.

Limitations[4,10]

1. Slower Onset of Anesthesia: Compared to retrobulbar anesthesia, peribulbar anesthesia may take longer to achieve adequate sensory block and akinesia due to its more diffuse spread.
2. Increased Volume of Anesthetic: A larger volume of anesthetic is required, which may increase the risk of complications such as orbital compartment syndrome.
3. Incomplete Akinesia: Achieving complete paralysis of extraocular muscles (akinesia) may be challenging, requiring supplemental injections.
4. Risk of Complications: Though safer than retrobulbar anesthesia, it still carries risks such as:

- Globe perforation (rare in experienced hands)
- Orbital hemorrhage
- Increased intraocular pressure
- Local anesthetic toxicity

5. Technical Difficulty in Certain Patients: Patients with high myopia, staphyloma, or orbital abnormalities may pose challenges, increasing the risk of incomplete anesthesia or complications.
6. Discomfort or Pain from Injection: Multiple injections may be required, which can cause discomfort, especially in anxious or sensitive patients.
7. Risk of Incomplete Anesthesia in Deep-Seated Structures: Peribulbar anesthesia might not fully anesthetize posterior globe or orbital apex regions, potentially leading to inadequate pain control in certain procedures.
8. Contraindications in Certain Populations: It may not be suitable for patients with bleeding disorders, coagulopathies, or severe infections, limiting its use.
9. Dependence on Patient Cooperation: Uncooperative or anxious patients may make administration difficult or unsafe.
10. Operator Dependence: The success and safety of the procedure depend heavily on the skill and experience of the anesthetist.

Complications[4,10]

Complications arising from orbital regional anesthesia may be local, or may manifest systemically and may arise immediately or may be delayed. Complications are related to the method of administration or local anesthetic agent and adjuvant used.

- **Local Complications**

1. Needle block complications - Conjunctival edema (chemosis) and subconjunctival haemorrhage (ecchymosis) may occur after needle block. Peribulbar block is associated with frequent chemosis and subconjunctival hemorrhage than retrobulbar block, due to anterior spread of the local anesthetic agent and the damage of minor blood vessels with needle tip, respectively. These minor complications usually do not interfere with surgery, and resolve spontaneously within few hours.

2. Retrobulbar hemorrhage: It is a serious complication of both the intraconal and extraconal blocks, which occurs following bleeding behind the globe. The hemorrhage may be either venous or arterial in origin and may be concealed, or revealed. Spread of blood into the periorbital tissues increases the tissue volume and pressure.

Management: Urgent measures must be taken to stop hemorrhage and reduce elevated intraocular pressure. Firm digital pressure usually stops the bleeding. Consideration must then be given to reduce the intraocular pressure, so that the blood supply to the retina is not compromised. Lateral canthotomy, intravenous acetazolamide, intravenous mannitol or even paracentesis, may need to be considered.

3. Globe damage: Damage to the globe is a rare, but serious complication which is reported following both intraconal and extraconal block and even following other forms of local anesthesia for minor procedures such as eyelid surgery. Globe perforation refers to double puncture wounds (wound of entry and exit), whereas globe penetration has only wound of entry Signs and symptoms of perforation include intense ocular pain, sudden loss of vision and hypotonus

Management: If globe perforation is suspected, the surgeon should be informed immediately. Ophthalmoscopy or ultrasound is performed to assess the damage. Cancellation of elective surgery and referral to a retinal surgeon should be strongly considered.

4. Optic nerve injury: Injury to the optic nerve and central retinal artery contained within the nerve are rare.This artery is the first and smallest branch of the ophthalmic artery, arising from that vessel, as it lies below the optic nerve These complications are thought to occur from the direct needle-stick injury to the optic nerve, secondary to hemorrhage within or around the optic nerve These can result in marked loss of vision or blindness and optic atrophy (a late finding).

Management: Surgical decompression of the optic nerve sheath should be considered, but the prognosis is poor.

5. Myotoxicity: Damage to extraocular muscles from orbital blocks can result in strabismus (causing diplopia), ptosis (drooping upper eyelid) and entropion (infolding of the eyelid). However, not all

cases of extraocular eye muscle problems are caused by orbital block, such as diplopia from the pre-existing condition that is unmasked after cataract surgery, sensory deviations and optical aberrations. Possible mechanisms of extraocular eye muscle damage include direct needle trauma, ischemic pressure necrosis caused by a large volume of local anesthetic, direct myotoxic effects of the local anesthetic agent on extraocular muscles and use of high concentrations of Lidocaine. Therefore, the smallest effective volume of anesthetic agent is advocated. Surgical causes of ptosis include, use of a superior bridal stitch, or application of a lid speculum.

- **Systemic Complications**

1. Local Anesthetic Toxicity: Accidental intravascular injection or high systemic absorption can lead to CNS toxicity (seizures, dizziness, respiratory depression) or cardiovascular collapse.
2. Bradycardia or Arrhythmias: Vasovagal reactions or direct effects of anesthetics on the heart.
3. Anaphylaxis or Allergic Reactions: Rare but potentially life-threatening.
4. Respiratory Depression: Particularly in older patients due to inadvertent brainstem anesthesia.

- **Procedure-Related Complications**

1. Inadequate Anesthesia or Akinesia: May require supplemental injections, increasing risks.
2. Needle-Related Injuries: Including damage to orbital tissues or inadvertent puncture of the sclera.
3. Post-Injection Pain: Due to tissue distension or inadvertent nerve injury.
4. Infection: Rare, but cellulitis or abscess can occur at the injection site.

DISCUSSION

Effective anesthesia is crucial for ensuring safe and comfortable intraocular surgeries. Over the years, techniques have evolved from performing surgeries without anesthesia to utilizing modern methods such as topical or regional anesthesia. Currently, the majority of cataract surgeries are conducted under local anesthesia, while general anesthesia is used only in select cases. But regional anaesthesia like Retrobulbar and Peribulbar anaesthesia are commonly used in most of the ocular procedures. Peribulbar anaesthesia is extraconal anaesthesia most widely used thar retrobulbar. A mixture of 5 ml bupivacaine 0.75%, 5 ml lignocaine 2% with or without 1:200,000 adrenaline, and with or without 150 units of hyaluronidase is prepared in a 10 ml syringe. Using a 3/4 inch, 24-26G needle, 5 ml is injected inferiorly at the junction of the outer one-third and inner two-thirds of the lower orbital rim. The solution is deposited progressively: 1 ml in the lid, 2-3 ml near the globe's equator, and 1-2 ml posterior to the equator. A superior injection (5 ml) may be given nasally above the medial canthus if needed, depending on the akinesia achieved after 3-5 minutes. Superior injection can be omitted if the inferior injection is sufficient. Orbital fullness confirms correct placement, and 10-20 minutes of intermittent ocular compression is applied post-injection to aid anesthetic spread and reduce orbital pressure. It is clear that serious complications can occur from all techniques of eye blocks. Before attempting to perform any regional orbital block, it is essential to learn the anatomy of orbital structures and the safe block technique. Dissection of a human cadaver orbit, when available.

CONCLUSION

Peribulbar anesthesia is a widely used and effective regional anesthetic technique for a variety of ocular surgeries. It provides reliable sensory anesthesia, akinesia (paralysis of eye muscles), and intraoperative comfort while avoiding the risks associated with general anesthesia but limitations in complex cases. Compared to retrobulbar anesthesia, it has a safer profile with a lower risk of severe complications, making it particularly suitable for elderly and systemically compromised patients. However, its success depends on the expertise of the practitioner and proper patient selection.

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