Brief Communication

Eyeball movement under anaesthesia: Where do we falter?

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Introduction

Execution of seamless ophthalmological procedure requires meticulous planning. Inhalational anaesthetic agents along with opioids and muscle relaxants create optimal surgical conditions and prevent emergence delirium, thus providing adequate pain relief and patient safety. As the anesthetized patients progress through Guedel's stages of general anaesthesia (GA), the extraocular muscles become flaccid, and eyeball movement ceases as the third stage of surgical anaesthesia is attained.[1] However even deeper anaesthesia planes do not ensure centric eye ball position and unwanted eye movements on operating table are a fairly common complaint. Approximately 18% of patients exhibit eccentric eye movements during ocular surgery under GA.[1] This is a notable challenge for the ophthalmic surgeons as a restricted surgical field and potential for sudden jerks may lead to inadvertent iatrogenic complications. This brief communication focusses on factors responsible for eccentric eye positioning / movements and suggestions for overcoming this complication.

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Eccentric Eye movements-definition, types

"Eccentric eye movement" refers to off-axis vertical motion of eye from its central position, characterized by a swift rolling or drifting pattern. On the other hand, an "eccentric position" is defined as the off-axis vertical deviation of eye from its central position following a vertical eye movement.[2] This eccentricity can be upward or downward, depending on whether the eye moves towards upper fornix or lower fornix. The terms "drift" and "roll" are used to describe sweeping eye movements with a slightly slower speed, distinguishing them from the rapid eye movements or saccades typical of the awake state.[2] Gaze stabilizing and gaze-shifting mechanisms play crucial roles in maintaining visual stability and tracking objects of interest during different head and eye movements. These mechanisms involve a combination of reflexes and involuntary eye movements.

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1. **Gaze Stabilizing:** Keeps object of interest in the field of vision when head or object is moving
    - **Vestibulo-Ocular Reflex (VOR)** helps in stabilizing gaze during head movements. Therefore when head turns, the eyes move in opposite direction to maintain a stable image on retina.
2. **Gaze-Shifting:** Keeps object out of field of vision when head or object is moving.
    - **VOR** not only stabilizes gaze, it can also cause gaze-shifting by moving eyes in direction opposite to head movement, thereby preventing object of interest from staying in field of vision.
    - **Vergence Movements: Convergence and Divergence:** These movements involve eyes turning inward (convergence) or outward (divergence) to maintain a clear, single image of an object at different distances.

Optokinetic Reflex (OKR):

- **Smooth Pursuit:** OKR allows eyes to smoothly follow a moving object, keeping it in the center of visual field. This is especially important for tracking moving objects.
- **Saccades:** Rapid, voluntary eye movements that shift gaze between different points of interest. Saccades are essential for redirecting line of sight quickly.

In resource constraint developing countries with high patient load, short surgeries are commonly conducted using sevoflurane anesthesia with a laryngeal mask, without the use of non-depolarizing muscle relaxants (NDMR).

This option is driven by the rapid titrating capabilities of the newer agents, enabling swift transitions between deep and superficial anesthesia planes.[2] However, the time of switching between superficial and deeper planes is associated with maximum disturbances in eye movements.

Mechanism of eye-ball up-rolling and down-rolling

Inadequate depth of anesthesia (DOA) without use of NDMR is associated with elevated eye positions, a correlation attributed to the inherent Bell's phenomenon. This phenomenon involves neural pathways in the brainstem, specifically connecting the seventh cranial nerve nucleus in the pons to the third cranial nerve nuclear complex in the rostral midbrain. Conversely, as anesthesia deepens, there is an observed downward positioning of the eyes. The potential pathophysiology underlying observed downward drift in anesthetized patients has been attributed to impact of various anaesthetics on brain systems involved in sleep-wake regulation.[3]

Mourisse et al observed that brainstem function is more susceptible to effects of sevoflurane compared to forebrain function.[4] Notably, specific structures at meso-diencephalic junction, such as interstitial nucleus of Cajal, mesencephalic reticular formation, and posterior commissure, are implicated in this susceptibility.[5] Lesions in this area are associated with a prominent forced downward gaze, indicating an imbalance in vertical gaze plane.[5]

The lesser sensitivity of prepubertal children to sevoflurane, particularly in specific subcortical areas like mesencephalic control,

when compared to older subjects, may provide an explanation for the prevalence of forced downward gaze observed primarily in select children.[6] Younger children's higher sensitivity to sevoflurane for specific subcortical areas (i.e. mesencephalic control) than older subjects may explain its greater prevalence only in younger children when the threshold was crossed.[6] Different flow rates of anesthetic agent used, different time taken, and different MAC value achieved during intubation as well as different DOA on which the patient was stabilized before handing them over to the ophthalmic surgeon for the procedure, could be factors influencing the occurrence of eye movements during repeat exposures in the same patients.

An alternative theory proposes that the shortened autoregulation and vasodilatory effects induced by sevoflurane contribute to transiently reduced cerebral blood flow (CBF) and an irritative impact, which reverses upon decreasing the concentration of sevoflurane.[7] The lower limits of sevoflurane autoregulation closely align with the basal mean arterial pressure of young children.[2] This suggests the possibility of a narrow and individual-specific window of CBF sensitivity. It is plausible that this narrow autoregulation limit is breached when the depth of sevoflurane anesthesia exceeds an acceptable limit for a child. The posterior circulation zone, responsible for supplying the mesencephalic-diencephalic junction, comprises structures crucial for vertical sight and vergence. Transient impairment in this region may manifest as abnormal eye movements.

A third possibility is that sevoflurane is known to excite the neurons in the Locus Coeruleus (LC).

The LC is a pontine nucleus, with the largest group of noradrenergic neurons in the brain, and is responsible for the tonic maintenance of the wakeful state.8 This nucleus has very widespread projections to cortical and subcortical regions and to the spinal cord.8 In addition, it also projects to the oculomotor nucleus, which has been shown to have a high density of α1-adrenoceptors. It is plausible that sevoflurane, at higher concentrations, induces the activation of the LC, leading to the tonic contraction of the muscles innervated by the oculomotor nerve. As the LC is also involved in maintaining the wakeful state, once the DOA is on the lighter side, it is possible that the same scenario of LC activation repeats itself.

How to provide Ideal Surgical conditions

- Clinical test
  - Presence of tachycardia, increased respiratory rate and lacrimation are important clinical indicators for light depth of anaesthesia and might be associated with eccentric eyeball movements.
  - Loss of verbal contact, eyelash reflex, corneal reflex, and jaw relaxation, are further used to assess the depth of anesthesia.
  - Trapezius squeeze test (TST) is one such simple test to perform in which 1–2 inches of trapezius muscle is held and squeezed in full thickness and response is evaluated in the form of toe/body movement. The presence of positive test would certainly require increasing the anaesthetic depth.

- Use of intermediate acting muscle relaxants- including atracurium not only provides controlled surgical condition but also ensures quick anaesthetic recovery.
- While using inhalational anaesthetic agents, the MAC of the inhalational agent should be achieved before examination.
- Administration of local or regional nerve blocks as a supplement to anaesthesia techniques may also help in mitigating response. Optimal surgical conditions (analgesia and akinesia) can be obtained with block techniques avoiding the risks of general anaesthesia for a population of patients who are often elderly with concurrent co-morbidities. These techniques also benefit a resource-poor environment, with limitations to anaesthetic personnel and equipment, hospital beds, recovery staff and overall allow a quicker turnover of patients at less cost. Sub-Tenon's block provides excellent anaesthesia and akinesia without requiring a sharp needle.
- If available bispectral index(BIS)and entropy should be monitored to ensure adequate depth of anaesthesia. Kook et al, demonstrated that BIS values correlated inversely with the end- tidal concentration of anaesthetic agent, whereas it correlated positively with the eye elevation score (eye position=0.014*BIS+0.699, p-0.011). The mean eye position score was significantly higher in patients whose BIS score was greater than 65.[9]

Conclusion

Unexpected eye movement during general anesthesia is an important entity during short ocular procedures or surgeries, especially without NDMR. be used during ocular procedures involving critical steps like cataracts and squints. More research is needed on link between eccentric downward movement, eccentric upward movement, and level of anesthesia (using BIS and MAC values) and electrical activity of the brain (Electro-encephalogram).

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