Review Article

Total Intravenous Anaesthesia in Ophthalmic Surgeries: A Review

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ABSTRACT

Introduction

Ophthalmic surgeries are done under topical anaesthesia, regional nerve blocks, and under general anaesthesia (GA). The goals of GA are smooth induction, stable intraocular pressure (IOP), and stable haemodynamics in the perioperative period.

Objective

Safety and efficacy of use of total intravenous anaesthesia (TIVA) for ophthalmic surgeries.

Methods

Literature search on PubMed, Google Scholar, and ScienceDirect to include randomised controlled trials, observational studies and case reports using TIVA for ophthalmic surgeries.

Results

Eleven studies, one meta-analysis and five case reports/case series were included. TIVA was found to be better or equivalent to inhalational anaesthesia in ophthalmic surgeries, as it provides stable IOP and haemodynamic control with smooth induction and emergence and prevents postoperative nausea and vomiting (PONV). TIVA is used for sedation as well as anaesthesia. Dexmedetomidine and ketamine are given as bolus/continuous using manual infusion pumps. Target-controlled infusion (TCI) pumps have been used for propofol, and the use of remifentanil has further facilitated enhanced recovery after surgery (ERAS).

Conclusion

TIVA is a reliable alternative to inhalational anaesthetic agents in ophthalmic surgery. Adequate training is, however, needed to popularise the use of TCI pumps.

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Article History
Received: 10th April 2026
Revision: 15th April 2026
Accepted: 22nd May 2026
Published: 25th June 2026

Key words

Total intravenous anaesthesia, Ophthalmic surgeries, Inhalational Anaesthesia, Eye surgeries, target-controlled infusion

How to cite this article: Sahil Garg, Bikram Ghosal, Tanvir Samra Total Intravenous Anaesthesia in Ophthalmic Surgeries: A Review. Ind J Ophthal Anaesth 2025;6(2)3-22

Introduction

Ophthalmic surgeries include cataract, glaucoma, vitreoretinal, oculoplastic, strabismus, orbital, corneal and conjunctival surgeries. The most common anaesthetic modality used for ophthalmic surgeries is topical and regional eye blocks. General anaesthesia (GA) is used for long-duration procedures and in specific patient groups, such as paediatric and geriatric patients. Smooth induction and emergence, stable intraocular pressure (IOP) and haemodynamics and less postoperative nausea and vomiting (PONV) are the anaesthetic goals.[1-3] This review aims to study the efficacy and safety of total intravenous anaesthesia (TIVA) in achieving the goals during ophthalmic surgery.

Materials And Methods

This review included literature published in the last 30 years, between 1996 and 2026, searched across PubMed, Scopus and Google Scholar. Search terms used were "Total Intravenous Anaesthesia" and "Ophthalmic surgeries" or "Eye surgeries". Randomised controlled trials, meta-analysis, observational studies, case series and reports published in the english language were included. Patients of all age groups and ASA grade I-III undergoing ophthalmic surgery operated using TIVA were included.

Results

Eleven studies, one meta-analysis and five case reports/case series were included. We found that TIVA is better or equivalent to inhalational anaesthesia in ophthalmic surgeries, as it provides stable IOP and haemodynamics, with smooth induction and emergence, and also prevents PONV as described in table 1 & 2. TIVA is used for sedation as well as anaesthesia. Dexmedetomidine and ketamine are given as bolus/continuous using manual infusion pumps. TCI pumps have been used for propofol and use of remifentanil has further facilitated enhanced recovery after surgery (ERAS).

Table 1: Studies summarising the use of total intravenous anaesthesia (TIVA) in ophthalmic anaesthesia

	Study & design	Number of patients	Age	Surgery	Primary aim	Results
1	**Sethi et al[4]** Prospective consecutive series	905	7-18 years	Cataract surgeries (only lens aspiration with intraocular lens implantation without vitrectomy), vitrectomy or scleral buckling coupled with endolaser and the squint surgeries in single eye with not more than two muscles.	Acceptability and feasibility of IV ketamine (0.5 mg.kg^{-1}) and IV midazolam (0.05 mg.kg^{-1}) diluted up to 10 mL given over 30 s with peribulbar block (5 ml of 1:1 ratio of 2% lignocaine mixed with 10 IU.mL^{-1} of hyaluronidase and 0.5% bupivacaine. In long duration surgeries, an additional 3 mL of drug was given via medial canthal injection. For extraocular surgeries, 2% lignocaine with adrenaline was infiltrated along the incision line and surgical area.	Cases conducted uneventfully without conversion to GA
2	**Zhang et al[5]** Prospective, single-center, randomized controlled study	122 (61 in each group)	16-65 years	Orbital fracture with reconstruction of extensive orbital floor and medial wall	To evaluate the efficacy and safety of OFA with MCPB with 1% ropivacaine compared to OSA with low-dose fentanyl, both combined with NSAIDs, for patients undergoing orbital fracture reconstruction. OSA: PCIA with a regimen of fentanyl (250 μg) and tropisetron OFA: MCPB combined with NSAIDs.	Both strategies provided effective postoperative pain relief, but OFA enhanced the quality of early postoperative recovery.
3	**Zhang et al[6]** Prospective, randomized, double-blind study	93	18-65 year	Fundus surgery ≥30 minutes with LMA insertion	The primary outcome was the time from drug withdrawal to eye opening in 3 groups: **HSK3486 (H group-** Ciprofol@) 0.4 mg/kg within 30 seconds with remifentanil 2 μg/kg IV followed by 0.1–0.3 mg/ kg/h and 0.1–0.2 μg/kg/min remifentanil during maintenance	Incorporation of flumazenil with remimazolam for TIVA provided rapid and reliable recovery of consciousness, although there were

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	Study & design	Number of patients	Age	Surgery	Primary aim	Results
3					**Remimazolam-saline (RS group)** remimazolam - 0.2 mg/kg and remifentanil (2 μg/kg). IV remimazolam 1–2 mg/kg/h and remifentanil 0.1–0.2 μg/kg/min were infused continuously for maintenance. **Remimazolam-flumazenil(RF group).** Flumazenil 0.5 mg	no significant visible differences between HSK3486 and Remimazolam-saline.
4	**De Nucci et al[7]** Prospective, observational, uncontrolled, single-center study	123	18 years and above	Elective ocular surgery under local anaesthesia	Evaluating the effectiveness and safety of dexmedetomidine conscious sedation during ocular surgery under local anaesthesia when IV infusion started 15 min before regional anaesthesia and maintained up to the end of surgery. 1.2 μg/kg/h and titrated after 10 min to 0.3 μg/kg/h	All patients reached the requested MOAA/S score of 5.
5	Zamzam et al[8] Prospective, randomized, single-center trial with two equal parallel arms	100	3-10 years	Cataract surgery	To assess the efficacy of the bispectral index monitor in quantifying the depth of anaesthesia and its correlation with ocular alignment during juvenile cataract surgery in two groups: Group S anaesthetized using sevoflurane maintenance only Group P anaesthetized using continuous intravenous anaesthesia (midazolam @ 0.05 mg/kg bolus plus propofol infusion) as maintenance after induction with sevoflurane anaesthesia 8%.	The authors proposed a correlation between the lower depth of anaesthesia and the elevated eye position in sevoflurane group only

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6	**Rajput et al[9]** Prospective study included pediatric patients undergoing ocular surgery under general anesthesia	55 children (62 eyes) were operated	<10 years	Lid tear (most common)	To study the safety profile of combined ketamine and regional anesthesia in pediatric ocular surgeries during the COVID-19 pandemic. Premedication with oral midazolam (0.25–0.50 mg/kg) or intramuscular ketamine (7-10 mg/kg), Anaesthesia achieved with intravenous ketamine (4–5 mg/kg) and local anaesthesia (peribulbar block or local infiltration).	Combined ketamine and regional anaesthesia is a safe and effective alternative to administer anaesthesia in a child during ocular surgeries.
7	**Na et al[10]** Randomized double blinded study	84	20–80 years	Elective vitrectomy under GA	To compare the quality of postoperative recovery on the day of vitrectomy using the Quality of Recovery (QoR)-40 questionnaire between TIVA (propofol group) and inhalation anaesthesia (desflurane group)	The median of QoR-40 score on the day of surgery was significantly higher in the propofol group than that in the desflurane
8	**Zhu et al[11]** Prospective randomized controlled trial	200	18–60 years	Strabismus	Desflurane anesthesia compared with TIVA on anaesthesia-controlled OR time	DES enhanced the ophthalmic OR efficiency by reducing the extubation time and OR exit time, and provided more stable hemodynamics intra-operatively than TIVA in patients undergoing strabismus ambulatory surgery

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	Study & design	Number of patients	Age	Surgery	Primary aim	Results
9	**Schäfer et al[12]** Prospective, randomized study	40	>50 years	Elective cataract surgery	To compare the effects on IOP of two different anaesthetic techniques: Group P: TIVA with propofol bolus 1.5–2.0mg/kg, maintenance 3.0-7.0 mg/kg/h Group S: sevoflurane, end-tidal concentration 0.7–1.2 vol.% An infusion of remifentanil (10mg/kg/h) in both	The decrease in IOP was significantly more pronounced in the group P than in the group S.
10	**Frey et al[13]** prospective, randomized, double-blinded	70	>60	Cataract extraction	To compare sedation quality, IOP changes, and recovery profiles in patients who received propofol or propofol-ketamine sedation during placement of the retrobulbar nerve block (RBB).	Using ketamine provided a faster onset and improved the quality of sedation during the retrobulbar block
11	**Li et al[15]**	90	5-12 years	Elective ophthalmic surgery	Awakening time between LG group: propofol-remifentanil intravenous anaesthesia with regional block Induction: propofol at a dose of 3–5 mg/kg remifentanil at a dose of 1–1.5 μg/kg 2-4 ml of 0.375% ropivacaine and 1% lignocaine mixture for local infiltration For surface anaesthesia, 0.4% oxybuprocaine, was used along with intermittent additional 2% lignocaine intra-operatively. G group: propofol at a dose of 3–5 mg/kg and sufentanil at a dose of 0.6 μg/kg	The awakening time after general anaesthesia and removal time of laryngeal mask were significantly shorter in the LG group than in the G group

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	Study & design	Number of patients	Age	Surgery	Primary aim	Results
	A systematic review and meta-analysis					
	Chen et al[14]	Literature was retrieved from 10 commonly used databases and randomized controlled trials published up to May 2022 A total of 13 articles were included in the analysis, comprising 1,018 patients who underwent strabismus surgery Aim: To evaluate the efficacy of dexmedetomidine in preventing anaesthesia related complications in strabismus surgery Result: Dexmedetomidine can alleviate postoperative delirium and reduce the incidence of PONV, as well as postoperative pain. Intravenous administration can lower the occurrence rate of OCR.				

[4]doses ≤4 mg/kg of ketamine showed no clinically meaningful association with IOP.

[5]Fentanyl was converted to an equivalent dose of remifentanil by a potency ratio of 1:1.2. Anaesthesia was induced with propofol, fentanyl and rocuronium, flexible laryngeal mask airway was inserted. For maintenance of anaesthesia, propofol and remifentanil were administered in target-controlled infusion mode

[8]MacFarlan regimen was used for propofol:

- 0–15min:15mg/kg/h
- 15–30mis:13mg/kg/h
- 30–60 min: 11 mg/kg/h

[10]Propofol and remifentanil administered using effect-site target-controlled infusion (TCI)

[11]TCI with propofol at an effect-site concentration (Ce) of 2.0 to 4.0 μg/mL and remifentanil 0.15 μg/kg/min in 100% oxygen at a flow rate of 2 L/min.

Abbreviations:

Opioid free anaesthesia (OFA); Opioid sparing analgesia (OSA); medial canthus peribulbar block (MCPB); patient-controlled intravenous analgesia (PCIA); oculocardiac reflex (OCR); postoperative nausea & vomiting (PONV); intra ocular pressure (IOP); operating room (OR); Modified Observer's Assessment of Alertness and Sedation (MOAA/S)

Table 2: Case reports/case series summarizing the use of TIVA in ophthalmic anaesthesia

1	Leka et al[16]	3-year-old male with a traumatic dog bite to the neck and face	Midazolam (0.05 mg) Propofol (2 mg/kg IV) Fentanyl (2 μg/kg IV). Vecuronium (0.1 mg/kg IV) Maintenance of Anaesthesia: Propofol infusion (100–200 μg/kg/min) supplemented by intermittent fentanyl boluses (0.5–1 μg/kg)	Better control of IOP, more stable hemodynamics, and a reduced incidence of PONV.
2	Hashimoto et al[17]	75-year-old female for right vitrectomy	Propofol 4–6 mg/kg/hr Ketamine 0.3–1 mg/kg/hr Fentanyl (total, 200 μg). Vecuronium (total, 5 mg).	Marked reduction in bispectral index with severe bradycardia without hypotension
3	Leister et al[18]	11 cases of chronic progressive external ophthalmoplegia (CPEO) i.e. mitochondrial encephalomyopathies underwent 12 surgical procedures from January 2012 to February 2022 in a German university hospital	6 underwent surgery using LA. Four cases within the GA cohort were administered propofol and remifentanil; one was given desflurane and remifentanil	Both LA and GA are feasible concepts for patients with CPEO
4	Watts et al[19]	A 25-year-old-female with Kugelberg–Welander Syndrome (type III Spinal Muscular Atrophy) presented for urgent corneal grafting due to keratoglobus	LMA was inserted and total, 1mg of remifentanil and 510 mg of propofol were administered.	TIVA using short acting drugs may provide an ideal way of avoiding longer acting medication, the action of which can be unpredictably prolonged by the underlying condition.
5	Lam et al[20]	45-year-old, 68-kg male with a 10-year history of myasthenia gravis listed for mid-face lifts and posterior lamellar hard palate grafts on both sides.	45-year-old, 68-kg male with a 10-year history of myasthenia gravis listed for mid-face lifts and posterior lamellar hard palate grafts on both sides.	The use of a short-acting intravenous anaesthetic technique virtually eliminated the risks of respiratory failure or aspiration despite surgery lasting 2–3 hours.

Discussion

Various drugs are used in current-day TIVA practice. The most common are Propofol, Dexmedetomidine, and Remifentanil.

1. **Propofol:** Pharmacodynamics in relation to ophthalmic anaesthesia: a. It decreases IOP during surgery when given as a bolus, followed by an infusion for maintenance.[21] b. Antiemetic action: A small bolus of propofol, i.e. 10-20mg, is sufficient for its antiemetic action.[21]

   Uses in ophthalmic procedures: Can be used for cases operated under monitored anaesthesia care (MAC), sedation along with regional nerve blocks, and GA cases.[15]

2. **Dexmedetomidine:** It is a selective alpha 2 adrenoceptor agonist with sedative, hypnotic, analgesic and sympatholytic effects.

   Pharmacodynamics: It induces sedation by activating alpha-2 receptors in the locus ceruleus, unlike propofol, which exerts its effect through GABA-A receptor activation. It has a dose-dependent action with hypotension at low doses and hypertension at higher doses. Subsequently, it has bradycardia caused by the baroreceptor reflex. Minimal respiratory depression is seen with dexmedetomidine. The elderly are more vulnerable to respiratory depression than young healthy volunteers

   Uses in ophthalmic surgery: i. PONV: It can help prevent postoperative delirium and reduce the incidence of PONV, as well as postoperative pain.

   ii. OCR: The effect of dexmedetomidine on the OCR remains controversial. It reduces the incidence of the OCR when used intravenously according to randomised controlled trials and meta-analysis,[14,22] While observational studies have suggested that dexmedetomidine may augment OCR.[23] These conflicting results across studies may be due to differences in dose, route of administration and anaesthetic technique used.

   iii. It can be used for patients undergoing MAC and regional nerve blocks for sedation, but caution is advised, especially in elderly patients and those with haemodynamic compromise due to cardiovascular and respiratory side effects.

3. **Remifentanil:** It is an ultra-short-acting opioid with a short half-life; its effective plasma concentration decreases to 50% in 3-4 minutes. It is a selective mu receptor agonist.[24]

   Pharmacokinetics: It is degraded by esterases in the blood and tissues and excreted in urine. Its elimination half-life is 8-20 mins.

   Pharmacodynamics: It helps decrease IOP and is thus used in combination with propofol. Adverse effects are bradycardia, hypotension, Nausea, vomiting, muscle rigidity, skin rash and respiratory depression.[24]

Uses in ophthalmic surgeries: It can be used for analgesia in cases performed under MAC, for sedation along with regional nerve blocks, and for GA.[24]

4. **Ketamine:** It is a non-barbiturate anaesthetic agent. It preserves airway reflexes and patency.

   Pharmacokinetics: It is metabolised in the liver and excreted in urine with an elimination half-life of 2-3 hours. Duration of anaesthetic action after a single dose is 5-10 mins with complete recovery after 1-2hours.[24]

   Pharmacodynamics: It can cause raised IOP during the intraoperative period, but doses less than 4mg/kg do not raise IOP.[4] Frey et al used propofol-ketamine sedation during retrobulbar block and observed that it produces analgesia at subanaesthetic doses with minimal effect on IOP.[13] Adverse effects include hallucinations, which can be avoided by using benzodiazepines (BZDs), cardiovascular stimulation, raised IOP & intracranial pressure (ICP), nystagmus, hypersalivation leading to increased chances of post op endophthalmitis.[24]

   Uses in ophthalmic surgeries: It can be used as a sedative, along with regional nerve blocks, in ophthalmic cases and in cases performed under MAC.

Table 3: Doses of Propofol and remifentanil to maintain effect site plasma concentration in different age groups.

Drug	Patient category	Dosage	
Propofol	Adults	Induction dose	2-3mg/kg
		Maintenance dose	150-200mcg/kg/min
		Effect site plasma concentration	Induction: 4-6 mcg/ml Maintenance: 2.5-4.5 mcg/ml (with opioids)
	Infants (<1 years)	Induction dose	2.5-4mg/kg
		Maintenance dose	250-350mcg/kg/min
		Effect site plasma concentration	Induction: 4-6 mcg/ml Maintenance: 3-5 mcg/ml (with opioids)
	Children (1-12 years)	Induction dose	2.5-3.5mg/kg
		Maintenance dose	150-250mcg/kg/min
		Effect site plasma concentration	Induction: 5-7 mcg/ml Maintenance: 4-6 mcg/ml (with opioids)

Drug	Patient category	Dosage	
Remifentanil	Adults	Induction dose	0.5-1 mcg/kg
		Maintenance dose	0.1-0.3 mcg/kg/min
		Effect site plasma concentration	Induction: 3-6 ng/ml Maintenance: 2-6 ng/ml
	Infants (<1 year)	Induction dose	0.5-1 mcg/kg
		Maintenance dose	0.25-1 mcg/kg/min
		Effect site plasma concentration	Induction: 3-6 ng/ml Maintenance: 2-6 ng/ml
	Children (1-12 years)	Induction dose	0.5-1 mcg/kg
		Maintenance dose	0.1-0.5 mcg/kg/min
		Effect site plasma concentration	Induction: 4-7 ng/ml Maintenance: 3-6 ng/ml

Note: 1. The above doses are based on the Propofol and Remifentanil combination used for TIVA.
2. We should titrate doses based on EEG-based BIS monitoring rather than solely on predicted plasma and effect-site concentrations.

Table 4: Doses of drugs used intravenously for sedation in regional nerve blocks.

Drugs	Loading dose	Maintenance infusion dose
Propofol	0.2-0.5 mg/kg	25-75mcg/kg/min
Remifentanil	0.25-1 mcg/kg	0.025-0.2mcg/kg/min
Dexmedetomidine	0.5-1 mcg/kg over 10 min	0.2-0.7mcg/kg/hr
Ketamine	0.25-0.5 mg/kg	0.1-0.6 mg/kg/hr
Midazolam	0.02-0.05 mg/kg	0.02-0.1 mg/kg/hr

TIVA in specific ophthalmic procedures and its effect on various parameters:

1. Cataract surgery: The most common eye surgery to be performed worldwide. It is usually performed under topical and regional anaesthesia. But GA may be required in certain populations, such as children, the geriatric population, those unable to remain sit idle, or those with multiple comorbidities.[2]

2. Glaucoma: It is usually done under topical and regional nerve blocks, but in cases done under GA, TIVA is a better choice as compared to inhalational anaesthetic agents, because of less PONV, smooth extubation, causing decreased chances of raised IOP leading to less chances of ischaemia of optic nerve and retina.[2]

A rapid rise in IOP can occur during anaesthetic management, causing the risk of retinal ischaemia and expulsive haemorrhage.[25] TIVA provides a smooth induction and emergence from anaesthesia leading to decreased chances of raised IOP during the perioperative period. Secondly, the use of supraglottic airway devices has gained popularity with TIVA, resulting in a lesser sympathetic response than with laryngoscopy and intubation and decreasing the risk of raised IOP.[1]

3. Strabismus: In paediatrics and even adults, strabismus surgery is preferred under GA by many surgeons as there are high chances of OCR and PONV.[1,26] TIVA with the use of propofol and antiemetics, i.e. dexamethasone 0.1mg/kg and ondansetron 0.1 mg/kg, is helpful in prophylaxis and treatment of PONV.[26] Furthermore, TIVA, when used with propofol and remifentanil, decreases the chances of OCR.[2] However, some studies suggest that OCR is better managed with inhalational anaesthetics than with TIVA, and vice versa. So, no anaesthetic agent can completely abolish OCR.[2]

4. Vitreoretinal surgery: Nowadays, advanced techniques have allowed vitreoretinal surgery to be done under regional anaesthesia. But macular surgical cases should preferably be done under GA, as slight movement can lead to adverse outcomes.[2] TIVA should be used for vitrectomy, as N_2O can raise IOP, and secondly, vitrectomy in an ambulatory setting will allow early mobility and better quality of recovery with TIVA compared to inhalational anaesthetic agents.[26,27] Scleral buckling involves traction of rectus muscles, leading to OCR, and can be avoided with the use of TIVA.[26]

5. Orbital and oculoplastic surgeries: Oculoplastic procedures are mostly done under local anaesthesia. But orbital procedures like orbital decompression, evisceration, enucleation, and brachytherapy are conducted under GA, as there may be blood loss and a high incidence of pain and PONV.[2,26]

6. Ocular trauma and emergencies: GA is preferred in these cases to avoid raised IOP, PONV and to prevent the chances of aspiration as the patient may be full stomach in an emergency scenario.[2,26]

7. Ophthalmic surgeries in paediatrics: TIVA is preferred in paediatric patients due to reduced airway irritation and secretions, stable haemodynamics, fewer adverse effects, and faster recovery.[3]

TIVA Techniques: TIVA can be administered in various ways. But, it is important to follow the guidelines outlined by Nimmo et al[28] including the requirement for a separate IV line for TIVA administration, Luer lock at each end of the infusion set, antisyphon valve on the drug delivery line, and antireflux valve on the fluid administration line. Program the infusion pump only after the drug-containing syringe is placed in the pump. The IV cannula should be visible throughout the procedure, if possible. The different methods of TIVA administration are:

1. Manual infusion: It is the most common method of administering TIVA. A bolus dose of the drug is given during induction, and then an infusion is started at a maintenance dose. But due to the complex pharmacokinetics of drugs like Propofol and Remifentanil, the dose of the drug administered will not be appropriate at all times during the maintenance phase, leading to awareness during anaesthesia or overdose.

2. Target-controlled infusion(TCI) Pump: The most reliable method of administering TIVA is the use of TCI pumps. The microprocessor in the pump will determine the dose required to achieve and maintain the selected adequate blood concentration set by the anaesthesiologist. Various pharmacokinetic models are used in TCI pumps to maintain steady-state plasma or effect site concentrations of anaesthetic drugs. PK models are mathematical algorithms used to calculate the drug in different compartments.

The most common PK models used for propofol are Marsch, Schnider. paedfusor and eleveld. Hannivoort is used for dexmedetomidine. While the Minto and Eleveld models are for remifentanil, as described in Table 5.[29–34]

3. Closed-loop anaesthesia delivery system (CLADS): It can be used to provide TIVA during surgery. It uses BIS as a control variable. contrast to manual infusion, CLADS is a more effective and efficient system to administer TIVA, as demonstrated by Puri et al.[35]

4. Monitored anaesthesia care (MAC): Procedural sedation with MAC is sufficient in most ophthalmic surgeries. Multipara monitoring, including baseline parameters such as heart rate, non-invasive blood pressure, arterial oxygen saturation (SpO2), end-tidal carbon dioxide (etCO2), and temperature, is used to monitor haemodynamic parameters.[25]

5. Sedation during ophthalmic regional blocks: Most of the surgeries, like cataract, glaucoma, oculoplasty and vitreoretinal surgeries, can be done under regional nerve blocks. These blocks are more efficient when administered using sedative agents. This will improve patients' comfort during regional nerve block administration.[24]

Table 5: Various models used in TCI pumps for TIVA drugs

Drugs	Model	Age range	Covariates	Effect site rate constant (Keo)	Fixed parameters	Variable parameters
Propofol	Marsch[29]	After 16 years of age	Patient's weight	1.2/min (Modified marsch model)	All rate constants	All compartment volumes (V1-V3)
	Schnider[30]	25-80 years	Lean body mass (LBM), age, sex, height	0.456/min	V1,V3,K13, K31	V2,K12,K21, Keo,K10

Drugs	Model	Age range	Covariates	Effect site rate constant (Keo)	Fixed parameters	Variable parameters
Propofol	Eleveld[31]	0.5-88 years	Age, weight, Gender, Height, Fat free mass, Co-medication.	0.146/min	All with fixed base value	All depending upon weight and age
	Paedfusor[36]	1-16 years	Weight	0.91/min	All rate constants except K10	V1,V2,V3 K10
	Kataria[37]	3-16 years	Weight	0.41/min	All rate constants	V1,V2,V3
Remifentanil	Minto[32]	20-85 years	Age, LBM, Sex, Height	0.595/min	V3	V1, V2, Rate constants
	Eleveld[33]	0.5-88 years	Age, weight, Gender, Height, Fat free mass, Co-medication.	1.09/min	All with fixed base value	All depending upon weight and age
Sufentanil	Gepts[38]	14-68 years	No covariates	----	All rate constants and compartment volumes	----
Alfentanil	Maitre[39]	18-70 years	Age, weight	0.77/min	V2, V3, K21, K31, Keo	V1, K10, K12, K13
Dexmedetomidine	Hannivoort[34]	20-70 years	Weight	0.456/min	-----	-----

V1 – V3 are Compartment volumes. Wherein V1 : Central compartment volume,

V2 : Rapidly equilibrating compartment volume,

V3 : Slowly equilibrating compartment volume.

K12: Rate constant between V1 and V2.

K21: Rate constant between V2 and V1.

K10: Rate constant for drug elimination from central comapartment.

Keo: Rate constant for equilibrium between plasma and effect-site concentration.

Monitoring during TIVA: Haemodynamic monitoring (heart rate, non-invasive blood pressure, SpO2) along with temperature and capnography is a basic requirement for any type of anaesthesia. In addition, BIS should be monitored in TIVA. BIS is an EEG-based neuromonitoring tool to assess the depth of anaesthesia.[25,40] BIS in TIVA is as essential as MAC is for inhalational anaesthetic agents to prevent awareness of anaesthesia. If muscle relaxants are used, neuromuscular monitoring is required to ensure adequate paralysis and prevent sudden patient movement during surgery.[26]

Recovery from TIVA: Recovery is rapid and smooth, with a low incidence of PONV, stable haemodynamics, decreased risk of emergence delirium compared with volatile anaesthetic agents, and less airway irritation and coughing.[41,42,43] Table 6 shows the effect site target concentration of propofol during the recovery phase.

Table 6: Effect site target concentration of propofol during recovery from anaesthesia.

Recovery state	Propofol (mcg/ml)
Eye opening	1-2
Extubation	1-1.5
Complete orientation	<1

TIVA in special situations: 1. Myasthenia gravis: Use of muscle relaxants is avoided in myasthenia gravis because of increased chances of respiratory failure, bulbar muscle weakness and interaction with muscle relaxants. Non-relaxant techniques using Propofol with remifentanil are ideal in such cases to avoid residual muscle weakness and paralysis.[20]

2. Malignant hyperthermia: Patients with a history of MH should be operated under TIVA, as inhalational agents are contraindicated.[44,45]

3. Rapid sequence induction: TIVA with the use of propofol and muscle relaxants like succinylcholine, and nowadays, due to the availability of sugamadex, rocuronium is used to provide rapid sequence induction during emergency situations.[46,47]

Advantages of TIVA: 1. Use of TIVA will lead to reduced risk of PONV.

2. Reduced chances of OCR when combined with regional nerve blocks.

3. IOP is maintained during the perioperative period when TIVA is given.

4 Smooth induction and emergence during extubation leading to stable IOP and decreased chances of retinal ischaemia and blindness.

5. Day care benefits, as patients can be discharged on the same day or within 24 hours of surgery.

6. The greenhouse effect is less, and carbon footprints are 20 times less than inhalational techniques.[48]

LIMITATIONS AND CHALLENGES FOR TIVA: 1. TCI pumps, along with BIS monitoring, are a necessary requirement for administering TIVA to avoid inappropriate dosing with the manual method and thus awareness under anaesthesia. TCI pumps are not available in every hospital, which is a major limitation to administering TIVA.[49]

2. This is difficult to put BIS sensors on a patient's forehead in ophthalmic surgeries, as it might interfere with the surgeon's field.

3. IV line insertion is a basic requirement for any TIVA technique to use, which can be difficult in the case of neonates and infants.

4. Training of anaesthesiologists is required to administer TIVA effectively, as most of the institutes give anaesthesia training to residents based on inhalational agents. So, anaesthesiologists are reluctant to use TIVA.[49]

5. A reliable method to detect disconnection and non-delivery of the drug is not available for TIVA.[49]

6. Pharmacokinetic methods used for different drugs are not accurate.[49]

7. TIVA can lead to cardiovascular instability in haemodynamically compromised patients, especially in emergency surgeries.[49]

8. There is a lack of availability of sensors for infants.

9. There is no data reliability in patients with neurological disorders.

FUTURE DIRECTIONS: 1. Use of TIVA in ophthalmic surgeries has a lot of potential in future as upcoming intravenous anaesthetic agents (Remimazolam, remifentanil, ciprofol) are ultrashort-acting, having less side effects and rapid recovery. So, infusion of these ultrashort-acting agents is very safe and reliable for the TIVA technique.[6]

2. The use of CLADS (Closed-loop anaesthesia delivery system) allows anaesthetists to devote attention to other important tasks during the intraoperative period, such as haemodynamic monitoring.[35]

3. Current use of TCI is restricted to Hypnotics & Analgesics. In future, can be used for other drugs.

4. Most of the TCI pumps are not tested in infants, obese, elderly & critically ill patients, which can be made available in future

5. More research should be done to refine TIVA techniques in the near future, as it has a much lower carbon footprint than inhalational agents, which is the need of the hour.[48,50]

Conclusion

TIVA in ophthalmic surgeries is a reliable alternative to inhalational anaesthetic agents, offering several advantages, such as reduced PONV, reduced incidence of malignant hyperthermia, less environmental impact, and stable IOP. Although there are limitations to the use of TIVA, they can be avoided, and new techniques can be used to administer TIVA, such as TCI Pumps and CLADS. Future research should be carried out to refine TIVA techniques, along with compulsory TIVA training for residents in

medical institutions, so that reluctance to its use can be minimised.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Kumar C, Seet E, Chua A. Updates in ophthalmic anaesthesia in adults. Br J Anaesth. 2023;23,153-9.
2. Pucchio A, Pur DR, Dhawan A, Sodhi SK, Pereira A, Choudhry N. Anesthesia for ophthalmic surgery: an educational review. Int Ophthalmol. 2023;43:1761-9.
3. Sahutoglu C. Anesthesia for ophthalmic surgery. Eur Eye Res 2024;1:90-102
4. Sethi S, Subhedar K, Sharma S, Sethi M. Acceptability and Feasibility of an Innovative Anesthesia Technique in a Low-Resource Setting at a Rural Community Ophthalmic Center: A Prospective Journey. Anesth Essays Res. 2020;14:203-7.
5. Zhang R, Mai Y, Ye H, Lian X, Yang H, Zhu Y, et al. A Randomized Controlled Non-Inferiority Trial Evaluating Opioid-Free versus Opioid-Sparing Analgesia for Orbital Fracture Reconstruction Under General Anesthesia. J Pain Res. 2024;17:3707-17.
6. Zhang S, Liu Y, Liu Y, Xu T. The Recovery of Ciprofol, Remimazolam and Remimazolam-Flumazenil for General Anesthesia Undergoing Fundus Surgery: A Single-Center, Prospective, Randomized, Controlled Clinical Study. Drug Des Devel Ther. 2025;19:3691-700.
7. De Nucci A, Scialdone A, Lando G, Monaco G, Cacioppo V, Davies SC, et al. Effectiveness and safety of intravenous dexmedetomidine sedation for ophthalmic surgery under regional anesthesia. Eur J Ophthalmol. 2022;32:2598-603.
8. Zamzam Z, Taraby A, AbdElmagid NA, Elsharkawy RA. The effect of propofol-midazolam versus sevoflurane on bispectral index and eye position in pediatric cataract surgery: A randomized controlled study. Egyptian Journal of Anaesthesia 2024; 40:237–45.
9. Rajput VK, Tuvar S, Bhalsing S, Bhalsing S. Resurgence of combined intravenous Ketamine and regional anesthesia in pediatric ocular surgery in COVID-19 pandemic. Indian J Ophthalmol 2021;69:395-9.
10. Na SH, Jeong KH, Eum D, Park JH, Kim MS. Patient quality of recovery on the day of surgery after propofol total intravenous anesthesia for vitrectomy: A randomized controlled trial. Medicine (Baltimore). 2018;97:e12699.
11. Zhu YL, Shen WH, Chen QR, Ye HJ, Huang JX, Kang Y, Chi W, Gan XL. Desflurane anesthesia compared with total intravenous anesthesia on anesthesia-controlled operating room time in ambulatory surgery following strabotomy: a randomized controlled study. Chin Med J (Engl). 2020;133:779-85.

12. Schäfer R, Klett J, Auffarth G, et al. Intraocular pressure more reduced during anesthesia with propofol than with sevoflurane: both combined with remifentanil. Acta Anaesthesiol Scand. 2002;46:703-6.

13. Frey K, Sukhani R, Pawlowski J, Pappas AL, Mikat-Stevens M, Slogoff S. Propofol versus propofol-ketamine sedation for retrobulbar nerve block: comparison of sedation quality, intraocular pressure changes, and recovery profiles. Anesth Analg. 1999;89:317-21.

14. Chen Y, Li M, Zheng Y, Chen A, Li C. The preventive effect of dexmedetomidine on anesthesia complications in strabismus surgery: a systematic review and meta-analysis. BMC Anesthesiol. 2023;23:53

15. Li MY, Fei YD, Zhang XX, Chen TW, Li J, Sun XL, Wang ZY Application of propofol-remifentanil intravenous general anesthesia combined with regional block in pediatric ophthalmic surgery. BMC Anesthesiol. 2024;24:147

16. Leka S, Reci E, Dogjani A. Anesthesia Management for a Pediatric Trauma Patient with Coloboma Following a Dog Bite. Albanian Journal of Trauma and Emergency Surgery. 2025;9:1902-4.

17. Hashimoto H, Nakamura H, Hirota K. Marked reduction in bispectral index with severe bradycardia without hypotension in a diabetic patient undergoing ophthalmic surgery. J Anesth. 2008;22:300-3.

18. Leister N, Wendt S, Hedergott A, et al. Anaesthesia Concepts in Patients with Chronic Progressive External Ophthalmoplegia Undergoing Ophthalmic Surgery-A Retrospective Cohort Analysis. J Clin Med. 2024;13:4710

19. Watts JC. Total intravenous anaesthesia without muscle relaxant for eye surgery in a patient with Kugelberg–Welander Syndrome. Anaesthesia. 2003; 58:96.

20. Lam S, Slater RM. Total intravenous anaesthesia for oculoplastic surgery in a patient with myasthenia gravis without high-dependency care. Anaesthesia. 2003;58:712–26.

21. Pryor KO, Myles PS. Milk of Amnesia: Propofol for TIVA. In: Irwin MG, Wong GTC, Lam SW, eds. Taking on TIVA: Debunking Myths and Dispelling Misunderstandings. Cambridge University Press; 2019:22-30.

22. Song IA, Seo KS, Oh AY, Baik JS, Kim JH, Hwang JW, Jeon YT. Dexmedetomidine Injection during Strabismus Surgery Reduces Emergence Agitation without Increasing the Oculocardiac Reflex in Children: A Randomized Controlled Trial. PLoS One. 2016;11:e0162785.

23. Arnold RW, Jansen S, Seelig JC, Glasionov M, Biggs RE, Beerle B. Anesthetic Impacts on the Oculocardiac Reflex: Evidence from a Large, Observational Study. Clin Ophthalmol. 2021;15:973-81.

24. Loots H, Wiseman R. Agents for sedation in ophthalmic surgery: A review of the pharmacodynamics and clinical applications. Current anaesth crit care. 2006;17:179-90.

25. Upadhyay P, Ichhpujani P, Solanki A. Recent trends in anesthetic agents and techniques for ophthalmic anesthesia. J Anaesthesiol Clin Pharmacol. 2023;39:343-8.

26. Young S, Basavaraju A. General anaesthesia for ophthalmic surgery. Anaesth intensive care med. 2019;20:716-20.

27. Norbury A, Rocke AD, Brock-Utne JG, Mackenzie R, Welsh N, Downing JW. Balanced total intravenous anaesthesia and intraocular pressure. Anaesth Intensive Care. 1981;9:255-9.

28. Nimmo AF, Absalom AR, Bagshaw O, Biswas A, Cook TM, Costello A, Grimes S, Mulvey D, Shinde S, Whitehouse T, Wiles MD. Guidelines for the safe practice of total intravenous anaesthesia (TIVA): Joint Guidelines from the Association of Anaesthetists and the Society for Intravenous Anaesthesia. Anaesthesia. 2019 Feb;74(2):211-224.

29. Marsh B, White M, Morton N, Kenny GN. Pharmacokinetic model driven infusion of propofol in children. Br J Anaesth 1991;67:41–8.

30. Schnider TW, Minto CF, Gambus PL, Andresen C, Goodale DB, Shafer SL, Youngs EJ. The influence of method of administration and covariates on the pharmacokinetics of propofol in adult volunteers. Anesthesiology. 1998;88:1170-82.

31. Eleveld DJ, Colin P, Absalom AR, Struys MMRF. Pharmacokinetic pharmacodynamic model for propofol for broad application in anaesthesia and sedation. Br J Anaesth 2018;120:942–59.

32. Minto CF, Schnider TW, Shafer SL. Pharmacokinetics and pharmacodynamics of remifentanil. II. Model application. Anesthesiology. 1997;86:24 33.

33. Eleveld DJ, Proost JH, Vereecke H, Absalom AR, Olofsen E, Vuyk J, et al. An allometric model of remifentanil pharmacokinetics and pharmacodynamics. Anesthesiology 2017;126:1005–18.

34. Hannivoort LN, Eleveld DJ, Proost JH, Reyntjens KMEM, Absalom AR, Vereecke HEM, et al. Development of an optimized pharmacokinetic model of dexmedetomidine using target controlled infusion in healthy volunteers. Anesthesiology 2015;123:357–67.

35. Puri GD, Kumar B, Aveek J. Closed-loop anaesthesia delivery system (CLADS) using bispectral index: a performance assessment study. Anaesth Intensive Care. 2007;35:357-62.

37. Kataria BK, Ved SA, Nicodemus HF, Hoy GR, Lea D, Dubois MY, Mandema JW, Shafer SL. The pharmacokinetics of propofol in children using three different data analysis approaches. Anesthesiology. 1994;80:104-22.

38. Gepts E, Shafer SL, Camu F, Stanski DR, Woestenborghs R, Van Peer A, Heykants JJ. Linearity of pharmacokinetics and model estimation of sufentanil. Anesthesiology. 1995;83:1194-204.

39. Maitre PO, Vozeh S, Heykants J, Thomson DA, Stanski DR. Population pharmacokinetics of alfentanil: the average dose-plasma concentration relationship and interindividual variability in patients. Anesthesiology. 1987;66:3-12.

40. Pritchard N. General anaesthesia for ophthalmic surgery. Anaesthesia and intensive care medicine. 2016;18:33-6.

41. Eikaas H, Raeder J. Total intravenous anaesthesia techniques for ambulatory surgery. Curr Opin Anaesthesiol. 2009 Dec;22(6):725-9.

42. Kanaya A, Kuratani N, Satoh D, Kurosawa S. Lower incidence of emergence agitation in children after propofol anesthesia compared with sevoflurane: a meta-analysis of randomized controlled trials. J Anesth. 2014;28:4-11.

43. Xiao Y, Jin X, Zhang Y, Huang T, Zhou L, Gao J. Efficacy of propofol for the prevention of emergence agitation after sevoflurane anaesthesia in children: A meta-analysis. Front Surg. 2022;9:1031010.

44. Lodhi O, Tripathy K. Anesthesia for ophthalmic surgery. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan–. Updated 2023 Aug 25.

45. Kulkarni S, Harsoor SS, Chandrasekar M, Bhaskar SB, Bapat J, Ramdas EK, Valecha UK, Pradhan AS, Swami AC. Consensus statement on anaesthesia for day care surgeries. Indian J Anaesth. 2017;61:110-24.

46. Avery P, Morton S, Raitt J, Lossius HM, Lockey D. Rapid sequence induction: where did the consensus go? Scand J Trauma Resusc Emerg Med. 2021;29:64.

47. Curley GF. Rapid sequence induction with rocuronium - a challenge to the gold standard. Crit Care. 2011;15:190.

48. Bernat M, Boyer A, Roche M, Richard C, Bouvet L, Remacle A, Antonini F, Poirier M, Pastene B, Hammad E, Fond G, Bruder N, Leone M, Zieleskiewicz L. Reducing the carbon footprint of general anaesthesia: a comparison of total intravenous anaesthesia vs. a mixed anaesthetic strategy in 47,157 adult patients. Anaesthesia. 2024;79:309-17.

49. G. Irwin M, T. C. Wong G. Why Bother?: The Advantages of TIVA. In: Irwin MG, Wong GTC, Lam SW, eds. Taking on TIVA: Debunking Myths and Dispelling Misunderstandings. Cambridge University Press; 2019:1-4.

50. Kong VKF. Saving the Whales by Taking on TIVA: The Environmental Impact of TIVA. In: Irwin MG, Wong GTC, Lam SW, eds. Taking on TIVA: Debunking Myths and Dispelling Misunderstandings. Cambridge University Press; 2019:146-53.