Advances in Total Intravenous Anesthesia (TIVA): Pharmacokinetics, Safety, and Clinical Applications

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***Abstract*—Total Intravenous Anesthesia (TIVA) has emerged considerably over the past few years, offering clinicians a versatile and controllable anesthetic technique without the use of inhalation agents. This review paper provides information of recent advances in TIVA, emphasizing developments in pharmacokinetics, safety profiles, and expanding clinical applications. TIVA uses IV drugs like propofol and fentanyl (analgesic) to make and maintain unconsciousness and easy. It's a second traditional general anesthesia methods that rely on inhalational anesthetics. We provide an overview of novel intravenous agents, refinements in delivery systems such as target-controlled infusion (TCI), and evidence-based assessments of TIVA's efficacy and safety across diverse surgical and diagnostic procedures.**

***Index Terms*—Total intravenous anaesthesia TIVA, target-controlled infusion TCI.**

I. INTRODUCTION

TIVA is anesthetic technique or method that avoids the use of anesthetics and maintains anesthesia only with intravenous medications. In the past, TIVA was constrained by inadequate pharmacokinetic knowledge and imprecise delivery methods. However, TIVA is now the recommended choice for many anesthetic operations due to advancements in delivery systems and contemporary pharmacokinetic models. A technique known as total intravenous anesthesia (TIVA) involves giving a patient anesthetic medications only by intravenous (IV) injection. With this method, anesthesia may be precisely and carefully managed, and the degree of anesthesia can be quickly changed to suit the demands of the patient. A variety of anesthetics, including fentanyl, ketamine, and propofol, are commonly used in TIVA.

This method is frequently employed settings, neurosurgery, and general surgery. It requires a deep comprehension of each drug's pharmacokinetic profile, as well as how it interacts with the patient and with other drugs. Although TIVA can be implemented using manually regulated infusion rate pumps, its use has been made easier in recent years by the introduction of pumps that are programmed with pharmacokinetic data. Each intravenous sedative-hypnotic and adjuvant drug has a different dosage.It is necessary to take into account both pharmacodynamic and pharmacokinetic aspects for every patient, including those with cardiac failure, blood abnormalities, and compromised kidney or liver function.

By avoiding the drawbacks of volatile anesthetic and conventional breathing medications, TIVA is utilized to provide general anesthesia.Stage III surgical anesthesia is maintained by titrating intravenous anesthetic drugs at safe levels (unconsciousness, amnesia, immobility, and absence of reaction to painful stimulus). In situations where volatile anesthetic is either impossible or extremely risky, such as when treating patients who are morbidly obese, TIVA is beneficial.In traumatizing situations like major accidents, natural catastrophes, and conflicts, TIVA has also been utilized to administer anesthesia.

The following are the main objectives of TIVA:

a seamless induction of anesthesia

Measurable and dependable anesthetic maintenance

II. INDICATIONS

TIVA is used in a number of circumstances, such as major pediatric procedures.
neurosurgical techniques.
spinal apparatus.
procedures for the airways.

Pharma cokinetics of TIVA Agents

Propofol

Because of its advantageous pharmacokinetics—rapid onset, brief duration, and predictable recovery—propofol continues to be the mainstay of TIVA. Its three-compartment model has been better understood, leading to better dosage techniques.

Remifentanil

Remifentanil, it has quick clearance and low buildup, remifentanil, an ultra-short-acting opioid that is metabolized by nonspecific esterases, has completely changed intraoperative analgesia.

Dexmedetomidine and Other Adjuncts

Dexmedetomidine, ketamine, lidocaine, and magnesium are useful adjuncts to lessen the need for propofol, improve analgesia, and decrease adverse effects, according to recent studies.

III. ADVANCES IN DELIVERY SYSTEMS

Target-Controlled Infusion

By employing pharmacokinetic (e.g., Schnider, Marsh) maintain target plasma or effect-site concentrations, TCI systems have increased drug administration precision while lowering anesthetic depth variability.

Closed-loop Systems and Pharmacodynamic Integration

TIVA agent safety and titration are further improved by emerging technologies, including as closed-loop anesthetic delivery and real-time monitoring (e.g., bispectral index [BIS]-guided devices).

IV. SAFETY CONSIDERATIONS

Cardiovascular and Respiratory Effects

New technologies that improve the safety and titration of TIVA drugs include closed-loop anesthetic delivery and real-time monitoring (such as bispectral index [BIS]-guided devices).

Postoperative Nausea and Vomiting (PONV)

TIVA, especially protocols involving propofol, shows a lower incidence of PONV than inhalational anesthesia.

Awareness and Depth of Anesthesia

The incidence of PONV is lower with TIVA, especially with protocols based on propofol, than with inhalational anesthesia.

V. CLINICAL APPLICATIONS

Ambulatory Surgery

TIVA offers rapid recovery, minimal PONV, and smooth emergence, making it ideal for outpatient procedures.

Neurosurgery and ENT Procedures

TIVA's enhanced cerebral dynamics and bloodless surgical fields make it useful for neurosurgery and ENT procedures.

Pediatrics and Geriatrics

Predictability and safety profiles are enhanced by TIVA procedures designed for older and pediatric patients.

ICU Sedation

Propofol and dexmedetomidine are two examples of agents that have entered the ICU sedation market and provide short-acting, controlled sedation.

Future Directions

To maximize TIVA safety and effectiveness, ongoing research is concentrating on new drugs (such ciprofol), machine learning-based closed-loop delivery systems, and pharmacogenomics-based tailored anesthetic procedures.

VI. DISCUSSION

An adaptable, manageable, and progressively safer substitute for inhalational anesthesia, total intravenous anesthesia (TIVA) has revolutionized anesthetic practice during the last few decades. By combining developments in pharmacokinetics, pharmacodynamics, and drug delivery technologies, TIVA's clinical uses have significantly expanded, improving patient outcomes and spreading its use over a range of surgical specialties.Advances in TIVA have greatly improved its safety profile, which is crucial in anesthetic care.

Improved monitoring technologies, such bispectral index (BIS) monitoring, which helps determine anesthetic depth and lowers the risk of awareness under anesthesia, have helped allay worries about intraoperative awareness, hemodynamic instability, and postoperative problems. Furthermore, more recent drugs such as the α2-adrenergic agonist dexmedetomidine have demonstrated promise in sedating patients with little respiratory depression, promoting hemodynamic stability and maybe helping those at risk for cardiovascular compromise. Crucially, postoperative nausea and vomiting, side effect of volatile anesthetics, has been linked to a lower incidence of TIVA, which improves patient satisfaction and speeds up recovery. Research has also shown that when TIVA is used instead of inhalational approaches, patients with asthma and chronic obstructive pulmonary disease 0bserve reduced rates of airway reactivity and bronchospasm.

TIVA's clinical uses have significantly increased. Because of its capacity to lower intracranial pressure and preserve cerebral autoregulation, TIVA is now often used in neuroanesthesia in addition to standard general anesthesia. Although conclusive findings require additional research, there is some indication that TIVA, particularly propofol-based regimens, may affect immune responses more favorably than volatile drugs in oncologic surgery, potentially impacting tumor recurrence and metastasis. Additionally, TIVA provides the benefits of quick recovery, little cognitive impairment, and lower medical expenses because of shorter stays in the post-anesthesia care unit for ambulatory and day-case procedures.

To sum up, developments in TIVA have significantly enhanced its safety, clinical adaptability, and pharmacokinetic control, making it a mainstay of contemporary anesthetic treatment. Its significance will probably be further cemented while resolving current issues with continued innovation in drug discovery, infusion technology, and monitoring techniques. Future studies should concentrate on long-term results, customized pharmacokinetic modeling, and growing the body of evidence supporting use of TIVA in particular patient groups and surgical techniques.

VII. CONCLUSION

Underpinned by enhanced pharmacokinetic knowledge, superior administration technologies, and favorable safety profiles, TIVA offers a substantial advancement in anesthetic practice. Clinical uses for TIVA are expected to grow further as pharmacological and technical advancements continue, providing physicians with a powerful tool for individualized and accurate anesthetic management. TIVA's development, propelled by advancements in pharmacokinetics, improved safety protocols, and burgeoning therapeutic uses, is indicative of its increasing importance in anesthetic practice. Its usefulness will probably be further enhanced by ongoing developments in medication formulations, intelligent delivery methods, and monitoring technologies, offering specialized and safer anesthetic care for a range of patient demographics. To maximize results with TIVA, proper training, attentive monitoring, and knowledge of patient-specific pharmacodynamics are still essential.

REFRENCES

[1] MacCallum CA, Russo EB (March 2018). "Practical considerations in medical cannabis administration and dosing". European Journal of Internal Medicine. 49: 12–19. doi:10.1016/j.ejim.2018.01.004. PMID 29307505

[2] Jump up to:[a] [b] Nimmo AF, Absalom AR, Bagshaw O, Biswas A, Cook TM, Costello A, et al. (February 2019). "Guidelines for the safe practice of total intravenous anaesthesia (TIVA): Joint Guidelines from the Association of Anaesthetists and the Society for Intravenous Anaesthesia". Anaesthesia. 74 (2): 211–224. doi:10.1111/anae.14428. PMID 30378102. S2CID 53107969.

[3] Ohashi K, Dalleur O, Dykes PC, Bates DW (December 2014). "Benefits and risks of using smart pumps to reduce medication error rates: a systematic review". Drug Safety. 37 (12): 1011–

1020. doi:10.1007/s40264-014-0232-1. PMID 25294653. S2CID 9308973.

[4] Kan K, Levine WC (2021-01-01). "Infusion Pumps". Anesthesia Equipment: 351–367. doi:10.1016/B978-0-323-67279-5.00016-9. ISBN 9780323672795. S2CID 243158761.

[5] Seo KS, Lee K (September 2016). "Smart syringe pumps for drug infusion during dental intravenous sedation". Journal of Dental Anesthesia and PainMedicine. 16 (3): 165173. doi:10.17245/jdapm.2016.16.3.165. PMC 5586553. PMID 28884149.

[6] Lee WK, et al. Type of anaesthesia and patient quality of recovery: a randomized trial comparing propofol-remifentanil total i.v. anaesthesia with desflurane anaesthesia. Br J Anaesth 2015;114(4):663-668

[7] Godet G, et al. A comparison of sevoflurane, target-controlled infusion propofol, and propofol/isoflurane anesthesia in patients undergoing carotid surgery: a quality of anesthesia and recovery profile. Anesth Analg 2001;93(3):560-565.

[8] McGrenaghan E, et al. Total intravenous anaesthesia. Anaesth Intens Care Med. 2019;20(2):130-5.

[9] Murat I, et al. Effects of fentanyl on baroreceptor reflex control of heart rate in newborn infants. Anesthesiol. 1988; 68:712-22.

[10] Hughes MA, Glass PS, Jacobs JR. Context-sensitive half-time in multicompartment pharmacokinetic models for intravenous anesthetic drugs. Anesthesiology 1992; 76: 334–41.

[11] Steur RJ, Perez RS, De Lange JJ Dosage scheme for propofol in children under 3 years of age. Pediatric Anesthesia 2004; 14: 462–7.

[12] McCormack J, Mehta D, Peiris K, et al. The effect of a target-controlled infusion of propofol on predictability of recovery from anesthesia in children. Pediatric Anesthesia 2010; 20: 56–62.

[13] Absalom A, Kenny G ‘Paedfusor’ pharmacokinetic data set. British Journal of Anaesthesia 2005; 95: 110.

[14] McFarlan CS, Anderson BJ, Short TG. The use of propofol infusions in paediatric anaesthesia: a practical guide. Paediatric Anaesthesia 1999; 9: 209–16.

[15] Al-Rifai Z, Mulvey D. Principles of total intravenous anaesthesia: basic pharmacokinetics and model descriptions. BJA Education 2016; 16: 92–

[16] Pandit JJ, Andrade J, Bogod DG, et al. The 5th National Audit Project (NAP5) on accidental awareness during general anaesthesia: summary of main findings and risk factors. Anaesthesia 2014; 69: 1089–101.

[17] Nimmo AF, Absalom AR, Bagshaw O, Biswas A, Cook TM, Costello A, et al. Guidelines for the safe practice of total intravenous anaesthesia (TIVA). Anaesthesia. 2019;74(2):211-24.

[18] Pollard BJ, Kitchen, G. Handbook of Clinical Anaesthesia. Fourth Edition. CRC Press. 2018. 978-1-4987-6289-2.