Total intravenous anaesthesia: Practices and training in an anaesthesiology department

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Medicine in the branch of Anaesthesiology.

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Declaration

I, Faaizah Dadoo declare that this research report is my own unaided work. It is being submitted for the Degree of Master of Medicine in the branch of Anaesthesiology at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

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Abstract

Background

Total intravenous anaesthesia (TIVA) provides an alternative to the classic volatile based anaesthetic, with a number of clinical benefits. Volatile anaesthesia has dominated general anaesthesia practices, despite improvements in intravenous agents and drug delivery systems for TIVA. This study aimed to describe the practices and training of anaesthetists in TIVA, in the Department of Anaesthesiology at the University of the Witwatersrand.

Methods

A prospective, contextual, descriptive study was undertaken, using a self-administered questionnaire.

Results

One hundred and fifty three questionnaires were completed, representing 73.6% of the department. TIVA usage was infrequent, with 67.3% of participants using it <10 times in the past year. Conversely, 88.9% reported that they would like to use TIVA more often. Of the participants, 56.9% experienced a situation where TIVA would have been ideal, but they lacked confidence in its use. Target controlled infusion was preferred by 78.4% of participants for TIVA administration. TIVA was viewed as advantageous over volatile anaesthesia in malignant hyperthermia (98.7%), to reduce postoperative nausea and vomiting (86.9%) and decrease environmental pollution (89.5%). The unavailability of depth of anaesthesia monitors was the greatest obstacle to TIVA use, reported by 85%. Only 24% perceived their training in TIVA as adequate.

Conclusion

TIVA usage was infrequent and participants lack confidence in its administration. TIVA is an important skill in the armamentarium of an anaesthetist and improving training should be prioritised.

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Table of contents

List of figures

List of tables

Abbreviations

ASA	American Society of Anesthesiologists
BIS	Bispectral index
EEG	Electroencephalogram
ENT	Ear, nose and throat
MAC	Minimum alveolar concentration
MH	Malignant hyperthermia
NAP 5	5th National Audit Project
PONV	Postoperative nausea and vomiting
TCI	Target controlled infusion
TIVA	Total intravenous anaesthesia
UK	United Kingdom
Wits	University of the Witwatersrand

Statement

The Research Report consists of a literature review, draft article, study proposal and appendices. The study proposal is included for background reference and is not for examination.

The formatting of this Research Report complies with the University of the Witwatersrand's Style Guide for Theses, Dissertations and Research Reports. The formatting of the draft article may differ from the rest of the Research Report in order to comply with the author guidelines of the Southern African Journal of Anaesthesia and Analgesia, the journal to which it is intended to be submitted.

Section 1: Review of the literature

1.1 Introduction

This literature review will provide an overview of general anaesthesia and the techniques by which it can be achieved, with a special focus on total intravenous anaesthesia (TIVA). A brief description of the history of TIVA as well as its frequency of use in anaesthesia practice will follow. The methods for administering TIVA as well as the agents that are commonly used will then be discussed. Thereafter, the potential reasons for anaesthetist's preferences in the choice of maintaining general anaesthesia by volatile versus intravenous techniques will be elucidated. The last aspect of this literature review will consider the indications for TIVA as well as the perceived barriers to its use, including training in TIVA and the adequacy thereof.

1.2 General anaesthesia

General anaesthesia has been defined by the American Society of Anesthesiology as: "a drug-induced loss of consciousness during which an individual is not arousable, even by painful stimulation ..." (1). General anaesthesia may be required in a number of clinical scenarios, some of which include: surgery, examination under anaesthesia as well as certain radiological, interventional and diagnostic procedures.

The process of general anaesthesia consists of an induction phase, a maintenance phase and an emergence phase. The induction phase involves taking an awake patient and converting them to an anesthetised state (2). This can be achieved by the administration of a volatile or intravenous agent or a combination thereof. The maintenance phase involves the maintenance of anaesthesia using either volatile and or intravenous agents. Finally, the emergence phase involves awakening the patient from the anaesthetised state through elimination of the volatile or intravenous agent (2). The technique utilised in the maintenance phase is often used to describe the type of general anaesthesia being administered, and usually falls into one of two categories, namely, volatile or total intravenous anaesthesia.

1.3 Volatile based anaesthesia

A volatile based anaesthetic, also referred to as inhalational anaesthesia, makes use of a volatile agent to maintain a state of general anaesthesia. Volatile agents are administered via inhalation using an anaesthetic machine fitted with a suitable vaporiser. The first public demonstration of general anaesthesia for surgery was by William Morton in 1846. This involved use of the now obsolete agent ether, for the removal of a mass under the jaw (3). Subsequently, other agents including: ethyl chloride, ethylene and cyclopropane came into use. Major unwanted side effects were associated with these early agents, such as flammability, pungency and significant cardiac and hepato-toxicity (4, 5). As advances were made, newer agents, with improved safety profiles, were introduced into anaesthetic practice and in the 1950s the fluorinated hydrocarbons came into use. The volatile agents belonging to this class, namely halothane, isoflurane, sevoflurane and desflurane have remained the mainstay of volatile agents used today (4, 5).

1.4 Total intravenous anaesthesia

1.4.1 History of total intravenous anaesthesia

TIVA refers to a technique of general anaesthesia that uses intravenous agents for both induction and maintenance (6). The use of intravenous anaesthetic agents can be traced as far back as 1656, when Percival Christopher Wren and Daniel Johann Major, used a goose quill and bladder to inject wine and ale into a dog's vein (7). However, the purposeful use of intravenous agents to produce anaesthesia in humans can be dated back to 1936, with the introduction of the barbiturate thiopental, which was favourably described in its initial use as producing a rapid and smooth induction with a return to consciousness within a few minutes (8). The subsequent unfortunate association of thiopentone to an excessive number of deaths in World War II appeared to have influenced the continued preference of ether by anaesthetists (8). Furthermore, the interest and advances that were being made in volatile based anaesthesia, led to TIVA being less popular and in most institutions volatile based anaesthesia was the preferred method for the maintenance of anaesthesia (9).

The introduction of propofol in the 1970s saw a resurgence in the use of intravenous anaesthesia (9). Propofol is a short acting intravenous anaesthetic agent that can be used for both induction and maintenance of anaesthesia. Synthetic opioid drugs developed within the last three decades, namely fentanyl, sufentanil, alfentanil and remifentanil have also aided the increase in the popularity of TIVA (6). An improved understanding of the pharmacokinetic principles of the intravenous agents used, together with developments in infusion pump technology, have further enhanced the development of TIVA (10).

1.4.2 Frequency of TIVA usage

In certain parts of the world, such as Europe, there appears to be a growing trend toward the use of TIVA (11). This can be evidenced by the development of organisations such as the European Society for Intravenous Anaesthesia (12), which was developed in 1999 with the aim to "promote the highest standards of practice in intravenous anaesthetic pharmacology and drug delivery through education, research and professional development in its broadest sense throughout Europe" (12). Other societies, with similar aims have also been formed including: The Society for Intravenous Anaesthesia (13), a United Kingdom (UK) based initiative and the Asia Oceanic Community for Intravenous Anaesthesia , with members across Asia, New Zealand and Australia (14).

The 2013 report on "The state of UK anaesthesia" reported that the usage of TIVA in the UK was 8% of all general anaesthesia cases (15). Anaesthetic activity in Ireland was reported on in Chapter 29 of the 5th National Audit Project (NAP5) on accidental awareness during general anaesthesia, where TIVA usage was estimated as 4.6% of general anaesthetics (16). A survey of volatile anaesthetic practice in France reported that 17% of respondents used TIVA regularly (17). A Thai study on perioperative and anaesthetic adverse events estimated that 8,2% of general anaesthetics performed at 22 participating hospitals were performed using TIVA (18).

In a review of target controlled infusion (TCI) technology, Absalom et al (19) estimated the usage of TIVA and TCI for maintenance of general anaesthesia as approximately 75% at their own university affiliated institution in the Netherlands,

The University Medical Centre Groningen (19). The authors do however note that this high figure is possibly influenced by the presence of TIVA enthusiasts at their institution. Absalom et al (19) also attempted to describe the availability of TCIs worldwide by looking at sales figures of commercially available TCI devices. From this they estimated that TCI is available in more than 90 countries worldwide (19). Interestingly, the United States of America remains one of the few places that has not gained regulatory approval for the use of TCI (19).

Literature regarding the practices and training in the use of TIVA is limited. Research from both developed countries, namely, the UK (20) and Australia (21) as well as developing countries, namely, Brazil (22), Colombia (23, 24), Peoples Republic of China (25) and Nigeria (26) suggest that there is increasing interest in TIVA, but that the widespread incorporation of TIVA into anaesthesia practice is lagging behind. In South Africa, no literature on the frequency or the perceptions of anaesthetists with regards to the use of TIVA could be identified.

1.4.3 Administration of TIVA

In order to achieve an adequate anaesthetic with TIVA, the concentration of the anaesthetic agents at the level of the brain must be in equilibrium with the plasma concentration (27). TIVA may be delivered using a number of techniques, including: intermittent bolus dosing, running a constant infusion using a syringe-type infusion pump and using a TCI system. Intermittent bolus dosing involves the administration of the required drugs through intermittent boluses administered by the anaesthetist throughout the anaesthetic to maintain the state of general anaesthesia. The major disadvantage when using this technique is that it may lead to fluctuations in drug levels, which may affect the quality of the anaesthetic and the rate of recovery (9).

A constant infusion involves the use of an infusion pump, most commonly a syringe pump, to deliver a set amount of the drug based either on weight (mg/kg/min) or volume (ml/hr). The limitation of this technique is that during the procedure different levels of stimulation may necessitate dosage adjustments. Bolus doses or changes to the set rate of infusion may be required and could

subsequently lead to under or overdosing (9, 28, 29). Furthermore, constant rate infusions may lead to drug accumulation.

A TCI system makes use of a microprocessor controlled syringe pump with a user interface (30). The microprocessor contains pharmacokinetic models for specific drugs and solves complex mathematical equations in an attempt to achieve the concentration of the drug at the level of the brain to produce the desired clinical effect (27). The anaesthetist enters variables, such as, height, weight and age, pertaining to the patient via the user interface (30). The target concentration at the patients effect site or in their plasma, for the agent chosen, is also required (30). The computer system then uses the patients variables to calculate the concentration of the drug within the different compartments of the body and continuously adjusts the rate of infusion to maintain the target concentration set by the anaesthetist (7, 29).

Only specific intravenous agents may be used with a TCI system, as only these agents have pharmacokinetic models that have been developed and incorporated into the microprocessor system by manufacturers. The commonly used agents compatible with TCIs include: propofol, remifentanil and sufentanil. Models for other agents, such as midazolam, alfentanil and fentanyl have also been described but are not in widespread use (19). The two TCI models currently available for propofol use in adults are the Marsh and Schnider models (27). Separate models are available for propofol use in paediatric patients, namely, Paedfusor and Kataria (27). No single model has been shown to be superior to another, and the anaesthetists' use of these models is guided by their experience, preference and the characteristics of the individual patient (31). The newer Eleveld model, also for propofol TCI, aims to provide a more comprehensive model applicable to a diverse patient population, appropriate for use over a wide range of ages from paediatric to elderly patients as well as obese patients (32). However, currently the Eleveld model is not available for use on commercial pumps (28). A single model for remifentanil exists, namely, the Minto model and the Gepts model is used with sufentanil (19).

The 2018, Guidelines for the safe practice of total intravenous anaesthesia (TIVA) (28), recommend that where general anaesthesia is to be maintained by a propofol infusion that a TCI be utilised (28). In the study by Wright and Dundee (33), conducted in 1982, prior to TCI's becoming widely available, the most commonly reported means of administering TIVA was by automatic infusion pumps, followed by the use of automatic syringe pumps, then burette infusion sets and lastly by plain infusion sets (33). With the introduction of commercial TCI programmes in the 1990s their use has steadily increased. A study in 2009 by Madhivathanan reported that 39% of trainees used TCI (20). More recent studies by Goh et al (34), Lim et al (21) and Wong et al (25) are in keeping with the 2018 guideline (28) recommendations and have shown that the majority of participating anaesthetists use TCI over manual infusion to deliver TIVA. Of note, a 2017 study in Colombia by Echeverry-Marín et al (24), showed that TCI usage is lagging behind volumetric pumps (53.9% vs. 31.9%), despite 60% of participants viewing a TCI pump as "absolutely necessary" to performing TIVA (24). The reason for this appears to relate to a shortage of pumps, which was reported as a limitation to TIVA use (24).

1.4.4 Choice of agents for TIVA

When choosing appropriate drugs for TIVA, it is important to balance an adequate level of anaesthesia and analgesia with a rapid recovery time (27). Drugs that produce analgesia may have a synergistic effect with hypnotic intravenous anaesthetic agents which could then lead to prolonged recovery from anaesthesia and respiratory depression postoperatively (35). Therefore, drugs with a rapid onset and offset with minimal accumulation over time are ideal for TIVA (27).

Propofol, a hypnotic intravenous anaesthetic agent, a derivative of the alkylphenols, is the most suitable intravenous agent for TIVA (9, 10, 27). In light of its favourable pharmacokinetic profile, which results in a rapid onset of action combined with a rapid recovery due to a high clearance rate and redistribution, even following a prolonged infusion, it is well suited to continuous infusion techniques (6, 7). Other advantages of propofol include an antiemetic effect and depression of laryngeal reflexes (36). The potential benefit of propofol TIVA on reducing cancer recurrence rates is a promising area of research with a number of

studies showing positive results, though at this stage, further studies are required to provide more definitive evidence (37-40).

The most commonly described drug combination with propofol based TIVA is remifentanil (28). Remifentanil is an ultra-short acting opioid with a rapid onset and offset of action with minimal accumulation independent of the duration of the infusion (41). The synergy between propofol and remifentanil is advantageous in reducing the dosage requirements of propofol and in providing ideal conditions for surgery (28).

Ketamine, a phencyclidine derivative, which causes a dissociative state of anaesthesia is receiving renewed interest by anaesthetists due its potential as a single drug with multiple uses (7). Some of these uses include, an analgesic drug with promising results in opiate tolerance and chronic pain management and a hypnotic agent which can be used as an induction agent as well as a maintenance agent in TIVA (30). Ketamine may also be used in small doses in combination with propofol for TIVA, the advantage that this offers is more stable haemodynamics as well as analgesia and minimal ventilatory depression (30). Despite these features of ketamine, one of the main factors that limits its use is the associated unwanted emergence reactions (7).

Other intravenous hypnotic agents, such as thiopentone and etomidate, which are commonly used in the induction of anaesthesia, are considered unsuitable for maintenance of TIVA due to accumulation of the drug over time resulting in unacceptably prolonged recovery times (42). Furthermore, the use of etomidate is limited by its associated adrenal suppression (7). Various other intravenous drugs such as short acting opioids, benzodiazepines and alpha-2-agonists may be used as adjuncts to TIVA. Dexmedetomidine, a selective alpha-2-agonist, is gaining popularity in various domains of anaesthesia. With regards to its role in TIVA, it can be used to reduce anxiety, may form part of the analgesic plan as well as reduce the requirements of propofol due to its synergy with hypnotic agents (43).

The use of neuromuscular blocking agents during surgery performed under TIVA is variable. In some instances they may be used to facilitate intubation and then

allowed to wear off or they may not be used at all as remifentanil in adequate doses may be used with propofol to achieve satisfactory conditions for airway manipulation and surgery (35). The advantage of avoiding neuromuscular blocking drugs during TIVA has been purported as decreasing the risk of awareness by allowing movement. If the patient has not been paralysed and falls into a lighter plane of anaesthesia, they are likely to move when stimulated, indicating the possibility of awareness and the need to deepen the plane of anaesthesia (1).

The study by Lim et al (21) reported that 84% of participants used a propofol infusion for TIVA with the following adjuncts used often: fentanyl 46%, remifentanil 46%, benzodiazepines 44% and other (ketamine and clonidine). Goh et al (34) reported that 73% of respondents used a combination of propofol and remifentanil for TIVA, with adjuncts including alpha-2 -receptor agonists (13%) and midazolam (10%).

1.4.5 Preferences for producing general anaesthesia

Despite the advancements made with regards to intravenous agents, it has remained common practice that they are used mainly for the induction phase of anaesthesia. Audits on anaesthesia practice and incident monitoring from various countries have shown that volatile agents continue to be used most commonly for the maintenance of general anaesthesia (15, 18, 28, 29, 44). Many anaesthetists appear to feel more comfortable with volatile anaesthesia than with TIVA (4, 42). Reasons for this may include: the ease of administration of a volatile agent, the availability of volatile agents on all anaesthetic delivery units, the ease of measuring minimum alveolar concentration (MAC) value for volatile agents and the ability to assess the concentration of the volatile in the exhaled gas to assist with ensuring adequate depth of anaesthesia (42).

Volatile agents are administered via inhalation using a breathing circuit. The breathing circuit is connected to the anaesthetic machine which supports the patient’s ventilation. Therefore, when using a volatile agent for general anaesthesia an additional apparatus for the administration of the anaesthetic agent is not required, as it is in TIVA, adding to the convenience of this technique.

The MAC for a volatile agent is defined as: “the alveolar concentration that prevents movement in 50% of patients in response to a standardized stimulus (e.g. surgical incision)” (5). The concept of the MAC value is unique to volatile agents. MAC reflects the partial pressure of the agent at the level of the brain, giving an indication of the depth of anaesthesia (5). It is also a used to compare the potency of different volatile agents (5). Measurement of the concentration of the volatile agent in the patient’s exhaled gas, is achieved by the use of a gas analyser which forms part of the anaesthetic machine. This gives the anaesthetist a real-time indication of the concentration of the volatile agent within the body, enhancing the titratabilty of the volatile agent (45).

Another reason for the marked difference in the frequency of usage between TIVA and volatile anesthesia may relate to familiarity and the concept of imprinting during initial training (46). A small study conducted in Japan showed that new anaesthetic trainees who were exposed to TIVA only as part of their initial anaesthesia training tended to subsequently use it more frequently in their practice and also scored higher in terms of skill achievement than their counterparts who were initially exposed to inhalational anaesthesia only (46).

1.4.6 Clinical scenarios where TIVA may be preferable

There is no predetermined way in which a general anaesthetic should be administered. In each case the anaesthetist will individualise the approach for the specific indication and patient (7, 9, 10, 29). The type of anaesthetic given may be influenced by the experience of the anaesthetist, the availability of drugs and equipment and the patient’s choice. There are however certain circumstances when a TIVA based anaesthetic may be more desirable than a volatile based anaesthetic. These include the patient at risk for malignant hyperthermia (MH), the patient with a high risk for postoperative nausea and vomiting (PONV), specific types of surgery, in order to improve airway management and to reduce the risk of emergence delirium.

Malignant hyperthermia

In anaesthetic teaching, the most compelling indication for TIVA is in the patient at risk for MH as triggering agents, namely, volatile agents and succinylcholine, must be avoided (47). Exposure to these triggering agents, in MH susceptible individuals, could result in life-threatening complications. Previous data suggested that mortality was as high as 60% of individuals, however this figure has decreased to 1.4% with increased awareness of the disorder as well as earlier detection and improved management (47).

After a review of available research on TIVA practices, it was found that MH was considered to be an important indication for TIVA in several studies. Lim et al (21) reported that 97% of participants indicated that MH was an important indication for TIVA (21). In the study by Goh et al (34) MH was considered the most important indication for TIVA while Pugh and Husaini (48) reported that the use of TIVA in MH susceptible patients was considered as one of the two most important advantages of TIVA. Of note however, in the 2017 study by Echeverry-Marín in Colombia, only 37% of respondents felt that MH was an indication for TIVA, following indications such as neurosurgery and sedation outside the operating theatre (24).

Postoperative nausea and vomiting

TIVA has been shown to be beneficial for use in patients who are known to be at high risk for PONV (49-52). PONV is a common complication of general anaesthesia, reported to occur in as many as 20 – 30% of patients (53). Patients presenting for general anaesthesia are assessed for their risk of developing PONV and stratified accordingly. If a patient is assessed as having an increased risk, the anaesthetic should to be planned accordingly, to minimise this risk. Risk factors are often categorised into patient, anaesthetic and surgical risk factors. The known anaesthetic contributors to PONV include the use of volatiles, nitrous oxide, opioids and neostigmine (53). A TIVA based anaesthetic has been shown to reduce the risk of PONV through a number of mechanisms including the avoidance of volatiles as well as by the use of propofol, which is known to have antiemetic properties (50, 51).

Despite a 2018 meta-analysis by Schraag et al (52), consisting of 229 randomised controlled trials, showing the benefits of TIVA in reducing the risk of PONV, research that has surveyed TIVA practices of anaesthetists has found varying rates of agreement with this. The study by Lim et al (21) found that 50% of participants felt that multiple risk factors for nausea and vomiting was often an indication for TIVA and 77.5% felt it was associated with less PONV than inhalational anaesthesia (21), whilst only 34% of those surveyed by Echeverry-Marín et al (24) felt the risk of PONV was an indication for TIVA. However, in the study by Goh et al (34), PONV rated as the second most common indication for TIVA, with 45.7% of participants selecting risk of PONV and 33.3% selecting previous PONV as an indication for TIVA (34). In the study by Pugh and Husaini (48), less PONV was listed as one of the main advantages of TIVA while Hill et al (54) found that 56% of participants felt that TIVA was beneficial in reducing the frequency of PONV.

Specific types of surgery

There are certain types of surgical cases where it has been shown that there may be advantages to using TIVA over a volatile based anaesthetic. These include neurosurgery (55) and head and neck surgeries (56). In neurosurgery, TIVA appears to be advantageous in patients with raised intracranial pressure and in cases which require neurophysiological monitoring (55). In the study by Lim et al (21), 88.5% of participants felt that neurosurgery was an indication for TIVA. Echeverry-Marín et al (24) reported that 38.3% of anaesthetists surveyed considered neurosurgery one of the main indications for TIVA. The study by Goh et al (34) reported that 15.5% of participants used TIVA for neurosurgery cases while the study by Hill et al (54) showed that only a small percentage (approximately 8%) of participants used propofol infusions for neurosurgery cases.

Head and neck surgeries that involve a shared airway between the surgeon and the anaesthetist, such as tracheal resection, often necessitate intravenous anaesthesia, due to the difficulty with the accurate delivery of inhaled agents associated with an open airway or an incomplete anaesthetic circuit (56). In ear, nose and throat (ENT) surgery, there has been a growing interest in the use of

TIVA for functional endoscopic sinus surgery (57). The use of TIVA may be preferred by ENT surgeons as it provides for more optimal surgical conditions, including a bloodless surgical field and reduced blood loss (58, 59). The studies by Goh et al (34) and Hill et al (54) reported that of all the surgical specialities in which TIVA was used ENT was the most popular. TIVA was less popular in the study by Echeverry-Marín et al (24), where only 20% felt that ENT surgery was an indication for TIVA.

Airway management

TIVA offers advantages over volatile anaesthesia with regards to the management of the patient's airway. It has been shown that volatile agents used in a volatile based anaesthetic, as compared to propofol based TIVA, caused a greater degree of depression of cilliary function which may subsequently lead to impaired bronchial mucous transport and pulmonary complications (60, 61). Propofol based TIVA may also reduce the risk of bronchospasm and laryngospasm in children due to a more pronounced suppression in airway responsiveness as compared to volatile agents. TIVA could therefore present as the anaesthetic of choice for paediatric patients with an increased risk of airway reactivity, such as a recent upper respiratory tract infection or asthma (49, 62). Despite these known properties of propofol, TIVA does not appear to be viewed as being distinctly advantageous in airway management. In their survey of paediatric anaesthetists, Goh et al (34) reported that only 7.5% of respondents considered a recent upper respiratory tract infection as an indication for TIVA. Lim et al (21) reported that only 29.8% of all participants in their study believed that TIVA offered easier airway management as compared to inhalational anaesthesia.

Emergence delirium

In the paediatric population, it has been suggested that TIVA may reduce the risk of emergence delirium. Chandler et al (63) found that compared to maintenance with sevoflurane, TIVA significantly reduced the incidence of emergence delirium. A previous episode of emergence delirium was seen as an indication for TIVA by 21.7% of anaesthetists who regularly anaesthetise paediatric patients in a study by Goh et al (34). A study by Lim et al (21) showed that as compared to inhalational

anaesthesia, TIVA was perceived as being associated with less emergence delirium by 45.6% of participants.

Other indications for TIVA may include the transportation of patients from theatre to another site, where TIVA may be required to maintain anaesthesia and or sedation, since an anaesthetic machine will not be available to deliver a volatile based anaesthetic (9). TIVA also provides an excellent adjunct to regional anaesthesia (49) and may be indicated for remote site anaesthesia (27).

1.4.7 Environmental pollution

The volatile anaesthetic agents that are currently in use, namely, sevoflurane, isoflurane, desflurane and halothane are halogenated compounds. For some time it has been recognised that these anaesthetic agents are contributing to greenhouse gas emission and climate change (64). Nitrous Oxide, which is commonly used as an adjunct in volatile anaesthesia, has also been shown to be a contributor to greenhouse gases (65). Greenhouse gases result in atmospheric pollution which deplete the ozone layer and result in the trapping of infrared radiation impacting on temperature regulatory mechanisms and ultimately resulting in a heating up of the earth (65, 66). This, in turn, can have devastating effects on rainfall, biodiversity and eco systems (65).

Previously it was believed that the contribution of volatile agents was small, and therefore negligible when compared to other contributors such as carbon dioxide and methane, which are mainly linked to deforestation and burning of fossil fuels (64). However, research has shown that this assumption may be incorrect and that if the number of anaesthetics performed worldwide are considered together with the fact that these compounds are stable for a long period of time in the atmosphere, the cumulative impact is likely to be significant (64, 66).

Anaesthetists should attempt to minimise the emission of greenhouse gases in their practices (66). A number of strategies to minimise this effect exist, including, the use of reliable gas scavenging systems and adequate ventilation in theatre, preventing the leakage of gases from spillage and open breathing systems and the

use of low flow anaesthesia (66). These strategies are important and should be implemented as far as possible, but the reality is that ultimately gas leakage and escape to the atmosphere does occur (64). TIVA offers an alternative to the use of volatile agents and as such may assist in decreasing the contribution of anaesthesia to the emission of greenhouse gases. As early as 1982, in a study by Wright and Dundee (33), 56% of participating anaesthetists were concerned about pollution in the operating theatre from volatile anaesthetics and the need to avoid it. A more recent study by Lim et al (21) reported that 80.7% of respondents felt that TIVA resulted in less environmental pollution as compared to inhalational anaesthesia.

1.4.8 Volatile agents and safety of health personnel

In addition to the potential hazards to the environment by volatile agents it has also been suggested that volatile agents may pose a health risk to the operating theatre personnel. To some degree leakage of anaesthetic gases to the operating theatre environment is unavoidable, resulting in operating theatre personnel being constantly exposed to these agents (66). Research into the effects of anaesthetic gases on humans has been conflicting since it is difficult to assess the direct effect of the volatile agent on the health of operating theatre personnel due to numerous other confounding factors such as the high levels of stress associated with this environment. Short-term adverse effects of exposure to anaesthetic gases include headache, fatigue, drowsiness, irritability and impaired judgment (67). Research into the long-term effects suggest the possibility of negative effects on reproductive health, including an increased rate of spontaneous abortions, miscarriages and birth defects (67, 68).

1.4.9 Barriers to the use of TIVA

Cost

Research on TIVA practices by anaesthetists has shown that one of the reasons limiting its use is the perceived cost (22, 23, 33). When discussing medical costs it is important to consider the direct costs as well as the indirect costs (69). TIVA has been shown to have higher direct costs than volatile anaesthesia (69, 70) but it is important to consider that costing is not always straightforward. A comparative

study of utilisation and cost of inhalational versus intravenous anaesthesia found that the duration of the procedure may impact on the cost and that propofol TCI became more cost effective than sevoflurane inhalational anaesthesia for procedures longer than three hours (71).

Indirect costs include factors such as complications of the anaesthetic, length of hospital stay and patient satisfaction. It is thus more complicated to take into account all the indirect costs related to medical practice. If significant indirect cost differences can be shown, this will imply cost effectiveness of one technique over another. A review article found that studies that have attempted to show the cost effectiveness of TIVA versus inhalational anaesthesia have found results that both support and negate this (69). It is therefore important for anaesthetists to understand true cost analysis when choosing between techniques, keeping in mind that the differences may in fact be small and should not necessarily be the deciding factor when choosing between inhalational anaesthesia versus TIVA (72).

Time to setup

TIVA can be performed using different techniques. Bolus dosing does not require any additional specialised equipment, and should therefore not require any extra preparation time as the required syringes and needles should already be available as part of the standard equipment required for an anaesthetic. Continuous infusion and TCI however, require the use of infusion pumps which may, in some instances, be locked away or be kept out of theatre due to limited resource availability and expense of this equipment (73). Specific infusion sets and syringes for the infusion pumps may also be required. In addition, these methods will usually require a dedicated intravenous line for the infusion, and a separate intravenous line for all other drugs required (73). Gathering this equipment and setting up for these techniques may therefore add additional time to the preparation time, particularly for the novice TIVA user, making it a less attractive option than volatile anaesthesia.

Research has shown that one of the factors that limit the use of TIVA is the time required to set up (21, 23, 33). Being cognisant of appropriate use of time is a vital factor within the theatre environment to ensure cost efficiency and to ensure that

the patients booked for that day can be done within the restricted time that may be available (74). In order to improve TIVA utilisation this may be an area that would need to be improved upon. One way to overcome this may be to make accessibility to equipment easier or to try and incorporate it as part of the standard equipment within theatre (75). Increased usage and familiarity with the equipment will also increase the efficiency in its use. This is supported by a recent study by Wong et al (25), who showed that time to setup was perceived to be a more significant limitation to TIVA administration by infrequent as opposed to frequent users.

Concerns with intraoperative awareness

One of the common limitations to the use of TIVA by anaesthetists has been cited as the fear of intraoperative awareness (6, 21, 24, 34, 48). This fear does not appear to be completely unfounded as a number of studies (29, 76-79) found that awareness appeared to be more common during general anaesthesia with TIVA as compared to inhalational anaesthesia. As compared to volatile based anaesthesia, where real-time end tidal concentration of the volatile as well as the MAC value are used to guide the depth of anaesthesia, such a value reflecting the true concentration of intravenous agents in the patient's blood is lacking when using TIVA (42). During TCI TIVA, reliance on the TCI model to calculate plasma or effect site concentration can lead to errors as patient variability can occur and differences may exist between the population used in the development of pharmacokinetic model and the patient at hand (42). Anaesthetists need to be aware of this limitation to optimise use of these models.

The largest study of its kind, the NAP5 of the Royal College of Anaesthetists and the Association of Anaesthetists of Great Britain and Ireland (29) aimed to estimate the incidence of accidental awareness under anaesthesia and determine the risk factors for it. NAP5 found that most important risk factor for accidental awareness was related to the use of neuromuscular blockers (29). In the conclusion from NAP5 (29), it was noted that even though most cases of awareness were during TIVA, this was associated with gross errors and considered largely preventable by ensuring adequate delivery of drugs as well as

proper training of anaesthetists in the use of TIVA (29). A similar conclusion was drawn from a study conducted in 1993, on the incidence of awareness during TIVA, which found that all five cases of awareness could have been prevented with “proper vigilance and experience”(80).

More recently, in 2018, researchers from Hong Kong conducted an international survey and showed that amongst frequent users of TIVA concerns of intraoperative awareness were significantly less than among infrequent users (25). Indicating that the problem appears to relate more to a lack of experience in the use of TIVA as opposed to a real increase in the incidence of awareness when using TIVA.

Depth of anaesthesia monitoring

The lack of availability and accessibility to depth of anaesthesia monitoring has previously been cited in the literature as a limitation to the use of TIVA (23, 24, 48). Interestingly, studies have shown conflicting results regarding the efficacy of the use of bispectral index (BIS), a type of processed electroencephalogram (EEG) monitor, as a depth of anaesthesia monitor, to decrease the risk of awareness during general anaesthesia (81-83). A recent meta-analysis on the use of BIS and intraoperative awareness showed that the use of BIS did not decrease the overall rate of awareness during anaesthesia but it did show that BIS decreased the rate of awareness during TIVA (84).

The 2006 ASA Practice Advisory for Intraoperative Awareness and Brain Function Monitoring (1) did not recommend the routine use of brain function monitoring to reduce the frequency of intraoperative awareness during general anaesthesia, but rather that it should be used on a case by case basis (1). The Guidelines for the safe practice of total intravenous anaesthesia (TIVA) (28) published in 2018, recommends the use of a processed EEG monitor when a neuromuscular agent is used during TIVA (28). Furthermore, it states that all anaesthetists should be trained in the use of a processed EEG monitor and that sufficient monitors should be available in settings where TIVA is performed (28).

Adequacy of training

TIVA is an evolving concept in the field of anaesthesia. Advances in pharmacokinetic and pharmacodynamic understanding of intravenous agents has greatly improved the administration of TIVA (42). These concepts can initially be seen as complex and difficult to grasp especially on a background of poor training. The inadequacy in TIVA training has been highlighted in research done internationally. In the UK, TIVA is considered a core clinical skill as per the Royal College of Anaesthesia (85), however, a 2010 survey showed that almost a third of respondents felt that their training in TIVA was inadequate (86). The survey by Madhivathanan et al (20), found that more than three quarters (78%) of the respondents did not receive any formal training. In Colombia, a 2017 study by Echeverry-Marín et al (24) reported that inadequate training is viewed as a limitation to TIVA use. A study conducted by Arevalo et al (23) reported that participants felt that training has been hindered both by a lack of expertise in TIVA as well as a lack of knowledge regarding the pharmacology of TIVA.

1.4.10 Best mediums for training

Limited literature could be identified with regards to the mediums used in the training of TIVA. The study by Goh et al (34), reported on multiple modes through which respondents received training including, lectures 38%, during anaesthesia training 36%, in theatre with another consultant 36%, self-teaching 36% and through workshops and scientific meetings. Pugh and Husaini (48) reported that 90% of TIVA training was “informal” and only 6% of respondents had received education through a conference or course. A study by Griffiths et al (86), reported that 69% of those surveyed had received their sole training during a consultant led teaching list and only 5.3% had attended a course.

A study by Konrad et al (87) demonstrated that learning manual skills in anaesthesia differed greatly between individual procedures and was a function of a number of factors, including, individual variation, the institution and its environment, as well as exposure to a sufficient number of cases. TIVA may be considered as a complex skill with multiple facets as it requires theoretical knowledge with an understanding of underlying complex pharmacology which then

needs to be applied and adjusted to individual patients under varied conditions. Research into the adult learning process often cites the pyramid approach (Figure 1) with an emphasis on the lower part of the pyramid, namely practical methods being linked to the greatest success (88). For a complex skill such as TIVA, a combination of theoretical knowledge gained through lectures, courses and self-reading as well as practical experience though workshops, simulation and supervised learning in theatre with appropriate feedback appears to be most suitable (89).

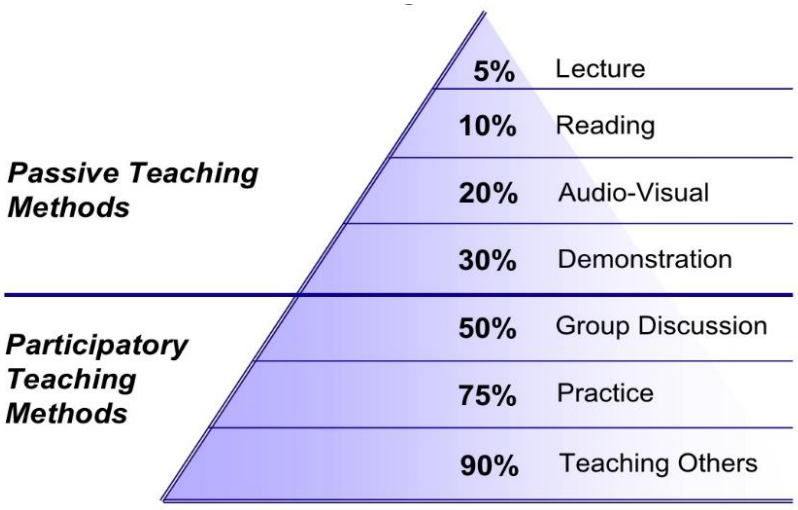

Figure 1.1: The learning pyramid

1.4.11 How to determine competency?

Within the medial field it is difficult to ascertain whether an individual has achieved competency with regards to a particular procedural skill during training. This appears to be related to a lack of a universally accepted and comprehensive tool to assess procedural skills (90). In anaesthesia, the assessment of a technical skill tends to rely on self-reported logbooks or observation from a senior consultant (90). Furthermore, there is no data to suggest the number of TIVA's or how frequently TIVA would need to be practiced to establish competency. In the curriculum for specialist training of anaesthetists, The College of Anaesthetists of South Africa (91) makes mention of TIVA as a required skill, however, no TIVA specific competencies or advise on course content are included.

The age old adage “practice makes perfect”, appears to be supported by research from surgical disciplines where an increased volume in performance of procedures has been linked to improved outcomes (92, 93). It is generally accepted that the more frequently a skill is performed the more proficient a person is likely to be at it. Research surveying TIVA practices have shown that the majority of anaesthetists use TIVA infrequently and less often than volatile based anaesthesia (15, 21, 48), which may indicate that competency in TIVA is likely to be lacking.

1.5 Conclusion

The clinical advantages of TIVA versus volatile anaesthesia remains widely debated. Advocates for TIVA boast a number of advantages, whilst advocates for volatile anaesthesia appear to be of the belief that these benefits can now also be achieved with the relatively new, shorter acting volatile agents, namely desflurane and sevoflurane (74, 94, 95). Rather than one method being seen as superior to the other, the consensus appears to be that for each patient the technique chosen should be optimal for that patient presenting for that particular procedure. This highlights the importance for anaesthetists to have a good working knowledge of both techniques so that they can offer the patient the best care possible.

The NAP5 (29) identified inadequate knowledge and experience in TIVA administration as the major cause of awareness during TIVA (29). These results are concerning as anaesthetists may find themselves in a situation where they must use TIVA, with no alternative available, for example in a case of MH or during surgery on the airway and this will directly affect the safety and satisfaction of the patient. Ultimately, as volatile anaesthesia continues to dominate general anaesthetic practice, expertise will be limited and training of young anaesthetists lacking, resulting in a cycle whereby TIVA will be consistently less utilised.

1.6 Summary

In this literature review we have provided an overview of general anaesthesia and the techniques that can be used to achieve it. A brief description of the history of TIVA as well as its frequency of use in current anaesthesia practice then followed. Insight into the methods for providing TIVA as well as the agents that are

commonly used were discussed. Thereafter, the reasons for anaesthetists' preferences in the choice of maintaining general anaesthesia by volatile versus intravenous techniques were explored. The last aspect of this literature review considered the indications for TIVA as well as the perceived barriers to its use, including training and the adequacy thereof.

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All articles should include an abstract. The structured abstract for an Original Research article should be between 200 and 230 words and should consist of four paragraphs labeled Background, Methods, Results, and Conclusions. It should briefly describe the problem or issue being addressed in the study, how the study was performed, the major results, and what the authors conclude from these results. The abstracts for other types of articles should be no longer than 230 words and need not follow the structured abstract format.

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Acknowledgements

In a separate section, acknowledge any financial support received or possible conflict of interest. This section may also be used to acknowledge substantial contributions to the research or preparation of the manuscript made by persons other than the authors.

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Cite references in numerical order in the text, in superscript format (Format> Font> Click superscript). Please do not use brackets or do not use the foot note function of MS Word.

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The following are sample references:

1. Jun BC, Song SW, Park CS, Lee DH, Cho KJ, Cho JH. The analysis of maxillary sinus aeration according to aging process: volume assessment by 3-

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8. It must be clear where every figure and table should be placed in the text. If possible, tables and figures must be placed in the text where appropriate. If too large or impractical, they may be featured at the end of the manuscript or uploaded as separate supplementary files.
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10. All numbers below ten, without percentages or units, must be written in words.
11. Figure numbers: Arabic, table numbers: Roman

Section 3: Draft article

Total intravenous anaesthesia: Practices and training in an anaesthesiology department

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Key words: TIVA, intravenous anaesthesia, anaesthetic practice

Abstract

Background

Total intravenous anaesthesia (TIVA) provides an alternative to the classic volatile based anaesthetic, with a number of clinical benefits. Volatile anaesthesia has dominated general anaesthesia practices, despite improvements in intravenous agents and drug delivery systems for TIVA. This study aimed to describe the practices and training of anaesthetists in TIVA, in the Department of Anaesthesiology at the University of the Witwatersrand.

Methods

A prospective, contextual, descriptive study was undertaken, using a self-administered questionnaire.

Results

One hundred and fifty three questionnaires were completed, representing 73.6% of the department. TIVA usage was infrequent, with 67.3% of participants using it <10 times in the past year. Conversely, 88.9% reported that they would like to use TIVA more often. Of the participants, 56.9% experienced a situation where TIVA would have been ideal, but they lacked confidence in its use. Target controlled infusion was preferred by 78.4% of participants for TIVA. TIVA was viewed as advantageous over volatile anaesthesia in malignant hyperthermia (98.7%), to reduce postoperative nausea and vomiting (86.9%) and decrease environmental pollution (89.5%). The unavailability of depth of anaesthesia monitors was the greatest obstacle to TIVA use, reported by 85%. Only 24% perceived their training in TIVA as adequate.

Conclusion

TIVA usage was infrequent and participants lack confidence in its administration. TIVA is an important skill in the armamentarium of an anaesthetist and improving training should be prioritised.

Introduction

The process of general anaesthesia involves an induction phase, a maintenance phase and an emergence phase. A state of general anaesthesia may be achieved through the use of volatile and intravenous agents. The most widely practised method to achieve general anaesthesia involves a combination of intravenous anaesthetic agents for induction and a volatile agent for maintenance [1]. Since it is the volatile agent which is used for maintenance this technique is often described as volatile or inhalational based anaesthesia. Where an intravenous agent is used for both induction and maintenance of anaesthesia, in the absence of a volatile agent, the technique is described as total intravenous anaesthesia (TIVA).

As the practice of general anaesthesia has developed over time, changes in the way in which it is provided have paralleled pharmacological and technological advances. Volatile based anaesthesia has dominated the practice of general anaesthesia for many years. With the introduction of propofol in the 1970s, there was a renewed interest in the use of intravenous anaesthesia [2, 3]. This was further aided by, an improved understanding of the pharmacokinetic and pharmacodynamic principles of drugs, the development of drugs with a rapid onset and offset as well as improved drug delivery systems [3, 4].

TIVA provides an alternative to the classic volatile based anaesthetic and offers a number of potential clinical benefits. These include decreased postoperative nausea and vomiting (PONV) [5-7], faster and smoother recovery [6, 8], reduced bronchial reactivity [6], reduced emergence delirium [6] and improved visualisation of the surgical site due to decreased intraoperative bleeding [9]. TIVA also serves as the ideal mode of general anaesthesia for patients at risk for malignant hyperthermia (MH) [2, 6, 10].

Despite the advances made in TIVA, this has not necessarily translated to an increased use. Some of the reasons for this have included the lack of confidence in its administration [11-13], inadequate training [11-15], unavailability of necessary equipment [15-17] as well as the perceived higher cost [15, 18, 19] and greater time required to set up TIVA as compared to volatile based anaesthesia [18, 19]. The familiarity for most anaesthetists in managing patients using volatile based

anaesthesia may also be one of the reasons why anaesthetists tend to avoid the use of TIVA [3].

TIVA is an important skill for an anaesthetist to master. It is listed as part of the curriculum for specialist training of anaesthetists as outlined by the College of Anaesthetists of South Africa, a college of the Colleges of Medicine of South Africa [20]. A good working knowledge in TIVA is essential in a number of clinical scenarios, including: patients at risk for MH, those at high risk for PONV, head and neck surgery as well as neurosurgical cases [6]. Training has been shown to be inadequate and subsequently experience is lacking within this area of anaesthesia [12, 16, 17]. In addition, various other factors such as cost, time involved in setup and concerns related to intraoperative awareness have been cited as obstacles to its use [15, 16, 18].

South African literature on the practices and training of anaesthetists in the use of TIVA could not be identified. The aim of this study was to describe the practices and training of anaesthetists in the use of TIVA, in the Department of Anaesthesiology at the University of the Witwatersrand (Wits).

Methods

This study followed a prospective, contextual, descriptive research design. Approval to conduct this study was obtained from the Wits Human Research Ethics Committee (Medical) and other relevant authorities.

The study population comprised 208 anaesthetists working in the Department of Anaesthesiology at Wits. A convenience sampling method was used and a minimum response rate of 125 (60%) participants was deemed an acceptable sample size [21]. In this study, the term junior anaesthetists referred to medical officers and registrars with less than four years of training and the term senior anaesthetists to registrars with four or more years of training, career medical officers and consultants.

A draft survey was developed based on a review of the literature to ensure content validity. The draft survey was reviewed by an anaesthesiologist with expertise in TIVA and two senior anaesthesiologists from the Department of Anaesthesiology

at Wits to ensure face and content validity. Corrections were made accordingly. The survey was self-administered and included the following domains: demographics, practices related to the use of TIVA, factors influencing the use of TIVA and training in TIVA.

Data were collected during departmental academic meetings and all anaesthetists present were invited to participate. Anaesthetists who agreed to take part received a study information sheet and a survey. Each survey had a unique number which was used for data collection purposes only. Consent was implied by completion of the survey. One author (FD) was available to assist with possible queries. Upon completion, anaesthetists folded the survey and place it into a sealed box to maintain the anonymity of the participants.

Data were entered onto a Microsoft Excel spreadsheet and analysed using Stata version 14 (StataCorp, USA). Categorical variables were described using frequencies and percentages and comparison of variables were made using Chi squared tests. A p value of <0.05 was considered statically significant. A five-point Likert scale (strongly agree, agree, neutral, disagree and strongly disagree) was used in sections 3 and 4 of the survey. This was presented in the results section as a summative analysis with strongly agree and agree collapsed into one category, neutral as a second category and strongly disagree and disagree as a third category.

Results

A total of 155 questionnaires were handed out, of which 153 were completed and returned, resulting in a 98.7% response rate, representing 73.6% of the department. Table I represents the demographics of the participants in this study.

Table I: Demographics of the participants

Demographics	Number (n)	Percentage (%)
Years of experience		
< 1 year	5	3.3
1-3 years	41	26.8
4-10 years	82	53.6
11-15 years	11	7.2
> 15 years	14	9.2
Professional designation		
Medical officer	23	15
Registrar (≤ 3 years)	44	28.8
Registrar (> 3 years)	27	17.6
Career medical officer	4	2.6
Anaesthesiologist	55	35.9

A large proportion, 103 (67.3%) participants reported that they had used TIVA fewer than 10 times in the past year. Figure 1 displays the frequency of the use of TIVA by participants in the past year.

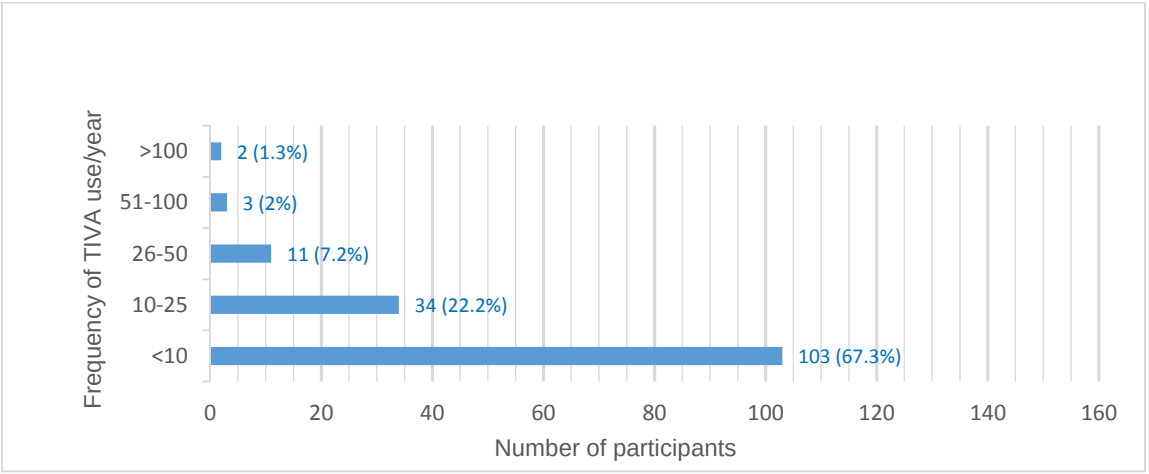

Figure 1: Frequency of TIVA administration by participants in the past year

Further analysis was performed to compare the frequency of TIVA use between junior and senior anaesthetists. Frequency was determined between < 10 and ≥

10 TIVAs performed in the past year. A statistically significant difference was found with more junior anaesthetists (85%) having performed more than 10 TIVA's in the past year (p<.000).

Most participants, 136 (88.9%), confirmed that they would like to use TIVA more often in their own practice. When participants were asked about having experienced a situation where TIVA would likely have been the best type of anaesthetic for a particular patient but was not utilised due to a lack of confidence in its administration, 87 (56.9 %) confirmed that they had experienced such a situation. When comparing the frequency of administration of TIVA in terms of those who performed < 10 and ≥ 10 in the past year to the participants confidence in its use, no statistically significant difference was apparent (p=0.059).

The preferred technique for the administration of TIVA to achieve general anaesthesia by most participants, 120 (78.4%), was TCI. TIVA via continuous infusion was reported to be the preferred technique by 24 (15.7%) and intermittent bolus dosing the least popular technique, preferred by only 5 (3.3%). Two participants (1.3%) selected all three techniques as their preferred method and both TCI and continuous infusion were selected by 2 (1.3%) of participants.

When asked about their preferred TIVA technique to achieve conscious sedation, 70 (45.8%) participants selected TCI. The use of intermittent bolus dosing was preferred by 42 (27.5%) participants and 33 (21.6%) preferred a continuous infusion. More than a single technique was selected by some participants: both intermittent bolus dosing and TCI were preferred by 3 (2%) participants, TCI and continuous infusion by 2 (1.3%) participants and intermittent bolus dosing and continuous infusion by 2 (1.3%) participants.

Figure 2 depicts the agents participants reported to using in the administration of TIVA to achieve general anaesthesia and conscious sedation. Of note, the most frequently utilised agent was propofol.

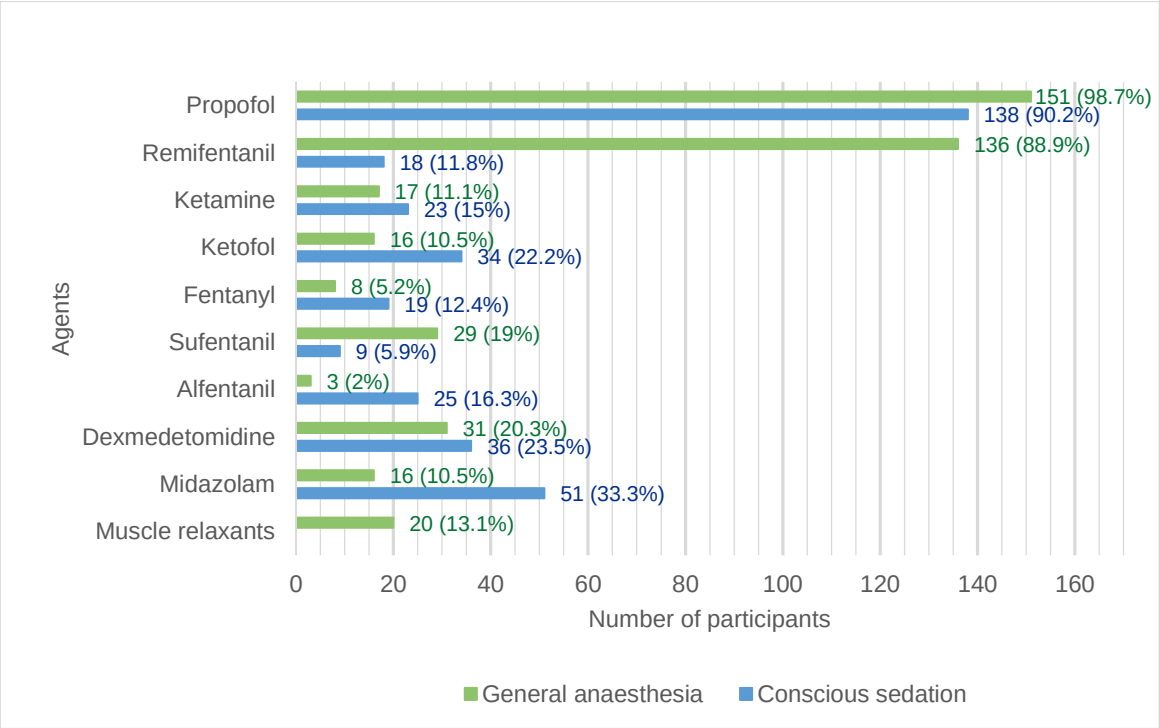

Figure 2: Agents used in the administration of TIVA

The majority of participants, 152 (99.3%) agreed that TIVA was a necessary skill to master. The importance participants attached to various factors with regards to the influence they had on their use of TIVA is shown in Table II.

Table II: Factors influencing the use of TIVA

	Agree n (%)	Neutral n (%)	Disagree n (%)	Not answered n (%)
Circumstances where TIVA may be advantageous over volatile anaesthesia				
Malignant hyperthermia	151 (98.7)	0	2 (1.3)	0
Neurosurgery with a raised intracranial pressure	69 (45.1)	67 (43.8)	14 (9.2)	3 (2)
To reduce emergence delirium	115 (75.2)	31 (20.3)	7 (4.6)	0
To reduce postoperative nausea and vomiting	133 (86.9)	14 (9.2)	6 (3.9)	0
Improved visualisation of surgical field when bleeding is a concern (e.g. spinal surgery)	102 (66.7)	40 (26.1)	10 (6.5)	1 (0.7)
Faster recovery times	71 (46.4)	46 (30)	36 (23.5)	0
Reduced airway reactivity	83 (54.3)	51 (33.3)	18 (11.8)	1 (0.7)
Reduced environmental pollution	137 (89.5)	13 (8.5)	3 (2)	1 (0.7)
Obstacles to the use of TIVA				
Expensive compared to volatile anaesthetic	87 (56.9)	43 (28.1)	23 (15)	0
Time consuming setup	109 (71.2)	23 (15)	21 (13.7)	0
Lack of availability of required pumps	107 (69.9)	23 (15)	23 (15)	0
Fear of intraoperative awareness	104 (68)	24 (15.7)	25 (16.3)	0
Availability of depth of anaesthesia monitors influences my use of TIVA	130 (85)	13 (8.5)	10 (6.5)	0
Lack of understanding of the pharmacology of TIVA	47 (30.7)	37 (24.2)	69 (45.1)	0

A participant's agreement that a lack of understanding of the pharmacology of TIVA was an obstacle to TIVA use was interpreted as discomfort with the pharmacology of TIVA, while disagreement was interpreted as comfort with the pharmacology of TIVA. The level of comfort with regards to the pharmacology of TIVA was then compared between junior and senior anaesthetists and a statistically significant result (p<.000) was found. A larger percentage of seniors as compared to juniors (57% vs. 29.9%) were comfortable with the pharmacology of TIVA.

Factors related to training in TIVA, namely the modes of training received, most suitable mediums and adequacy of training are reflected in Table III. Participants were able to select more than one option.

Table III: Training in TIVA

	Number (n)	Percentage (%)
Modes of training in TIVA		
Informal “on the job”	123	80.4
Lectures	69	45.1
Self-taught	47	30.7
Workshops	32	20.9
Simulation classes	2	1.3
None	3	2
Most suitable mediums to receive training in TIVA		
Workshops	105	68.6
Simulation	103	67.3
Lectures	49	32
In theatre	15	9.8
Adequacy of training		
Inadequate	80	52.3
Neutral	34	22.2
Adequate	37	24

Participants were asked to comment on when they felt teaching in TIVA should occur during registrar training time. Figure 3 below displays these results.

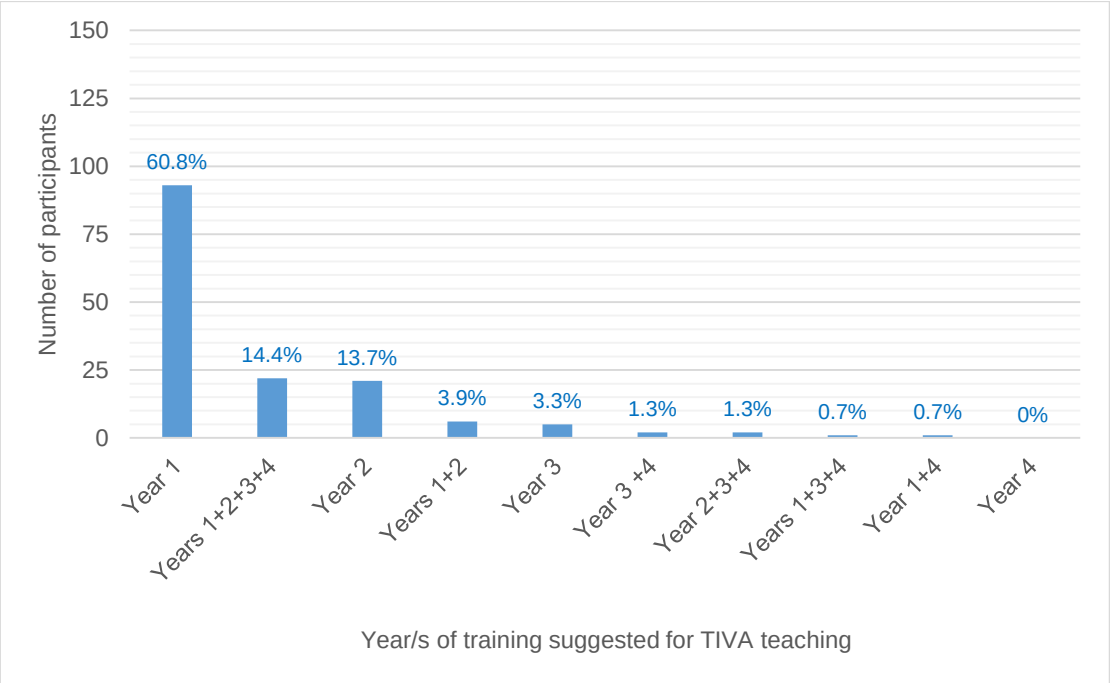

Figure 3: Suggested year/years during registrar training in which TIVA teaching should occur

Discussion

The frequency of TIVA usage by anaesthetists, in the Department of Anaesthesiology at Wits, was found to be extremely infrequent, with 67.3% of participants reporting to have used it less than 10 times in the past year. Furthermore, only a small minority, 1.3%, reported to using it more than a 100 times in the past year. Surveys conducted in other countries have also found that TIVA was used infrequently by the majority of participants [12, 13, 16-18, 22].

Wong et al [17] suggested that a reason for the infrequency with which TIVA is used may relate to the concept of familiarity. Most anaesthetists receive their initial training in volatile anaesthesia and as their experience with it grows, they subsequently tend to continue to use this technique, rather than attempting a new technique [17]. This reasoning seems plausible in our setting too, as initial exposure of trainees to general anaesthesia is usually with volatile anaesthesia. Furthermore, in our study, we found that fewer senior anaesthetists had performed ≥ 10 TIVAs in the past year than junior anaesthetists (53.5% vs. 85.1%). It follows from this that, if those responsible for training new trainees are primarily using volatile anaesthesia, they are likely to teach this method resulting in a cycle of

repetitively low TIVA usage. Furthermore, if juniors are performing TIVA more frequently than their seniors, it raises concerns about where they are receiving training from and the level of supervision they are receiving when performing TIVA.

In our study, more than half, 56.9%, of the anaesthetists felt uncomfortable in administering TIVA. It is reasonable to hypothesise that if an anaesthetist is not comfortable with a particular technique, they are less likely to use it so as to avoid the delivery of an inferior quality anaesthetic and possibly compromising patient safety. When comparing confidence in TIVA administration with frequency of usage no statistically significant difference was found, indicating that an increased frequency of usage does not necessarily translate to an increase in confidence in use. This may indicate the need for supervised training with an expert as opposed to simple repetition to develop competence and confidence in TIVA administration.

Interestingly, despite the low rates of TIVA usage, the majority of respondents, 88.9%, reported that they would like to use TIVA more often and 99.3% felt that TIVA was an important skill to master. Similar findings were echoed by Madhivathanan et al [12], Nora et al [14], Goh et al [13] and Arevalo et al [15]. A study by Wright and Dundee [19], in 1982, found that 92% of respondents would use TIVA more often if a more suitable drug were available. This study was conducted before propofol became a component of TIVA, yet despite the current availability of this “more suitable drug”, similar rates of infrequency in TIVA usage continue to be found more than 30 years later.

The decision to use a particular anaesthetic technique may be influenced by various factors, including, the benefit the anaesthetist perceives in using one technique over another as well as the perceived barriers that may act as limitations to use. The most compelling indication for TIVA use is the patient susceptible to MH. In our study, it was found that 98.7% of participants agreed that TIVA was advantageous over volatile anaesthesia in MH. A similar finding was also reported by Lim et al [18], Goh et al [13] and Pugh and Husaini [23]. The other areas where TIVA was viewed as advantageous over volatile anaesthesia included: environmental pollution (89.5%), reduced PONV (86.9%) and reduced

emergence delirium (75.2%). This indicates that theoretical knowledge regarding the indications and benefits of TIVA is satisfactory in our department.

The most important obstacle to the use of TIVA identified in our study was the unavailability of depth of anaesthesia monitors, reported by 85% of participants. This is surprising as the literature has not conclusively shown that these monitors decrease the risk of awareness during TIVA. Furthermore, guidelines advising on the use of depth of anaesthesia monitors have stated that these monitors are not required in every case of TIVA but should be individualised on a case by case basis [24-26]. This may reflect a potential knowledge gap which may need to be explored further. Alternatively, this may indicate a lack of comfort with the administration of TIVA and improving skill level may result in depth of anaesthesia monitors no longer being viewed as a limitation.

Other important limitations identified in our study included, the time to setup (71.2%), availability of infusion pumps (69.9%) and fears of intraoperative awareness (68%). In the study by Wong et al [17], when asked about “reasons not to use TIVA”, infrequent users perceived logistical reasons as a greater impedance to use than frequent users. This illustrates that with increased experience, anaesthetists are likely to become more efficient at administering TIVA and factors such as time to setup will be less important in deciding to use one technique over another.

The direct costs of TIVA are generally considered higher than the direct costs of volatile anaesthesia. Despite being a resource constraint department, within a developing country, cost was viewed as an obstacle by only 56.9% of anaesthetists in our study. Similarly, a number of other studies also found that cost was rated as a lesser obstacle to use as compared to other factors [13-18]. A reason for this may be that the perceived benefits of TIVA, such as reduced PONV and improved patient satisfaction, justify its use despite the additional expense.

TCI was reported as the preferred technique to administer TIVA by 78.4% of participants in our study. This is in keeping with the 2018 guidelines on TIVA administration [24]. The most common drugs utilised for TIVA were propofol (98.7%)

and remifentanil (88.9%), which is also in keeping with the guidelines [24], as these agents currently offer the best pharmacokinetic profile for use in TIVA.

Despite TIVA being in the curriculum of The College of Anaesthesia of South Africa [20] for specialist training, a mere 24% of participants reported that the training they had received in TIVA was adequate. This points to a deficiency in training in TIVA in our department and the need for a review of the way in which it is currently being taught. The majority of participants felt that practical approaches including workshops and simulation training would be the best mediums in which to receive training. It is important to note that inadequate training does not appear to be limited to our department alone, but rather is common to the international anaesthetic community with multiple other studies [11, 12, 14, 15, 17] identifying the need to improve training in TIVA.

The extrapolation of these results to the broader South African anaesthetic community is limited due to possible differences in institutional preferences, training and exposure as well as resource availability within different institutions.

Conclusion

Overall the frequency of TIVA usage was low and participants appeared to lack confidence in its administration. From this study it is apparent that theoretical knowledge about TIVA is satisfactory but that practical training in TIVA requires greater emphasis in the teaching programme. To reduce the impact of logistical reasons as a limitation to the use of TIVA it is important for the department to address the unavailability of required equipment for TIVA administration. Training anaesthetists with expertise in both TIVA and volatile anaesthesia should be a priority for the department as TIVA is a skill that all anaesthetists should master.

Conflict of interest

The authors declare that we have no financial or personal relationships which may have inappropriately influenced us in writing this paper.

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Section 4: Proposal

Total intravenous anaesthesia: Practices and training in an anaesthesiology department

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4.1 Introduction

General anaesthesia has been defined by the American Society of Anesthesiology (ASA) as: “a drug-induced loss of consciousness during which an individual is not arousable, even by painful stimulation. The ability to independently maintain ventilatory function is often impaired. The individual often requires assistance in maintaining a patent airway, and positive pressure ventilation may be required…” (1). The scope for general anaesthesia is wide and it may be required in a number of clinical scenarios, including surgery, examination under anaesthesia and radiological procedures.

The process of general anaesthesia involves an induction phase, a maintenance phase and an emergence phase. A state of general anaesthesia may be achieved through the use of volatile and intravenous agents. The most widely practised method to achieve general anaesthesia involves a combination of intravenous anaesthetic agents for induction and a volatile agent for maintenance (2). Since it is the volatile agent which is used for maintenance this technique is often described as volatile or inhalational based anaesthesia. Where an intravenous agent is used for both induction and maintenance of anaesthesia, in the absence of a volatile agent, the technique is described as total intravenous anaesthesia (TIVA).

Intravenous anaesthetic agents may also be used to achieve conscious sedation and the term TIVA is often used interchangeably to describe the use of intravenous agents to achieve general anaesthesia as well as conscious sedation. Anaesthetists have an increasingly important role in providing conscious sedation to facilitate patient comfort during a variety of diagnostic and therapeutic procedures and as an adjuvant to regional anaesthesia. Conscious sedation is defined by the ASA as “a drug-induced depression of consciousness during which an individual responds purposefully to verbal commands, either alone or accompanied by light tactile stimulation. No interventions are required to maintain a patent airway, and spontaneous ventilation is adequate...”(1).

As the practice of general anaesthesia has developed over time, changes in the way in which it is provided have paralleled pharmacological and technological

advances. Volatile based anaesthesia has dominated the practice of general anaesthesia for many years. With the introduction of propofol in the 1970's, there was a renewed interest in the use of intravenous anaesthesia (3, 4). This was further aided by, an improved understanding into the pharmacokinetic and pharmacodynamic principles of drugs, the development of drugs with a rapid onset and offset as well as improved drug delivery systems (4, 5).

TIVA provides an alternative to the classic volatile based anaesthetic and offers a number of potential clinical benefits. These include decreased postoperative nausea and vomiting (6-8), faster and smoother recovery (7, 9), reduced bronchial reactivity (7), reduced emergence delirium (7) and improved visualisation of the surgical site due to decreased intraoperative bleeding (10). TIVA also serves as the ideal mode of general anaesthesia for patients at risk for malignant hyperthermia (3, 7, 11).

Despite the advances made in TIVA, this has not necessarily translated to an increase in the practice of TIVA. Some of the reasons for this have included the lack of confidence in its administration (12-14), inadequate training (12-16), as well as the perceived higher cost (16-18) and greater time required to set up TIVA as compared to volatile based anaesthesia (17, 18). The familiarity for most anaesthetists in managing patients using volatile based anaesthesia may also be one of the reasons why anaesthetists tend to avoid the use of TIVA (4).

4.2 Problem statement

TIVA is an important skill for an anaesthetist to master. It is listed as part of the curriculum for specialist training of anaesthetists as outlined by the College of Anaesthetists of South Africa, a college of the Colleges of Medicine of South Africa (19). A good working knowledge in TIVA is essential in a number of clinical scenarios, including: patients at risk for malignant hyperthermia, those at high risk for postoperative nausea and vomiting, head and neck surgery as well as neurosurgical cases (7). Research has shown that training is inadequate and subsequently experience is lacking within this area of anaesthesia (13, 20, 21). In addition, various other factors such as cost, time involved in setup, and concerns

related to intraoperative awareness have been cited as obstacles to its use (16, 17, 21).

South African literature on the practices and training of anaesthetists in the use of TIVA could not be identified. Furthermore, in the Department of Anaesthesiology at the University of the Witwatersrand (Wits), the practices and training of anaesthetists in the use of TIVA is unknown.

4.3 Aim and objectives

4.3.1 Aim

The aim of this study is to describe the practices and training of anaesthetists in the use of TIVA, in the Department of Anaesthesiology at Wits.

4.3.2 Objectives

The primary objectives of this study are to:

- describe the anaesthetists practices related to TIVA
- describe the factors that influence the use of TIVA
- describe the training received in TIVA.

The secondary objectives of this study are to:

- compare the frequency of use of TIVA between junior and senior anaesthetists
- compare the level of comfort with regards to the pharmacology of TIVA between junior and senior anaesthetists
- compare the frequency of administration of TIVA to participants confidence in the use of TIVA.

4.4 Research assumptions

The following definitions will be used in this study:

Anaesthetist: refers to a qualified doctor including medical officers, registrars and consultants working in the Department of Anaesthesiology, skilled in the administration of anaesthesia for surgery and other purposes.

Medical officer: is a qualified doctor practising in the Department of Anaesthesiology under specialist supervision**.**

Registrar: is a qualified doctor that is registered with the Health Professions Council of South Africa as a trainee, undergoing training to become a specialist anaesthesiologist**.**

Career medical officer: is a medical officer with more than 10 years of anaesthetic experience, able to practise anaesthesia independently.

Anaesthesiologist: is a qualified doctor, who has subsequently undergone registrar training and has passed the examinations required by the College of Anaesthetists of South Africa, to qualify as a specialist anaesthetist.

Consultant: Is an anaesthesiologist or career medical officer.

Junior anaesthetists: in this study, refers to medical officers and registrars with less than four years of training.

Senior anaesthetists: in this study, refers to career medical officers and registrars with four or more years of training and consultants.

Total intravenous anaesthesia (TIVA): is the provision of anaesthesia solely by means of intravenous agents, without the use of volatile agents.

Target controlled infusion (TCI): refers to the delivery of an infusion intravenously by a microprocessor-controlled syringe pump, which automatically and variably controls the rate of infusion of a drug to attain a user defined target level in an effect site in the patient (22).

4.5 Demarcation of study field

This study will be conducted in the Department of Anaesthesiology, affiliated to the Faculty of Health Sciences of the University of the Witwatersrand. The staff

complement of the department comprises of: 74 consultants, 112 registrars and 22 medical officers. The following hospitals are affiliated to the department:

- Charlotte Maxeke Johannesburg Academic Hospital, a 1200 bed central hospital
- Chris Hani Baragwanath Academic Hospital, a 3200 bed central hospital
- Helen Joseph Hospital, a 500 bed tertiary hospital
- Rahima Moosa Mother and Child Hospital, a 338 bed tertiary hospital
- Wits Donald Gordon Medical Centre, a 190 bed public/private hospital.

4.6 Ethical considerations

An application for approval to conduct the study will be submitted to the Human Research Ethics Committee (Medical) and the Graduate Studies Committee of Wits.

The researcher will explain the objectives of the study to the anaesthetists and invite them to participate. The survey will be voluntary and an information sheet (Appendix A) with details pertaining to the study will be presented to those who agree to participate. Consent will be implied by completion of the survey.

Care will be taken to maintain anonymity and confidentiality. No personal information will be requested from participants and surveys will be numbered for data collection purposes only. Completed questionnaires will be folded in half and returned to a sealed box. The raw data will only be available to the researcher and the supervisors. Data will be stored securely for six years after completion of the study.

If a deficiency in training is identified it will be reported to the Head of the Department with suggestions to institute changes in the training programme as appropriate.

This study will be conducted according to the principles of the Declaration of Helsinki (23) and the South African Guidelines for Good Clinical Practice (24).

4.7 Research methodology

4.7.1 Research design

This study will follow a prospective, contextual, descriptive research design.

A prospective study refers to a study in which a specific population is followed over time to observe an outcome (25). Data in this study will be collected at the time the study is conducted.

Context can be described as a “small-scale world” which, amongst others can be clinics, hospital wards or critical care units(26) . This study is contextual as it will be conducted with anaesthetists working in the Department of Anaesthesiology at Wits.

According to Brink (25), a descriptive study is one in which a populations characteristics are being described, in order to answer a specific question about the population, without attempting to establish a causal link. In this study, the practices and training of anaesthetists with regards to the use of TIVA will be described.

4.7.2 Study population

The study population will comprise the anaesthetists working in the Department of Anaesthesiology at Wits.

4.7.3 Study sample

Sample size

At the time of the study, the department had a total of 208 anaesthetists employed. A response rate of 60% (125) would be deemed as an acceptable sample size (27).

Sampling method

In this study a convenience sampling method will be used. Convenience sampling, also known as availability sampling, involves participants that are readily available

to the researcher (25). In this study the most convenient way to survey the anaesthetists in the Department of Anaesthesiology is at departmental academic meetings, which carry compulsory attendance by all those who are not otherwise committed elsewhere.

4.7.4 Inclusion and exclusion criteria

Anaesthetists in the Department of Anaesthesiology willing to take part in the study will be included. There are no exclusion criteria.

4.7.5 Data collection

Questionnaire development

A draft survey was developed based on a review of the literature to ensure content validity. The draft survey was reviewed by a co-supervisor, who is an anaesthesiologist with expertise in TIVA, and two senior anaesthesiologists from the Department of Anaesthesiology at Wits to ensure face validity. Corrections were made accordingly.

The survey will be self-administered and the following information will be sought:

- demographics
- practices related to the use of TIVA
- factors influencing the use of TIVA
- training in TIVA.

Data collection

Data will be collected during departmental academic meetings, with the aim of obtaining a minimum of a 60% response rate.

The researcher will approach the chairperson of the meeting for permission to address the meeting. A brief overview of the study will be given and the researcher will request participation from the anaesthetists. If an anaesthetist agrees to take part in the survey, the researcher will provide the anaesthetist with an information sheet (Appendix A) and a survey (Appendix B).

Each survey will have a unique number which will be used for data collection purposes only. Consent will be implied by completion of the survey. The researcher will be available during this time to assist with possible queries relating to the study or the survey.

Upon completion, the anaesthetist will be asked to fold the survey in half and place it into a sealed box provided by the researcher. This will further maintain the anonymity of the participants.

4.7.6 Data analysis

Data will be entered onto a Microsoft Excel spreadsheet and analysed using descriptive and inferential statistics. The statistical program Stata 14 (Statacorp, USA) will be used. Categorical variables will be described using frequencies and percentages. Comparison of variables will be made using Chi squared tests. A p value of <0.05 will be considered statically significant.

4.8 Significance of the study

TIVA is a rapidly advancing field in anaesthesia. The development of technology to assist in improved methods of administering TIVA as well as advances in pharmacology have led to an increasing interest in TIVA over the past three decades (3, 5). Despite this, research suggests that the actual use of TIVA remains low in comparison to volatile anaesthesia (28). Several reasons for this have been identified including a lack of confidence and inadequate training in TIVA (13, 16, 20). In addition, anaesthetists appear to prefer volatile anaesthesia due to: familiarity with the technique, perceived economic benefits, the fact that it is less cumbersome to administer and a perceived greater control in the depth of anaesthesia (4, 17).

Achieving competency in the delivery of TIVA is cited in the curriculum for the training of anaesthesiologists by the College of Anaesthetists of South Africa (19). Furthermore, a good working knowledge in TIVA is important in a number of clinical scenarios including patients at risk for malignant hyperthermia, those at high risk for postoperative nausea and vomiting, head and neck surgeries as well as neurosurgical cases (7). Numerous other benefits have also been associated

with TIVA, such as a smoother recovery, reduced airway reactivity, reduced emergence delirium and reduced environmental pollution as compared to volatile anaesthesia, making it an attractive alternative mode of anaesthesia (3, 7).

In South Africa, research on the practices of anaesthetists with regard to the use of TIVA could not be identified, nor could such information be found within the Department of Anaesthesiology at Wits. The results of this study will provide a better understanding of how TIVA is practised in the department, which factors influence the use of TIVA and the level of training anaesthetists received. If it is found that there are barriers to the use of TIVA or that the training is inadequate, the department would then be able to use this information to address these issues. Furthermore, with the results of this study it may be possible to assess how the department compares to international trends with regards to the practices and training in the use of TIVA.

4.9 Validity and reliability of the study

According to Bothma et al. (29) the validity of a study refers “to the degree to which a measurement represents a true value” and reliability “represents the consistency of the measure achieved.”

The validity and reliability of this study will be ensured by the following means:

- choosing an appropriate study design
- using a survey with content and face validity
- distributing a standard survey to all participants
- the survey being completed in a non- threatening environment and placed into a sealed box, with the aim to encourage honest answering of the survey
- the researcher being available during the completion of the survey to answer any questions and to prevent data contamination
- checking every 10th entry onto the spreadsheet for accuracy
- analysing data in consultation with a biostatistician.

4.10 Potential limitations

The study is contextual and the results from the study may not be generalisable to other institutions. Despite this, the study will provide valuable information for the Department of Anaesthesiology regarding the use of TIVA.

The study sample size will be dependent on the attendance at departmental academic meetings and the willingness of the anaesthetists to participate in the study.

A convenience sample is being used, this may not accurately reflect the practices of all anaesthetists in the department, but rather of those attending the meetings on the days on which data collection is carried out.

4.11 Project outline

4.11.1 Time frame

Activity	Nov 2016	Jan 2017	May 2017	Jun 2017	Sep 2017	Jan 2018	Sep 2018	Oct 2018	Nov 2018	Dec 2018
Proposal preparation										
Literature review										
Proposal submission										
Ethics approval										
Postgraduate approval										
Data collection										
Data analysis										
Draft article										
Submission										

4.11.2 Budget

Item	Price per page	Number of pages	Copies	Total
Proposal	1	15	10	R 150
Ethics	1	10	25	R 250
Post graduate form	1	2	6	R 12
Complete report	1	100	4	R 400
Grand total				**R 812**

The Wits Department of Anaesthesiology will incur the costs of paper and printing.

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4.13 Appendices

Appendix 1 Participants' information sheet

Dear Colleague,

Hello, my name is Faaizah Dadoo and I am a registrar in the Department of Anaesthesiology at Wits.

I would like to invite you to participate in my research study titled: **Total intravenous anaesthesia: Practices and training in an anaesthesiology department**. This study will be submitted to the Faculty of Health Sciences at Wits in partial fulfilment of my specialist qualification.

Total intravenous anaesthesia (TIVA) is a rapidly advancing field in anaesthesia and offers an alternative mode to volatile based anaesthesia. There are a number of clinical situations where TIVA may be preferred over volatile based anaesthesia. Furthermore, as part of the training of anaesthesiologists in South Africa, the College of Anaesthetists of South Africa requires that all trainees attain competence in the use of TIVA. It is therefore imperative that anaesthetists are able to confidently and safely provide TIVA to their patients. It is not known whether anaesthetists in the department are confident in the administration of TIVA and if the training received is adequate. Obtaining this information may assist in improving our professional development.

Participation is voluntary and consent will be implied by completion of the survey. All information will be kept confidential and anonymity will be maintained as no identifying information will be required from participants. Numbering of the surveys is for data collection purposes only, and will not identify the participants involved. No penalty will be incurred for not participating in the study. All information provided in the survey will only be viewed by myself and my supervisors.

The survey will be self-administered and should take no longer than 10 minutes to complete. Please fold the survey in half when completed and place it into the sealed box provided.

Your time and participation is greatly appreciated.

Please direct any queries regarding the study to:

- Faaizah Dadoo (researcher): 0848829786
- Ethics committee chairperson: 011 717 1234

Appendix 2 Survey

Study Number ☐

Please provide the following information by placing a tick in the appropriate box

1. Demographics

Years of experience in anaesthesia	< 1 year	
	1-3 years	
	4-10 years	
	11-15 years	
	>15 years	

Professional Designation	Medical officer	
	Registrar (1st to 3rd year)	
	Registrar (4th year)	
	Career medical officer	
	Consultant anaesthesiologist	

In this study, the term TIVA refers to the administration of anaesthesia using intravenous agents only (in the absence of volatile agents), and may be achieved through: intermittent bolus dosing, a constant infusion or a target controlled infusion.

A target controlled infusion (TCI) refers to refers to the delivery of an infusion by a microprocessor-controlled syringe pump, which automatically and variably controls the rate of infusion of a drug to attain a user defined target level in an effect site in the patient.

2. Practice

2.1. In the last year approximately how many TIVA's have you done?

<10	
10-25	
26-50	
51-100	
>100	

2.2.	I would like to use TIVA more often	Yes	No
2.3.	Have you been in a situation where you felt that a TIVA was the best choice for a patient but you were not confident in its administration?	Yes	No

2.4. To achieve a general anaesthetic using TIVA, what is your preferred method?

Intermittent bolus dosing	
Continuous infusion	
Target controlled infusion (TCI)	

2.5. Which of the following intravenous agents do you use when administering TIVA to achieve general anaesthesia? (you can choose more than one answer)

Propofol	
Ketamine	
Ketofol	
Remifentanil	
Alfentanil	
Sufentanil	
Fentanyl	
Dexmedetomidine	
Midazolam	
Muscle relaxants	

2.6. To achieve conscious sedation using TIVA, what is your preferred method?

Intermittent bolus dosing	
Continuous infusion	
Target controlled infusion (TCI)	

2.7. Which agents do you use when administering TIVA to achieve conscious sedation?

Propofol	
Ketamine	
Ketofol	
Remifentanil	
Alfentanil	
Sufentanil	
Fentanyl	
Midazolam	
Dexmedetomidine	

3. Factors influencing your use of TIVA

	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree
3.1. TIVA is an important skill for anaesthetists to master					

3.2. Is TIVA advantageous over volatile based anaesthetic techniques with regards to the following?

	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree
Patients at risk for malignant hyperthermia					
Patients presenting for neurosurgery who have raised intracranial pressure					
Reduced emergence delirium					
Less postoperative nausea and vomiting					
Improved visualisation of the surgical field with less bleeding in certain cases (such as, spinal surgery or functional endoscopic sinus surgery)					
Faster recovery time					
Reduced airway reactivity					
Reduced environmental pollution					

3.3. The following are obstacles to your use of TIVA.

	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree
TIVA is more costly than volatile based anaesthesia					
TIVA is more time consuming to set up as compared to volatile anaesthesia					
The lack of availability of pumps prevents my use of TIVA					
When I use TIVA, I am insecure about the possibility that my patients may experience intraoperative awareness					
The availability of depth of anaesthesia monitors would increase my use of TIVA.					
I am not comfortable with the pharmacology and pharmacokinetics of TIVA					

4. Training in TIVA

4.1. What training have you received in TIVA?

None	
Informal “on the job”	
Lectures	
Workshops	
Simulation classes	
Self-taught	
Other	

If other, please specify

……

4.2. When do you feel registrars should receive training in TIVA?

1st year	
2nd year	
3rd year	
4th year	

4.3. The best medium to receive training in TIVA would be through

Lectures	
Workshops	
Simulation classes	
Other	

If other please specify

……..

	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree
4.4. I feel that the training I have received with regards to TIVA is adequate					

Thank you for taking the time to complete this survey, your participation is greatly appreciated.

Section 5: Annexures

5.1 Ethics approval

5.2 Graduate studies approval

5.3 Turnitin report

R14/49 Dr Faaizah Dadoo et al

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M170125

NAME: (Principal Investigator)	Dr Faaizah Dadoo et al
DEPARTMENT:	Anaesthesiology University of the Witwatersrand
PROJECT TITLE:	Total Intravenous Anaesthesia: Practices and Training in an Anaesthesiology Department
DATE CONSIDERED:	27/01/2017
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Juan Scribante
APPROVED BY:	Professor P. Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	17/05/2017

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand. I/We fully understand the the conditions under which I am/we are authorised to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. in this case, the study was initially review in January and will therefore be due in the month of January each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES