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ORIGINAL RESEARCH

Total intravenous anaesthesia: a survey of practices and training at an anaesthesiology department

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Background: Total intravenous anaesthesia (TIVA) provides an alternative to the classic volatile agent-based anaesthetic, with several clinical benefits. Volatile agent-based 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 at the Department of Anaesthesiology at the University of the Witwatersrand.

Methods: A prospective, cross-sectional study was undertaken using a self-administered questionnaire.

Results: In total, 153 questionnaires were completed, representing 73.6% of anaesthetists in the department. TIVA was infrequently used; 67.3% of participants reported using it < 10 times during the past year. Conversely, 88.9% of participants reported that they would like to use TIVA more often. Significantly more juniors than seniors performed ≥ 10 TIVAs during the past year ($p < 0.0001$). Of the participants, 56.9% experienced a situation where TIVA would have been ideal, but they lacked the confidence to use it. Anaesthetists who had performed ≥ 10 TIVAs were not significantly more confident in its use ($p = 0.059$). Seniors were significantly less deterred by a lack of understanding of the pharmacology of TIVA as an obstacle to TIVA use, compared to juniors ($p < 0.0001$). Target-controlled infusion (TCI) was preferred by 78.4% of participants for the administration of TIVA. TIVA was viewed as advantageous over volatile agent-based anaesthesia in malignant hyperthermia (98.7%), to reduce postoperative nausea and vomiting (86.9%) and to decrease environmental pollution (89.5%). The lack of availability of depth of anaesthesia monitors was the greatest obstacle to TIVA use, reported by 85% of participants. Only 24% of participants perceived their training in TIVA as adequate.

Conclusion: TIVA usage was infrequent and participants lacked confidence in its administration. TIVA is an important skill in the armamentarium of an anaesthetist and, therefore, improved training should be prioritised.

Keywords: TIVA, intravenous anaesthesia, anaesthetic practice

Introduction

As the practice of general anaesthesia has developed over time, modifications to how it is administered have paralleled pharmacological and technological advances. 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] Volatile agent-based anaesthesia has dominated the practice of general anaesthesia for many years. With the discovery 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]

Total intravenous anaesthesia (TIVA) can be defined as anaesthesia which is administered exclusively by the intravenous route.[4] TIVA may be delivered using a number of techniques, including intermittent bolus dosing, running a constant infusion using a manually controlled syringe-type infusion pump, and using a target-controlled infusion (TCI) system. Propofol, a hypnotic intravenous anaesthetic agent, is a derivative of the alkylphenols and is currently the most suitable intravenous agent for TIVA.[5] The most commonly described drug combination with propofol-based TIVA is remifentanil. The synergy between propofol and remifentanil is advantageous to both reduce the dosage requirements of propofol and to provide ideal conditions for surgery.[6] The guidelines for the safe practice of TIVA[6] recommend that where general anaesthesia is to be maintained by a propofol infusion, that a TCI be used. Various other intravenous drugs such as other short-acting opioids, benzodiazepines and alpha-2-agonists may be used as adjuncts to TIVA.

TIVA provides an alternative to the classic volatile agent-based anaesthetic and offers several potential clinical benefits. These include decreased postoperative nausea and vomiting (PONV),[7-9] faster and smoother recovery,[8,10] reduced bronchial reactivity,[8] reduced emergence delirium[8] and improved visualisation of the surgical site due to decreased intraoperative bleeding.[11] TIVA also serves as an ideal mode of general anaesthesia for patients at risk of malignant hyperthermia (MH).[2,8,12] Other potential benefits include use during ENT surgery, with the need for a 'tubeless' surgery, surgery requiring neurophysiological monitoring,

anaesthesia in a non-theatre environment, and in patients with neuromuscular disorders where neuromuscular blocking agents should preferably be avoided.[5]

Despite the advances made in TIVA, there is not necessarily an increase in its use. Some of the reasons for this include a lack of confidence in its administration,[13-15] inadequate training,[13-17] inaccessibility of necessary equipment,[17-19] concerns related to intraoperative awareness,[17,18,20] as well as the perceived higher cost[17,20,21] and greater time required to set up TIVA compared to volatile agent-based anaesthesia.[20,21] For most anaesthetists, the familiarity in managing patients using volatile agent-based anaesthesia may also be one of the reasons why they 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.[22] However, training has been shown as inadequate in several countries, and subsequently, expertise is lacking within this area of anaesthesia.[14,18,19]

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

Methods

This study followed a prospective, cross-sectional research design. Approval to conduct this study was obtained from the Wits Human Research Ethics Committee (Medical) (M170125).

The study population comprised 208 anaesthetists working in the Department of Anaesthesiology at Wits. Using an online precision-based sample size calculator, with a confidence interval (CI) of 95%, an acceptable margin of error of 5% and a population proportion of 50%, a sample size of 135 was deemed adequate. A convenience sampling method was used. In this study, 'junior anaesthetists' referred to medical officers and registrars with less than four years of training while 'senior anaesthetists' referred to registrars with four or more years of training, career medical officers and consultants.

A draft survey was developed based on a literature review 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. Thereafter, corrections were made according to the feedback received. No pretesting was performed. The survey was self-administered and included the following four sections: demographics (which consisted of two questions), practices related to TIVA use (which consisted of seven questions), factors influencing the use of TIVA (which consisted of three questions) and training in TIVA (which consisted of four questions).

Data were collected during departmental academic meetings in June and July 2017, 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 placed it into a sealed box to maintain the anonymity of the participants.

The data were analysed using Stata version 14 (StataCorp, USA) in consultation with a biostatistician. Categorical variables were described using frequencies and percentages, and comparisons were made using chi-square tests. A p-value of < 0.05 was considered statically significant. When all respondents did not answer a question, the number of respondents to a question is indicated. 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 these, 153 were completed and returned, resulting in a 98.7% response rate and representing 73.6% of anaesthetists in the department. The margin of error calculated for the population size of 208, with

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

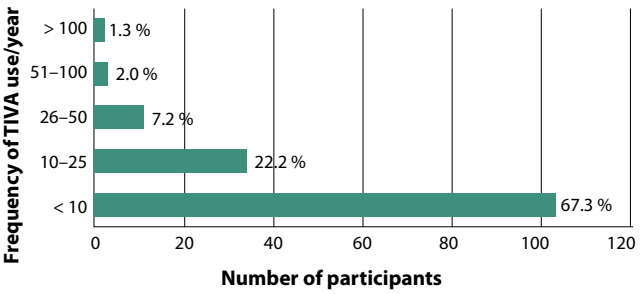


Figure 1: Frequency of TIVA administration by participants during the past year

153 responses is 4.1%. Table I shows the demographics of the participants in this study.

A large proportion of the participants (103; 67.3%; 95% CI 59.2–74.6) reported that they had used TIVA fewer than 10 times during the past year. Figure 1 displays the frequency of the administration of TIVA by participants during 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 during the past year. A greater proportion of junior anaesthetists (85%; 95% CI 74.2–92.6) had performed more than 10 TIVAs during the past year compared to senior anaesthetists (54%; 95% CI 42.4–64.3) ($p < 0.0001$).

Most participants (136; 88.9%; 95% CI 82.8–93.3) confirmed that they would prefer to use TIVA more often in their practice. When participants were asked about situations where TIVA would likely have been the best type of anaesthetic for a particular patient but was not used due to a lack of confidence in its administration, 87 (56.9%) of the participants confirmed that they had experienced such situations. In comparing the frequency of TIVA administration (in terms of those who performed < 10 and ≥ 10 during the past year) to the participants' confidence in its use, no statistically significant difference was apparent ($p = 0.059$).

Most participants (120; 78.4%; 95% CI 71.0–84.6) preferred TCI as the technique of choice for the administration of TIVA to achieve general anaesthesia. TIVA via manually-controlled continuous infusion was reported to be the preferred technique by 24 participants (15.7%; 95% CI 10.3–22.4) while intermittent bolus dosing was the least popular technique, preferred by only five participants (3.3%; 95% CI 1.0–7.4). Two participants (1.3%; 95% CI 0–0.7) selected all three techniques as their preferred method and both TCI and manually-controlled continuous infusion were selected by two participants (1.3%; 95% CI 0–0.7).

When asked about the preferred TIVA technique to achieve conscious sedation, 70 participants (45.8%; 95% CI 37.6–53.9) selected TCI. The use of intermittent bolus dosing was preferred by 42 participants (27.5%; 95% CI 20.5–35.2), while 33 participants (21.6%; 95% CI 15.3–28.9) preferred a continuous infusion. More than a single technique was selected by some participants: both intermittent bolus dosing and TCI were preferred by three participants (2%; 95% CI 0–0.5), TCI and continuous infusion by two participants (1.3%; 95% CI 0–0.7), and intermittent bolus dosing and continuous infusion by two participants (1.3%; 95% CI 0–0.7).

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

The majority of participants (152; 99.3%) agreed that TIVA was a necessary skill to master. The importance of various factors regarding the influence these had on anaesthetists' use of TIVA, is shown in Table II.

Significantly more senior anaesthetists than juniors (57%; 95% CI 43.2–73.0 versus 29.9%; 95% CI 15.9–43.4) reported that they did not consider a lack of understanding of the pharmacology of TIVA as an obstacle to its use ($p < 0.0001$).

Factors related to TIVA training, namely the modes of training received, most suitable media and adequacy of training, are

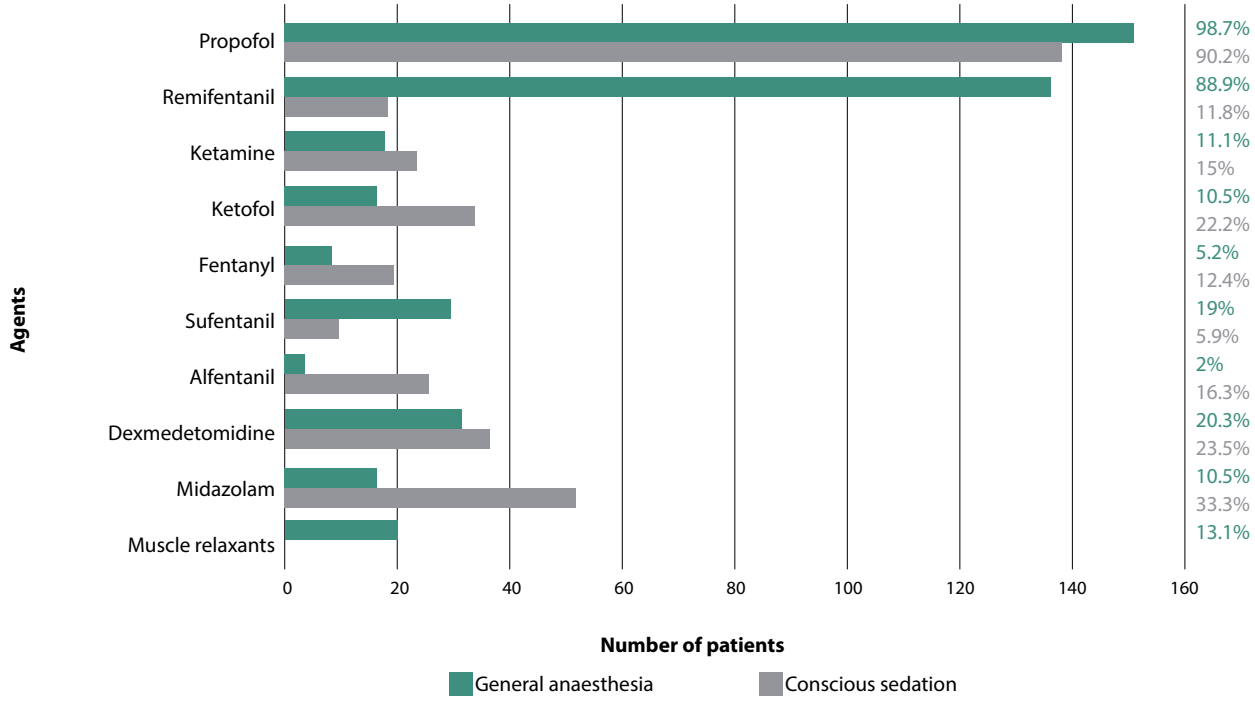


Figure 2: Agents used in the administration of TIVA

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)
Reduced emergence delirium	115 (75.2)	31 (20.3)	7 (4.6)	0
Reduced postoperative nausea and vomiting	133 (86.9)	14 (9.2)	6 (3.9)	0
Improved visualisation of surgical field when bleeding is a concern (for example, 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	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

reflected in Table III. Participants were allowed to select more than one option.

Table III: TIVA training factors

	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 media for 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 also asked when they felt teaching in TIVA should occur during registrar training time. Figure 3 displays these results.

Discussion

In the Department of Anaesthesiology at Wits, TIVA was used infrequently, with 67.3% of participants using it < 10 times during the past year. Furthermore, only a minority (1.3%) reported using

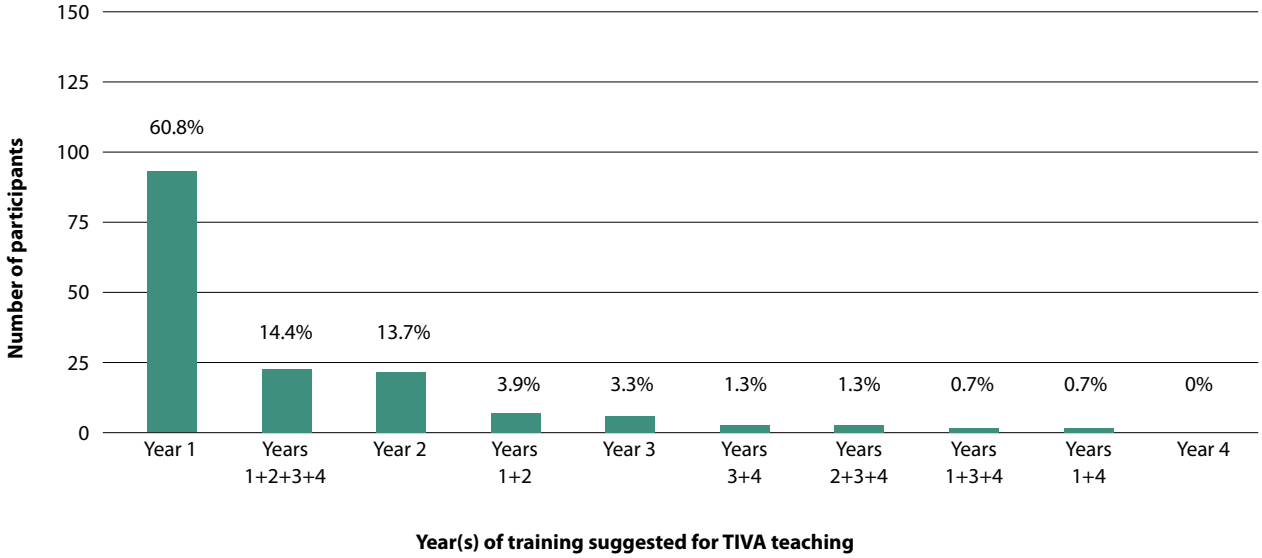


Figure 3: Suggested year(s) during registrar training in which TIVA teaching should occur

it more than 100 times during the past year. Surveys conducted in other countries have also found that TIVA was used infrequently by the majority of participants.[14,15,18-20,23]

Wong et al.[19] 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. As their experience grows, they subsequently tend to continue to use this technique rather than attempting a new technique.[19] This reasoning seems plausible in our setting as well, as initial exposure of trainees to general anaesthesia is usually with volatile agent-based anaesthesia. Furthermore, our study found that fewer senior anaesthetists had performed ≥ 10 TIVAs during the past year compared to junior anaesthetists (53.5% vs 85.1%). It follows that if those responsible for training new trainees are not performing TIVA, they are less 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, there are concerns about where they receive training from and the level of supervision when performing TIVA.

In our study, more than half of the anaesthetists (56.9%) felt uncomfortable 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 that could possibly compromise patient safety. When comparing confidence in TIVA administration with frequency of usage, no statistically significant difference was found.

Interestingly, despite the low rates of TIVA usage, the majority of participants (88.9%) reported that they want 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.,[14] Nora et al.,[16] Goh et al.[15] and Arevalo et al.[17] A study by Wright and Dundee in 1982,[21] 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 use are reported more than 30 years later.

The decision to use a particular anaesthetic technique may be influenced by various factors, including the perceived benefit of the technique and the perceived barriers that may limit usage. The most compelling indication for TIVA use is in MH susceptible patients. Our study found that 98.7% of participants agreed that TIVA was advantageous over volatile agent-based anaesthesia in MH. Similar findings were also reported by Lim et al.,[20] Goh et al.[15] and Pugh and Husaini.[24] 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 using 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 regarding the use of depth of anaesthesia monitors have stated that these monitors are not required in every case of TIVA but its use should be determined on a case by case basis.[6,25,26] This may reflect a potential knowledge gap that 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 unavailability of depth of anaesthesia monitors no longer being viewed as a limitation.

Other important limitations identified in our study included the time to set up (71.2%), availability of infusion pumps (69.9%) and fears of intraoperative awareness (68%). In the study by Wong et al.,[19] 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 the time to set up 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 agent-based anaesthesia.[27] Despite being a resource-constrained department within a developing country, cost was viewed as an obstacle by only 56.9% of the participants in our study. Similarly, several other studies also found that cost was rated as a lesser obstacle to use compared to other factors.[15-20] 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 costs.

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.[6] The most common drugs used in TIVA were propofol (98.7%) and remifentanil (88.9%), which is also in keeping with the guidelines,[6] 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[22] 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 how it is currently being taught. The majority of participants felt that practical approaches, including workshops and simulation training, would be the best media in which to receive training. It is important to note that inadequate training does not appear to be limited to our department but is common to the international anaesthetic community, with multiple other studies[13,14,16,17,19] identifying the need to improve training in TIVA.

Study limitations

A limitation of this study is that the extrapolation of these results to the broader South African anaesthetic community may not be accurate due to possible differences in institutional

preferences, training and exposure as well as resource availability within different institutions. An additional limitation of the study is that the questionnaire did not specifically enquire about the perception of participants regarding the use of depth of anaesthesia monitors in the presence or absence of neuromuscular blocking agents. Guidelines on the use of TIVA have recommended that depth of anaesthesia monitors should be used during TIVA in the presence of neuromuscular blocking agents.[6]

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, the department needs to address the lack of availability 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.

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Conflict of interest

The authors declare no conflict of interest.

Ethical approval

Ethical approval was obtained from the University of the Witwatersrand Human Research Ethics Committee (170125)

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