Monitoring consciousness under anaesthesia: the 21st century isolated forearm technique

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The isolated forearm technique (IFT), first introduced by Tunstall1 for short term use during Caesarean section, was modified by the author2 and subsequently used successfully with many neuromuscular blocking agents (curare, alcuronium, fazoquinium, atracurium, vecuronium) for longer operations. However, with the longer lasting muscle relaxants (pancuronium, rocuronium), the recommended intubation doses generally result in paralysis of the hand when the tourniquet is released.3,4 With an intubating dose of rocuronium (0.3 mg kg−1), half that usually recommended, and judicious top-up dose titration, given only as required for surgical requirements, the author (I.F.R.) has used the IFT successfully during total i.v. anaesthesia (TIVA/TCI) for women undergoing radical hysterectomy. Nevertheless, when using the recommended intubating dose of rocuronium, the subsequent paralysis of the isolated hand after cuff deflation is a major obstacle to using the IFT. In this issue of the journal an intriguing ‘proof of concept’ study suggests the possibility that this obstacle to the use of the IFT with rocuronium can be overcome.5

The authors of the study call their technique the reversed IFT (rIFT). Instead of using a tourniquet to prevent the arm muscles being blocked by rocuronium the authors, using the principle of a Bier’s block with dilute sugammadex, antagonized the paralysis already present in one arm. When the tourniquet was deflated 15 min later, the arm remained unparalysed and there was no significant change in the muscle relaxation in the rest of the body. It is also worth noting that the authors observed no significant complications, with only minor bruising in three patients. In the author’s (I.F.R.) experience, bruising and nipping from the NIBP cuff is more of an issue than any problem noted with the rIFT cuff (Fig. 1A and B).

As rocuronium is now a commonly used neuromuscular blocking agent, the principal merit of the rIFT lies in its potential to minimize restrictions on the intubating dose of rocuronium, as the paralysis in one arm can be antagonized. Alternatively, the authors suggest that the rIFT can be used ‘instantly, whenever the depth of anaesthesia becomes unclear’ allowing a direct assessment of the patient’s conscious state. However, as described, there is a major limitation with the rIFT as there is no possibility of monitoring consciousness during the early stages of anaesthesia: induction, intubation and stabilization of the patient. Even excluding drug errors and syringe swaps, induction of anaesthesia accounts for half the cases of AAWR and, during the maintenance phase of anaesthesia, 40% of AAWR cases occurred at skin incision.6 Thus, for a more appropriate use of the rIFT, the normal IFT should be used from the start of anaesthesia and, after deflation of the tourniquet, if the hand becomes very weak or paralysed as a result of rocuronium, then is the time for the rIFT.

For various, mostly unjustified, reasons7 the IFT is rarely used, with one UK activity survey indicating that it was used in only five (0.03%) patients,8 yet it has the potential to address many of the issues raised in the NAPS report,9 ranging from simple clinical utility to more complex research protocols.

Examples of these are:

1. As outlined above, a high proportion of AAWR occur during induction and the early maintenance phase of anaesthesia. A specific problem was patients regaining consciousness, unknown to the anaesthetist, during difficult airway management. Addressing these issues offers a simple introduction to the IFT – use the IFT during this early phase of anaesthesia, but when the time comes to deflate the cuff, continue the procedure using one’s normal anaesthetic and clinical monitoring. Even without continuing the formal IFT technique, direct assessment of the patient’s responsiveness to command can be made for as long as the arm remains unparalysed.

2. At the end of the procedure, the anaesthetist often faces a dilemma. The surgeon may request additional muscle relaxation to close the abdomen but, at the same time, the anaesthetist wishes the patient to regain consciousness quickly. These conflicting requirements are probably the reason why almost 25% of AAWR cases occur at this time, with 85% of them causing distress to the patient.7 The IFT is the most reliable method of monitoring conscious levels accurately at this stage of surgery, allowing anaesthetic concentrations to be reduced to a minimum in the presence of full muscle relaxation: average wake up times are 3–4 min after antagonism of the neuromuscular blocking agent.10 11

References


3. There is a recommendation that a DOA monitor should be considered when using TIVA/TCI anaesthesia with neuromuscular blocking agents. Even were electronic DOA monitors reliable indicators of awake patients,\(^7\) because of cost it is unlikely that UK hospitals would have sufficient monitors to provide for this number of patients. The IFT can be readily used to monitor TIVA/TCI patients with minimal cost.

4. It was noted in the NAP5 study\(^7\) that for some 25% of AAWR patients occurring during the maintenance phase of anaesthesia there was no obvious contributory factor, raising the possibility of ‘anaesthetic resistance’ and under-dosing. In a similar vein, appropriate drug dosing schedules for the obese are unknown, with debate as to which weight should be used for calculating drug doses. For both these situations the IFT helps to eliminate guesswork, as doses can be titrated to clinical signs and lack of response.\(^2\)\(^3\)\(^21\)

5. As regards DOA monitors, recent studies cast serious doubt as to the clinical utility of processed EEG (pEEG) monitors, especially in the presence of neuromuscular blocking agents.\(^7\)\(^10\)\(^11\)\(^14\)\(^15\)

6. In neuroscience, behavioural report remains the gold standard for verifying conscious experience,\(^16\) de facto, the IFT is the ‘gold standard’ for identifying intraoperative consciousness.

7. At the level of the individual patient there is now little, if any, place for future studies into the efficacy of DOA monitors being based simply on postoperative recall, as the amnestic effects of anaesthetic drugs render recall of intra-operative consciousness unlikely. The IFT provides considerable scope for research into clinically relevant intraoperative consciousness and the ability of DOA monitors to detect this. Conscious experience is most commonly recognized during wakefulness when an external sensory stimulus triggers some kind of response, so called ‘connected consciousness,’ as it is connected to the external world. The alternative is ‘disconnected consciousness’ where the experience is generated internally (without external sensory input), such as in dreaming.\(^17\) For anaesthesia this is not just semantics. Connected consciousness is by far the more clinically relevant consciousness, and it is detected by the IFT. In contrast disconnected consciousness is not detected by the IFT, as the subject would not consciously hear the command and hence would not respond. The IFT’s ability to specifically identify real-time clinically relevant consciousness gives it a unique utility, providing direct insight into that most important mental state which anaesthesia aims to prevent – connected consciousness. In this regard the IFT possesses a distinct advantage over any DOA monitor, that would detect consciousness without differentiating between connected or disconnected consciousness. Any DOA monitor not identifying whether consciousness is connected or disconnected would lead to anaesthesia being unnecessarily deepened in the latter state.

8. Studies into intraoperative IFT responsiveness, the surrogate of connected consciousness, and how such responsiveness can be manipulated by alterations to the anaesthetic regimen\(^17\)\(^13\) should be a continued area of research. Many patients would regard any episode of intraoperative awareness as undesirable, irrespective of the lack of later recall,\(^18\) and anaesthetists should strive to meet these expectations by continuing to improve their monitoring capabilities.

9. An EEG biomarker that could predict rousability to a noxious stimulus, verified by the IFT, would be of immense benefit in predicting the likelihood of intraoperative awareness. To this end, when using the IFT, rather than using a single twitch or a train of four stimuli to test the neuromuscular integrity under and beyond the cuff, a tetanic stimulus could be used. A 50 Hz, 5-s-long supramaximal tetanus has been proposed as being equivalent to an invasive surgical stimulus.\(^15\) In IFR’s experience of major gynaecological surgery undertaken with general and epidural anaesthesia, when titrating anaesthetic delivery to cardiovascular parameters a tetanic stimulus to the elbow (i.e. above the level of the neuraxial block) will occasionally ‘wake up’ a patient to a responsive state, even though there is no response to the surgery. Another noxious stimulus, the patient’s response to intubation,\(^14\)\(^20\) could be an alternative on which to base a dosing regimen.

In conclusion, when using neuromuscular blocking agents as part of an anaesthetic technique, the IFT is the only method currently available that can monitor consciousness directly. In addition, of all the DOA monitors, it is by far the cheapest. Although, at times, there can be some difficulty differentiating between strong reflex movements and response to command, this is a problem only for research studies. In the future, we hope there may be methods to differentiate between these two responses by altering the anaesthetic regimen to reinforce disconnection, through targeted disruption of sensory signalling,\(^17\) but for current day to day anaesthetic practice, the management/treatment of such
undefined movements is the same as if no neuromuscular blocking agents were involved – deepen anaesthesia.

**Declaration of interest**

R.D.S. is a Board member of the BJA.

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**Anaesthesia for awake craniotomy**

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Groucho Marx, who famously claimed that ‘military intelligence’ was a contradiction in terms, would quite likely express similar sentiments about the title of this editorial, were he still alive. What we really mean with this phrase, is ‘anaesthetic management’ of a patient who is required to be conscious and co-operative during some period of time during a brain tumour resection procedure. A wide range of anaesthetic management strategies are used, but most techniques involve sedation or general anaesthesia before and after mapping, and are probably better referred to as ‘craniotomy with intraoperative awakening.’

Awake craniotomy is growing in popularity among neurosurgeons, to the extent that it has been suggested that it should be used for all brain tumor excisions.1 Readers unfamiliar with this field will naturally be asking themselves why it is necessary for a patient to be conscious during the procedure, so we will first deal with this issue. For most axial or intrinsic brain tumours, surgical excision is not curative. Low grade gliomas, for example, have no distinct boundaries with the surrounding brain parenchyma. By the time the tumour is symptomatic, cells will have migrated widely, making a complete excision neither possible