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Original Contribution

Asleep-awake-asleep regimen for epilepsy surgery: a prospective study of target-controlled infusion versus manually controlled infusion technique☆,☆☆,★,★★

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Abstract

Background: Asleep-awake-asleep (AAA) protocol for epilepsy surgery is a unique opportunity to accurately map epilepsy foci involved in motor and eloquent areas, allowing the operator to optimize the resection. Two different application modes of intravenous anesthesia for AAA craniotomies are widely used: infusion by means of target-controlled infusion (TCI) and traditional manually-controlled infusion (MCI). We conducted this study to examine whether intravenous anesthesia using the TCI system with propofol and remifentanil would be a more effective method than MCI in AAA epilepsy surgery.

Methods: This prospective and single center study compared patients undergoing either TCI or MCI techniques for functional AAA epilepsy surgery. 35 cases used TCI including TCI-E (resection of epileptogenic foci in an eloquent area, n = 18) and TCI-M (resection of epileptogenic foci in a motor area, n = 17). Thirty-six cases used MCI including MCI-E (epileptogenic foci in an eloquent area, n = 16) and MCI-M (epileptogenic foci in a motor area, n = 20). Bispectral index value and hemodynamic profiles at different time points during the awake phase were recorded along with time for awakening and the occurrences of adverse events.

Results: The TCI technique significantly shortened intraoperative awakening times during the third phase, TCI-E vs MCI-E 12.82 min ± 6.93 vs 29.9 min ± 9.04 ($P = .000$) and TCI-M vs MCI-M 16.8 min ± 5.19 vs 30.91 min ± 15.32 ($P = .010$). During the awake phase, the highest bispectral index score values appeared in the

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★★ TCI vs MCI for epilepsy AAA
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TCI-E group at all-time points. Mean arterial pressure and heart rate were more stable in the TCI-E group compared with the MCI-E group during the awake phase. Tachycardia and hypertension were most common in the MCI-E group (52.9% and 29.4%, $P = .001$ and $P = .064$).

Conclusion: We found the superiority of TCI, which is faster intraoperative awakening and better hemodynamics along with secure airway management conditions. It is suggested that the TCI technique may be a feasible and effective technique and it might be a viable replacement of the MCI technique for AAA epilepsy surgery.

1. Introduction

Epilepsy is one of the most common brain disorders in the world [1]. As epileptogenic foci frequently involve or arise within close proximity to eloquent and motor brain areas, preservation of neurological function is a major concern for neurosurgeons. Motor-related cortex is one of the areas that, if removed, will result in loss of motor ability. The most common areas of eloquent cortex are in the left temporal and frontal lobes, if this area removed will result in loss of sensory processing or linguistic ability. The intraoperative asleep-awake-asleep (AAA) technique allows the operator to optimize the resection while preserving the patient's quality of life. However, in the AAA craniotomy, challenges present to the anesthesiologist in the form of providing suitable sedatives, analgesic depth, and stable hemodynamics along with providing secure airway management conditions. In addition, reducing the physiological and psychological distress of the patient, ensuring awakening patients timely for neurological testing remain concerns.

Target-controlled infusion (TCI) is an emerging intravenous technique that has already been widely used in various types of surgery and has shown promising results. It can achieve a desired drug plasma or effect-site concentration using pharmacokinetic models incorporated into computerized pumps [2]. These continuously calculate the concentration of the drug in different compartments using individual covariates as the weight, gender, or age, and taking into account the distribution and elimination of the drug. In this way, these target-controlled infusion systems allow rapid establishment of a stable blood concentration of the drug, which the anesthesiologist can easily assess via the effect on different clinical measures. In a series of studies, TCI was associated with a faster recovery time, better hemodynamic stability, less drug consumption, and reduced relative risk of desaturation and PONV (postoperative nausea and vomiting) [3–5].

In this study, based on the promising potential of TCI stated above, we tested the hypothesis that TCI offers advantages over routine MCI. We highlight issues faced during the awake phase just like the time for awakening, bispectral index score (BIS) value, hemodynamic parameters, and occurrence of adverse events ultimately evaluated the feasibility and effectivity of TCI.

2. Methods

2.1. Patients' profile and study setting

The Xuanwu Hospital Ethics Committee approved this study. Patients were explained the process of AAA epilepsy surgery and written informed consent. Between July 2011 and September 2013, this study enrolled 71 consecutive patients of American Society of Anesthesiology (ASA) class I to II, ranging in age from 18 to 60 years. Exclusion criteria were ASA >II, IQ <80(Wechsler Adult Intelligence Scale, WAIS-RC), non-cooperators, emergency surgery, morbid obesity (BMI >35 kg/m^2), and gastroesophageal reflux. Different medicine doses and different procedures of airway, motor (TCI-M, MCI-M), and eloquent (TCI-E and MCI-E) groups were delineated from each other. Thirty-four cases presented with epileptogenic foci in eloquent brain areas, including 18 cases using the TCI technique and 16 cases using the MCI technique. For specific airway management, we used laryngeal mask airway (ATLAN; Royal Fornia Medical Equipment Co Ltd, ShenZhen, China). During the awakening phase for the procedures involving eloquent areas, the laryngeal mask airways (LMA) were removed at the beginning of the phase and then the LMA was reinserted before the closure of the dura and remained in place until the end of surgery. Thirty-seven cases presented with epileptogenic foci in motor brain areas, including 17 cases using the TCI technique and 20 cases using the MCI technique, in which there was no need to remove LMA during the awake phase due to the use of moving limbs to implement intra-operative cortical motor function mapping. Both the neurosurgeons and the anesthesiologists were experienced in AAA craniotomy and familiar with both techniques. Before giving the patients preoperative drugs, we measured each patient's heart rate and blood pressure to establish a baseline.

2.2. Anesthesia and surgical protocol

Two peripheral intravenous catheters were placed in all patients before induction. Propofol and remifentanil infusion were used in all patients. Anesthesia and surgical protocol included 4 phases (Fig. 1).