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Lidocaine as an Induction Agent for Intracranial Aneurysm Surgery: A Case Series

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Abstract

Introduction: Induction of anaesthesia and its associated spikes in blood pressure can cause rupture of an aneurysm during intracranial surgery. Lidocaine can reportedly provide hemodynamic stability when applied before endotracheal intubation. Rapid injection of large doses of lidocaine can cause unconsciousness.

Case Presentation: Lidocaine was applied as the sole anaesthetic for induction and maintenance during aneurysm surgery in four patients undergoing intracranial aneurysm surgery. Blood pressure alteration after induction and during surgery, bleeding, brain laxity, intracranial pressure and extubation time were acceptable.

Conclusions: Although propofol remains a standard agent for such types of surgeries, lidocaine proved equally effective and coupled with its low cost, minimal side effects and omission of other hypnotic agents was a plausible induction agent and a maintenance drug in the selected cases.

Keywords: Anaesthesia, Clipping, Lidocaine, Intracranial Aneurysm

1. Introduction

Intracranial aneurysm is the most common cause of subarachnoid hemorrhage. Anaesthetic protocols are focused on smooth anaesthetic induction to prevent rupture of an aneurysm and the rise of intracranial pressure (ICP) (1).

Lidocaine has a central sedative-analgesic effect. Central nervous system (CNS) suppression follows at blood levels of 25 μg/mL after rapid injection of large doses of lidocaine and the first symptoms such as drowsiness can lead to unconsciousness and respiratory arrest (2).

The current novel study produced CNS depression with large doses of lidocaine as the sole anaesthetic agent to induce anaesthesia for intracranial aneurysm clipping.

2. Case Presentation

After ethics committee approval, an informed consent letter was obtained from each patient and the patients' information during and after the study remained confidential. This study was conducted on four patients scheduled for elective craniotomy under general anaesthesia for intracranial aneurysm clipping surgery in a referral hospital during a period of six months.

Patients with addiction to opioids, ischemic heart disease, heart failure, liver or kidney dysfunction and history of previous allergic reaction to local analgesic agents or the ones who fell in the American Society of Anesthesiologists (ASA) class III or above were excluded from the study.

Patients were premedicated with 0.2 mg/kg intravenous (IV) diazepam and 2 μg/kg IV fentanyl. After premedication, an arterial catheter was inserted to continuously monitor the blood pressure and also obtain blood samples for arterial blood gas (ABG) analysis during the surgery. Standard monitors were applied along with a bispectral index (BIS; Aspect Medical Systems, Natick MA) to clinically document a hypnotic state. After pre-oxygenation of the patient for five to ten minutes, the initial bolus dose of intravenous lidocaine (5 mg/kg) was administered to induce anaesthesia, and then atracurium 0.5 mg/kg was administered to facilitate endotracheal intubation. Lidocaine adverse effects were prevented on the valid assumption that the initially administered diazepam could mitigate any untoward effects. Tracheal intubation was performed when the patients visually had a complete loss of all four reactions to train-of-four (TOF) stimulation carried out every 15 seconds. Intubation conditions were assessed based on the easiness of laryngoscopy, vocal cord opening and immobility of vocal cords, reactions to insertion of the endotracheal tube and inflation of its cuff according to

generally accepted criteria. After endotracheal intubation, via the subclavian approach, the subclavian vein was cannulated to monitor central venous pressures (CVP) during the surgery. The ventilator was adjusted to obtain an end-tidal carbon dioxide (Et-CO2) of 30 - 35 mmHg. Patients' blood pressures were registered before and after induction and during surgery. Regarding the fast metabolism of lidocaine in liver after the initial dose, additional doses of lidocaine were injected at the rate of 6 mg/kg/h. A nitrous oxide-oxygen, 1-1 inhalation mixture was then started and incremental doses of fentanyl were used accordingly. A dose of 0.1 mg/kg pancuronium was injected to achieve dense muscle paralysis and was repeated every 40 minutes. During the surgery 20 mg furosemide, 300 mL of mannitol in a 20% solution and 16 mg of dexamethasone were administered to reduce the intracranial pressure and ensure laxity of the brain. Infusion of lidocaine was given to maintain the bispectral index less than 50 throughout the procedure. The neuromuscular junction block was monitored by observing the reactions of the thumb adductor to stimulation of the ulnar nerve at the wrist by the 60 mA, 2 Hz current (each stimulus lasting 0.2 ms) induced with the peripheral nerve stimulator (TOF-Watch, Organon Laboratories Limited, Ireland) .The BIS was maintained within the required range of 30 - 40.

Lidocaine infusion was discontinued at the end of the surgery and neostigmine and atropine were administered to counteract any residual effects of pancuronium. Complete neuromuscular recovery was a TOF of 0.9. After ensuring an appropriate tidal volume and respiratory rate if the patient was stable and the surgeon agreed, extubation was performed. After surgery, patients were carefully monitored for any changes in blood pressure.

3. Discussion

During the surgery, the blood pressure and other hemodynamic signs remained stable in the four patients and the bispectral index reflected a deep hypnotic state with the lidocaine regimen that the patients received as the maintenance therapy (Table 1). None of the patients had recall or awareness after surgery. Surgeon's satisfaction regarding bleeding, brain relaxation and ICP was acceptable.

The principal goal of anaesthesia in such patients is to prevent any rise in ICP during laryngoscopy and tracheal intubation while preserving an adequate cerebral perfusion pressure (CPP). Intravenous lidocaine can prevent systemic hypertension and rise in ICP during laryngoscopy or intubation by suppressing the airway reflexes and providing an adequate depth of anaesthesia (3-6). It suppresses the cough by affecting the cough center in the medulla oblongata and directly blocks the mechanoreceptors of the airways (7, 8).

Lidocaine blocks Na channels, inhibits ionic transportation and therefore inhibits action potential initiation and conduction in excitable tissues (9). It has both a direct depressant effect on the cardiovascular system and an indirect stimulant effect. The stimulant effect is mediated by the autonomic nervous system. As blood level increases, CNS autonomic effect on cardiovascular system reduces and depressant effects dominate. Excessive blood levels may lead to cardiotoxicity which is manifested by hemodynamic depressions such as bradycardia, hypotension and even cardiovascular collapse and cardiac arrest due to a decrease in myocardial contractility and vasodilatation (9, 10).

The cardiovascular and CNS toxicity occur when blood lidocaine level exceeds 5 μg/mL. CNS toxicity has both excitatory and inhibitory components. The cortical effect of toxicity extends from diffuse electroencephalogram (EEG) slowing to convulsions (11). Owing to the location of the surgery, it was altogether not feasible to apply an EEG monitoring in this case series. Certainly, such a monitoring may help in the early detection of EEG signals signifying convulsions if the surgical location was not an intracranial surgery. There was no trace in the literature to clarify whether such signals appear, if at all, in the patient with a BIS value of 40 - 50 and in an unconscious state warrants any treatment or not. Nonetheless, authors do emphasize that an EEG monitoring should be employed, when feasible, in all patients receiving large doses of lidocaine. Convulsions are reported after intravenous bolus doses of lidocaine (2). They can be treated with barbiturates or other depressants. But CNS depressants have cardiovascular effects that could be additive with lidocaine effect and thus cause cardiovascular depression (12).

Table 1. Clinical and Demographic Characteristics of the Patients

	Case 1	Case 2	Case 3	Case 4	Values [a]
Age, y	58	70	55	50	58.25 ± 8.5
Weight, Kg	60	58	59	61	59.5 ± 1.3
SBP alteration with intubation, mmHg	10	18	14	19	15.25 ± 4.1
DBP alteration with intubation, mmHg	6	10	8	9	8.25 ± 1.7
Surgery duration, h	7.5	6.5	5.5	6.5	6.5 ± 0.8
Apnea Occurrence Time, min	3	2	4	2	2.7 ± 0.9
Extubation time after surgery, min	20	15	25	20	20 ± 4

Abbreviations: DBP, diastolic blood pressure; SBP, systolic blood pressure.
[a]Data are presented as mean ± SD.

The excitatory manifestations of lidocaine toxicity could be very brief and the first signs of drowsiness can lead directly to unconsciousness and respiratory arrest (2). Excitatory symptoms are caused by primary blockade of inhibitory pathways in the cerebral cortex by local anaesthetic (LA) drugs. As the levels of L.A increase, the activity of facilitatory and inhibitory circuits decreases and causes generalized CNS depression.

The current study used this agent to induce anaesthesia in the subjects. Generally, the reported dosing for general anaesthesia varies from no IV bolus to 1 - 1.5 mg/kg IV bolus followed by 0.9 to 3.6 mg/kg/h as infusion rates. These doses result in plasma levels of 1.3 - 3.7 μg/mL and do not cause toxicity (13). Combining lidocaine with thiobarbiturate and other anaesthetic agents are usually used to produce a suitable level of anaesthesia (14).

In contrast with other studies, the current study used lidocaine 5 mg/kg IV bolus as the sole agent for induction followed by 6 mg/kg/h as a maintenance dose which could raise the plasma levels up to 10 μg/mL. By using large doses as a bolus injection, patients speedily and smoothly lost consciousness and showed no signs of convulsion. In this method, no other anaesthetic agents were used.

The obtained results showed that in some patients, transient and mild swings of blood pressure occurred after intubation (from 115/75 to 120/83 mmHg). Other studies corroborate with the current study findings that lidocaine could not completely blunt hemodynamic responses following intubation. Both the heart rate and blood pressure were within the acceptable normal range and CPP maintained within the range of 60 - 70 mmHg except during aneurysm clipping when the MAP was transiently kept decreased and maintained at the level of 50 mmHg. Extrapolation of the obtained results and the fact that the BIS values remained within the range reflecting a truly hypnotic state, it can be deduced that lidocaine worked well to provide an unconscious state. Staikou et al. (5) used 1.5 - 2 mg/kg IV lidocaine prior to performing rapid sequence induction (RSI). They found that lidocaine was ineffective in blunting RSI hemodynamic responses. In contrast, the current study findings revealed no rises in blood pressure, possibly because large initial doses of the principal drug were used; the lidocaine which helped to blunt any rises in blood pressure. The BIS values after diazepam were less than 80; thus, producing a state of sedation where in the verbal contact was maintained rendering loss of unconsciousness unlikely. This level of sedation helped to curtail the total dose of lidocaine for induction. Lidocaine 1.5 mg/kg administered intravenously during RSI does not affect the BIS values. The employed larger doses resulted in BIS values from 40 and to 50. The actual dose of lidocaine and the need for incremental dose was determined by the BIS values. The BIS values were maintained in 40 - 60; although at times they did reach a value of 35. Systemic lidocaine levels decrease BIS and are able to suppress it to 0 (15).

Postoperative intracranial hemorrhage is a serious and devastating complication and frequently necessitates surgical exploration (16, 17). Different techniques such as meticulous surgical hemostasis and timely utilization of topical hemostasis have been of some help in preventing a postoperative hemorrhage (18).

Traditionally, induced hypotension is employed during aneurysm clipping. This method by itself may cause occult bleeders to spurt again, once the surgical hemostasis is finished, thereby resulting in postoperative hemorrhage or edema with its attendant detrimental sequelae. Methods of induced hemodynamic stress can successfully recognize potential arteriolar bleeders and help to perform re-hemostasis; thus, preventing postoperative hemorrhage (19).

The underlying hypothesis to use lidocaine as the sole anesthetic agent in aneurysm surgery was to prevent excessive alterations of blood pressure normally observed with the conventionally employed anesthetic agents or drugs inducing deliberate hypotension during the critical phases of aneurysm clipping.

In comparison with other studies, average extubation period in the patients under study was longer (20 minutes). Some researchers administered 1.5 mg/kg IV bolus lidocaine followed by 2 mg/kg/h in laparoscopic cholecystectomy. The extubation time in lidocaine group was 11 minutes and that of the control group was 8.3 minutes (20). The subjects received larger doses of lidocaine and the extubation time was much longer than those of the other studies, therefore, it can be assumed that extubation time may be prolonged as the dose increases. Other than the above problems, there were no complications both during surgeries and postoperatively.

At the first glance, the use of lidocaine as the sole agent for intracranial surgery would look hazardous and perhaps heroic, but owing to its pharmacokinetics and pharmacodynamics, the agent proved valuable. The current case series could obtain general anesthesia with lidocaine. Lidocaine could effectively affect both the cortical (amnesia and unconsciousness) and subcortical (antinociception, immobility and autonomic stability) components of anesthesia. Under no circumstances would the authors like to negate the sterling qualities of propofol in such types of surgeries both as an induction agent and a maintenance drug, nevertheless, the current study aimed to introduce lidocaine as a putative or an alternative agent that not only provided ideal intraoperative conditions but at the same time immensely curtailed the cost.

The study had some limitations. First of all, there was not a control group and thus it is not possible to determine its superiority over propofol which remains as the drug of choice for such types of surgeries. Secondly, the results obtained from this small series of cases cannot be extrapolated to all patients unless a randomized case control study is conducted. Lastly, the tangible fear of convulsions with high doses of lidocaine does remain a drawback to initiate such studies in future.

In summary, considering the role of lidocaine to reduce intracranial pressure, its low cost and minimal side effects, coupled with its advantages to omit other anaesthetic agents, it can be an acceptable agent to induce anaesthesia in patients with intracranial aneurysms and perhaps in other setups of the patients. The main limitation in the study was the small sample size. Therefore, the results cannot be interpreted properly. Prospective randomized clinical trials with large sample sizes in future are recommended to apply this method in clinical practices to establish its possible unequivocal role in intracranial aneurysms and perhaps other cases who are critically ill and would not withstand an induction with the routine agents presently available. However, authors are of the opinion that an EEG monitoring should be employed to redo this study.

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Footnotes

Authors' Contribution: Study concept and design: Zahid Hussain Khan and Cyrus Emir Alavi; acquisition of data: Zahid Hussain Khan and Cyrus Emir Alavi; analysis and interpretation of data: Shahram Samadi and Sanaz Ameli; drafting of the manuscript: Sanaz Ameli and Shahram Samadi; critical revision of the manuscript for important intellectual content: Zahid Hussain Khan and Shahram Samadi; statistical analysis: Shahram Samadi and Sanaz Ameli; administrative, technical, and material support: Zahid Hussain Khan, Cyrus Emir Alavi and Shahram Samadi; study supervision: Zahid Hussain Khan.

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