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## Sevoflurane in bolus: Induction, maintenance and emersion in ambulatory orthopedic surgery

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Abbreviations: VAS: Visual analog scale, SBP: Systolic blood pressure, PL: Pressure loss, LCR: Loss of verbal commands response, LPR: Loss of palpebral reflex.

### SUMMARY

**Objective:** To demonstrate sevoflurane's usefulness as a general anesthetic for orthopedic ambulatory surgery. **Material and methods:** We include 50 patients from 18 to 65 years old, they underwent to removal of osteosynthesis material, capture and application of skin allograft, shoulder mobilization, wrist tunnel liberation, closed reduction of the shoulder and pulley release. Heart rate, blood pressure and hemoglobin oxygen saturation were measured at 5, 10, 15, 20, 30 minutes. Statistical analysis with analysis of variance and t Student. **Results:** The induction were measured with loss of command response: 62 seconds, loss of eye lash reflex: 79 seconds, and press loss in 100 seconds. The maintenance showed haemodynamic stability. This was mostly reflected in the heart rate. The Emersion was observed in 7.71 minutes. **Conclusions:** Due to its characteristics, sevoflurane is the most suitable inhaled anesthetic for handling patients on orthopedic ambulatory surgery. Obtained cardiovascular stability evidence is benefic and it covers security requirements for the ambulatory patient.

**Key words:** Sevoflurane, induction, maintenance, emersion, orthopedic ambulatory surgery.

### RESUMEN

**Objetivo:** Demostrar que el sevoflurano es un anestésico general útil para manejo en cirugías ortopédicas ambulatorias. **Material y métodos:** Se incluyeron 50 pacientes de 18 a 65 años de edad, sometidos a retiro de material de osteosíntesis, toma y aplicación de injerto cutáneo, movilización de hombro bajo anestesia, liberación de túnel del carpo, reducción cerrada y liberación de polea. En transanestésico la frecuencia cardíaca, tensión arterial, saturación de oxígeno se midieron a los 5, 10, 15, 20, 30 minutos. Análisis estadístico: análisis de varianza y t-Student. **Resultados:** La inducción se midió con pérdida de respuesta a órdenes: 51 segundos, pérdida de reflejo palpebral: 58 segundos, pérdida de presión 63 segundos. El mantenimiento mostró estabilidad hemodinámica que fue más evidente en la FC. La emersión tuvo una duración de 7.71 minutos. **Conclusión:** Sevoflurano es el anestésico inhalatorio que por sus características, resulta idóneo para el manejo de pacientes para cirugía ambulatoria ortopédica. La evidencia de la estabilidad cardiovascular que proporciona es benéfica y cubre los requerimientos de seguridad para el paciente que va a ser egresado rápidamente de una unidad hospitalaria.

**Palabras clave:** Sevoflurano, inducción, mantenimiento, emersión, cirugía ortopédica ambulatoria.

## SCIENTIFIC BACKGROUND

The objectives of general ambulatory anesthesia are usually accepted because they give a rapid induction without any side effects; a light maintenance, with a good physiological control and amnesia without an excessive deepness that may lengthen the awakening and recovery. It also produces a quick awakening and a proper discharge with minimal post-analgesic effects, what allows the patient to come back to his/her family, social, and labor background very quickly<sup>(1)</sup>.

A general anesthetic should deliver a blockade in the motor and sympathetic response at the level of the spinal cord or the peripheral nerves. It should also eliminate hemodynamic responses to surgery without causing significant cardiovascular depression<sup>(2)</sup>.

Inhaled general anesthesia became obsolete since some time ago due to the side effects from volatile anesthetics.

The emergence of intravenous agents played a decisive role in this last fact.

Propofol has reached a great popularity all over the world as the preferred diffusion agent for surgery in ambulatory procedures because of two main reasons, such as the quick dissipation of its effect and its pharmacokinetics. However, its use is associated with burn at the moment of the injection, vasodilatation, and cardiac and respiratory depression. On the other hand, propofol presents high operative costs<sup>(1,3)</sup>.

Nowadays, we count on an inhalation agent that offers a light and rapid induction thanks to its lack of pungency, what provokes that the so-feared laryngospasm in induction become a very remote possibility; a safe maintenance because of its lack of myocardial sensitization caused by catecholamines during the short-anesthetic period. Furthermore, propofol provides a short recovery time because of its low blood/gas solubility<sup>(4,5)</sup>.

Sevoflurane was synthesized at the end of the decade of 1970 by Tallin *et al* at Travenol Laboratories. Sevoflurane is a volatile anesthetic that belongs to the family of halogenated esters.

Induction using inhaled anesthetics (sevoflurane) produces a soft and rapid anesthesia, eliminating the need for needle punctures, especially on pediatric or adult patients who present difficulties for peripheral venous access<sup>(6)</sup>.

Sevoflurane has little odor, it is not irritant for airways, presents a low blood/gas solubility coefficient (0.66), and it facilitates dose adjustments. These properties suggest that it may be specific for rapid induction and emersion<sup>(7)</sup>. Its control over the hemodynamic response to stress may be the consequence of its effects in the spinal cord over immobility and nociceptive transmission deadening.<sup>(2)</sup> Because of the aforementioned characteristics, sevoflurane is regarded as a very efficient anesthetic for ambulatory surgeries<sup>(6,8)</sup>.

There have been several studies on spinal cord *in vitro* preparations that have demonstrated that halogenated esters may depress specific components of the ventral root reflexes provoked by the stimulation of the dorsal root. It has been also demonstrated that sevoflurane depresses the monosynaptic reflex<sup>(9)</sup>. Inhalation bolus may be defined as the dynamic use of vaporizer and a flow of fresh air in order to control the hemodynamic responses to stress caused during surgery<sup>(6)</sup>.

In the whole, there is a delay between a change in vaporizer adjustment and the appearance or disappearance of the desired clinical effect. Using the inhaled bolus this hysteresis is reduced to a minimum by the optimal employment of the anesthesia apparatus, the adjustments in the vaporizer and the fresh airflow. The contraindications for the use of this technique include sensitivity to the agent, personal or family background of malignant hyperthermia, full stomach, no adaptability of facial mask to patient's face due to anatomy or lesions, and patient's voluntary refusal to wear the facial mask<sup>(2)</sup>.

Sloan *et al* demonstrated that sevoflurane might be used for induction with inhaled bolus in adult patients. When it is compared to conventional inhalation induction, sevoflurane produces rapid anesthesia establishment with less excitement<sup>(7)</sup>.

In a study performed by Beverly *et al* on 56 adult women with ASA I and II and subjected to ambulatory surgical procedures, they compared inhalation induction through the technique of sevoflurane inhaled bolus against propofol intravenous induction. These authors found that the evaluated induction times were significantly lower in the sevoflurane group<sup>(10)</sup>.

Ashworth *et al* studied 90 patients comparing intravenous anesthetics against inhalation agents and demonstrated that the emersion time was similar for both groups<sup>(11)</sup>.

## MATERIAL AND METHODS

### CHARACTERISTICS OF THE PLACE WHERE THE STUDY WAS PERFORMED

The present study was carried out in the operating room and the Service of Hospital Extension of «Victorio de la Fuente Narváez» Orthopedics Hospital, with the previous authorization of the Local Committee of Research, obtaining the written informed consent by part of the patients.

*Design:* Prospective, longitudinal, non-randomized, on patient programmed for ambulatory orthopedic surgery. The inclusion criteria were as follows: adult patients from 18 to 65 years old, from both sexes, with ASA I – III physical condition. Those patients who required intravenous anes-

thetics during the surgical procedure were excluded from the study.

The universe of the study was compound of the patients that were subjected to the following procedures: removal of osteosynthesis material, capture and application of cutaneous (skin) graft, shoulder mobilization under anesthesia, carpal tunnel release, close reduction, and pulley release.

The assigned anesthesiology physician programmed for the anesthetic procedure in the anesthesia room recorded the patient's initial data. The patients had been previously informed about the anesthetic technique to be used and they were taken their basal signs (HR %heart rate, NIATT %Non-Invasive Arterial Tension Technique, SpO<sub>2</sub>% %pulse oximetry)

**Technique:** Upon the peripheral vein permeabilization through #20 catheter with Ringer's lactate solution and hydric requirements according to Hollyday-Segar formula, 10 mg of IV (intravenous) metoclopramide were given 30 minutes before the beginning of the anesthetic procedure. It began with a continuous type-I monitoring, then it was practiced inhaled induction during two minutes with oxygen at 4 liters per minute plus sevoflurane at 8 volumes with inspiration retention after forced expiration. Once the loss of verbal command response, loss of palpebral reflex, and press loss were obtained, sevoflurane concentration was decreased to a 3% and oxygen flow to one liter per minute. In case of existing important changes (over the 25% of the basal value) in patient's hemodynamics, sevoflurane concentration was increased to the initial amounts during a maximum period of between 1 to 3 minutes.

The initial monitoring (AT, HR and oxygen saturation) went on during the surgical practice at 5, 10, 15, 20, and 30 minutes and at emersion. At the end of the surgery, the dial of sevoflurane was closed and the time up to the patient's awakening was taken. The patient was watched over during 60 minutes in the Unit of Post-anesthetic Care in order to discard the presence of nausea or vomits. The patient was showed the Visual Analog Scale and if it referred a value of VAS higher than 4, it was administered 60 mg of intravenous ketorolac at a single dose and as an analgesic. If there were no side effects, the patient was discharged from the service. The statistical analysis was carried out using analysis of variance and the Student's «t» test with the GraphPad. InStat version 3 program.

## RESULTS

Fifty patients subjected to ambulatory surgery were studied. They presented ASA I-III (I n: 20, II n 27, III n: 3) physical condition. The mean body weight in all the patients was of 71.8 kg (ranging from 42 to 131 kg), con a mean height of 1.59 m (ranging from 1.41 to 1.78) (Table I).

**Table I.** Demographic data.

	N	Minimum	Maximum	Mean	Standard deviation
Age	50	18	65	48.46	12.81
Weight	50	42	131	71.80	15.65
Height	50	1.41	1.78	1.59	8.85

**Table II.** Surgical procedures performed.

	N	(%)
Removal of osteosynthesis material	17	34
Making and enforcement of graft	4	8
Mobilization under anesthesia	11	22
Carpal tunnel release	12	24
Close reduction	1	2
Liberation pulley	5	10

From the entire universe of study, 29 patients were women and 21 of them were men, with an average age of 48.46 years old (ranging from 18 to 65 years old).

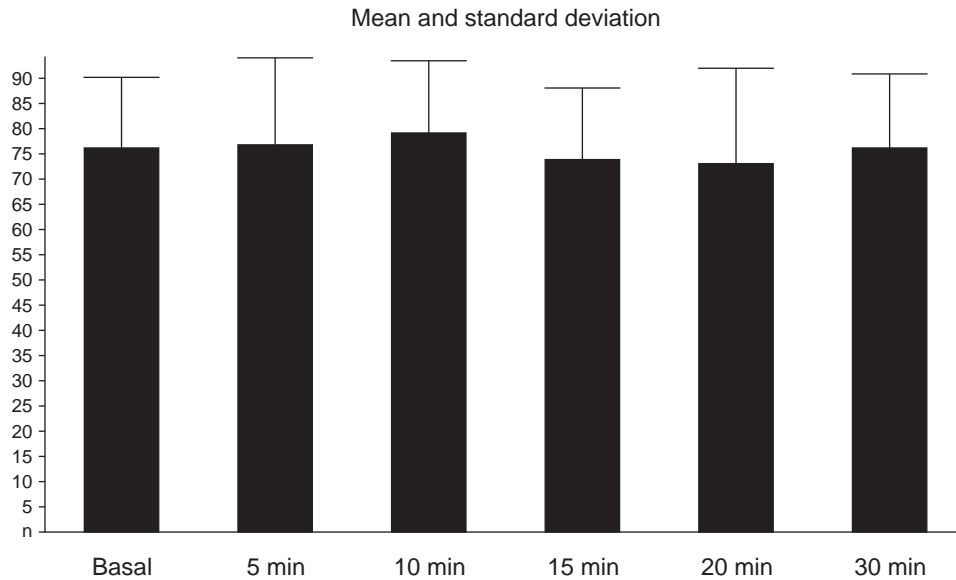
The performed surgical procedures were: removal of osteosynthesis material (n:17), capture and application of graft (n:4), shoulder mobilization under anesthesia (n:11), release of carpal tunnel (n:12), close reduction n:1), pulley release (n:5). The average procedure length was of 17.7min (ranging from 5 to 30 minutes) (Table II).

The added pathologies were: Type 2 diabetes mellitus (n:12), arterial hypertension (n:12), dyslipidemia (n:3) chronic renal insufficiency (CRI) (n:1), obesity (n:2), hyperuricemia (n:1), gastritis (n:1), migraine (n:1), and asthma (n:1).

The anesthesia induction through bolus was measured with the needed time in seconds in order obtain loss of verbal commands response (LCR), loss of palpebral reflex (LPR), and press loss (PL). It was found the following results ELR, 51 seconds; ELR, 58 seconds; PL 63, seconds. Value of  $p > 0.05$ , without any significant (Table III and Figure 1).

The maintenance control was measures through the following variables: heart rate (HR), basal systolic blood pressure (SBP) and diastolic blood pressure (DBP) at 5, 10, 15, 20, 30 minutes. With regard to HR, it was found that there was no significant difference, ( $p > 0.05$ ) (Table IV). Regarding SBP and DBP an extremely significant difference was found ( $p < 0.0001$ ) (Tables V, VI; Figures 2 y 3).

The emersion was measured through time in the necessary minutes since the fluorine dial was closed until the

**Figure 1.** HR anesthetic maintenance.**Table III.** Induction with sevoflurane.

	N	Mean	Standard deviation
LCR	50	51 seg.	10.38
LPR	50	58 seg.	10.17
PL	50	63 seg.	10.50

LCR Loss of verbal commands response, LPR Loss of palpebral reflex, PL Pressure loss.  
 $p > 0.05$

**Table IV.** Heart rate in anesthetic maintenance.

Group	N	Mean	Standard deviation
HR basal	50	76.5 beat/min	13.88
5 minutes	50	77.0 beat/min	17.29
10 minutes	48	79.3 beat/min	14.33
15 minutes	29	74.1 beat/min	14.35
20 minutes	23	73.3 beat/min	19.11
30 minutes	13	76.2 beat/min	14.76

$p > 0.05$ .

patient presented spontaneous. The measured time was of 7.71 minutes (Table VII).

Regarding the Visual Analog Scale (VAS), it was observed that 24 patients referred a value  $> 4$ , which required the administration of 60 mg IV UD ketorolac in

**Table V.** Systolic blood pressure in anesthetic maintenance.

Group	N	Mean	Standard deviation
SBP basal	50	141.3 mmHg	20.76
5 minutes	50	117.2 mmHg	23.30
10 minutes	48	132.6 mmHg	19.81
15 minutes	29	118.7 mmHg	22.41
20 minutes	23	117.8 mmHg	20.32
30 minutes	13	119.0 mmHg	17.03

$p < 0.0001$

**Table VI.** Diastolic blood pressure in anesthetic maintenance .

Group	N	Mean	Standard deviation
DBP Basal	50	83.1 mmHg	11.51
5 minutes	50	71.9 mmHg	15.32
10 minutes	48	80.4 mmHg	14.48
15 minutes	29	71.5 mmHg	14.56
20 minutes	23	70.5 mmHg	13.30
30 minutes	13	75.2 mmHg	12.60

$p < 0.0001$

the Unit of Post-anesthetic Care. The rest of the patients were handled through oral route analgesics at home (Figure 4).

No patients referred side effects, such as drowsiness, nausea, vomits in the Unit of Post-anesthetic Care.

Only two patients were discharged from the mentioned room with an Aldrete classification of 9; the rest of them presented an Aldrete classification of 10 when discharged.

## DISCUSSION

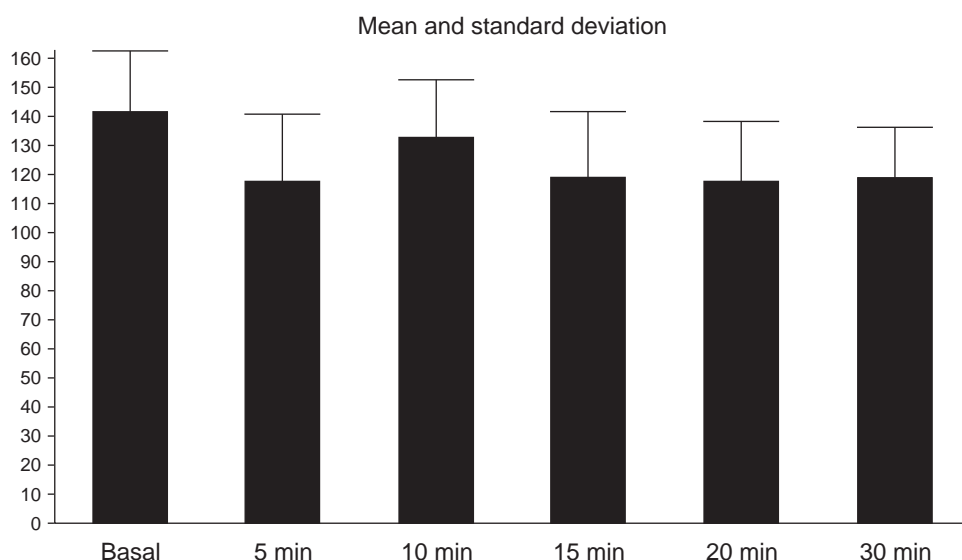
In the United States, ambulatory surgery has increased from a 26% to a 67% in 1981 and it has been growing up to date.

This fact remarks the importance of offering quality and efficiency in anesthesiology, which is fortunately promot-

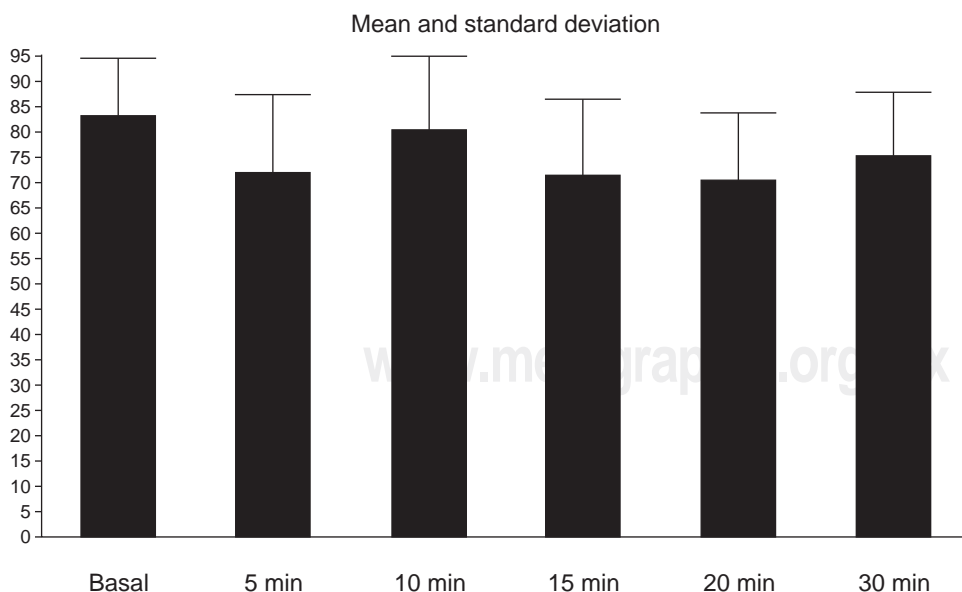
ed by the increasing better analgesics on what we may count at present. In fact, the development of every surgical specialty has been carried out along with anesthesiology improvements, with the result of the possibility of minimally invasion surgery, what closes the circle for the benefit of patients.

The concept of inhaled bolus has been introduced in an attempt for optimize the inhaled agent administration. The purpose is to increase the tidal volume concentration of the volatile agent the sooner the better, obtaining clinical effects in a short time<sup>(12)</sup>.

In a study performed by Fredman *et al* comparing propofol against sevoflurane for induction, maintenance and em-



**Figure 2.** Systolic blood pressure in anesthetic maintenance.



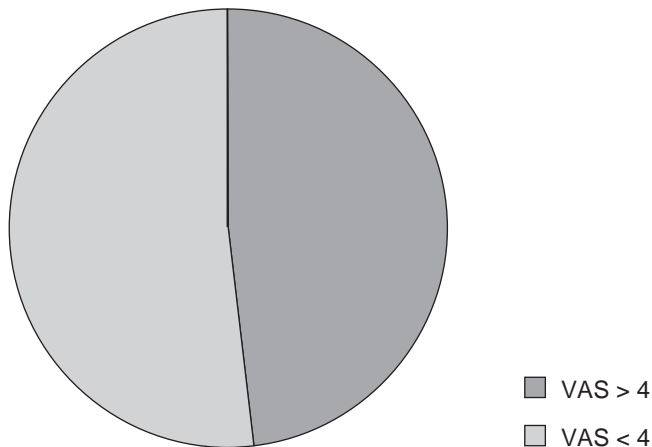
**Figure 3.** Diastolic blood pressure in anesthetic maintenance.



**Table VII.** Emergence from anesthesia.

	N	Mean	Standard deviation
Emergence	50	7.71 min	3.42

$p < 0.0001$

**Figure 4.** VAS on emergence.

ersion on 48 patients subjected to ambulatory surgery, they demonstrated that sevoflurane produced highly satisfactory surgical and anesthetic conditions with a few peri-operative complications.

Induction with sevoflurane was well tolerated in patients subjected to ambulatory surgery without any pre-medication.

In our study, induction did not show any significant difference, since the three studied variables (PP, PRO, PRP) presented  $p > 0.05$ .

Fredman demonstrated that sevoflurane anesthesia induction is slower than propofol intravenous induction, but it is equally tolerated by this group of non-pre-medicated patients. Sevoflurane may be a useful choice for general anesthesia induction and/or maintenance during ambulatory surgery<sup>(3)</sup>.

With regard to hemodynamic control and response to stress, we found a CF with no difference from the basal values at 5, 10, 15, 20 y 30 minutes; therefore, this finding demonstrates hemodynamic stability. In the figures from arterial tension, actually was a significant difference, which may have been caused because 12 out of all the patients included in the study suffered from controlled SAH (Systolic Arterial Hypertension). Nevertheless, their response to

stress was higher, since their figures of basal arterial hypertension were higher when compared to the patients that did not present this problem. Matute *et al* compared two groups of 60 patients each with sevoflurane-inhaled bolus against remifentanyl intravenous bolus for the control of hemodynamic responses to surgical stress during major surgery. They concluded that sevoflurane-inhaled bolus is not sufficient for anesthesia induction, but it appears to be more effective than remifentanyl bolus during anesthesia maintenance. Sevoflurane was associated with a better control of hemodynamic responses, what was achieved without affecting recovery quality<sup>(2)</sup>.

This mentioned study included patients subjected to six different surgical procedures, which presented a length ranging from 2 to 30 minutes; therefore, sevoflurane exposure time was very heterogeneous and the minimum patients' awakening time went from two to 19.5 minutes, depending on the surgical procedure and the surgeon's ability. The average emersion time was 7.71 minutes, with a significant difference among patients.

A study performed by Jellish *et al* compared the effects of sevoflurane *versus* propofol in anesthesia induction and maintenance. These authors demonstrated that there was no significant difference in induction and emersion. Both groups presented a similar incidence of nausea and vomits. Sevoflurane may be used in patients subjected to anesthetic procedures, when fast emersion and recovery of cognitive functions are desirable<sup>(5)</sup>.

## CONCLUSIONS

Sevoflurane is the inhaled anesthetic that, because of its characteristics, is apt for the handling of patients programmed for ambulatory orthopedic surgery.

The evidence on cardiovascular stability supplied by sevoflurane shows that it is benefic and covers safeness requirements for patients who need to be discharged very quickly from a hospital unit.

It is important to mention that sevoflurane cost-benefit rate is very advantageous, since it provides the necessary conditions when compared against current intravenous anesthetics. Finally, sevoflurane allows a lower expense in pesos, what at present implies a great advantage, since economic conditions are relevant at world level at the time being.

Pain in this type of procedures is well managed through high sevoflurane concentrations plus a steroid analgesic, without any need of causing the patient respiratory depression due to the use of narcotics.

With regard to side effects, as it can be seen in the statistical analysis, nausea and vomits are far from presenting a problem.

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