Concentrations and Costs of a Thirty Second Priming Technique with Sevoflurane Using the Circle Circuit

SOMBOON THIENTHONG, MD*,
CHAICHANA SINKUAKOOL, MD*,
PLAT JITRANIYOM, Dip in Sci*
WIMONRAT KRISANAPRAKORNKIT, MD*,
WORRANUT TAESIRI, BSc*,

Abstract

Background : Priming the circuit for an application of inhalation agent depends on the time taken, the fresh gas flow (FGF) rate, the concentration setting of the agent on the vaporizer, and the priming technique. Based on previous studies, the priming time for a desirable concentration of sevoflurane varied between 30 seconds and 5 minutes. Remarkably, although the cost of priming with sevoflurane was lowest at 30 seconds, concentrations in the circuit were not clearly stated. The aim of this study was to test the success (and cost) of a 30-second priming technique to achieve a 4.5 per cent sevoflurane concentration in the circle circuit.

Method : Analyses were done on 20 samplings. Each time the adjustable pressure-limiting (APL) valve on the assembly was closed, the 2-liter reservoir bag emptied and the patient end occluded. For 30 seconds, the circuit was filled with oxygen (8 $L \cdot min^{-1}$) and 8 per cent sevoflurane. The pressure in the circuit was kept constant at 10 mbar by partially releasing the excess gas at the patient end. After 30 seconds, the sevoflurane concentration at the patient end of the circuit was analyzed and the highest concentration recorded. The cost of the sevoflurane used was then calculated.

Results : The sevoflurane concentration in all of the samples was more than 4.5 per cent (mean 6.40%; SD 0.30%). The average amount of liquid sevoflurane used was 1.8 ml at a cost of 42.30 baht (0.9 US$).

Conclusion : A 30-second priming technique was sufficient to achieve the required concentration of sevoflurane in the circle circuit thus reducing costs for gaseous induction.

Key word : Sevoflurane, Anesthetic Circuit, Cost, Priming Technique

THIENTHONG S, KRISANAPRAKORNKIT W, SINKUAKOOL C, TAESIRI W, JITRANIYOM P
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* Department of Anesthesiology, Faculty of Medicine, Khon Kaen University, 40002, Thailand.

Gaseous induction of anesthesia in adult patients is an alternative to intravenous induction. Sevoflurane is a volatile anesthetic agent with low blood-gas solubility and lack of a pungent odor. Since its introduction there has been widespread interest in administering techniques. Examples of recently described induction techniques include single vital capacity inhalation induction[1,2], three sequential vital capacity breaths[3], and tidal breathing technique[4,5].

Gaseous induction is a two-stage procedure: priming - an application of a high concentration of sevoflurane into the circuit - followed by inhalation of the gas mixture by the patient. The concentration of sevoflurane in the circuit depends on the time used, the FGF rate, the concentration settings of sevoflurane on the vaporizer and the priming techniques used. Previous studies confirmed that a sevoflurane concentration of at least 4.5 per cent in the circuit was sufficient for gaseous induction[4,6] and increasing the concentration over 6 per cent did not markedly shorten induction[6]. The shortest priming time reported for sevoflurane was 30 seconds (range, between 30 to 45 seconds[3,7-9] and 3 to 5 minutes [1,10,11]). Remarkably, although the priming time was a major cost factor, its concentration in the circuit was not clearly stated. The authors' aim was to test the concentration (and cost) of sevoflurane in a circle circuit using a 30-second priming technique.

METHOD

Study design

Experimental, descriptive study.

Sample size

The authors postulated that a 4.5 per cent concentration of sevoflurane would be achieved after 30 seconds of priming. Based on pilot studies, the prediction of success according to the hypothesis approached 95 per cent. At the 0.05 level of significance and an acceptable error of 10 per cent, 20 samplings would be needed to confirm the hypothesis.

Priming technique

A standard circle anesthetic circuit with CO_2 absorber was assembled by closing the adjustable pressure-limiting (APL) valve, emptying the 2-liter reservoir bag connected with corrugated tube and occluding the patient end (an elbow connector) with the thumb. A flowmeter, vaporizer and gas monitor were calibrated. For 30 seconds, the circuit was then filled with oxygen (8 $L \cdot min^{-1}$) and 8 per cent sevoflurane (Drägerwerk AG vaporizer) resulting in a fully inflated reservoir. In order to keep the pressure in the circuit constantly at 10 mbar (approximately 10 cmH_2O) by using the AP monitor of the anesthesia machine (Sulla 808V: Dräger), the excess gas was partially released at the patient end of the circuit. After the 30 seconds, the circuit was re-blocked and the concentration of sevoflurane at the patient end was analyzed by an infrared gas analyzer (Agilent gas monitor: Omnicare; a real time monitor with gas sampling at 120 ml/min) and the highest concentration recorded. A concentration of more than 4.5 per cent was considered successful. Results were presented as the mean ± standard deviation and the percentage of success. The liquid sevoflurane priming and cost were calculated using Dion's formula: PFTMC/2412d where P = % gas concentration, F = fresh gas flow (L/min), T = time (min), M = molecular weight (200 g), C = cost/ml (24 baht/ml), and d = density (1.505 g/ml). The calculation was based on a FGF of 8 $L \cdot min^{-1}$ and 8 per cent sevoflurane for 30 seconds[3,12].

RESULTS

Twenty samplings were analyzed and 100 per cent had a sevoflurane concentration greater than 4.5 per cent (range, between 5.90 and 6.95%; mean 6.40%; SD 0.30%). The average amount of liquid sevoflurane used was 1.8 ml at a cost of 42.30 baht (0.9US$).

DISCUSSION

The mean (6.40%) sevoflurane concentration in the present study was high enough for gaseous induction. Muzi et al[3] primed the circuit for 30 seconds with FGF 6 $L \cdot min^{-1}$ and reported the inspired sevoflurane concentration, the first reading on the monitor after placing the face mask on the patient, was about 8 per cent. Since their study measured the concentration at 30-second intervals, the first reading on the monitor after the 30-second priming meant approximately one minute had elapsed since priming began. Consequently, the sevoflurane concentration in the circuit at the end of the 30-second priming should be less than 8 per cent. Philip[9] used a 45-second priming technique and claimed that the sevo-

flurane concentration in the inspired-limb was more than 6 per cent, a concentration similar to the present study though the priming time was 15 seconds longer. In fact, the authors' priming technique differed from the two previous studies, in that:

1. The circuit was sealed by closing the APL valve and occluding the patient end. This technique trapped a high concentration of sevoflurane gas in the circuit; resulting in the reservoir bag being fully inflated. In previous studies[3], the open APL valve allowed gas to escape. When short-priming, the APL valve should be closed to save gas; only opening it before placing the mask on the patient's face.

2. The excess gas was only partially released at the patient end, allowing the trapped gas with a high concentration of sevoflurane in the reservoir bag to move into the inspired limb of the circuit. In the fill-empty technique[9], gas was lost from the reservoir bag during the empty phase so that at least 15 seconds was needed to refill the bag. Since the patient end of the circuit was occluded during priming with the fill-empty technique, the concentration of sevoflurane in the inspired-limb increased slowly.

3. In a previous study using the circle circuit, a 2-liter reservoir bag was large enough for gaseous induction[13]. With a short priming time, both the bag size and the FGF rate may affect the concentration of sevoflurane in the circuit. The authors used a FGF rate of 8 $L \cdot min^{-1}$ and 8 per cent sevoflurane (compare Philip)[9]. Therefore, the priming time required to adequately fill the circle circuit with a total volume of about 4 liters (include anesthetic circuit, CO_2 absorber, 2-liter reservoir bag with corrugated tube) was 30 seconds.

The amount of liquid sevoflurane for priming used in the present study was 1.8 ml, at a cost of 42.30 baht (0.9 US$). The cost of sevoflurane would be lower if the FGF rate were reduced to 6 $L \cdot min^{-1}$. Baker[8] used an FGF rate of 6 $L \cdot min^{-1}$ for 45 seconds, which cost £1.05 of sevoflurane. Since the induction time reported in many studies[14,15] counted time from 'starting prime' to a loss of consciousness, the main cost of priming the circuit hardly differed.

In conclusion, a 30-second priming technique was demonstrably sufficient for achieving the required induction concentration of sevoflurane and it reduced the cost of gaseous induction. The clinical parameters used should be further explored.

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ความเข้มข้นและต้นทุนของยาสลบเซโวฟลูเรน ในการปูพื้นวงจรวางยาสลบชนิดรอบด้วยเวลา 30 วินาที

สมบูรณ์ เทียนทอง, พบ, วิมลรัตน์ กฤษณะประกรกิจ, พบ*,*
ชัยชนะ สินเกื้อกูล, พบ, วรนุช แต้ศิริ, วทบ*, พลัฏฐ์ จิตรนิยม, ปวส**

บทนำ : การ prime วงจรวางยาสลบให้ได้ระดับความเข้มข้นของยาดมสลบที่ต้องการขึ้นอยู่กับ เวลาที่ใช้ในการ prime, fresh gas flow rate (FGF), ความเข้มข้นของยาดมสลบที่เปิดจาก vaporizer และเทคนิคของการ prime จากการศึกษาที่ผ่านมาพบว่า การ prime วงจรด้วย sevoflurane เพื่อให้ได้ระดับยาตามที่ต้องการ ใช้วลาแตกต่างกันตั้งแต่ 30 วินาที จนถึง 5 นาที ถึงแม้ว่าการ prime ด้วยเวลา 30 วินาทีจะเสียค่าใช้จ่ายน้อยที่สุด แต่ยังไม่มีรายงานการวัดความเข้มข้นของ sevoflurane ในวงจรวางยาสลบที่ชัดเจน

วัตถุประสงค์ : เพื่อหาอัตราความสำเร็จในการ prime วงจรวางยาสลบด้วย FGF 8 ลิตรต่อนาที เปิด sevoflurane 8% เป็นเวลา 30 วินาที ให้ได้ความเข้มข้นของ sevoflurane อย่างน้อย 4.5% ว่าจะมีอัตราความสำเร็จเท่าใด และหาค่าใช้จ่ายของการ prime ในส่วนของยา sevoflurane ว่าเป็นเท่าใด

วิธีการศึกษา : ศึกษาจากการวิเคราะห์ตัวอย่างก๊าซจำนวน 20 ตัวอย่าง โดยใช้วิธีการ prime ดังต่อไปนี้ ปิด adjustable pressure-limiting valve ของเครื่องวางยาสลบ บีบไล่ก๊าซใน reservoir bag ขนาด 2 ลิตรออกให้หมด อุดปลายวงจรชนิด circle ด้านที่จะต่อเข้ากับผู้ป่วยให้สนิท แล้วเปิดออกซิเจน 8 ลิตรต่อนาที เปิด sevoflurane ความเข้มข้น 8% นาน 30 วินาที รักษาความดันในวงจรวางยาสลบที่ 10 mbar โดยเปิดให้ก๊าซส่วนเกินบางส่วนไหลออกทางปลายวงจรด้านที่จะต่อเข้ากับผู้ป่วย บันทึกค่าความเข้มข้นสูงสุดที่วัดได้ที่ 30 วินาที รวมทั้งคำนวณปริมาตรและราคาของ sevoflurane ที่ใช้ในการ prime ด้วย

ผลการศึกษา : ความเข้มข้นของ sevoflurane ของทุกตัวอย่าง วัดได้สูงกว่า 4.5% (mean 6.40%; SD 0.30%) คำนวนปริมาตรเฉลี่ยของ sevoflurane ที่ใช้ ได้ 1.8 มล คิดเป็นราคา 42.30 บาท

สรุป : การ prime วงจรวางยาสลบด้วยด้วยเทคนิคดังกล่าวข้างต้น เป็นเวลา 30 วินาที สามารถทำให้ความเข้มข้นในวงจรวางยาสลบเพียงพอที่จะใช้นำสลบได้ และช่วยลดค่าใช้จ่ายในการนำสลบได้ด้วย

คำสำคัญ : เซโวฟลูเรน, วงจรวางยาสลบ, ค่าใช้จ่าย, เทคนิคในการปูพื้นวงจรวางยาสลบ

สมบูรณ์ เทียนทอง, วิมลรัตน์ กฤษณะประกรกิจ,
ชัยชนะ สินเกื้อกูล, วรนุช แต้ศิริ, พลัฏฐ์ จิตรนิยม
จดหมายเหตุทางแพทย์ ฯ 2546; 86: 617-621

* ภาควิชาวิสัญญีวิทยา, คณะแพทยศาสตร์ มหาวิทยาลัยขอนแก่น, ขอนแก่น 40002