



AKILLI İLAÇ KULLANIMINDA DÜŞÜK AKIM ANESTEZİSİ



İstanbul Üniversitesi
İSTANBUL TIP FAKÜLTESİ



Zerrin Sungur

AKIŞ

- **Tanımlar**
- **Güvenlik**
- **Ekonomi**
- **Çevre kirliliği**
- **Tartışmalı konular**
- **Gelecek**



REVIEW ARTICLE/BRIEF REVIEW

Brief review: Theory and practice of minimal fresh gas flow anesthesia

Metha Brattwall, MD, PhD · Margareta Warrén-Stomberg, PhD ·
Fredrik Hesselvik, MD, PhD · Jan Jakobsson, MD, PhD

Metabolik akım	250ml/dak
Minimal akım	250-500ml/dak
Düşük akım	500-1000ml/dak
Orta akım	1-2l/dak
Yüksek akım	2-4l/dak
Çok yüksek akım	>4l/dak

Hasta güvenliđi

- **Hipoksi**
- **Teknik eksiklikler** *gazların monitorizasyonu, CO₂ absorbanı, gaz kaçađını azaltan tasarımlar*

AB standartlarına (EN 740) göre inspiryum/ekspiryumda O₂, CO₂, inhalasyon anestetikleri, N₂O görülmeli!

Mutlak kontrendikasyonlar

- 1. Sepsis**
- 2. Duman, gaz
inhalasyonu**

Rölatif kontrendikasyonlar

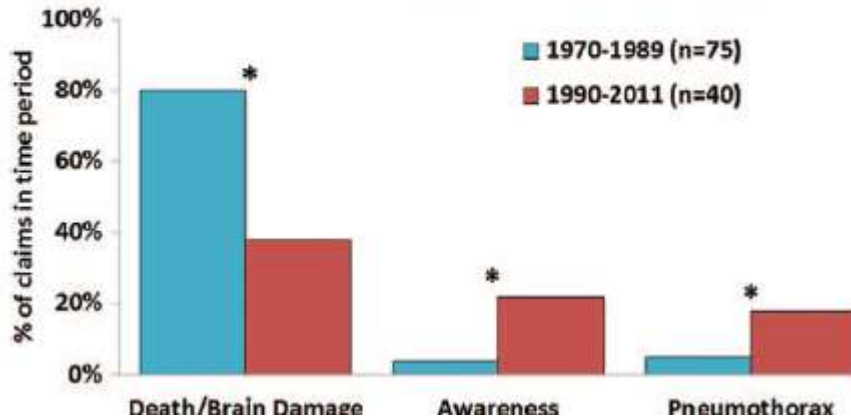
- 1. Acil, hemonamik
instabilite**
- 2. Kötü kontrollü DM**
- 3. Ciddi beslenme
bozuklukları**
- 4. Yoğun sigara
kullanım öyküsü**
- 5. Kronik alkolizm,
akut ↑↑**

Patient Injuries from Anesthesia Gas Delivery Equipment

A Closed Claims Update

Sonya P. Mehta, M.D., M.H.S.,* James B. Eisenkraft, M.D.,† Karen L. Posner, Ph.D.,‡
Karen B. Domino, M.D., M.P.H.§

Outcomes in Anesthesia Gas Delivery Claims



- ✓ Anestezi gaz teçhizatı ile ilgili sorun çok seyrek (üretici, rutin kalibrasyon!)
- ✓ Isı artışı Ø
- ✓ 1 CO entoksikasyonu

- **O₂ kullanımı**

teorik 2-3ml/kg/dak (GAA)

$$\bullet \text{O}_2 \text{ kullanımı} = (\text{fiO}_2 - \text{feO}_2) \times \text{MV} \times 10$$

fiO₂ inspiyum O₂ konsantrasyonu

feO₂ ekspiyum O₂ konsantrasyonu

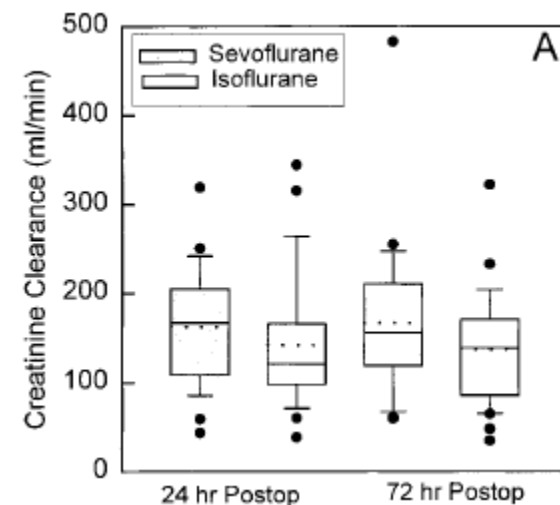
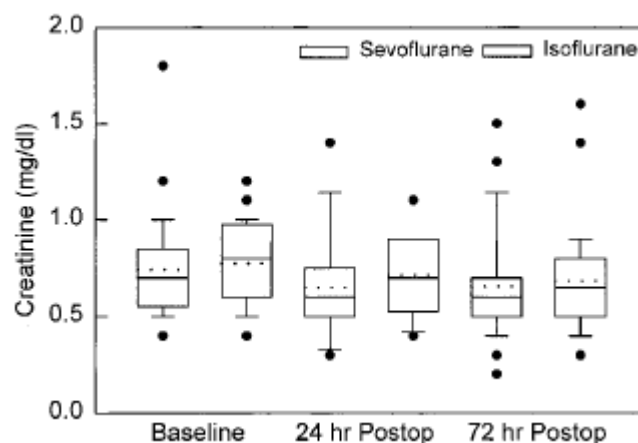
MV dakika ventilasyonu

Long-Duration Low-Flow Sevoflurane and Isoflurane Effects on Postoperative Renal and Hepatic Function

Evan D. Kharasch, MD, PhD*†, Edward J. Frink, Jr., MD‡, Alan Artru, MD*, Piotr Michalowski, MD, PhD*†, G. Alec Rooke, MD, PhD*†, and Wallace Nogami, MD‡
(Anesth Analg 2001;93:1511–20)

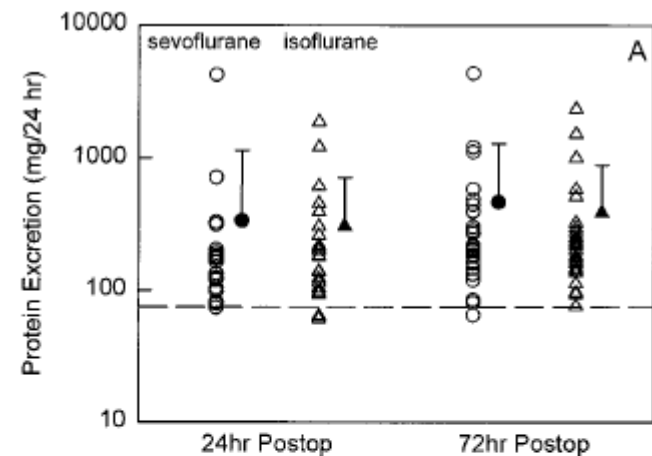
- ASA I-III
- ≥ 8 saat cerrahi
- 0.8-1l/dak
- sevo vs iso
- ✓ BUN, kreatinin, AST, ALT
- ✓ Kreatinin klirensi
- ✓ Bileşik A(Fi)

Variable	Sevoflurane (n = 28)	Isoflurane (n = 27)
Duration of anesthesia (h)	9.1 ± 3.0 (3.3–17.6)	8.2 ± 3.0 (4.0–13.0)
Duration of low-flow anesthesia (h)	8.9 ± 3.0 (3.1–17.5)	8.0 ± 3.0 (3.7–13.0)
Average anesthetic concentration (MAC)	1.0 ± 0.2 (0.7–1.5)	1.1 ± 0.2 (0.8–1.5)
Anesthetic exposure (MAC-h)	9.2 ± 3.6 (3.8–17.8)	9.1 ± 3.7 (4.2–18.5)
Compound A inspired mean (ppm)	16 ± 6 (4–34)	
Compound A inspired maximum (ppm)	25 ± 9 (6–49)	
Compound A inspired AUC (ppm · h)	165 ± 95 (35–428)	

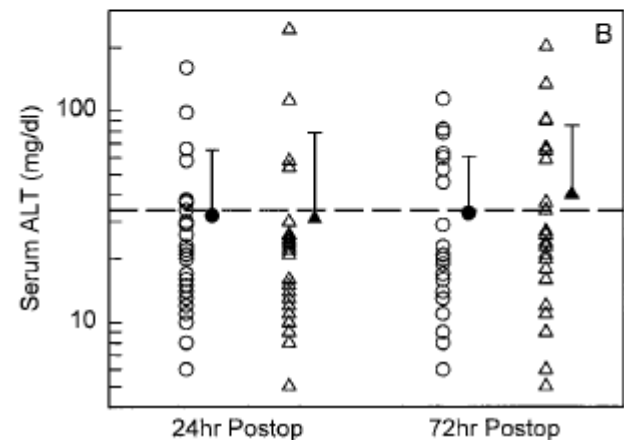
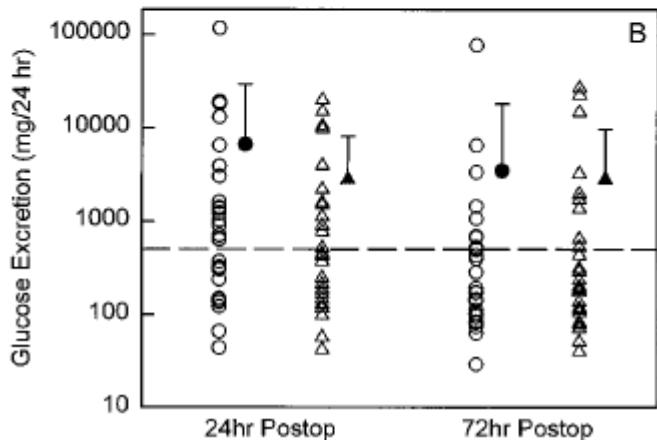
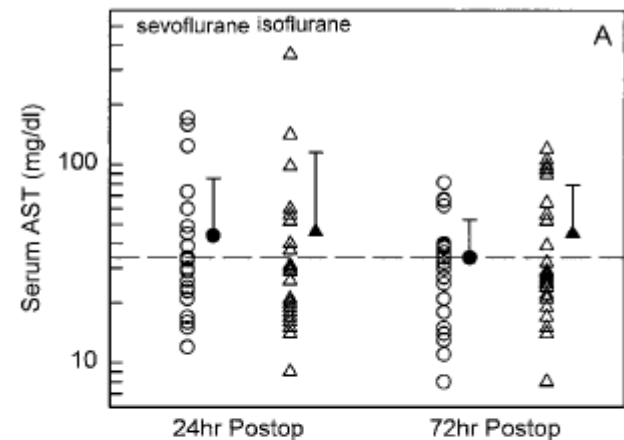


Long-Duration Low-Flow Sevoflurane and Isoflurane Effects on Postoperative Renal and Hepatic Function

Evan D. Kharasch, MD, PhD*†, Edward J. Frink, Jr., MD‡, Alan Artru, MD*, Piotr Michalowski, MD, PhD*†, G. Alec Rooke, MD, PhD*†, and Wallace Nogami, MD‡

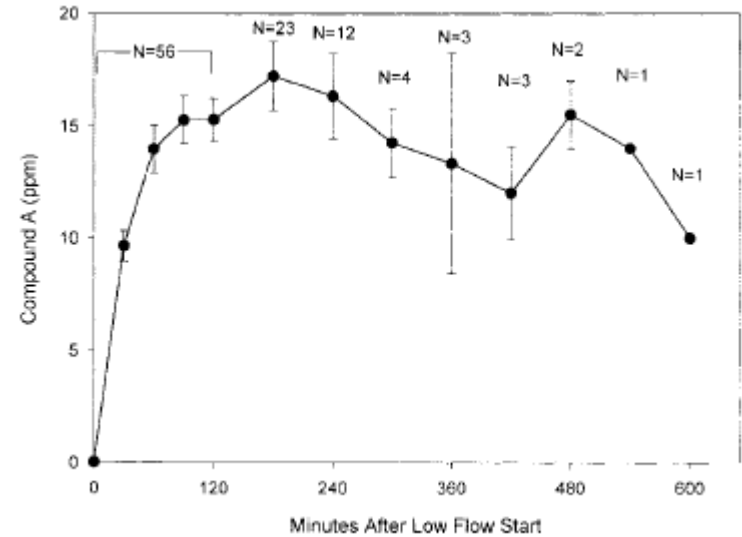
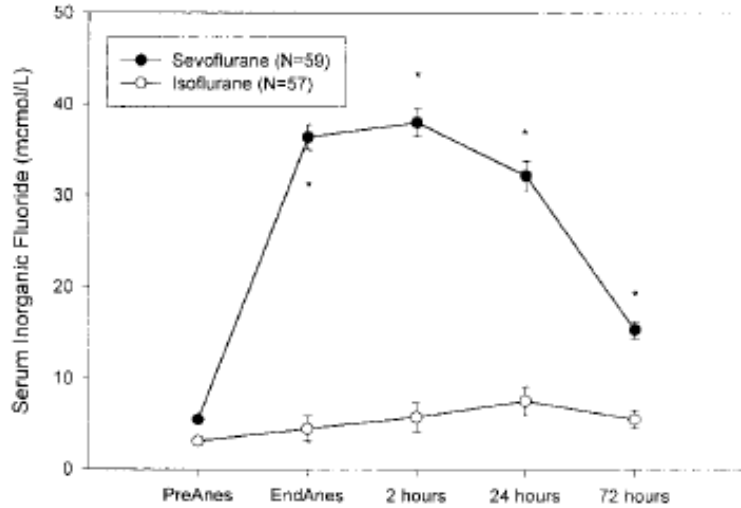


Hafif,
geçici
proteinüri



Low-flow Sevoflurane Compared with Low-flow Isoflurane Anesthesia in Patients with Stable Renal Insufficiency

Peter F. Conzen, M.D.,* Evan D. Kharasch, M.D., Ph.D.,† Stephan F. A. Czerner, M.D.,‡ Alan A. Artru, M.D.,† Florian M. Reichle, M.D.,‡ Piotr Michalowski, M.D., Ph.D.,§ G. Alec Rooke, M.D., Ph.D.,|| Branko M. Weiss, M.D.,# Thomas J. Ebert, M.D., Ph.D.**



1. Düşük akımda (≤ 11 /dak) sevo, isofluran kadar güvenli
2. Bileşik A miktarı ile böbrek işlev testlerinde korelasyon \emptyset
3. Böbrek işlevinde kötüleşme VA'ten bağımsız (%12 vs %14)

The influence of low flow anaesthesia on renal function in cancer patients previously treated with nephrotoxic chemotherapeutic agents

Maria Wujtewicz¹, Wioletta Sawicka¹, Wojciech Wenski², Andrzej Marciniak¹, Magdalena A. Wujtewicz¹, Piotr Stepnowski³, Paweł Twardowski¹, Anna Dylczyk-Sommer¹, Radosław Owczuk¹

- Nefrotoksik KT+DAA (0.8-1)
 - Nefrotoksik KT+YAA (6)
 - kontrol+DAA (0.8-1)
- BUN, kreatinin, elektrolitler
sistatin C

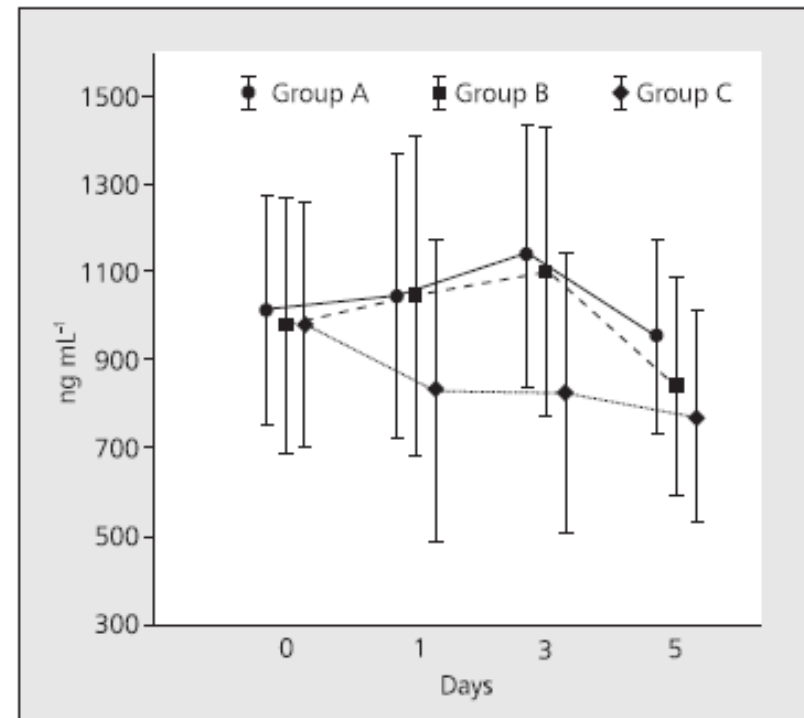


Figure 3. Changes in serum cystatin C levels (0 and 95% confidence interval of means) 11

Compound A and carbon monoxide production from sevoflurane and seven different types of carbon dioxide absorbent in a patient model

C. KEIJZER¹, R. S. G. M. PEREZ² and J. J. DE LANGE²

¹Department of Anesthesiology and Intensive Care, Netherlands Cancer Institute, Antoni van Leeuwenhoek Hospital and

²Department of Anesthesiology, VU University Medical Center, Amsterdam, the Netherlands

Areas under the curve (AUCs, p.p.m. min) of compound A (CA) and carbon monoxide (CO) based on the mean concentrations from the duplicate experiments of each desiccated and normally hydrated carbon dioxide absorbent used in combination with sevoflurane 0.8%.

CO ₂ absorbent	AUC-CA-d	AUC-CA-f	AUC-CO-d	AUC-CO-f
Drägerorb 800 plus [®]	351	1695	4516	0
Medisorb [®]	327	1228	1452	0
Spherasorb [®]	294	301	1866	0
Loflosorb [®]	0	0	0	0
Superia [®]	0	0	0	0
Amsorb [®]	2937	0	0	0
Lithium hydroxide	396	0	0	0

- Hepsinde bileşik A < 22 ppm
- CO düzeyi klinik anlamlı değil

Ekonomi

- **minimal akımdan yüksek akıma (>4l)
inhalasyon anestetik maliyeti X10 kadar ↑**
Weiskopf RB, Anesthesiology 1993
- **sevofluran kullanımını TGA düşüşü ile
lineer ↓**
Ekbon K, Acta Scand Anesthesiol 2007

The effect of low fresh gas flow rate on sevoflurane consumption

Ho-Geol Ryu¹, Ji-Hyun Lee², Kyung-Ku Lee², Nam-Su Gil¹, Chong Soo Kim¹, Sung-Eun Sim¹, Sang Chul Lee², and Seong-Won Min¹

Department of Anesthesiology and Pain Medicine, ¹Boramae Medical Center, ²Seoul National University Hospital, Seoul, Korea

Table 1. Cases and Duration of General Anesthesia Using Sevoflurane and Consumed Sevoflurane

	Number of general anesthesia cases using sevoflurane	Hours of anesthesia using sevoflurane	Number of consumed sevoflurane bottles (250 ml)
Week -4-0	419	1,082.4	108
Implementation of low fresh gas flow rate			
Week 1-5	474	1,253.7	72
Week 6-10	425	1,050.6	90
Week 11-15	415	994.5	76

ORIGINAL

Economic considerations in the use of inhaled anesthetic agents

J. Golembiewski

Clinical Associate Professor, Colleges of Pharmacy and Medicine, University of Illinois, Chicago

Original publicado en *Am J Health-Syst Pharm* 2010;67(15)Suppl4

Autor para correspondencia: jgolemb@uic.edu

- ml başına üretim ederi
- 1ml'den çıkan buhar
- potens
- atılan miktar

ESTIMATED COST PER MAC HOUR (\$) OF INHALED ANESTHETIC AGENTS*^{a b c}

Fresh Gas Flow Rate (L/min)	Isoflurane ^a	Desflurane ^b	Sevoflurane ^c
1	0.52	12.96	6.05
2	1.04	25.93	12.10
3	1.56	38.88	18.15

		Gaz akımı	Taze Gaz Akımı (L/dak)	Günlük tüketim	Birim Fiyatı TL/L	Günlük maliyet	Günlük maliyet	Aylık maliyet	Yıllık Maliyet (248 gün)	TASARRUF
Çok Yüksek Akım	O ₂ ,	3	6	1080	0,32	0.401	159,4	3.506	39.531	0%
	N ₂ O	3		1080	0,007	8				
	Vapor (%)	2,1		226,8	0,672	151				
Yüksek Akım	O ₂ ,	2	4	720	0,32	0,267	111,3	2.449	27.602	31%
	N ₂ O	2		720	0,007	5,04				
	Vapor (%)	2,2		158,4	0,672	106				
Düşük Akım	O ₂ ,	1	2	360	0,32	0,13	58,73	1.292	14.565	64%
	N ₂ O	1		360	0,007	3				
	Vapor (%)	2,3		82,8	0,672	55,6				
Minimal Akım	O ₂ ,	0,5	1	180	0,32	0,06	33,97	747	8.425	79%
	N ₂ O	0,5		180	0,007	1,26				
	Vapor (%)	2,7		48,6	0,672	32,6592				

Öztürk E, TARK 2014

		Gaz akımı	Taze Gaz Akımı (L)	Günlük tüketim	Birim Fiyatı TL/L	Günlük maliyet	Günlük maliyet	Aylık maliyet	Sodalayım maliyeti	Toplam
Yüksek Akım	O ₂ ,	2	4	720	0,32	0,267	111,3	2.449	14,43	2463,43
	N ₂ O	2		720	0,007	5,04				
	Vapor (%)	2,2		158,4	0,672	106				
Minimal Akım	O ₂ ,	0,5	1	180	0,32	0,06	33,97	747	28,87	775,87
	N ₂ O	0,5		180	0,007	1,26				
	Vapor (%)	2,7		48,6	0,672	32,6592				

Günde aktif olarak 6 saat
Ayda 22 gün

- CO₂ absorbanı maliyeti, akım 0.5l düşünce 3-7 kat ↑
Baum JA, Anesthesiol Reanim 1993
- bireysel (metabolik hız)
- teçhizat (kullanım sıklığı, süresi)

Çevresel faktörler

Çevresel faktörler

- 1. Mikro** *ameliyathane,*
çalışan sağlığı
<20ppm/8 saat halojene anestetikler
20-100ppm/8 saat N₂O
- 2. Makro** *sera gazı etkileri,*
küresel ısınma (?)

Sustainable Anesthesia

Susan Ryan, PhD, MD,* and Jodi Sherman, MD†

May 2012 • Volume 114 • Number 5

www.anesthesia-analgesia.org

- **WHO**
- **Sağlık endüstrisinde CO₂ ↑↑**
- **Ameliyathaneler!!**
- **Yeniden dönüşüm**
- **Anestetiklerin C ayak izi**

Life Cycle Greenhouse Gas Emissions of Anesthetic Drugs

Jodi Sherman, MD,* Cathy Le,† Vanessa Lamers,†† and Matthew Eckelman, PhD§

(Anesth Analg 2012;114:1086–90)

- **Desfluran** çevresel etki ↑↑
- MAC %si ↑
- Metabolizma Ø
- Saçılma enerjisi ↑
- **N₂O** salıverilme ↑

Low and minimal flow anesthesia: Angels dancing on the point of a needle

George Mychaskiw II

Department of Anesthesiology, Nemours Children's Hospital, University of Central Florida College of Medicine, Florida State University College of Medicine, Nemours Parloway, Orlando, Florida, USA

Journal of Anaesthesiology Clinical Pharmacology | Oct-Dec 2012 | Vol 28 | Issue 4

In the tradition of “everything old is new again”, the use of low (250–500 ml/min) and minimal (250 ml/min) flow is once again of interest to the anesthesia community. These techniques have been discussed and infrequently utilized, possibly for as long as there has been an organized science of anesthesiology. In previous generations, low and minimal flow anesthesia was primarily an academic demonstration tool of a very sophisticated few who sought to explore the pharmacokinetics and theories of volatile anesthesia and associated breathing systems. Given the nature of anesthesia equipment of the

- **TGA: 1-2l**
- **Minimal akım modern anestezi ekipmanı, yakın monitorizasyon**
- **Minimal akım akademik: farmakodinamik**

Tartışmalı konular
Pediatrik
Supraglottik gereçler
Kısa girişimler

N₂O-free low-flow anesthesia technique for children

P. BOZKURT¹, N. SAYGI EMİR², E. TOMATIR³ and Y. YEKER¹

¹Department of Anesthesiology and Reanimation, Istanbul University Cerrahpasa Medical Faculty, Istanbul, ²Bakirkoy Municipality Hospital, Istanbul, and ³Department of Anesthesiology and Reanimation, Pamukkale University, Denizli, Turkey

- ✓ 35 çocuk
 - ✓ 2-13 yaş
 - ✓ Kademeli
- DAA(4-2-1)
- Hipoksemi Ø, ajitasyon benzer

Changes in hemodynamic, respiratory parameters and temperature during the study (mean ± SD).

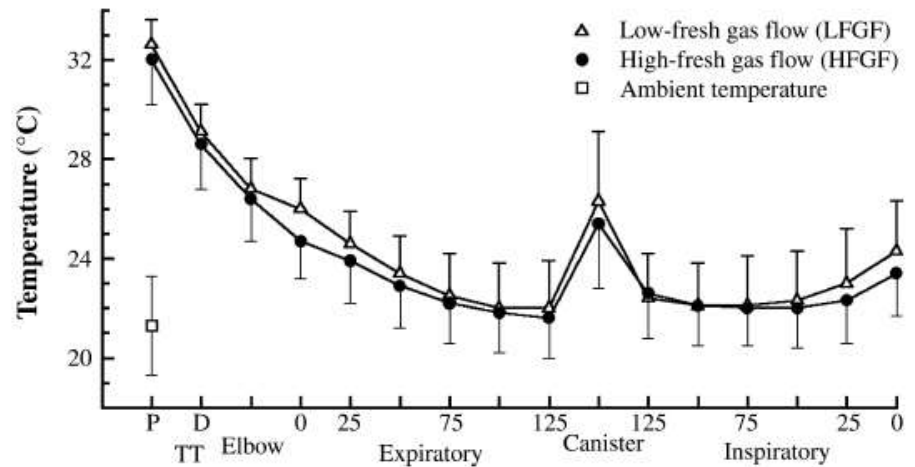
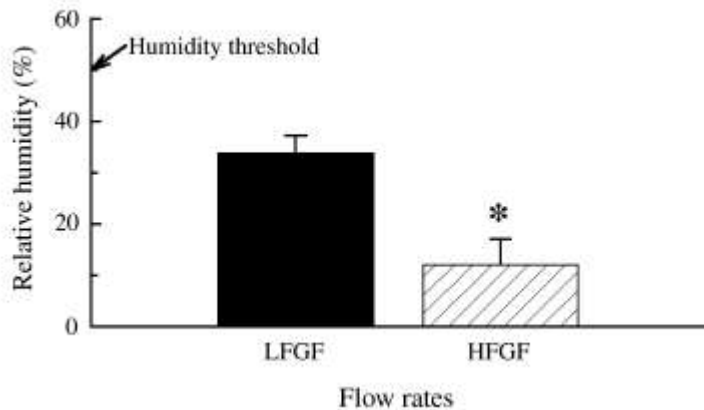
	4 l	2 l	1 l initial	1 l 5. min	1 l 10 min	1 l 30 min	1 l 1st h	1 l end
HR bpm	113.4±22.9	114.8±25.5	112.5±23.5	104.3±23.7	112±24.3	106.5±22.2	111.1±18.1	109.6±18.3
MAP mmHg	73.9±18.3	76.2±15.9	73.5±18.7	89.9±18.4	77.1±17.1	72.7±15.1	70±15.1	68.6±12.8
SpO ₂ %	99.8±0.7	99.6±1.1	99.6±1.1	99.7±1.1	99.5±1.6	99.7±0.8	99.4±1.7	99.7±0.8
iCO ₂ mmHg	0.8±0.9	0.8±0.8	1.4±1	1.6±1.4	1.6±1.4	1.9±1.9	2±2.2	1.6±2.2
ETCO ₂ , mmHg	34.3±5.3	34.5±4.1	33.5±4.7	34.2±3.7	34.2±4.9	34.9±4	35.3±4.2	35.3±4.3
Temp., °C (esophageal)	35.9±1	36.02±0.6	36.05±0.6	36.03±0.6	36.07±0.6	36.21±0.7	36.48±0.7	36.58±0.9

11 pediatrik anestezi de güvenli

The temperature and humidity of inspired gases in infants using a pediatric circle system: effects of high and low-flow anesthesia

TED HUNTER MD FRCPC*, JERROLD LERMAN BaSc MD FRCPC
FANZCA† AND BRUNO BISSONNETTE MD FRCPC‡

- ✓ 20 çocuk
- ✓ 2-12 ay
- ✓ Her çocukTA DAA (0.6L) ve YAA (6l) fazları



kısa süreli girişimler

- <40 dakika girişimlerde propofole göre sevo (idame ve indüksiyon+idame) daha ucuz

Smith I, BJA 1999

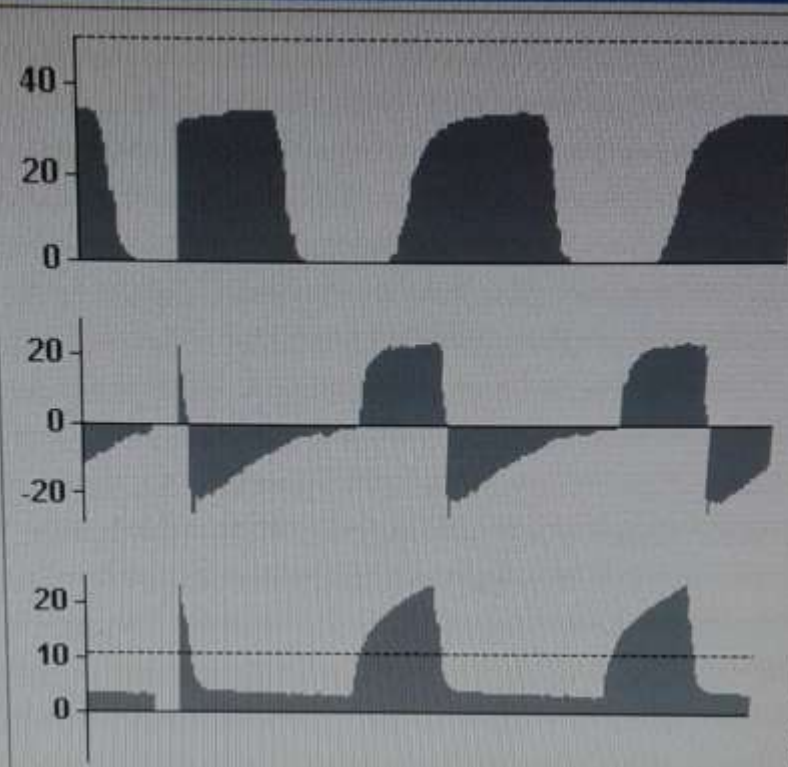
- <20 dakika girişimlerde sevo tüketimi akımla ilişkili

Ekbom K, Acta Scand Anesthesiol 2007

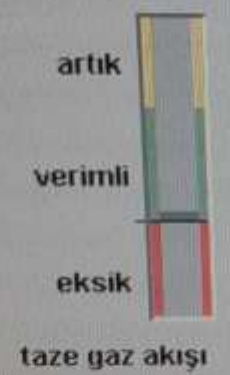
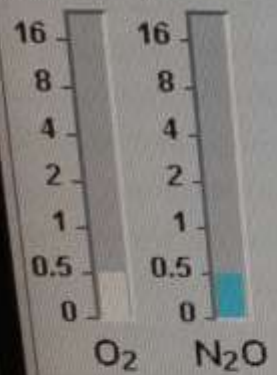
Eksikler ve Gelecek

- Volatil anestetiklerin uzaklaştırılması, yeniden kazanımı
- Organa özel etkiler *solunum*
- Derlenme niteliği üzerine etkisi

	insp.	exp.	
O ₂ <input checked="" type="checkbox"/>	45	43	%
N ₂ O	51	49	%
Sev. <input checked="" type="checkbox"/>	2.2	1.7	%
MAC	yaş 54	1.4	



etCO ₂ <input checked="" type="checkbox"/>	34
mmHg	
inCO ₂	0
MV	5.7
V _T	475
Frek.	12
PEAK	23
PLAT	18
PEEP	3



C _{PAT}	33.0	V _T INSP	539	ΔV _T	64
P _{MEAN}	9	V _T	475		
		P _{KW}			

kPa x 100	mrkz.sist.	silindir
O ₂	5.0	157
Air	4.8	--
N ₂ O	5.2	0

TAZE GAZ

I:E = 1 : 1.9

Tetickl. = OFF

O ₂ %	akış L/dak	P _{MAX} hPa	V _T mL	frek. 1/dak	T _{INSP} sn	Δ P _{ps} hPa	PEEP hPa	ekstra ayarlar
50	1.00	40	510	12	1.7	OFF	3	

SONUÇ

- **Modern anestezi cihazları ile düşük akım anestezi güvenlidir.**
- **Çevre ve maliyet açısından düşük akım anestezi daha fazla öne çıkmaktadır.**