Inhaled sedation and ECMO

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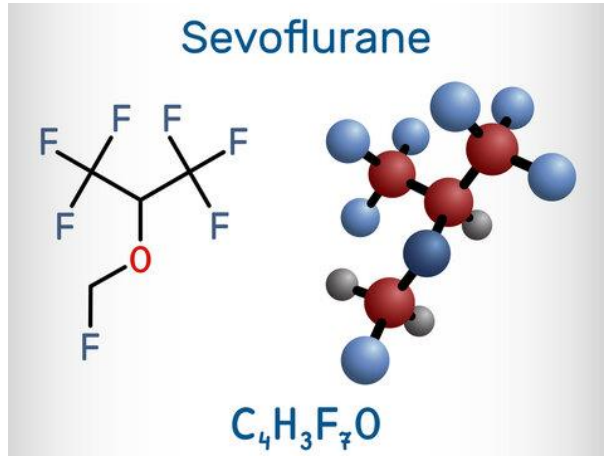
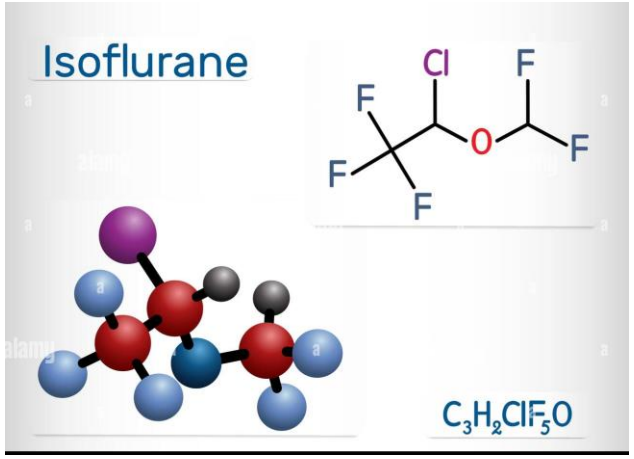
Disclosures

- ✓ Lectures fees for :
  - Getinge
  - Dräger
  - Fresenius Medical Care
  - Baxter
- ✓ RCTs funded by grants from the French Ministry of Health

Pharmacological basis of halogenated agents

- Liquid at room pressure and temperature.
- Must be transformed into breathable vapor by vaporizers, depending on their boiling temperatures
- Pulmonary elimination and low level of hepatic metabolism
- Very low plasma solubility → rapid onset and offset of action and low individual varation

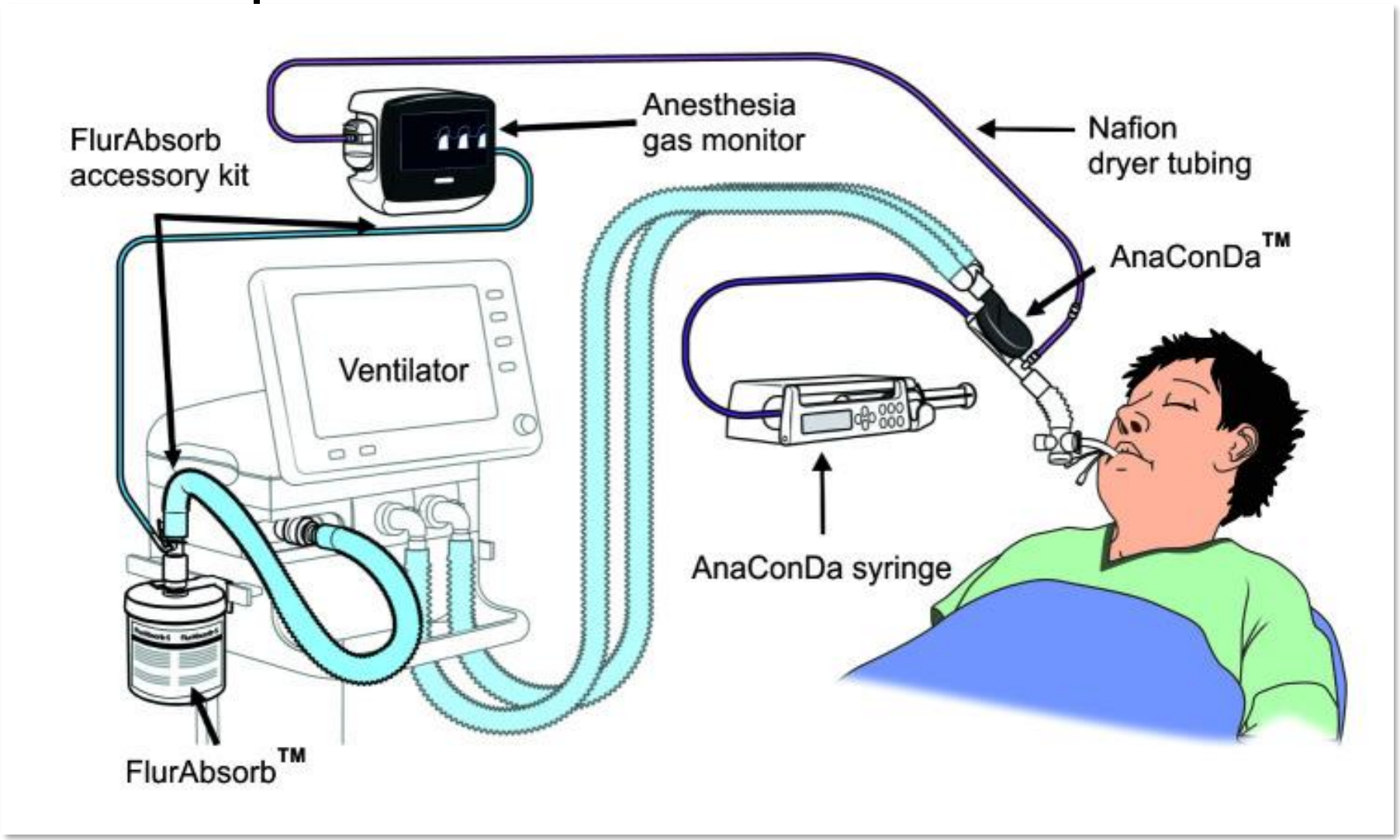




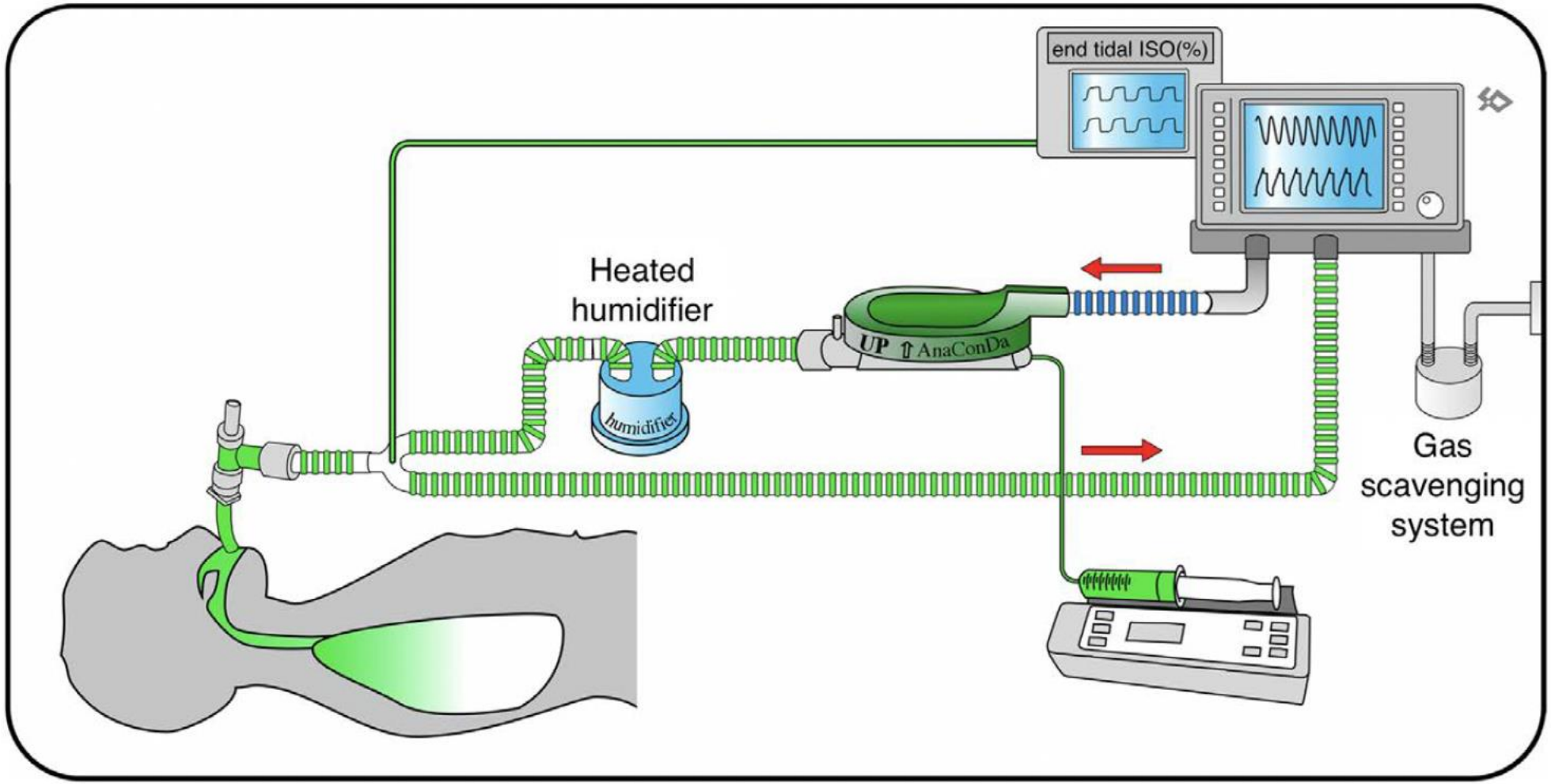
Pharmacological basis of halogenated agents

- Fast-onset (1–2 min) and fast-offset (4– 7 min) drugs that induce a dose-dependent reduction in respiratory drive and allow light-to-deep sedation targets.
- End-tidal gas fractions are good surrogates of cerebral concentrations of the drugs (usual range of 0.2–1.4%)

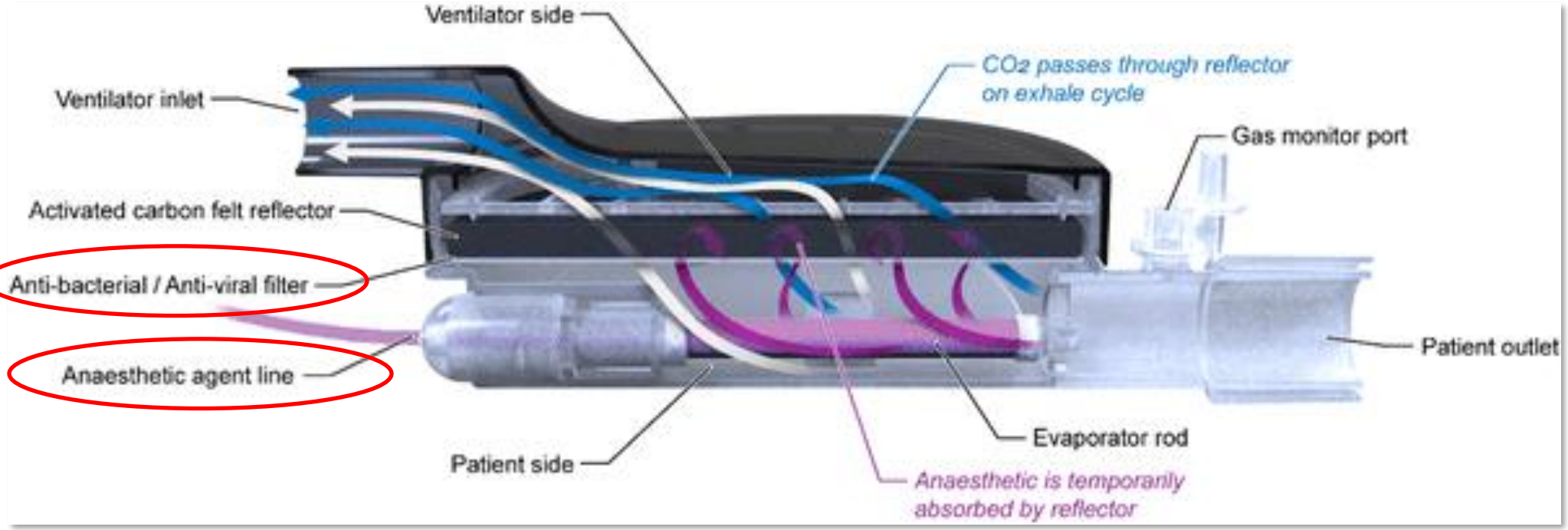
Halogenated agents in the ICU



Halogenated agents in the ICU

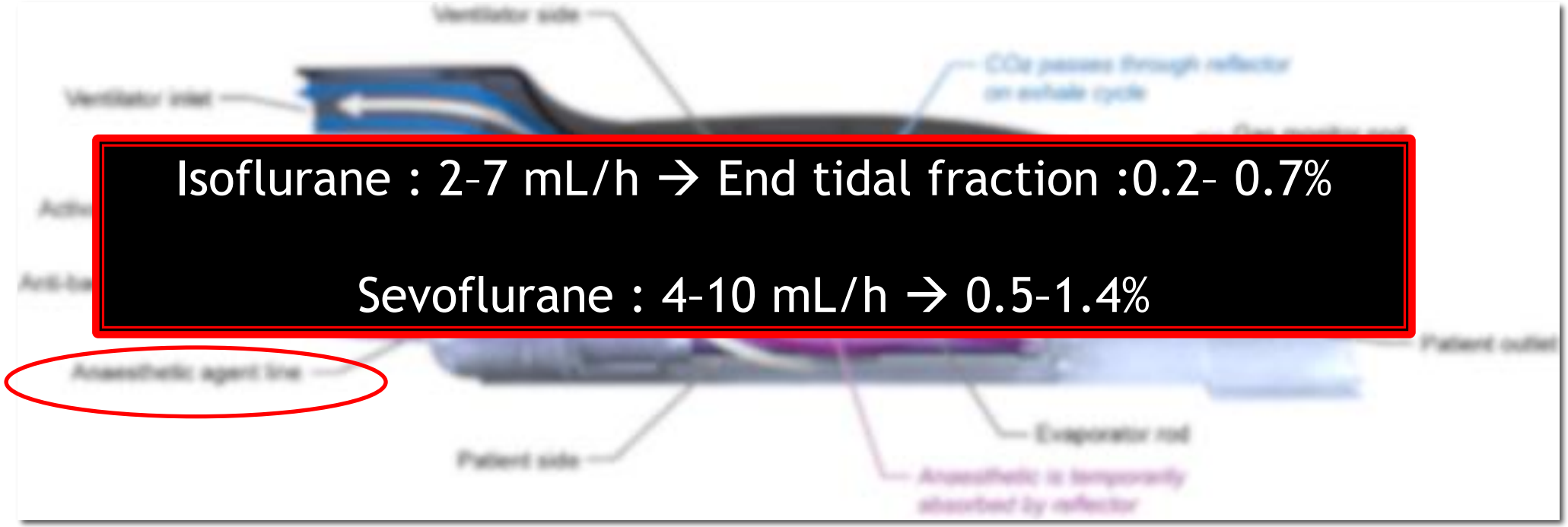


Halogenated agents in the ICU



- ✓ Dead space 50mL
- ✓ Heat and Moisture Exchanger
- ✓ Change every 24h (ANACONDA-ACD) or 7days (MIRUS)

Halogenated agents in ICU



Isoflurane : 2–7 mL/h → End tidal fraction :0.2– 0.7%

Sevoflurane : 4–10 mL/h → 0.5–1.4%

- ✓ Dead space 50mL
- ✓ Heat and Moisture Exchanger
- ✓ Change every 24h (ANACONDA-ACD) or 7days (MIRUS)

Inhaled isoflurane via the anaesthetic conserving device versus propofol for sedation of invasively ventilated patients in intensive care units in Germany and Slovenia: an open-label, phase 3, randomised controlled, non-inferiority trial

Andreas Meiser, Thomas Volk, Jan Wallenborn, Ulf Guenther, Tobias Becher, Hendrik Bracht, Konrad Schwarzkopf, Rihard Knafelj, Andreas Faltlhauser, Serge C Thal, Jens Soukup, Patrick Kellner, Matthias Drüner, Heike Vogelsang, Martin Bellgardt*, Peter Sackey*, on behalf of the Sedaconda study group

Lancet Respir Med 2021; 9: 1231–40

	Isoflurane (n=150)	Propofol (n=151)
Age, years	65·8 (11·8)	64·3 (12·9)
Age group		
≥18–64 years	68 (45%)	70 (46%)
≥65–84 years	78 (52%)	74 (49%)
≥85 years	4 (3%)	7 (5%)
Sex		
Female	46 (31%)	53 (35%)
Male	104 (69%)	98 (65%)
BMI, kg/m²	28·0 (6·0)	28·3 (7·7)
Main reason for ICU admission		
Medical	59 (39%)	61 (40%)
Neurosurgical	1 (1%)	1 (1%)
Surgical	86 (57%)	82 (54%)
Trauma	4 (3%)	7 (5%)
Type of admission		
Emergency	98 (65%)	98 (65%)
Non-emergency	52 (35%)	53 (35%)
Any infection at admission		
Yes	72 (48%)	78 (52%)
No	78 (52%)	73 (48%)
SAPS II score	42·3 (16·9)	43·8 (18·5)

- Phase 3
- 24 adult ICUs
- Randomized, controlled
- open-label non-inferiority
- Up to 54 h of isoflurane vs propofol

Inhaled isoflurane via the anaesthetic conserving device versus propofol for sedation of invasively ventilated patients in intensive care units in Germany and Slovenia: an open-label, phase 3, randomised controlled, non-inferiority trial

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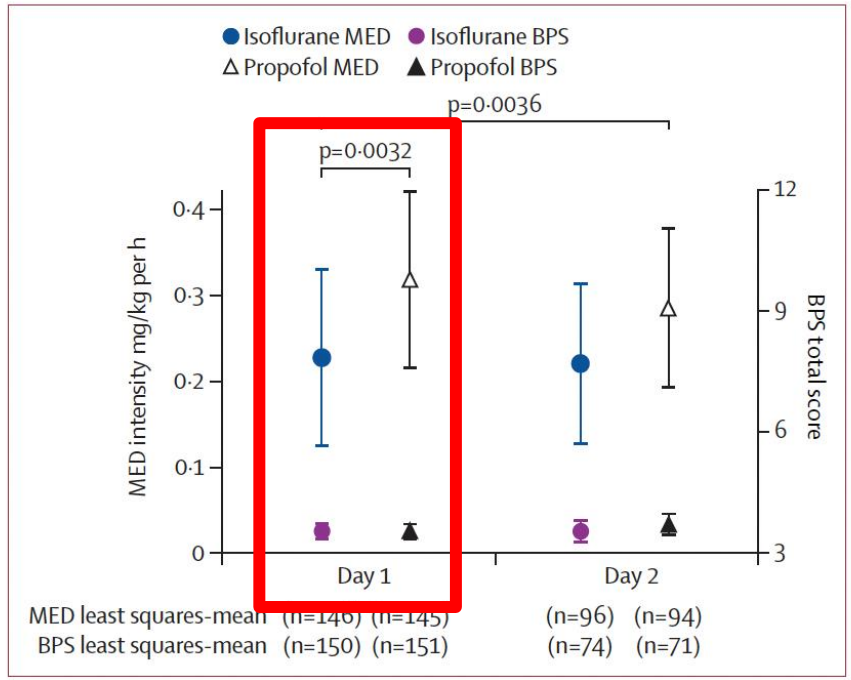
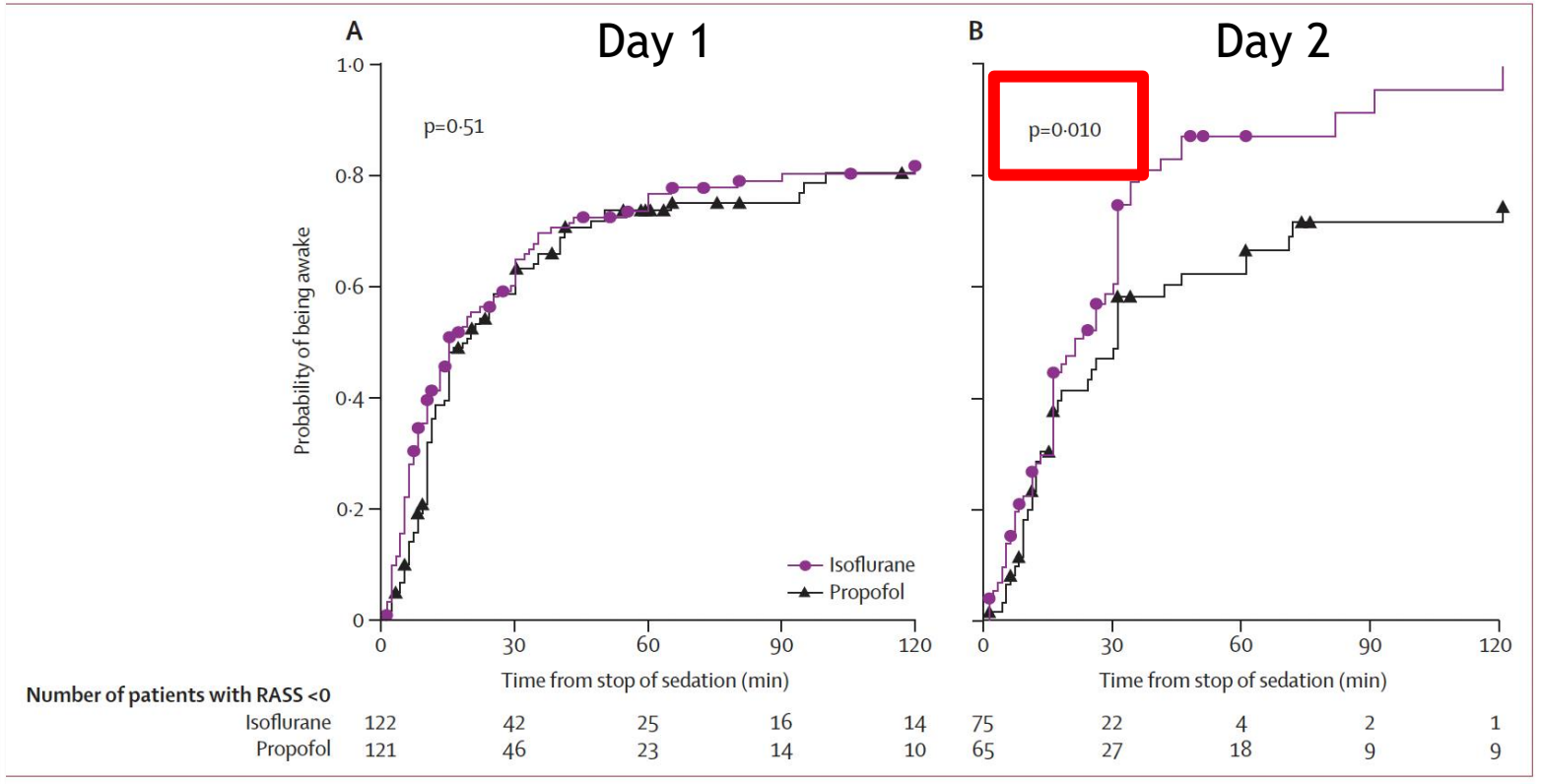


Figure 3: Morphine equivalent dose intensity and BPS during study sedation in the full analysis set



Malcie Mesnil
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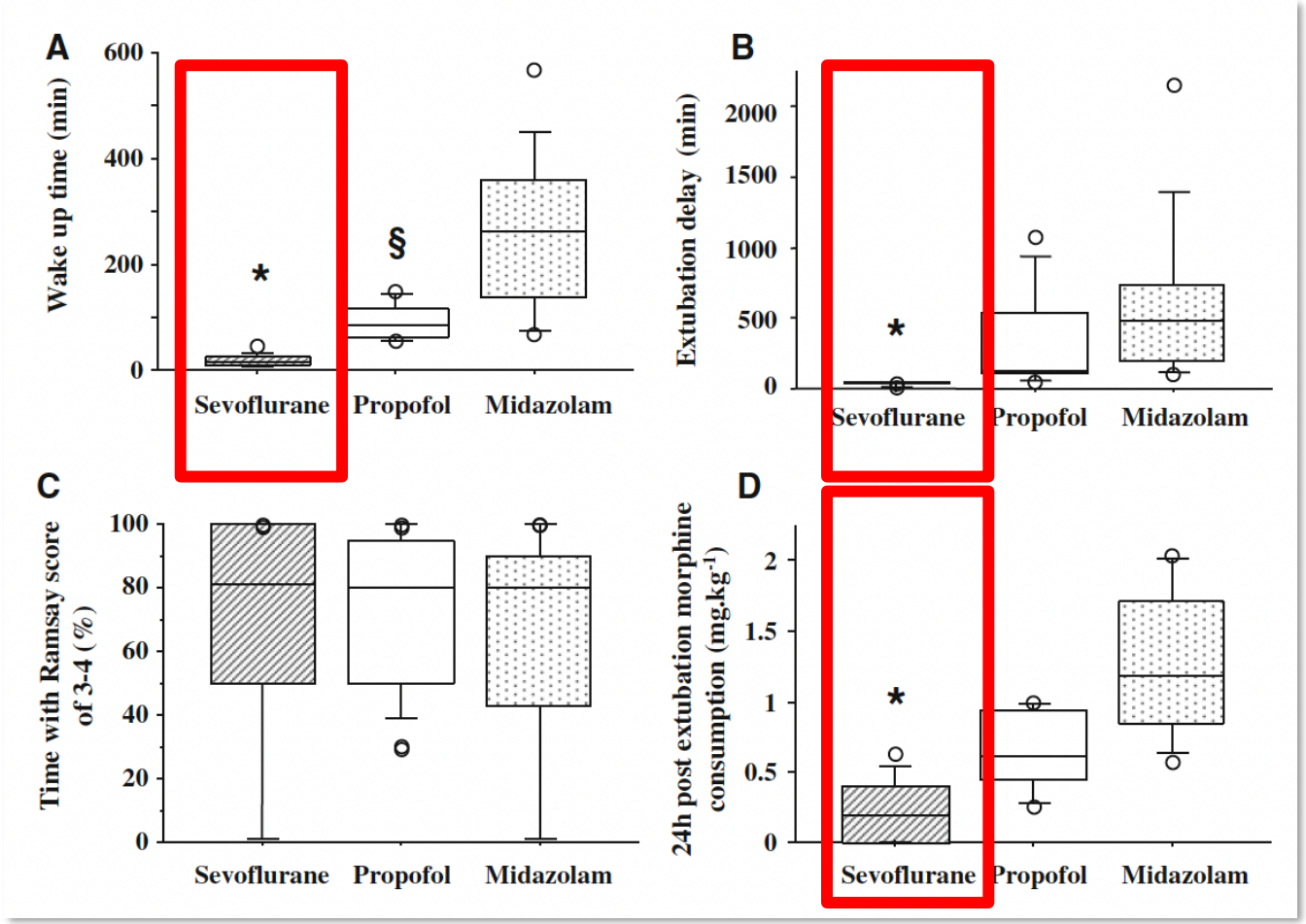
Samir Jaber

Long-term sedation in intensive care unit: a randomized comparison between inhaled sevoflurane and intravenous propofol or midazolam

Intensive Care Med (2011) 37:933–941

	Sevoflurane ($n = 19$)	Propofol ($n = 14$)	Midazolam ($n = 14$)
Age (years)	52 [33–64]	54 [45–63]	55 [31–61]
Sex ratio (M/F)	10/9	9/5	10/4
Body mass index (kg/m^2)	25 [24–27]	26 [24–30]	25 [24–26]
Admission diseases:			
Trauma	9	7	7
Chest trauma	5	4	5
Abdominal and pelvis trauma	3	2	4
Spine and limbs trauma	8	7	6
Miscellaneous	3	3	2
Pneumonia	3	1	2
Post surgery	3	2	2
Acute respiratory failure	1	1	1
Infection/sepsis	1	3	2
APACHE II	21 [15–25]	28 [21–31]	18 [13–22]
SAPS II	21 [16–28]	25 [22–37]	24 [18–28]
PaO_2/FiO_2 (mmHg)	261 [205–345]	253 [215–360]	295 [263–350]
Duration of sedation (h)	50 [39–71]	57 [35–89]	50 [38–71]
Duration of invasive mechanical ventilation (h)	51 [44–74]	61 [41–66.5]	58 [52–74]
ICU stay (days)	10 [5–16]	12 [7–19]	12 [9–17]

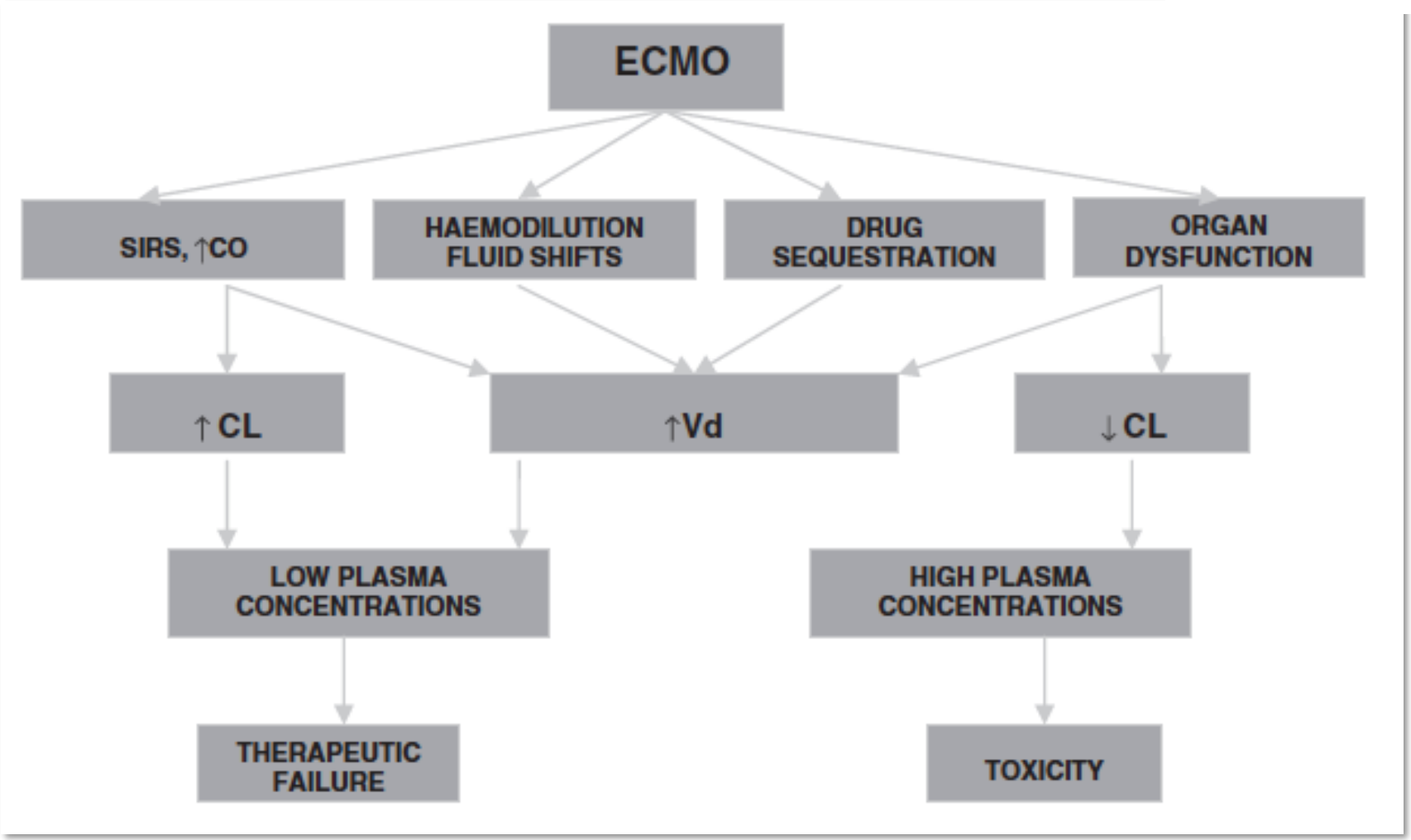


Rationale for inhaled anesthetics on ECMO ?

Pharmacokinetic changes in patients receiving extracorporeal membrane oxygenation☆

Kiran Shekar FCICM [a,*], John F. Fraser PhD [a], Maree T. Smith PhD [b], Jason A. Roberts PhD [c]

Journal of Critical Care (2012)

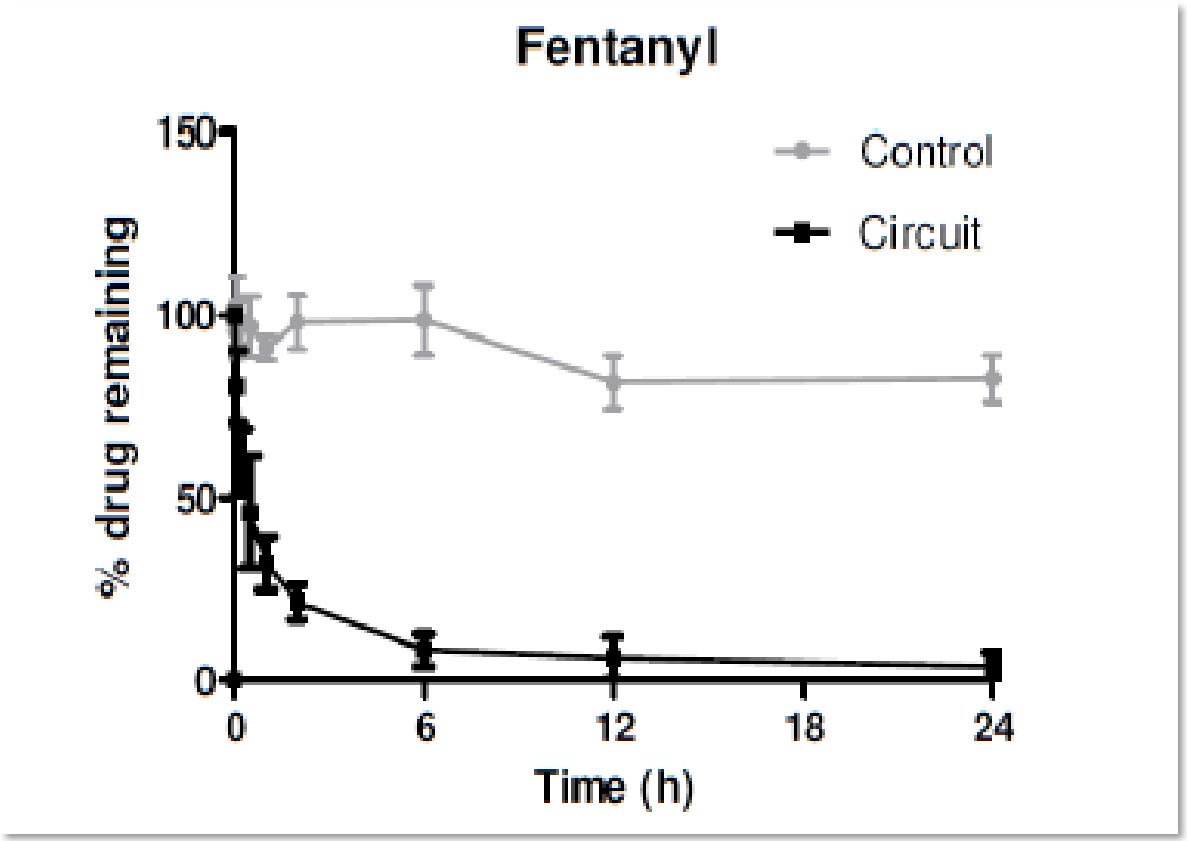


Sequestration of drugs in the circuit may lead to therapeutic failure during extracorporeal membrane oxygenation

Kiran Shekar[1*], Jason A Roberts[2], Charles I Mcdonald[1], Stephanie Fisquet[1], Adrian G Barnett[3], Daniel V Mullany[1], Sussan Ghassabian[4], Steven C Wallis[2], Yoke L Fung[1], Maree T Smith[4] and John F Fraser[1]

EX - VIVO

Shekar *et al. Critical Care* 2012



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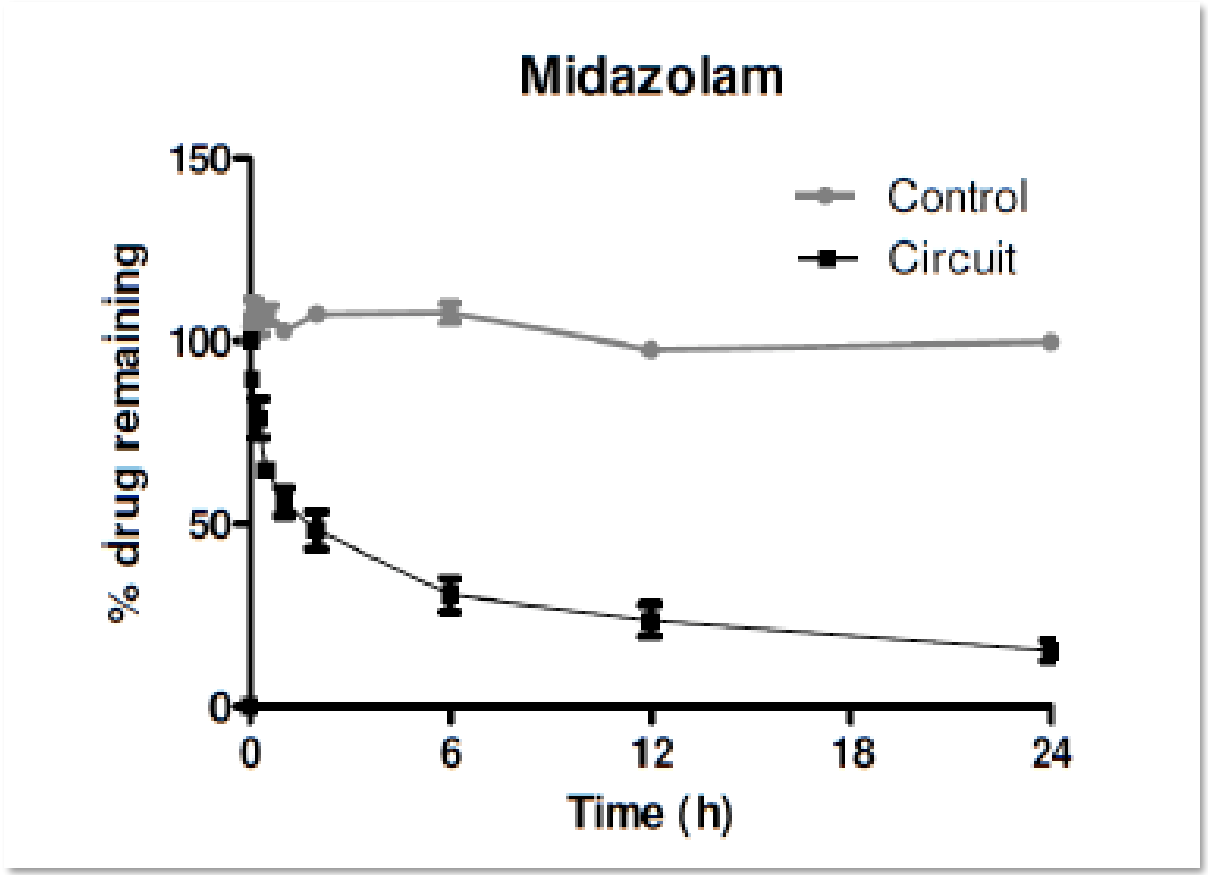
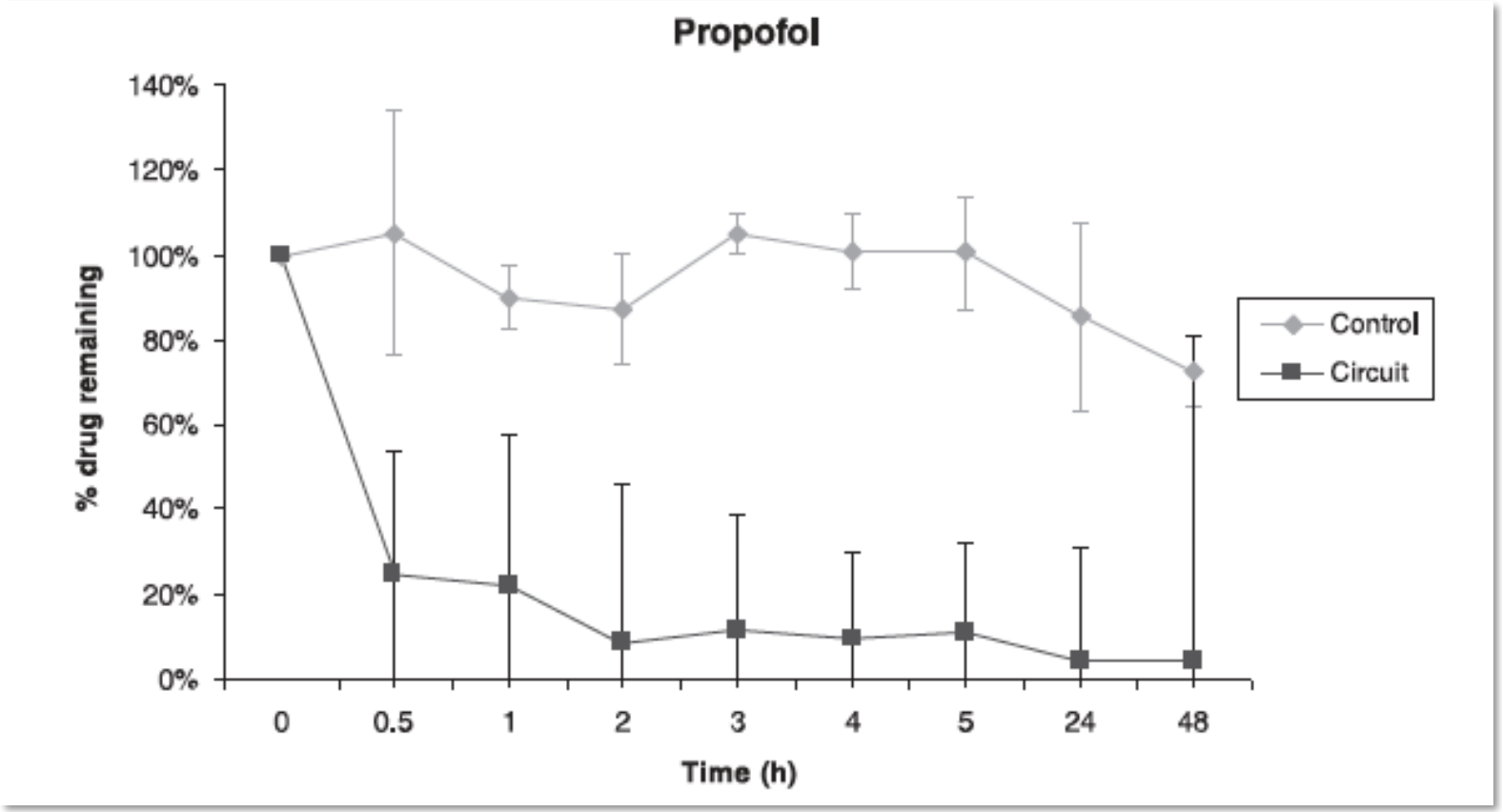


Propofol, midazolam, vancomycin and cyclosporine therapeutic drug monitoring in extracorporeal membrane oxygenation circuits primed with whole human blood

Florian Lemaitre[1,2,3,4], Nesrine Hasni[1], Pascal Leprince[6,7], Emmanuel Corvol[7], Ghassen Belhabib[1], Pierre Fillâtre[2,3,4], Charles-Edouard Luyt[5,6], Cyril Leven[2,3,4], Robert Farinotti[1], Christine Fernandez[1,8] and Alain Combes[5,6*]

Lemaitre *et al. Critical Care* (2015)

EX - VIVO



Feasibility and Potential Cost/Benefit of Routine Isoflurane Sedation Using an Anesthetic-Conserving Device: a Prospective Observational Study

Erwan L'Her MD PhD, Lenaïg Dy MD, Riccardo Pili MD, Gwenaël Prat MD, Jean-Marie Tonnelier MD, Montaine Lefevre MD, Anne Renault MD, and Jean-Michel Boles MD

RESPIRATORY CARE • OCTOBER 2008 VOL 53 NO 10

Conclusions

Routine ICU isoflurane sedation with the AnaConDa is easily feasible, efficacious, safe, and provides rapid onset and offset. Isoflurane is highly effective, and in this study it succeeded in sedating certain patients who failed our conventional sedation protocol. Isoflurane significantly decreases sedation cost in some patients. In our ICU we now use isoflurane as a standard sedation tool in certain cases, especially when deep sedation is required during the initial phase of care.

IV drug user

Burn

COVID-19

ECMO ??

Shortage of anesthetics: Think of inhaled sedation!

Journal of Critical Care 63 (2021) 104–105

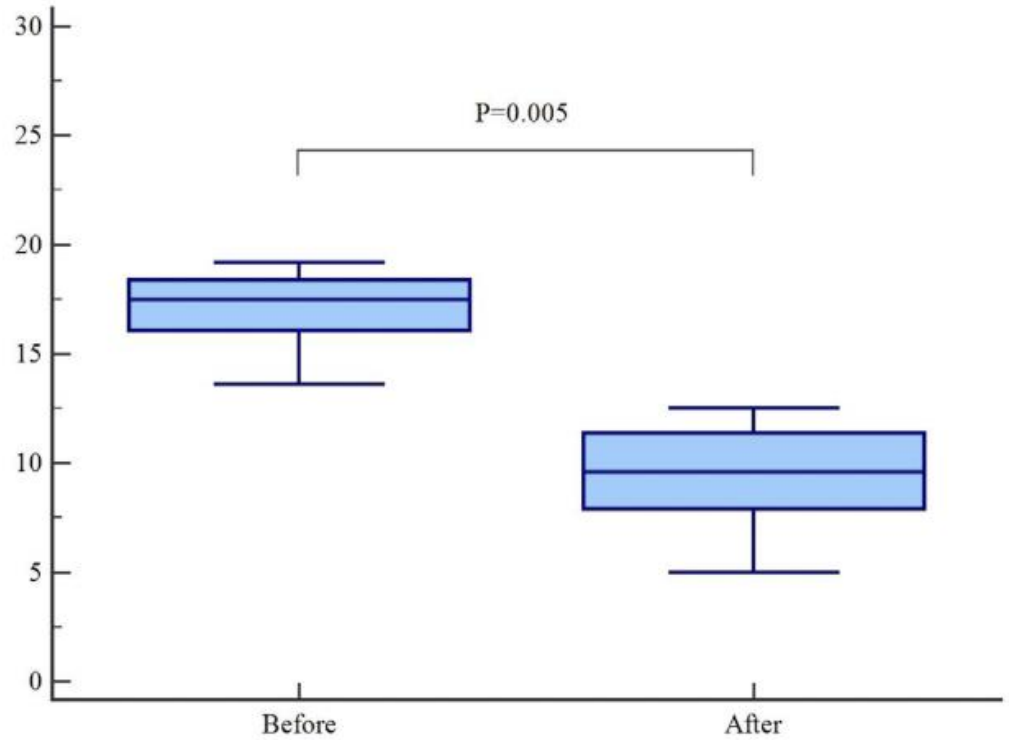


Fig. 1. Sufentanyl consumption before and after volatile anesthetics introduction. The figure displays the Box-and-whisker plot of the sufentanyl consumption, before and after volatile anesthetics introduction while keeking the same sedation goal. Central

Cardiac and hemodynamic benefits

Comparison of Isoflurane-, Sevoflurane-, and Desflurane-Induced Pre- and Postconditioning Against Myocardial Infarction in Mice *In Vivo*

Andreas Redel,*,[1] Jan Stumpner,* Tobias Tischer-Zeitz,* Markus Lange,* Thorsten M. Smul,* Christopher Lotz,* Norbert Roewer,* and Franz Kehl†

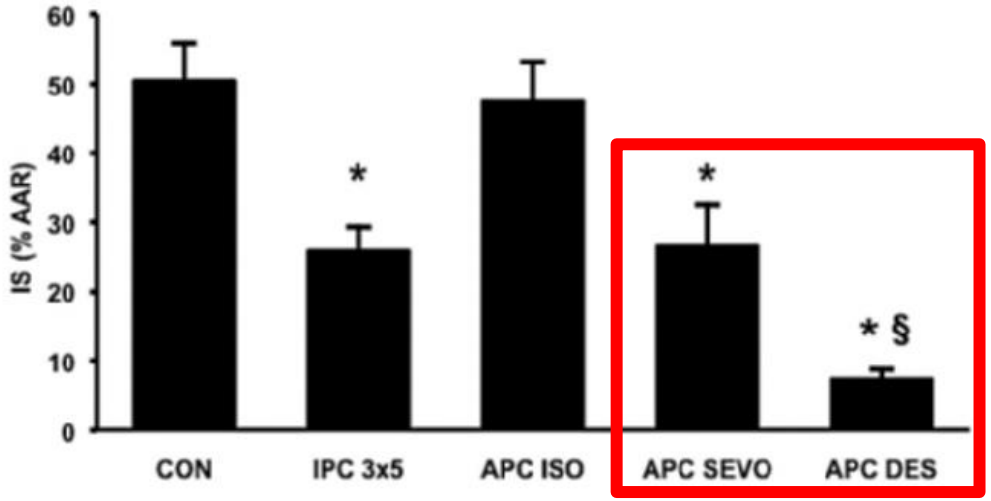


Figure 2. Influence of ischemic and anesthetic-induced preconditioning on myocardial infarct size. Mice received ischemic preconditioning (3 × 5 min ischemia/reperfusion, IPC 3×5, $n = 7$) or anesthetic preconditioning (APC) with 1.0 MAC isoflurane (APC ISO, $n = 7$), sevoflurane (APC SEVO, $n = 8$) and desflurane (APC DES, $n = 8$). Volatile anesthetics were administered for 15 min. Infarct size (IS) is expressed as a percentage of the left ventricular area at risk (AAR). Data are mean ± SEM. * Significantly ($P < 0.05$) different vs. CON. § Significantly ($P < 0.05$) different vs. IPC 3×5 and APC SEVO.

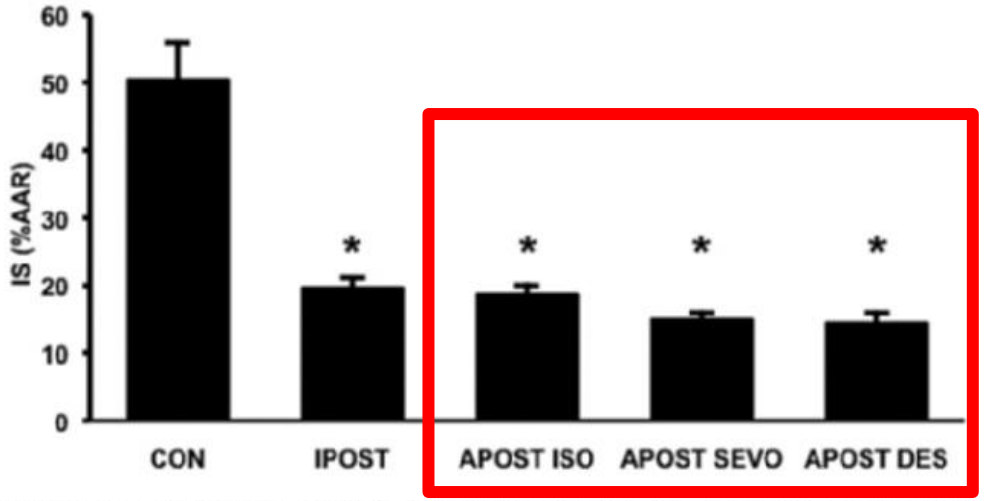


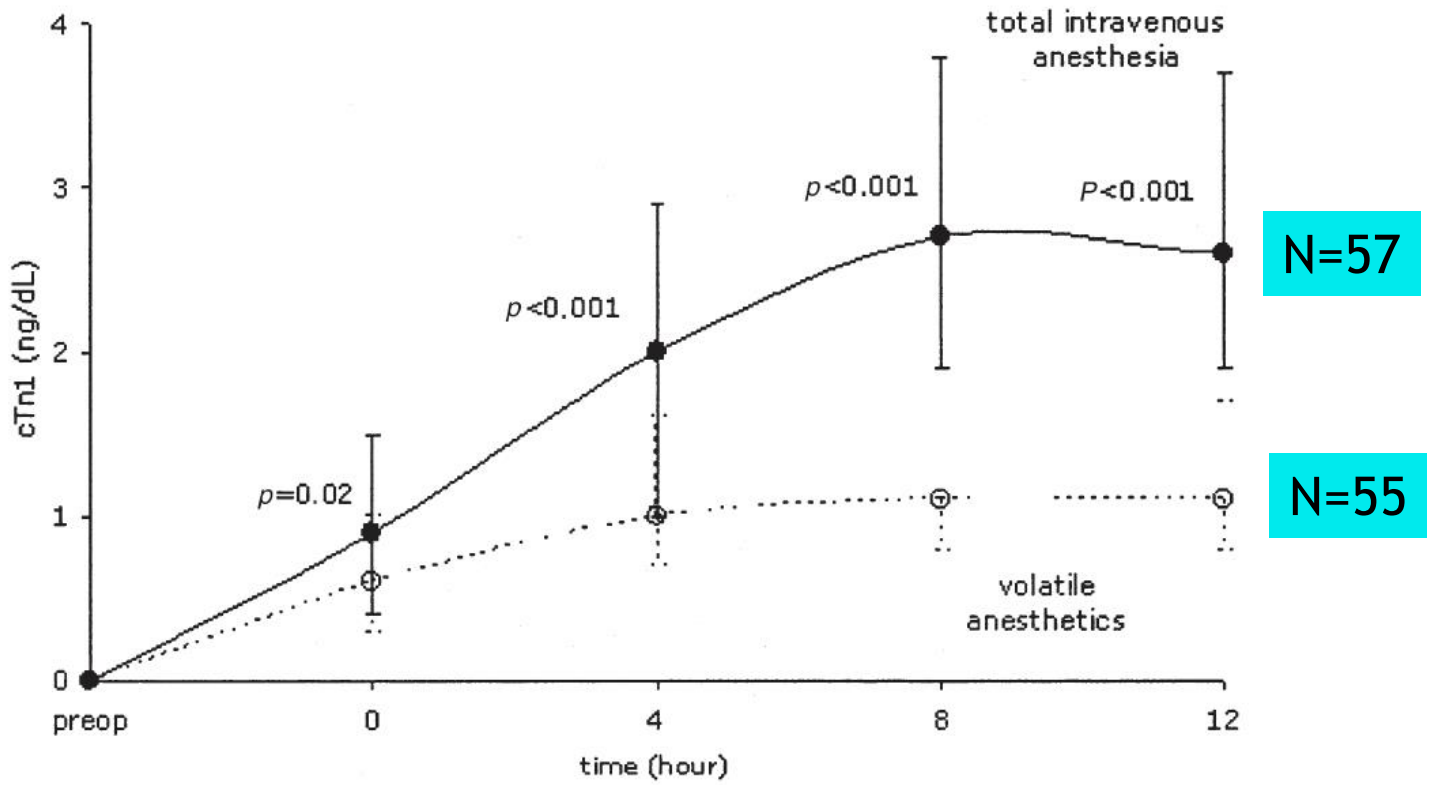
Figure 3. Influence of ischemic and anesthetic-induced postconditioning on myocardial infarct size. Mice received ischemic postconditioning (3 × 30 sec reperfusion/ischemia, IPOST, $n = 7$) or anesthetic postconditioning (APOST) with 1.0 MAC isoflurane (APOST ISO, $n = 8$), sevoflurane (APOST SEVO, $n = 8$) and desflurane (APOST DES, $n = 8$). Volatile anesthetics were administered for 18 min. Infarct size (IS) is expressed as a percentage of the left ventricular area at risk (AAR). Data are mean ± SEM. Note that CON data are the same as in Figure 2. * Significantly ($P < 0.05$) different vs. CON.

Cardiac and hemodynamic benefits

Myocardial Damage Prevented by Volatile Anesthetics: A Multicenter Randomized Controlled Study

Fabio Guarracino, MD,* Giovanni Landoni, MD,† Luigi Tritapepe, MD,‡ Francesca Pompei, MD,‡ Albino Leoni, MD,† Giacomo Aletti, PhD,§ Anna Mara Scandroglio, MD,† Daniele Maselli, MD,* Monica De Luca, MD,† Chiara Marchetti, MD,† Giuseppe Crescenzi, MD,† and Alberto Zangrillo, MD†

Journal of Cardiothoracic and Vascular Anesthesia, Vol 20, No 4 (August), 2006: pp 477-483



N=57

N=55

Fig 2. Median (25th-75th percentiles) of troponin I after off-pump coronary artery bypass grafting in patients receiving either volatile anesthetics or total intravenous anesthesia.

Malcie Mesnil
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Long-term sedation in intensive care unit: a randomized comparison between inhaled sevoflurane and intravenous propofol or midazolam

Cardiac and hemodynamic benefits

Intensive Care Med (2011) 37:933–941

47 patients, sedation D1-D4

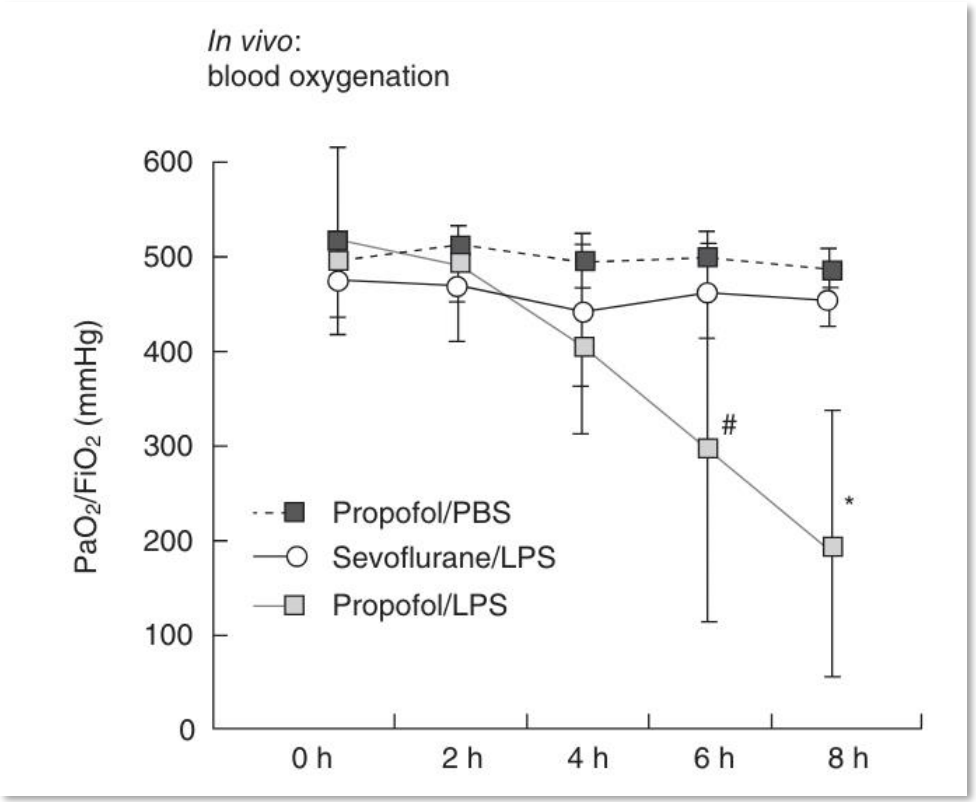
	Sevoflurane ($n = 19$)	Propofol ($n = 14$)	Midazolam ($n = 14$)	P value
Number of hypnotic dose changes/day (n)	1.5 [0–2.5]*	5 [4–8.5]	3.5 [2–5]	<0.001
Number of remifentanil dose changes/day (n)	1.5 [1–2.5]*	4.5 [3–6]	4.5 [2.5–7]	0.002
Percentage of time within Ramsay score 3–4 (%)	75 [55–94]	75 [50–90]	70 [50–90]	0.681
Percentage of time with MAP between 65 and 95 mmHg (%)	92 [85–98]*	85 [68–92]	80 [65–90]	0.002
Use of vasoactive drugs during the study period (%)	35*	48	42	0.001
Awaking quality score	1 [1–1]*	2.5 [1–5]	2 [2–3]	<0.001
Pain score at end of sedation	1 [0–1]*	2.5 [1–5]	2 [2–3]	<0.001
Remifentanil infusion rate during the study period ($\mu g\ kg^{-1}\ h^{-1}$)	9 [5–10]	12 [6–13]	10 [5–15]	0.962
24 h post extubation morphine consumption (mg)	20 [4.5–30]*	40 [30–60]	76 [55–111]	<0.001

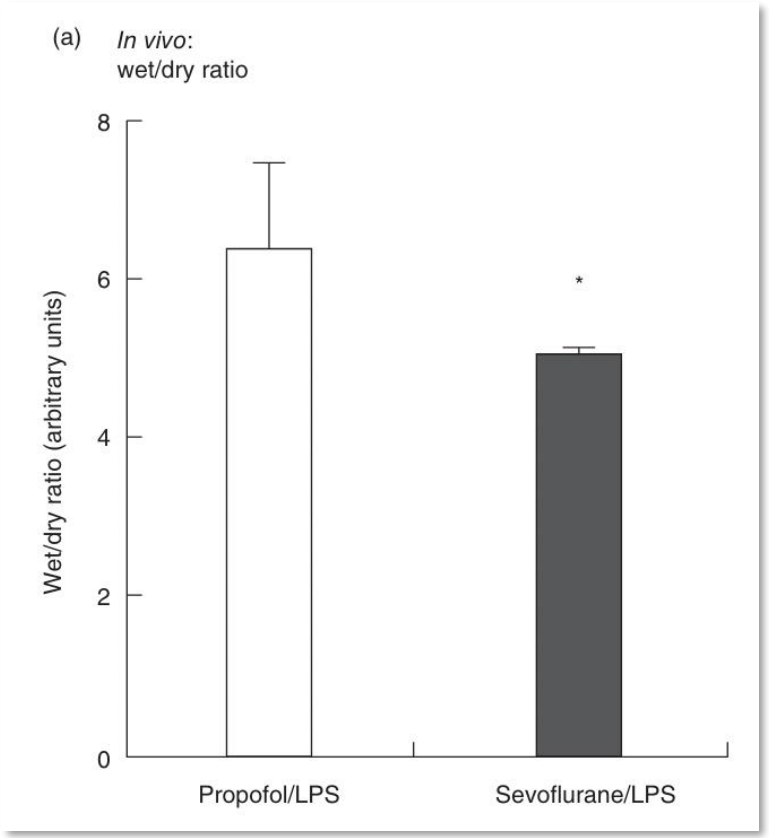
Pulmonary benefits

Sevoflurane reduces severity of acute lung injury possibly by impairing formation of alveolar oedema

2012 , *Clinical and Experimental Immunology*, **168:** 125–134

M. Schläpfer,[1*†] A. C. Leutert,[1*†] S. Voigtsberger,[*†] R. A. Lachmann,[*†] C. Booy[†] and B. Beck-Schimmer[*†]
[*]Institute of Anesthesiology, University Hospital Zurich, and [†]Institute of Physiology and Center for Integrative Human Physiology, University of Zurich, Zurich, Switzerland





Pulmonary benefits

Sevoflurane for Sedation in Acute Respiratory Distress Syndrome
A Randomized Controlled Pilot Study

Matthieu Jabaudon[1,2], Pierre Boucher[1], Etienne Imhoff[1], Russell Chabanne[1], Jean-Sébastien Faure[1], Laurence Roszyk[2,3], Sandrine Thibault[4], Raiko Blondonnet[1,2], Gael Clairefond[2], Renaud Guérin[1], Sébastien Perbet[1,2], Sophie Cayot[1], Thomas Godet[1], Bruno Pereira[4], Vincent Sapin[2,3], Jean-Etienne Bazin[1], Emmanuel Futier[1,2], and Jean-Michel Constantin[1,2]

American Journal of Respiratory and Critical Care Medicine Volume 195 Number 6 | March 15 2017

	Sevoflurane Group ($n = 25$)	Midazolam Group ($n = 25$)	*P* Value
Age, yr	66 ± 10	63 ± 14	0.9
Male sex, n (%)	17 (70)	19 (75)	0.8
Body mass index, kg/m^2	29.6 ± 9.4	28.1 ± 8.2	0.7
SAPS II	55.6 ± 14.7	51.3 ± 17.0	0.2
Lung injury score (Murray)	2.9 ± 0.3	2.8 ± 0.6	0.4
Medical history, n (%)			
Peripheral arterial disease	5 (20)	2 (8)	0.2
Stroke	0 (0)	2 (8)	0.5
Liver cirrhosis	2 (8)	2 (8)	1
Hypertension	9 (36)	12 (48)	0.6
Coronary disease	1 (4)	4 (16)	0.4
Diabetes	3 (12)	4 (16)	1
Dyslipidemia (previous or ongoing treatment with statins)	3 (12)	6 (25)	0.5
Alcohol dependence	6 (25)	9 (36)	0.5
Chronic respiratory disease	4 (16)	6 (25)	0.7
Active tobacco smoking	7 (28)	7 (28)	1
Chronic renal failure	1 (4)	1 (4)	1
Previous or ongoing treatment with corticosteroids	0 (0)	0 (0)	1
Type of ICU admission: medical vs. surgical, n (%)	21 (84) vs. 4 (16)	16 (64) vs. 9 (36)	0.2
Cause of ARDS, n (%)			
Pneumonia	19 (76)	19 (76)	1
Extrapulmonary causes	6 (24)	6 (24)	1
Associated shock	13 (52)	12 (48)	0.8
Respiratory parameters			
Expired V_T, ml/kg of PBW	6.9 ± 0.9	7.1 ± 1.3	0.9
Positive end-expiratory pressure, cm H_2O	11.4 ± 3.1	11.8 ± 3.2	0.7
Inspiratory plateau pressure, cm H_2O	25.1 ± 3.5	23.8 ± 5.6	0.4
Static pulmonary compliance, ml/cm H_2O	32.3 ± 9.6	42.7 ± 19.1	0.1
Airway resistance, cm $H_2O \cdot L^{-1} \cdot s^{-1}$	15.6 ± 4.6	12.9 ± 3.3	0.08
$F_{I_{O_2}}$, %	80 ± 21	76 ± 18	0.4
Arterial pH	7.32 ± 0.11	7.37 ± 0.09	0.2
Respiratory rate, min^{-1}	26 ± 3	25 ± 2.8	0.3
Pa_{CO_2}	43.7 ± 7.4	45.0 ± 7.5	0.7
$Pa_{O_2}/F_{I_{O_2}}$ ratio	111 ± 37	117 ± 45	0.8
Mean arterial pressure, mm Hg	74 ± 9	79 ± 10	0.06

Pulmonary benefits

Sevoflurane for Sedation in Acute Respiratory Distress Syndrome
A Randomized Controlled Pilot Study

Matthieu Jabaudon[1,2], Pierre Boucher[1], Etienne Imhoff[1], Russell Chabanne[1], Jean-Sébastien Faure[1], Laurence Roszyk[2,3], Sandrine Thibault[4], Raiko Blondonnet[1,2], Gael Clairefond[2], Renaud Guérin[1], Sébastien Perbet[1,2], Sophie Cayot[1], Thomas Godet[1], Bruno Pereira[4], Vincent Sapin[2,3], Jean-Etienne Bazin[1], Emmanuel Futier[1,2], and Jean-Michel Constantin[1,2]

American Journal of Respiratory and Critical Care Medicine Volume 195 Number 6 | March 15 2017

	Sevoflurane Group ($n = 25$)	Midazolam Group ($n = 25$)	P Value
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Medical history, n (%)			
Peripheral arterial disease	5 (20)	2 (8)	0.2
Hypertension	9 (36)	12 (48)	0.6
Coronary disease	1 (4)	4 (16)	0.4
Diabetes	3 (12)	4 (16)	1
Dyslipidemia (previous or ongoing treatment with statins)	3 (12)	6 (25)	0.5
Alcohol dependence	6 (25)	9 (36)	0.5
Chronic respiratory disease	4 (16)	6 (25)	0.7
Active tobacco smoking	7 (28)	7 (28)	1
Cause of ARDS, n (%)			
Pneumonia	19 (76)	19 (76)	1
Extrapulmonary causes	6 (24)	6 (24)	1
Associated shock	13 (52)	12 (48)	0.8
Respiratory parameters			
Expired V_T, ml/kg of PBW	6.9 ± 0.9	7.1 ± 1.3	0.9
Static pulmonary compliance, ml/cm H_2O	32.3 ± 9.6	42.7 ± 19.1	0.1
Airway resistance, cm $H_2O \cdot L^{-1} \cdot s^{-1}$	15.6 ± 4.6	12.9 ± 3.3	0.08
F_{IO_2}, %	80 ± 21	76 ± 18	0.4
Arterial pH	7.32 ± 0.11	7.37 ± 0.09	0.2
Pa_{CO_2}	43.7 ± 7.4	45.0 ± 7.5	0.7
Pa_{O_2}/F_{IO_2} ratio	111 ± 37	117 ± 45	0.8

Pulmonary benefits

Sevoflurane for Sedation in Acute Respiratory Distress Syndrome
A Randomized Controlled Pilot Study

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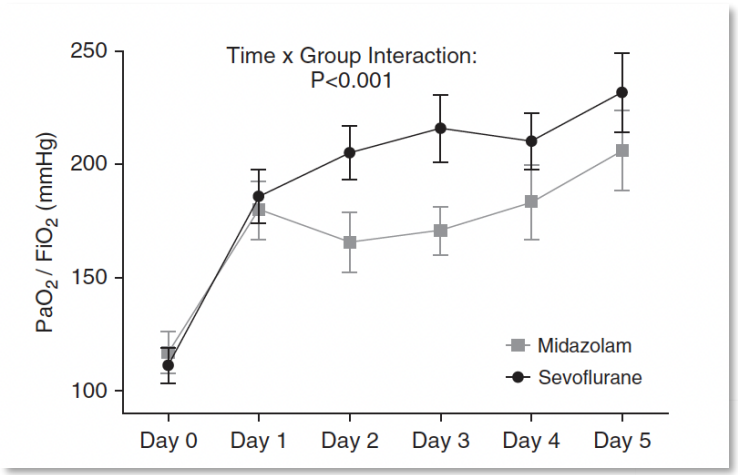
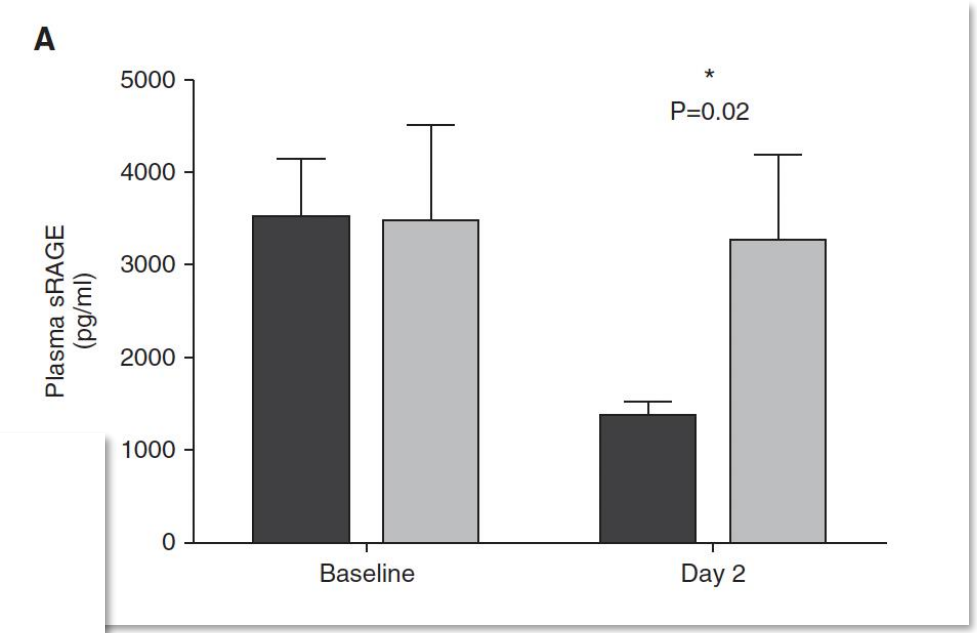
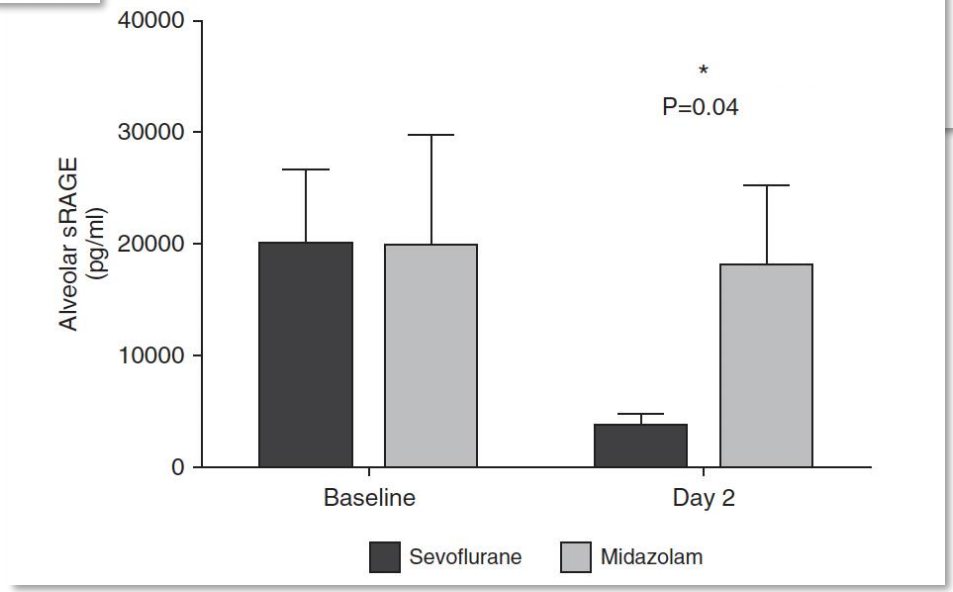
American Journal of Respiratory and Critical Care Medicine Volume 195 Number 6 | March 15 2017







Pulmonary benefits

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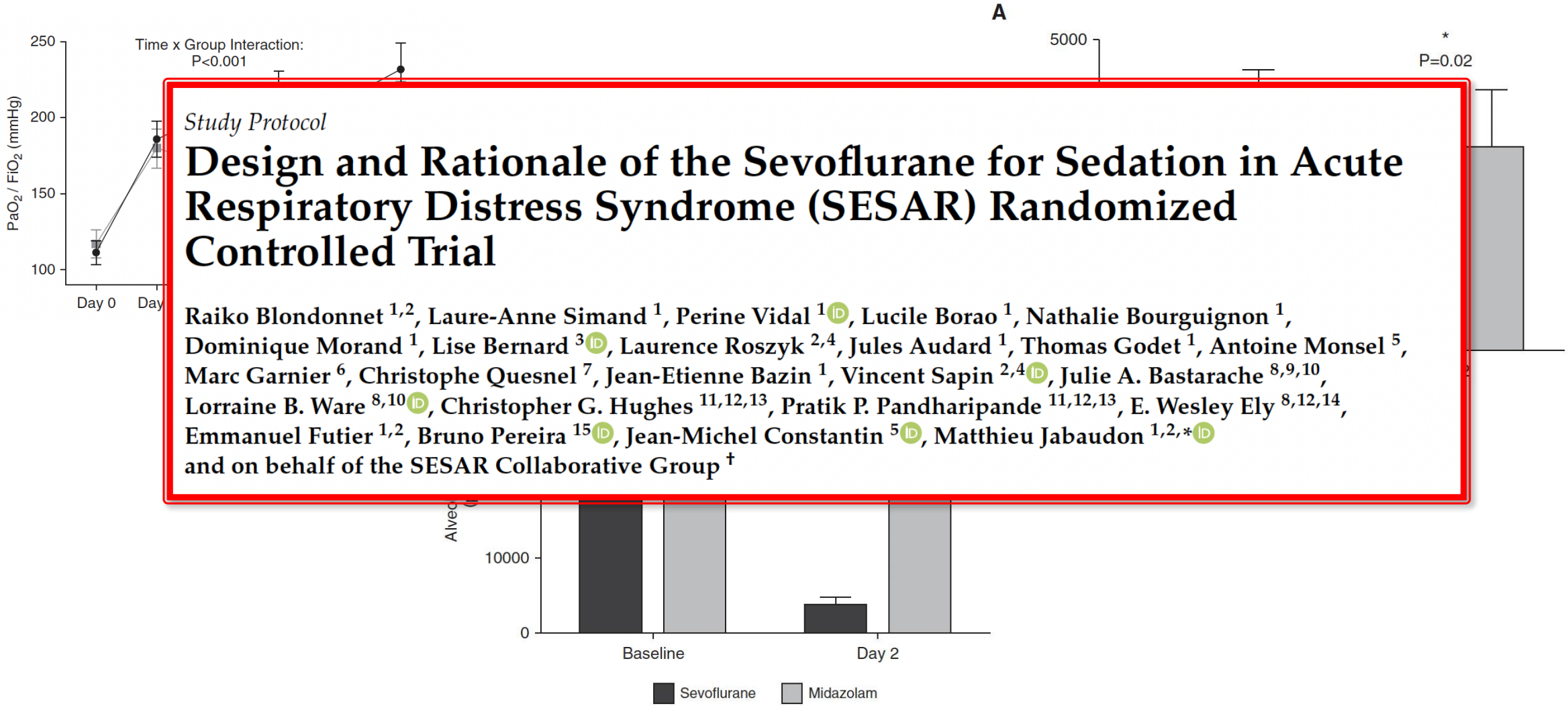

Study Protocol

Design and Rationale of the Sevoflurane for Sedation in Acute Respiratory Distress Syndrome (SESAR) Randomized Controlled Trial

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and on behalf of the SESAR Collaborative Group †

Specific data on ECMO…

Volatile Sedation for Acute Respiratory Distress Syndrome Patients on Venovenous Extracorporeal Membrane Oxygenation and Ultraprotective Ventilation

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Nicolò Patroniti, MD[5,6]
Antonio Pesenti, MD[1,2]
Giuseppe Foti, MD[3,4]

Critical Care Explorations | January 2021 • Volume 3 • Number 1

Age, yr	50 (43–56)
Females, *n*	26 (35%)
Body mass index, kg/m^2	26 (23–31)
Sequential Organ Failure Assessment score	9 (6–12)
Simplified Acute Physiology Score II score	35 (27–48)
Pao_2/Fio_2, mm Hg	70 (52–88)
Cause of acute respiratory distress syndrome	
Viral pneumonia	26 (30%)
Bacterial pneumonia	25(30%)
Autoimmune disorder	10 (17%)
Trauma	3 (6%)
Unknown	10 (17%)

All patients received ultraprotective ventilation, with a mean TV of 3.7 ± 1.4 mL/kg of ideal body weight and an average respiratory rate of 10 ± 3 breaths/min. Mean TV during the isoflurane phase was 264 ± 79 mL, ranging from 45 to 584 mL. Only

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Parameter	IV Before Isoflurane (260 d)	Isoflurane (506 d)	IV After Isoflurane (204 d)	*p*
Sedative agents				
Isoflurane				
No. of days (%)		506 (100%)		
Infusion rate, mL/hr		12.5 ± 4.4		
End tidal, %		1.2 ± 0.4		
Propofol				
No. of days (%)	218 (83.8%)		169 (82.8%)	0.802
Dose, mg/kg/hr	3.97 ± 1.42		3.76 ± 1.59	0.626
Midazolam				
No. of days (%)	81 (31.1%)	20 (4.0%)[a,b]	58 (28.4%)	< 0.001
Dose, mg/kg/hr	0.08 ± 0.05	0.05 ± 0.04[a]	0.06 ± 0.03[a]	< 0.001
Bispectral index	42 ± 8		43 ± 9	< 0.001
Richmond Agitation-Sedation Scale, No. of days (%)				0.128
−5	224 (86.2%)	474 (94.4%)	174 (85.3%)	
−4	28 (10.8%)	28 (5.6%)	20 (9.8%)	
−3	4 (1.5%)	0	5 (2.5%)	
−2	1 (0.4%)	0	4 (2%)	

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Parameter	IV Before Isoflurane (260 d)	Isoflurane (506 d)	IV After Isoflurane (204 d)	*p*
Opioids, No. of days (%)	250 (96.2%)	464 (91.7%)[a]	194 (95.1%)	0.036
Fentanyl				
Dose, μg/kg/hr	1.63 ± 0.54	1.41 ± 0.57[a,b]	1.78 ± 0.96	< 0.001
Remifentanyl				
Dose, μg/kg/min	0.14 ± 0.07	0.07 ± 0.04[a,b]	0.12 ± 0.03	0.005

CONCLUSIONS

Long-term volatile sedation is a feasible alternative to IV sedation in ARDS patients on V-V ECMO requiring ultraprotective ventilation. These findings need to be confirmed in larger, prospective studies comparing sedation with IV and volatile agents.

Volatile sedation practices in patients with severe acute respiratory distress syndrome under VV-ECMO support

Sara Alcántara Carmona[1*], Ana del Saz[2], Sofía Contreras[3], Jordi Riera[3,4,5] and Aaron Blandino[6] on behalf of the Volatile Sedation on VV-ECMO Research Group

Intensive Care Med

Supplementary Table 3. Mechanical ventilation and main ECMO settings

	D0		D1			D3		
Variable	Mean ± SD	Coeff (95%CI)	Mean ± SD	Coeff (95%CI)	p	Mean ± SD	Coeff (95%CI)	p
Tidal volume (ml)	273 ± 123	RC	292 ± 143	24.6 (-5.7; 54.9)	0.11	303 ± 140	34.9 (4.1; 65.7)	0.03
PEEP (cmH_2O)	11 ± 3	RC	10 ± 2	- 0.8 (-1.2; -0.34)	0.00	10 ± 2	- 0.6 (-1.08; -0.13)	0.01
RR (bpm)	15 ± 5	RC	15 ± 5	0.94 (-0.42; 2.3)	0.17	16 ± 5	1.2 (-0.18; 2.57)	0.09
DP (cmH_20)	11 ± 4	RC	11 ± 4	0.11 (-0.83; 1.06)	0.81	12 ± 4	0.57 (-0.4; 1.54)	0.24
ECMO flow (lpm)	3.7 ± 0.55	RC	3.6 ± 0.65	-0.07 (-0.27; 0.12)	0.46	3.6 ± 0.8	-0.15 (-0.53; 0.04)	0.12
FGF (lpm)	5 ± 1.9	RC	5.2 ± 1.9	0.24 (-0.26; 0.76)	0.95	5.2 ± 2.5	0.19 (-0.32; 0.72)	0.74
paO_2/FiO_2 (mmHg)	136 ± 70	RC	147 ± 72	12.14 (-3.4; 27.6)	0.12	152 ± 77	15.7 (-0.02; 31.4)	0.05
$paCO_2$ (mmHg)	51.4 ± 12.4	RC	49.8 ± 9.4	-1.8 (-4.5; 0.9)	0.19	49.6 ± 9.5	-1.4 (-4.1; 1.34)	0.32

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Categorical variables

Variable (YES)	D0		D1			D3		
	N (%)	OR (95%CI)	N (%)	OR (95%CI)	p value	N (%)	OR (95%CI)	p value
Propofol	52 (78.8)	RC	26 (39.4)	0.05 (0.01; 0.24)	0.00	18 (27.3)	0.02 (0; 0.11)	0.00
MDZ	45 (68.2)	RC	24 (36.4)	0.1 (0.03; 0.37)	0.00	13 (19.7)	0.02 (0;0.11)	0.00
Ketamine	5 (7.6)	RC	7 (10.6)	0.27 (0.02; 3.16)	0.27	4 (6.1)	0.12 (0; 1.92)	0.14
DXMD	6 (9.1)	RC	4 (6.1)	0.3 (0.06; 1.53)	0.15	4 (6.1)	0.30 (0.06; 1.53)	0.15
Clonidine	5 (7.6)	RC	6 (9.1)	2.73 (0.15; 50.25)	0.5	5 (7.6)	2.73 (0.15; 50.25)	0.5
Remifentanil	22 (33.3)	RC	27 (40.9)	7.86 (0.81; 76.1)	0.07	26 (39.4)	3.3 (0.51; 21.42)	0.21
Fentanyl	26 (39.4)	RC	21 (31.8)	0.19 (0.03;1.16)	0.07	19 (28.8)	0.19 (0.03; 1.16)	0.07
Morphine	16 (24.2)	RC	19 (28.8)	2.38 (0.5; 11.26)	0.27	20 (30.3)	5.26 (0.86; 32)	0.07
cNMB	32 (48.5)	RC	20 (30.3)	0.26 (0.09; 0.71)	0.00	18 (27.3)	0.23 (0.08; 0.66)	0.01

Sevoflurane administration from extracorporeal membrane oxygenation via the AnaConDa device for a patient with COVID-19: A breakthrough solution for the shortage of intravenous anesthetics

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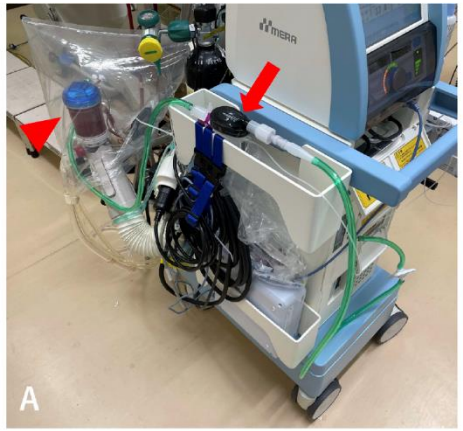
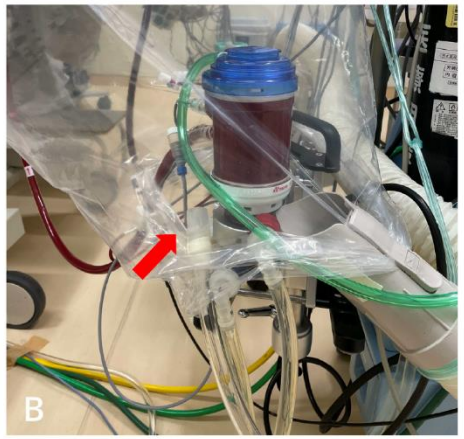
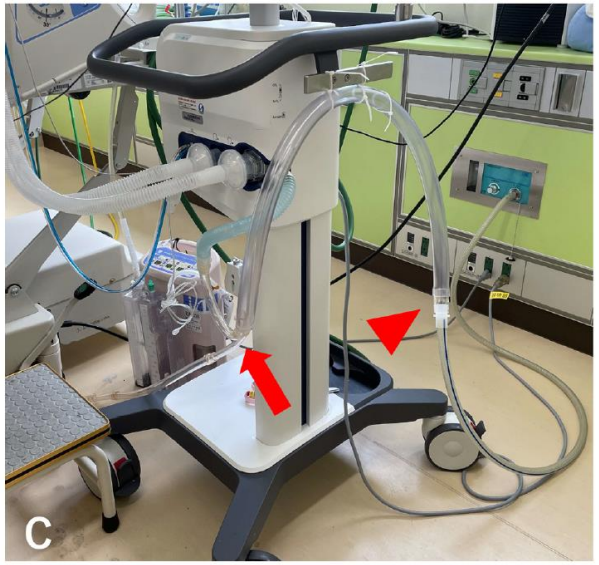
Heart & Lung 56 (2022) 70–73







- Severe ARDS on VV ECMO
- COVID 19
- Difficult with IV sedation
- MinVent : 0.5L/min

Table 1
Dosage adjustment table of sevoflurane.

Sweep gas of ECMO (L/minute)	Target SEV in constant gas flow (%)		
	0.5	1	1.5
1	1.7	3.3	5.0
2	3.3	6.6	9.9
3	5.0	9.9	14.9
4	6.6	13.2	19.8
5	8.3	16.5	24.8
6	9.9	19.8	29.7
7	11.6	23.1	34.7
8	13.2	26.4	39.6
9	14.9	29.7	44.6
10	16.5	33	49.5

The numbers in the table represent the flow rate of sevoflurane administered by the syringe pump (unit: ml/h).
ECMO, extracorporeal membrane oxygenation; SEV, sevoflurane.

Conclusion

- Inhaled anesthetics is a valuable alternative to IV sedation
- Fast onset-offset drugs, shorter awake time
- Easy to manage without significant adverse events
- Important rationale for using Inhaled anesthetics on ECMO
- Further studies, including RCT, are needed