St.Marien- und
St.Annastiftskrankenhaus

Inhalational sedation in the ICU – a „must have“

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BASF
The Chemical Company

St.Marien- und
St.Annastiftskrankenhaus

Conflict of interest

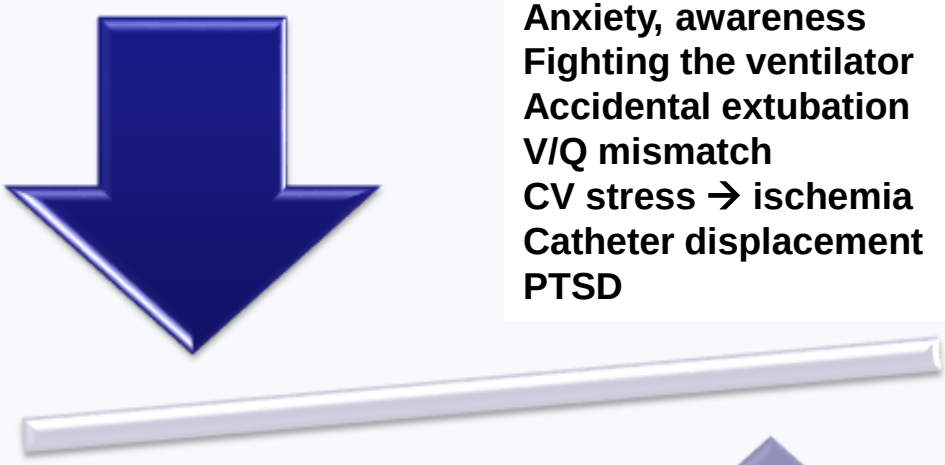
Study grants, consulting and lecture fees received from:

Abbvie Germany
Sedana Medical GmbH
Baxter Global
Dr. F. Köhler Chemie GmbH
Fresenius Kabi Health Care
B.Braun GmbH Melsungen

Content – Part I

- **Sedation in the ICU – „State of the Art“**
- **Volatile anaesthetics from OR to ICU**
- **Studies on Inhalational Sedation**

The “Art” of sedation



Under-sedation:
Anxiety, awareness
Fighting the ventilator
Accidental extubation
V/Q mismatch
CV stress → ischemia
Catheter displacement
PTSD

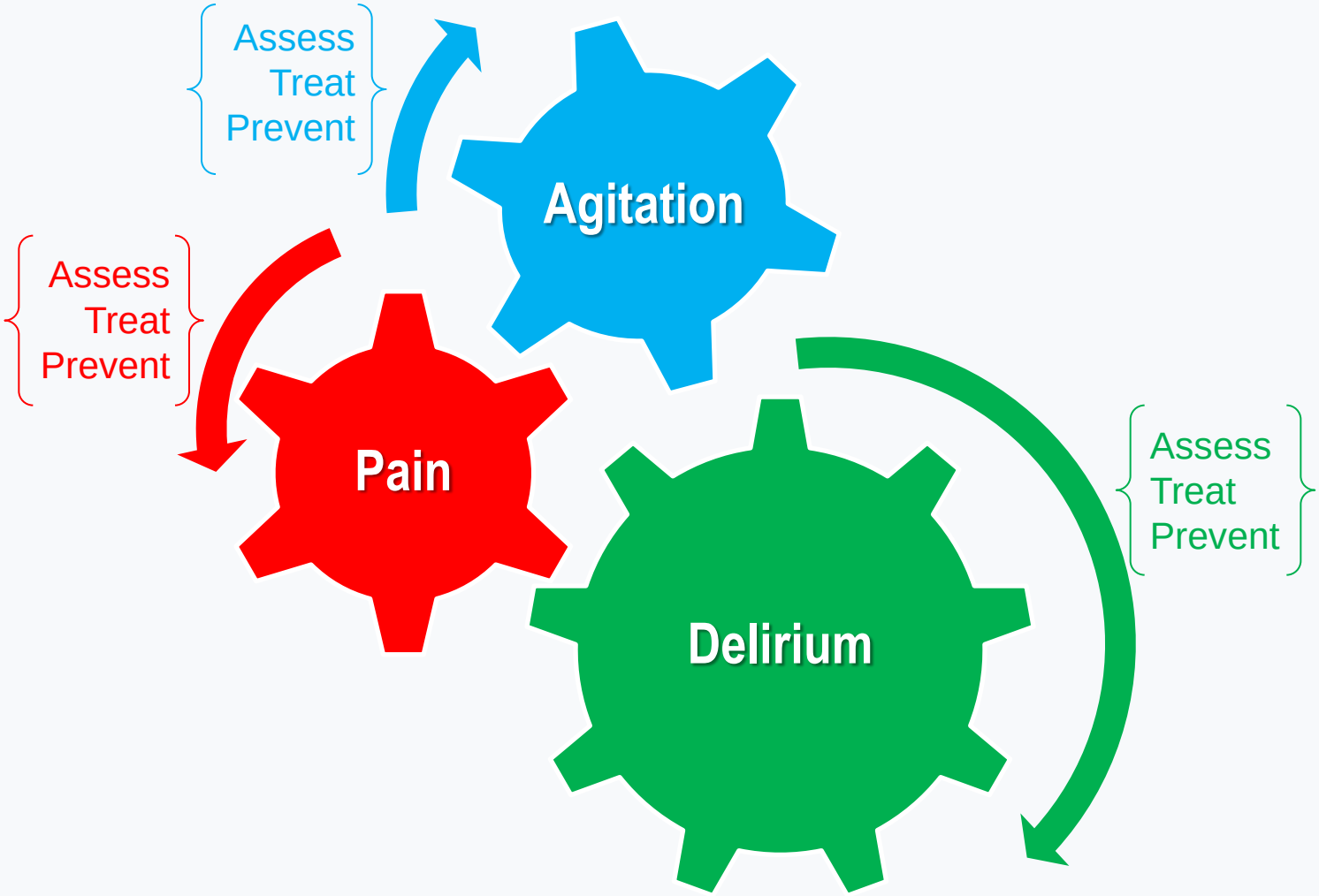
Targeted sedation with protocols → 1-year mortality↓

Over-sedation:
Prolonged ventilation
CV depression
Withdrawal syndrome
Delirium
Sleep disturbances
Ventilator-associated pneumonia
Prolonged hospital stay

Balzer F et al. Crit Care 2013; 19: 197
Strom T et al. Lancet 2010; 375: 475-80
Landoni G et al. CCM 2015; 43: 1559-68

PAD-Management

American guidelines 2013



PAD-Management

American guidelines 2013, Summary

- ✓ **Analgesia-first sedation to be used in adult mechanically ventilated ICU patients (2B)**
- ✓ **Maintaining light sedation is associated with improved clinical outcomes (shorter ventilation, shorter LOS in ICU)**
- ✓ **Sedative medicaments to be titrated to maintain lighter rather than deep sedation levels (1B)**
- ✓ **Daily interruption of sedation or light target levels of sedation in mechanically ventilated patients (1B)**
- ✓ **Sedation using non-benzodiazepine sedatives (propofol, dex) to improve outcome (2B)**
- ✓ **Routine monitoring of delirium (e.g. CAM-ICU)**
- ✓ **Early mobilization (1B)**

Ideal sedative…?

- Quick onset/offset of sedation → Short wake-up times and predictable extubation times
- Easy titration of sedation level
- No development of tolerance
- No accumulation
- No withdrawal symptoms
- No severe cardiodepressive properties
- Independance of renal or hepatic elimination

British Journal of Anaesthesia 87 (2): 186–92 (2001)

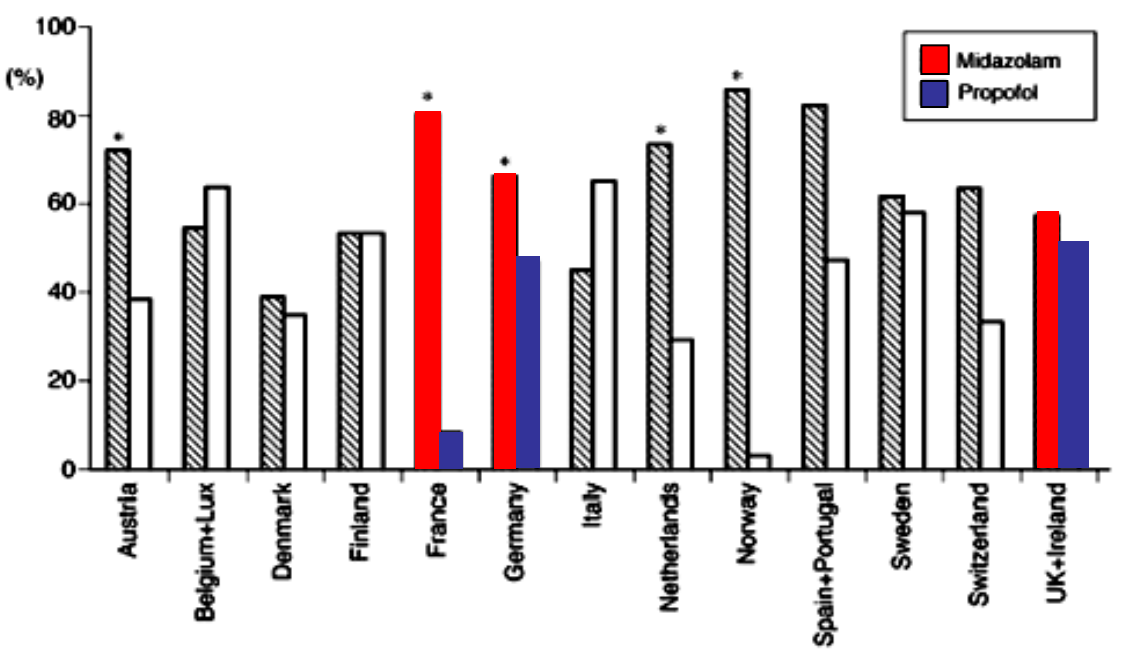
BJA

CLINICAL INVESTIGATIONS

Sedative and analgesic practice in the intensive care unit: the results of a European survey†

H. M. Soliman, C. Mélot and J.-L. Vincent*

[1]Department of Intensive Care, Erasme University Hospital, Free University of Brussels, Route de Lennik 808, B-1070 Brussels, Belgium

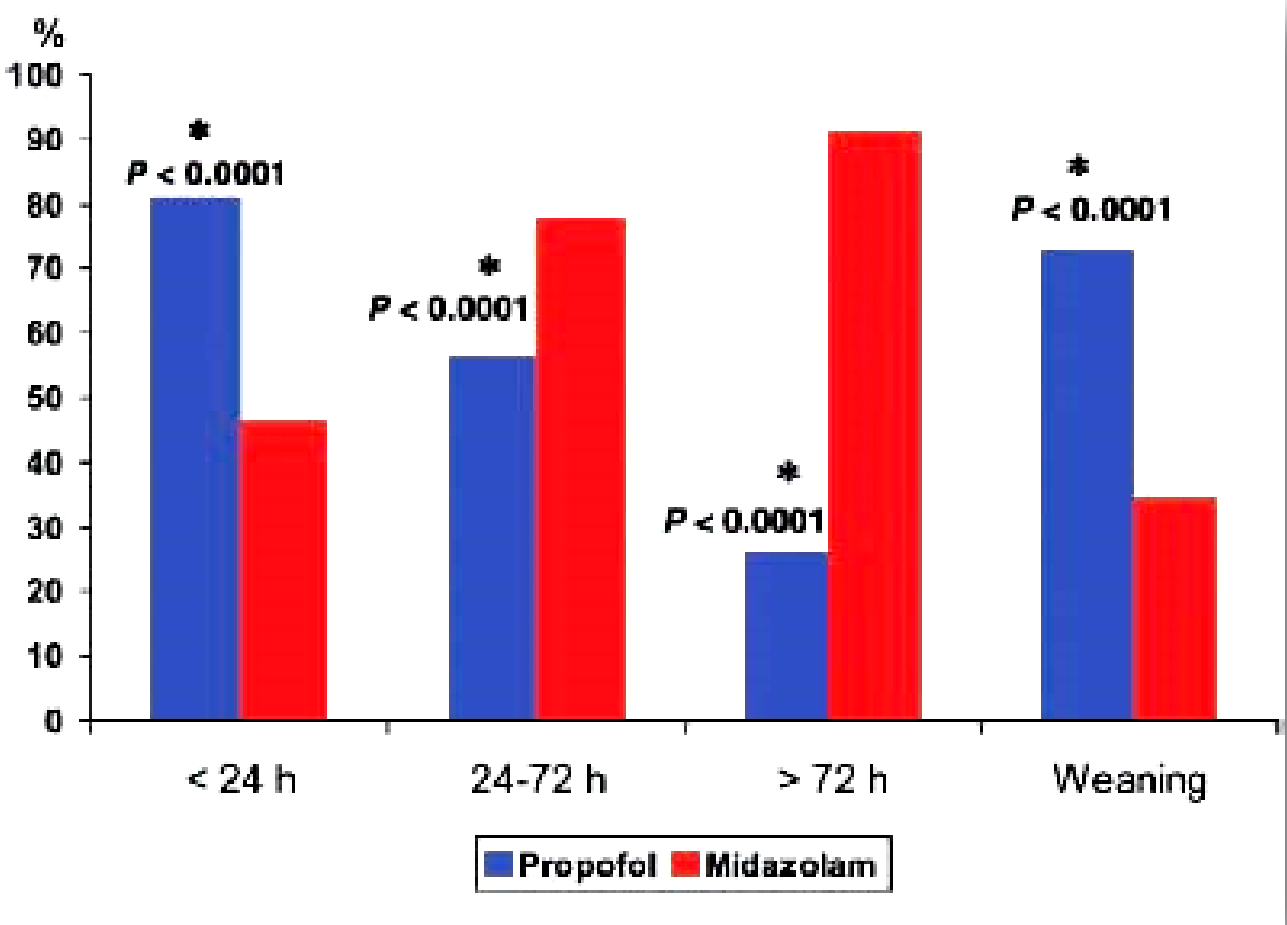


Sedative drug	Number (%)
Midazolam	408 (63)
Propofol	229 (35)
Haloperidol*	58 (9)
Clonidine	12 (1.8)
Ketamine	8 (1.2)
Flunitrazepam	6 (0.9)
Droperidol	5 (0.7)
Alfentanil	5 (0.7)
Lorazepam	3 (0.5)
Diazepam	2 (0.3)
Methohexital	2 (0.3)

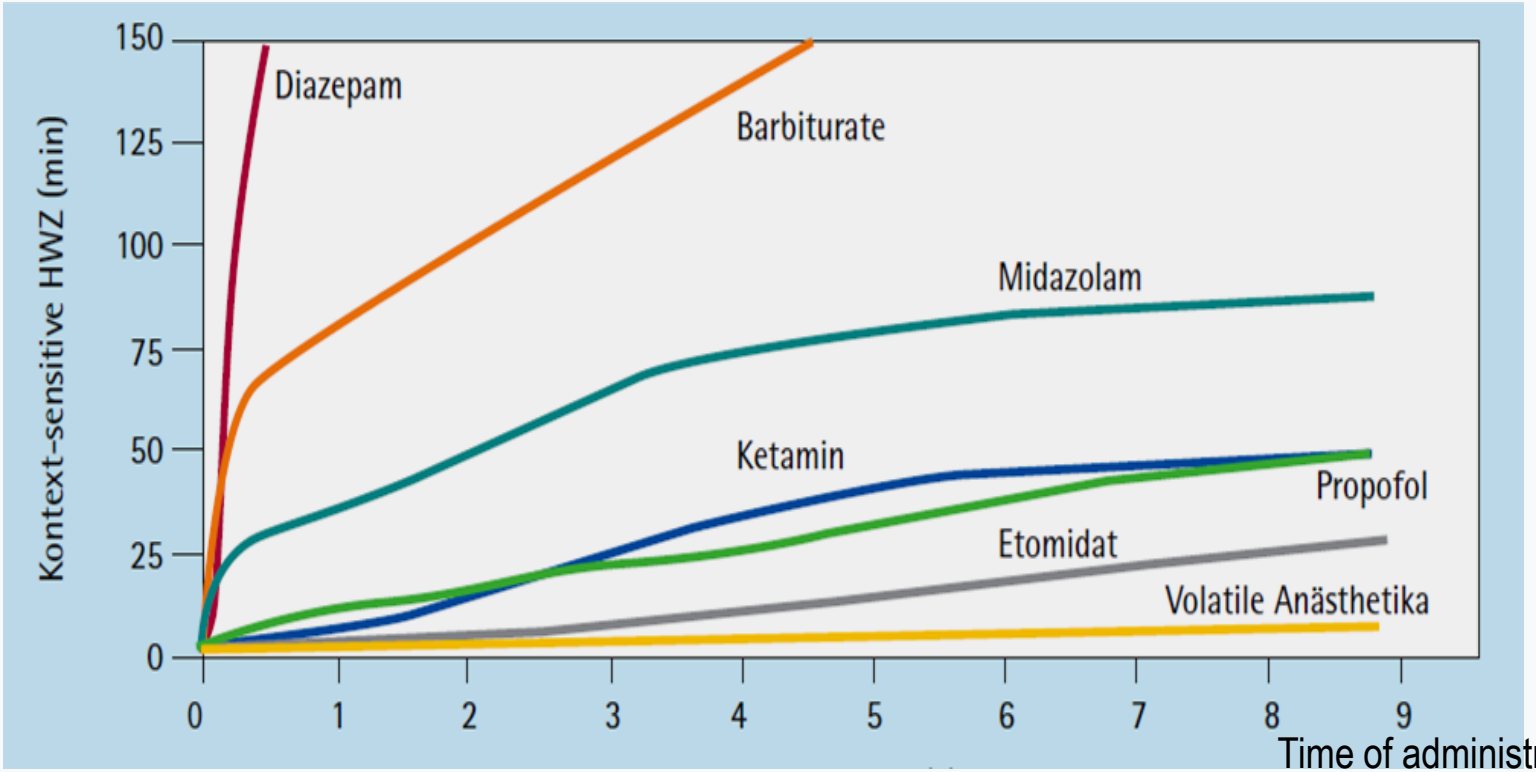
Practice of sedation and analgesia in German intensive care units: results of a national survey

Jörg Martin[1], Axel Parsch[2], Martin Franck[3], Klaus D Wernecke[4], Matthias Fischer[5] and Claudia Spies[6]

Crit Care 2005; 9: R117-123

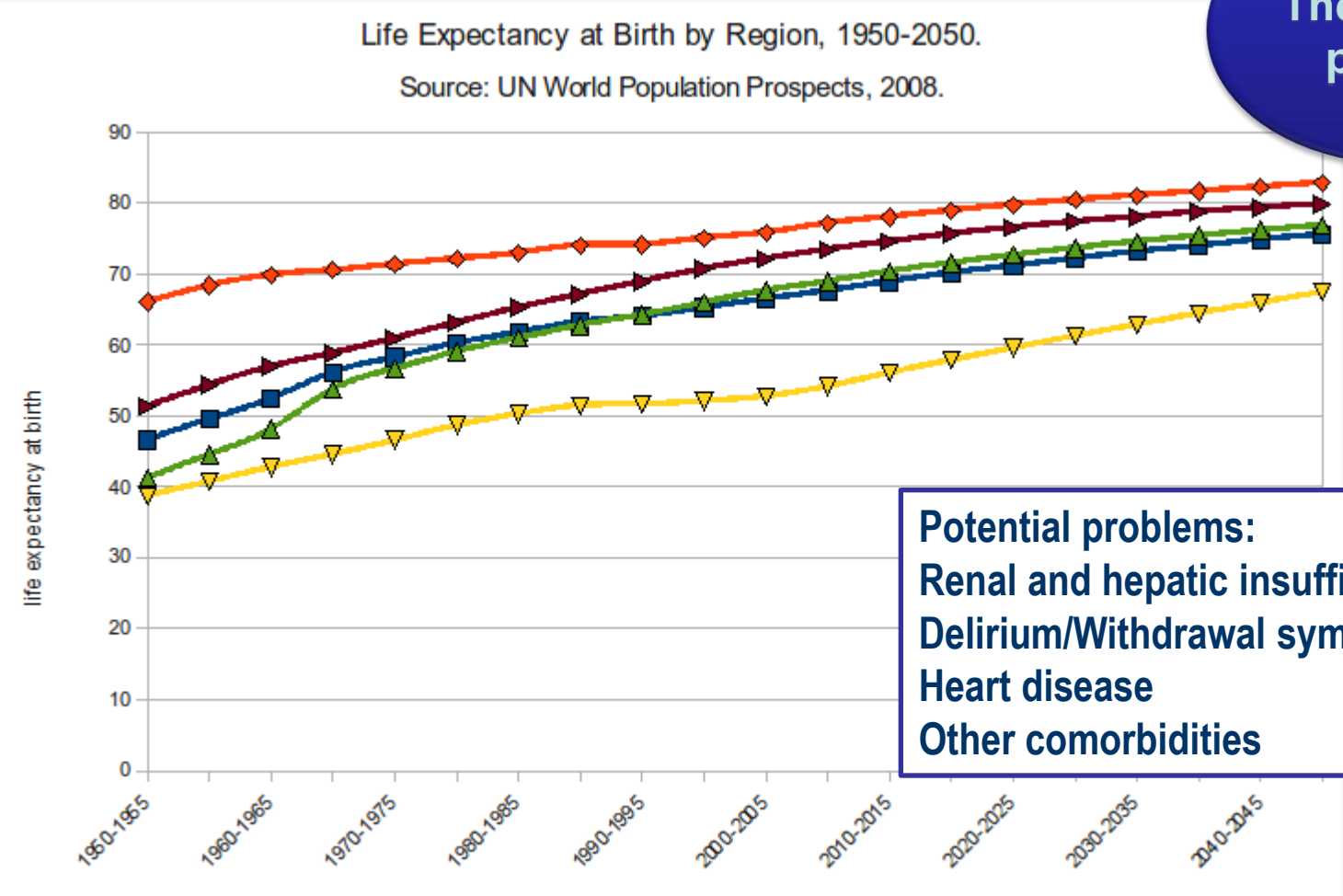


Context-sensitive half-time



Accumulation and active metabolites
Poor control of action
Tolerance and ceiling effect

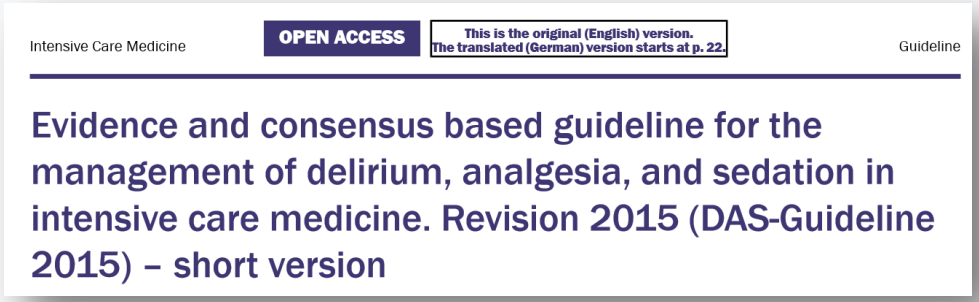
Mean life expectancy in humans



The elderly patient

Potential problems:
Renal and hepatic insufficiency
Delirium/Withdrawal symptoms
Heart disease
Other comorbidities

S3-Guidelines 2010 & 2015


Intensive Care Medicine

OPEN ACCESS

This is the original (English) version. The translated (German) version starts at p. 22.

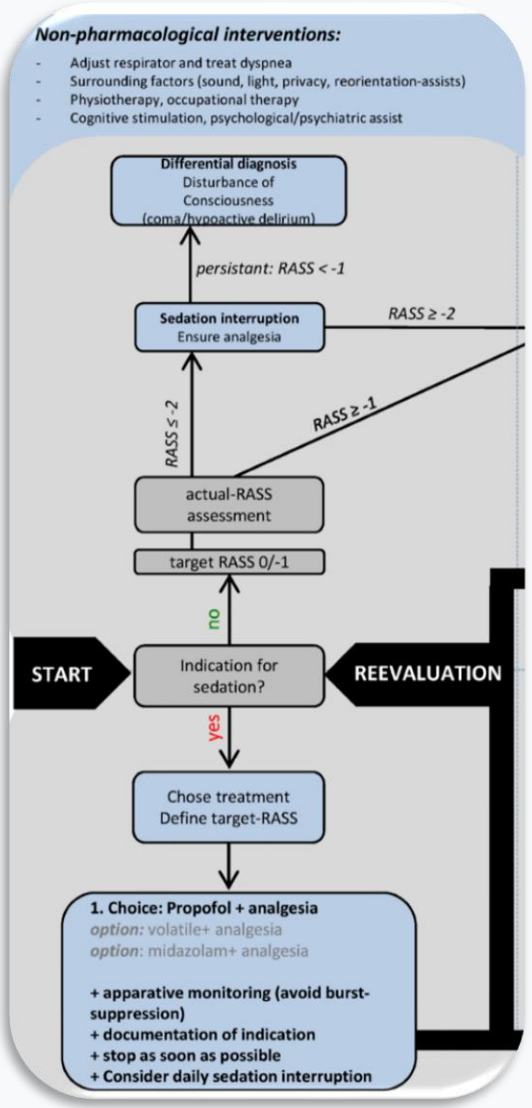
Guideline

Evidence and consensus based guideline for the management of delirium, analgesia, and sedation in intensive care medicine. Revision 2015 (DAS-Guideline 2015) – short version

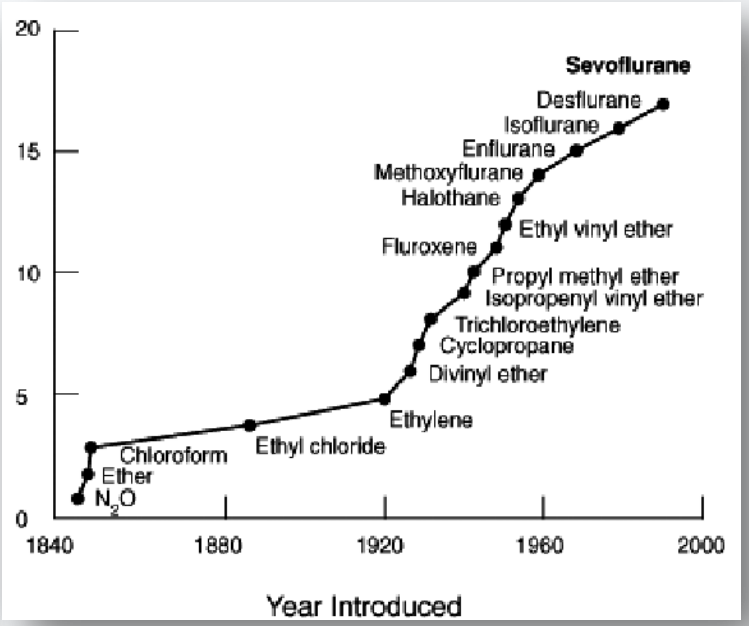
German guidelines

Inhalational sedation:

Patients who are mechanically ventilated via an endotracheal tube or tracheostomy, can be sedated inhalationally as an alternative to intravenous sedation. The inhalational sedation is achieved with volatile anaesthetics which are commonly used in general anaesthesia, but in much lower dosage.



1st Ether Anaesthesia



William T. Green Morton
1846

Classification of volatile anaesthetics

Anorganic Gases	Halogenated hydrocarbons	Halogenated ethers
• Nitrous oxide • Xenon	• Alkane: Cyclopropan • Alkene: Ethylen • Alkine: Acetylen • Alkylhalogenide: Chloroform, Halothane	• Diethylether • Halogene: Diethyl-methylether; Enflurane, Isoflurane, Sevoflurane, Desflurane

Potency and Dosage

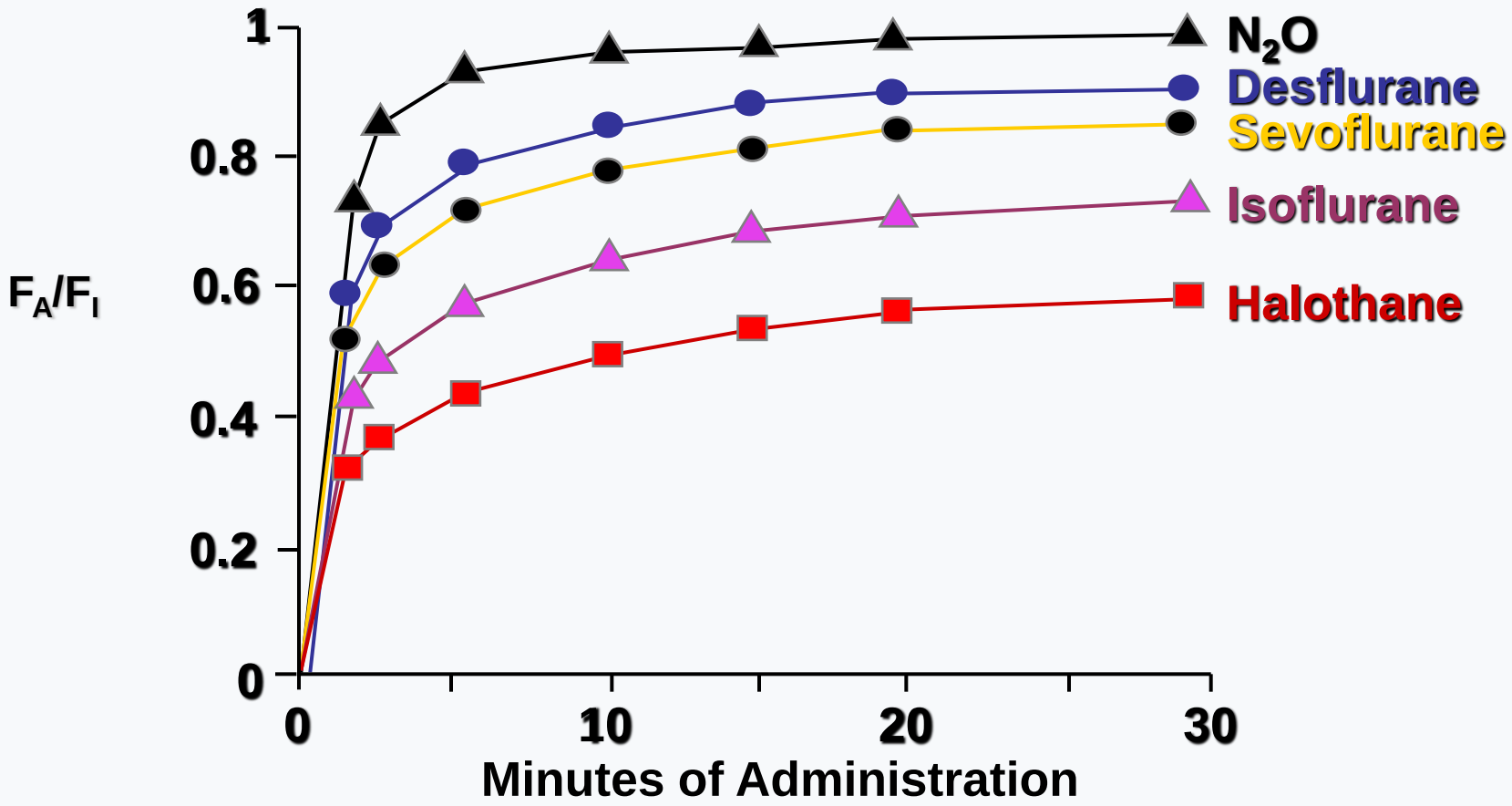
MAC = minimal alveolar concentration (in Vol%)

No defense reaction due to skin incision in 50% of probands

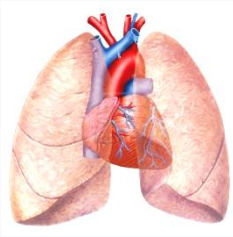
	Halothan	Isofluran	Enfluran	Sevofluran	Desfluran
MAC	0,75%	**1,28%**	1,68%	**2,05%**	**6 - 7%**

Inspired and alveolar concentration (F_A/F_I) of volatile anaesthetics

Yasuda et al. Anesth Analg 1991



Determination of gas intake: “Washin – Washout”



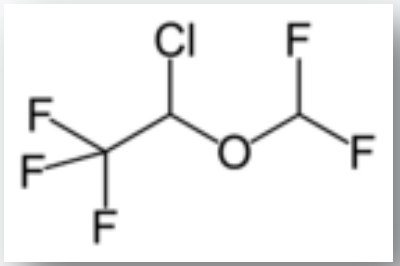
Delivery → **Inspiration** → **Alveolar** → **Arterial** → **Brain**

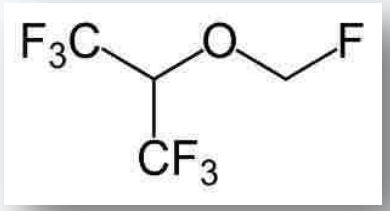
Fi: inspiratory fraction
(fresh gas flow,
concentration vaporizer)
V_{alv}: alveolar ventilation

$P_{alv} – P_{ven}$
Cardiac output
Alveolar blood flow
Lungperfusion (V/Q)
Blood solubility
(Blood/gas coefficient)

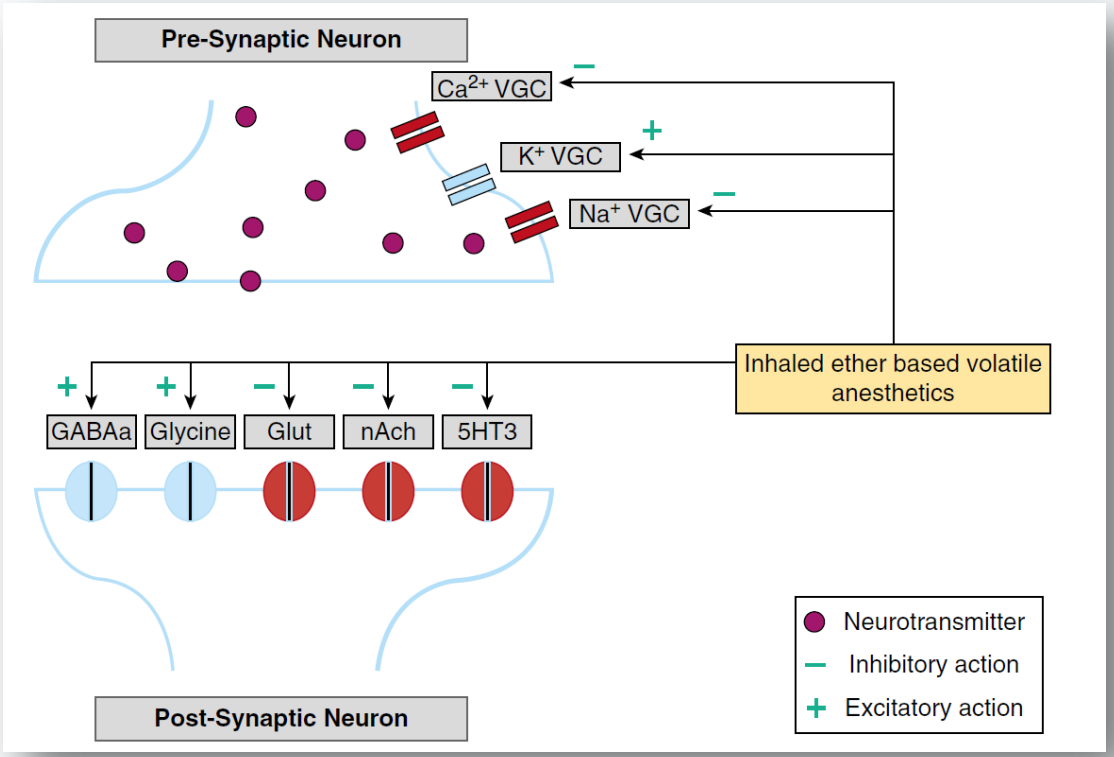
$P_{art} – Pt$
Tissue blood flow/perfuson
Blood/tissue coefficient

	ISOflurane	SEVOflurane	DESflurane
Synthesis	• 1964	• 1968	• 1985
Clin. introduction	• 1984	• 1990	• 1990
MAC	• 1,3 Vol%	• 2,05 Vol%	• 6-7 Vol%
Boiling point	• 48,5°	• 58,5°	• 22,8°
Vapour pressure	• 240	• 157	• 700
Metabolization	• 0,5%	• 2-5% • Compound A	• <0,02%



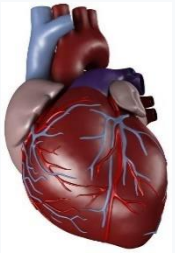


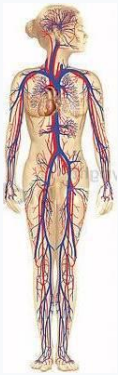
Mode of action



Campagna JA et al. N Engl J Med 2003; 348: 2110-24

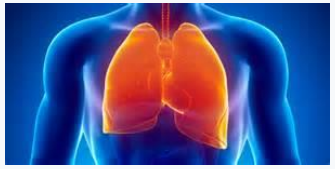
Specific side effects





Decrease in cardiac contractility (negative intropic effect)
Cardiac protection
Desflurane: tachycardia in high concentrations

Vasodilation and hypotension, reduction in systemic resistance in both arteries and venes



Respiratory depression (but early return of spontaneous breathing)
Decrease in airway resistance (potent bronchodilators)
Inhibition of hypoxic pulmonary vasoconstriction (HPV) in vivo

Inhibition of phagocytosis and production of oxygen radicals
Inhibition of NO production

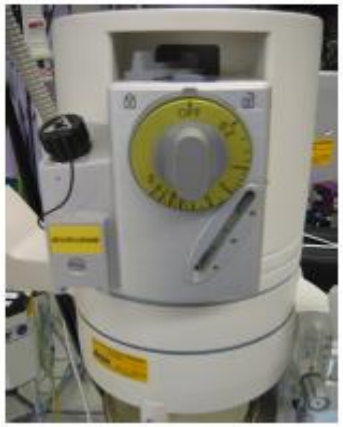
Autoimmune hepatitis (halothane >> iso > des)

Muscle relaxation, uterus relaxation

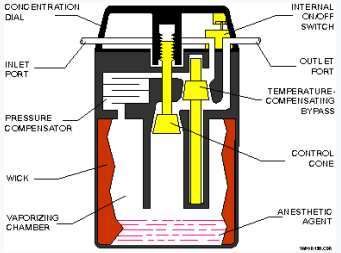
Delivery of volatile anaesthetics

Bypass-Systeme
als „Verdunster“
z.B. Dräger Vapor

Venturi-Systeme
als „Vergaser“
z.B. Siemens Vaporizer



Zumisch-Systeme als
„Heizkammervergaser“
z.B. Ohmeda TEC 6



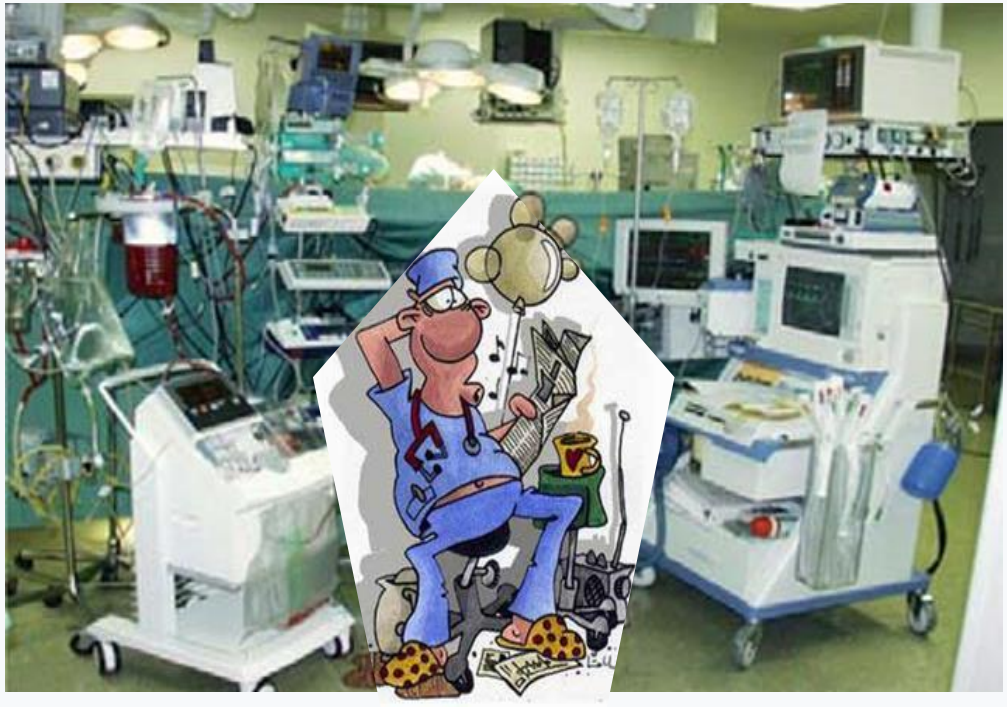
Ventilator equipment

Open: (e.g. ether mask)
Uncontrolled gas distribution (dependant on ambient airflow)

Half open: (e.g. Siemens C900; Dräger Evita)
Controlled gas distribution without rebreathing (no lime absorber)

Half closed: (e.g. Dräger Cicero EM, Dräger Julian/Primus)
Controlled gas distribution with >50% rebreathing (lime absorber within the circle system)

Closed: (e.g. Physioflex, Dräger Zeus)
Complete rebreating (after CO_2 absorption) and readmission of volatile substances to the patient



→ Good control of action and rapid change in anaesthesia depth (programmed extubation, independant from age, BMI, liver- & kidney)

→ Early spontaneous breathing

→ Bronchodilation

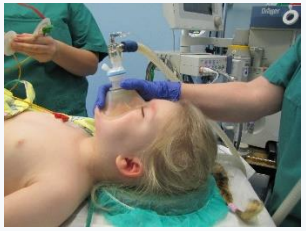
→ No postoperative breathing depression

→ Early discharge from PACU after GA…

→ Organ protection (heart, brain, kidney)

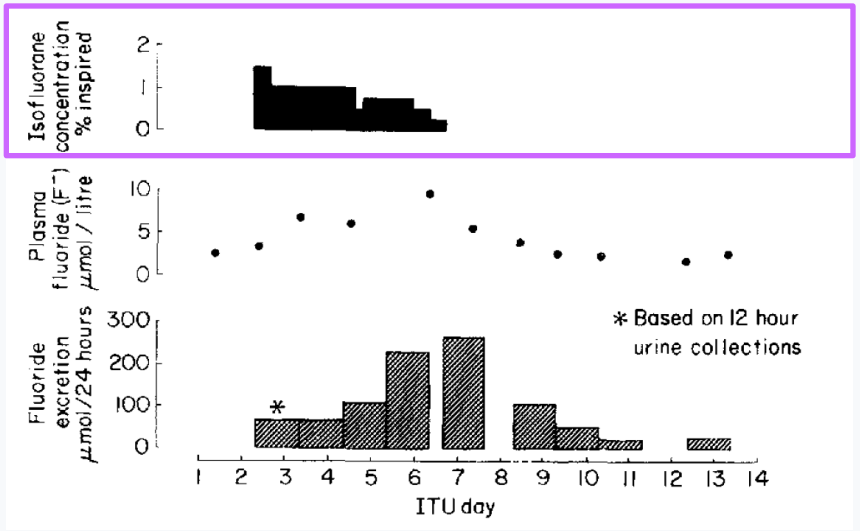
→ Intestinal function preserved

Volatile anaesthetic as *ultima ratio*



Revell S et al. Anaesthesia 1988; 43: 477-9

22-month old child
Upper airway tract infection, bronchospasm (diagnosed the last 12 mo)
Spinal dysrhaphism



Aminophylline + hydrocortisone

Intubation
Sedation with pethidine

Isoprenaline + adrenaline nebulizer

Methylprednisolone + salbutamol + adrenaline i.v. infusion

+ Isoflurane (102 h)

History

1st randomized clinical study

Kong KL et al. BMJ 1989; 298: 1277-80

	Isoflurane	Midazolam	P value
Extubation (min)	**60 (30-135)**	**195 (50-1080)**	0,0016
Number of patients (n)	14	13	
Follow commands/ Toe movement (min)	**0 (0-10)**	**0 (0-300)**	0,0167
Number of patients (n)	29	27	

Isoflurane: 0.1-0.6 Vol% vs. Midazolam: 3.1 mg/h

Duration of sedation ≤ 24 h

Why did inhalational sedation not enter the ICU?

Millane TA et al. Anaesthesia 1992; 47: 768-74

Comparison of isoflurane vs. Propofol in 24 patients (surgical/medical)
No differences in sedation quality or recovery from sedation

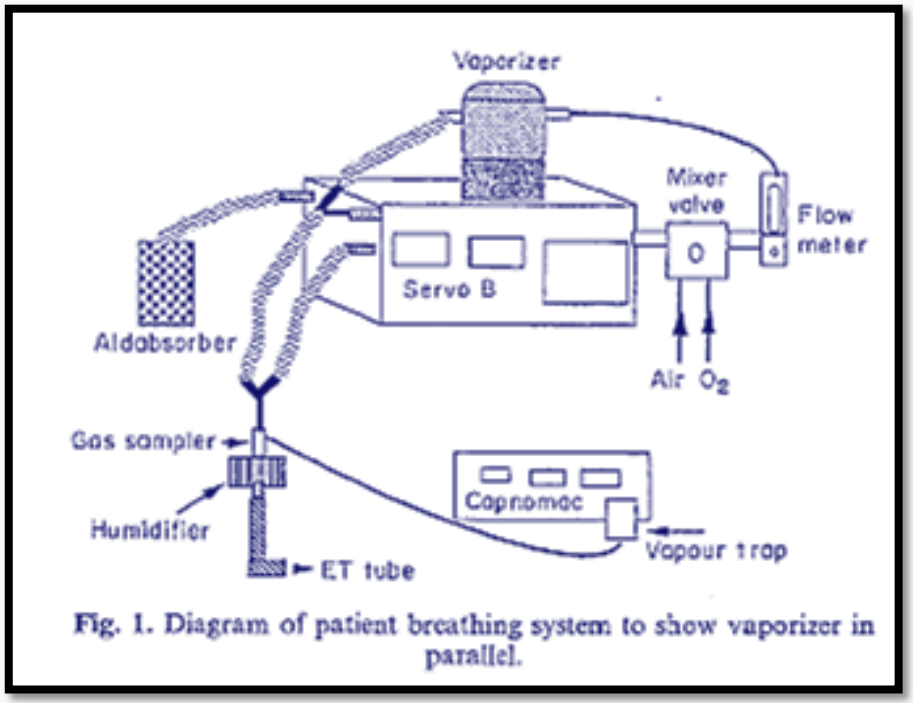


Fig. 1. Diagram of patient breathing system to show vaporizer in parallel.

Leck of administration tool → Sedation only by using anaesthesia ventilator and vapor technique

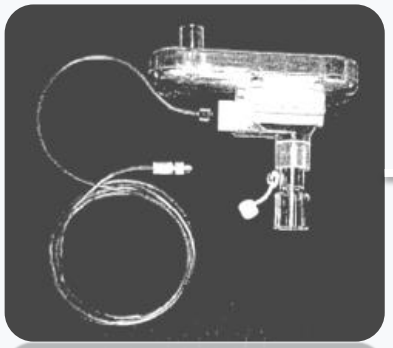
High FGF rates → high costs

Concerns of environmental pollution

History

Intraoperative use of AnaConDa

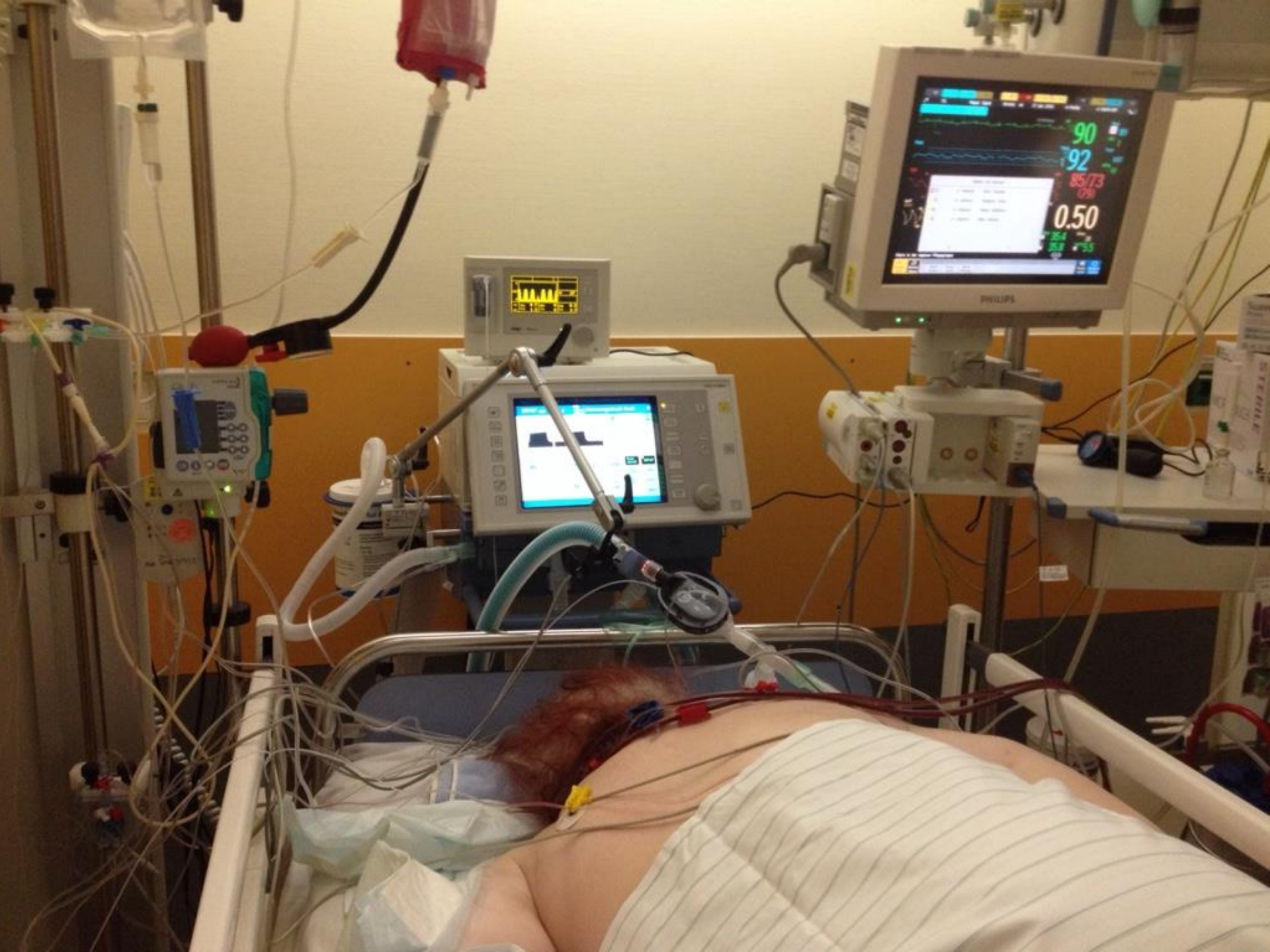
2005 Admission in Germany
02/2017 South Korea



Enlund M et al. Anaesthesia 2001; 56: 429-32
Enlund M et al. Acta Anaesth Scand 2002; 46: 506-11

Anesthetic Conserving Device (n=8) vs. Vaporizer (n=7) Intraoperative use of Isoflurane
→ 40% saving of Isoflurane with the use of AnaConDa

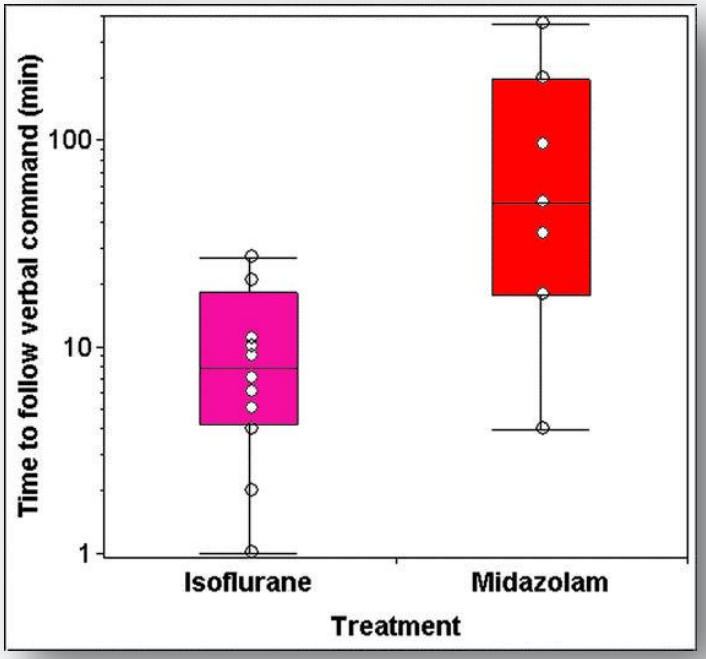
16 Patients in general anaesthesia with Sevoflurane
→ Consumption of volatile anaesthetic was shown comparable to a vaporizer technique with a fresh gas flow of 1.5 l/min using the AnaConDa


90
92
0.50
PHILIPS

Prolonged isoflurane sedation of intensive care unit patients with the Anesthetic Conserving Device

Peter V. Sackey, MD; Claes-Roland Martling, MD, PhD; Fredrik Granath, PhD; Peter J. Radell, MD, PhD

Crit Care Med 2004; 32: 2241-6



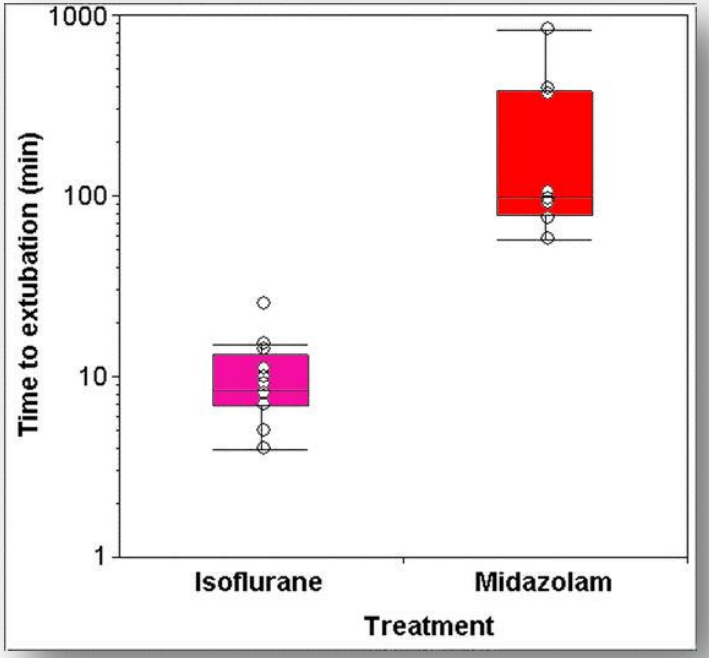
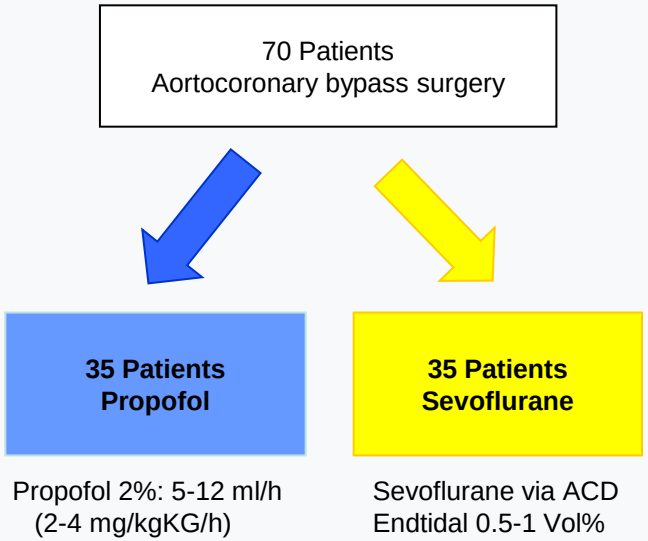


Figure 3. Box plot of time to extubation from termination of sedation in study groups.

Short-term sevoflurane sedation using the Anaesthetic Conserving Device after cardiothoracic surgery

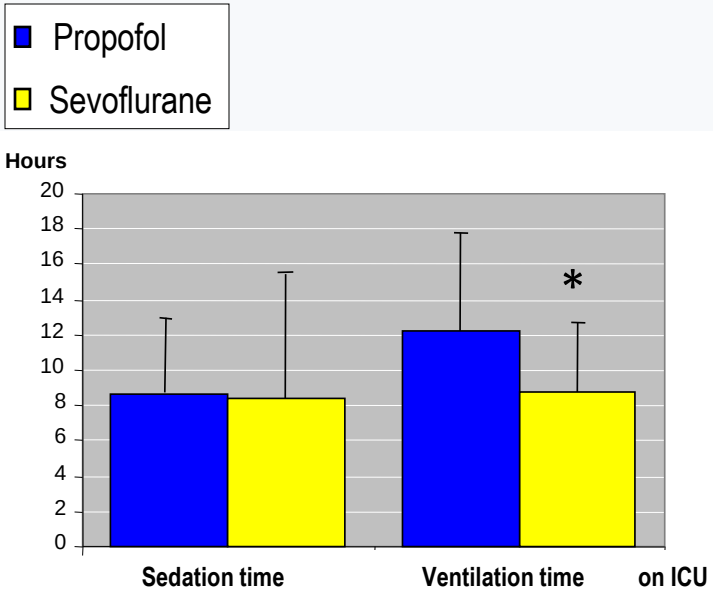
Röhm KD et al. Int Care Med 2008; 34: 1683-9



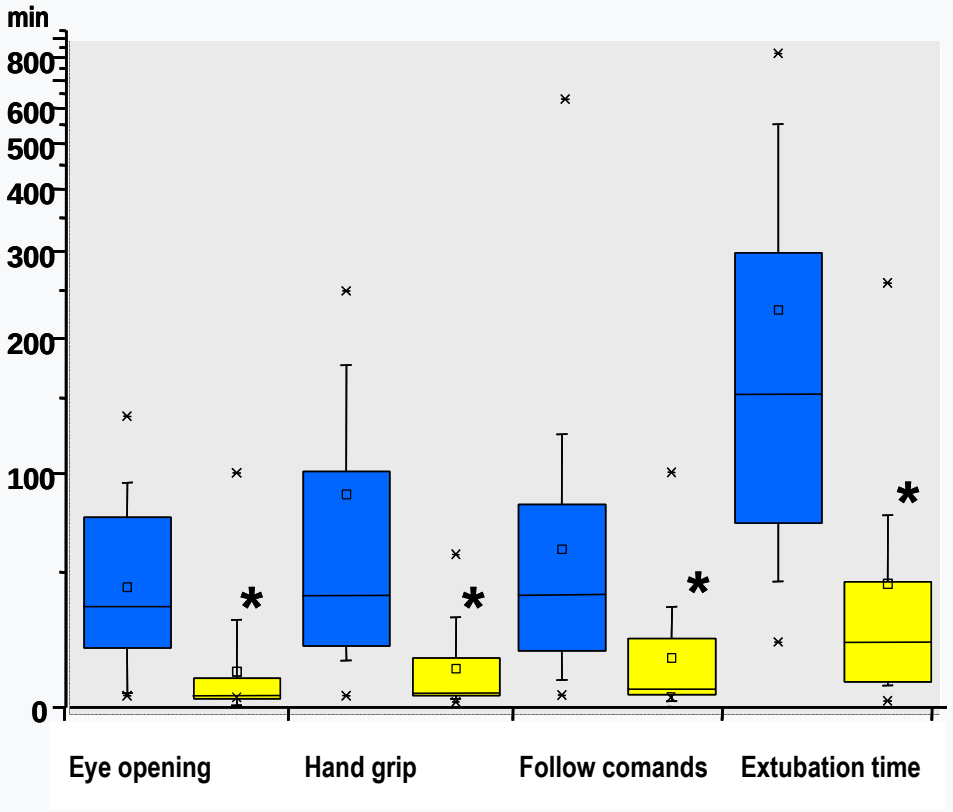
	Sevoflurane ($n = 35$)	Propofol ($n = 35$)
Age (years)	64.6 ± 8.6	66.4 ± 8.0
Height (cm)	171.7 ± 8.7	169.5 ± 10.2
Weight (kg)	82 ± 16	82 ± 17
Gender (male/female)	28/7	25/10
Coronary heart disease, (1/2/3, *n*)	2/6/27	1/8/26
Main stem stenosis (>50%) (*n*)	8	10
Valvular defect (*n*)	10	7
Ejection fraction (%)	58 ± 11	57 ± 13
Surgical procedures		
Left intrathoracic artery graft (*n*)	31	35
Venous grafts (1/2/3) (*n*)	13/18/4	13/19/3
Valve replacement (*n*)	4	3
Time of surgery (min)	144 ± 42	139 ± 41
Cardiopulmonary bypass time (min)	68 ± 26	61 ± 22
Aortic clamping (min)	41 ± 18	37 ± 10
Intraoperative anaesthetic agents		
Sufentanil (µg)	350 ± 147	330 ± 116
Midazolam (mg)	12.1 ± 3.2	10.3 ± 4.8
Pancuronium (mg)	10.2 ± 5.1	11.8 ± 3.2

Data are presented as mean and standard deviation, or number

Röhm KD et al. Int Care Med 2008; 34: 1683-9



*p<0,05 vs. Propofol



Sevoflurane consumption:
Syringe pump rate 2.5-5 ml/h
Fet 0.45-1 Vol%

Malcie Mesnil
Xavier Capdevila
Sophie Bringuier
Pierre-Olivier Trine
Yoan Falquet
Jonathan Charbit
Jean-Paul Roustan
Gerald Chanques
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

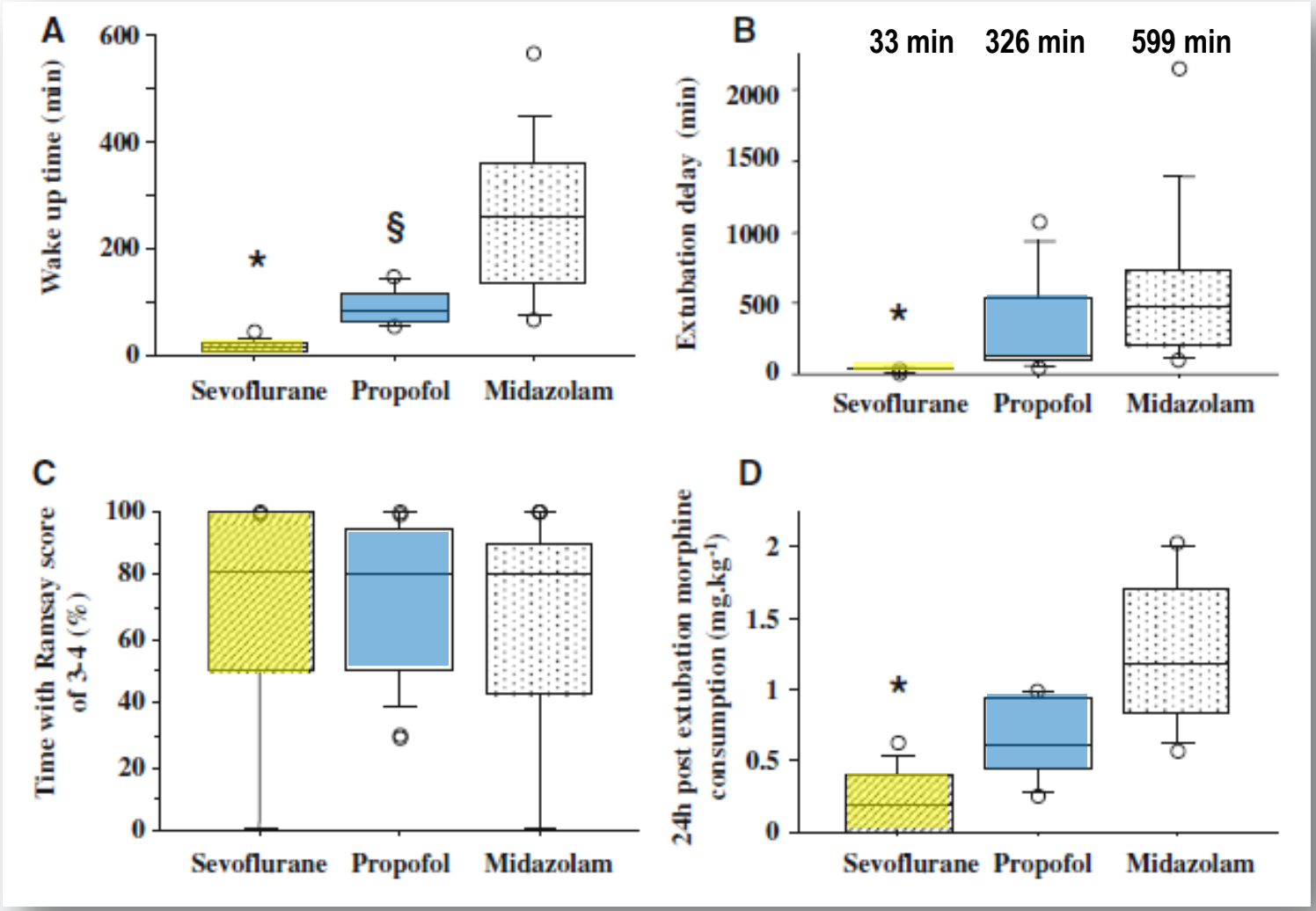
60 Patients
(Trauma, Pneumonia)

47 Patients

Remifentanil 0.15 µg/kg/min

Sevoflurane n=19	Propofol n=14	Midazolam n=14
• 2-6 ml/h • 0.6 ± 0.1 Vol%	• 2 mg/kg/h	• 0.1 mg/kg/h

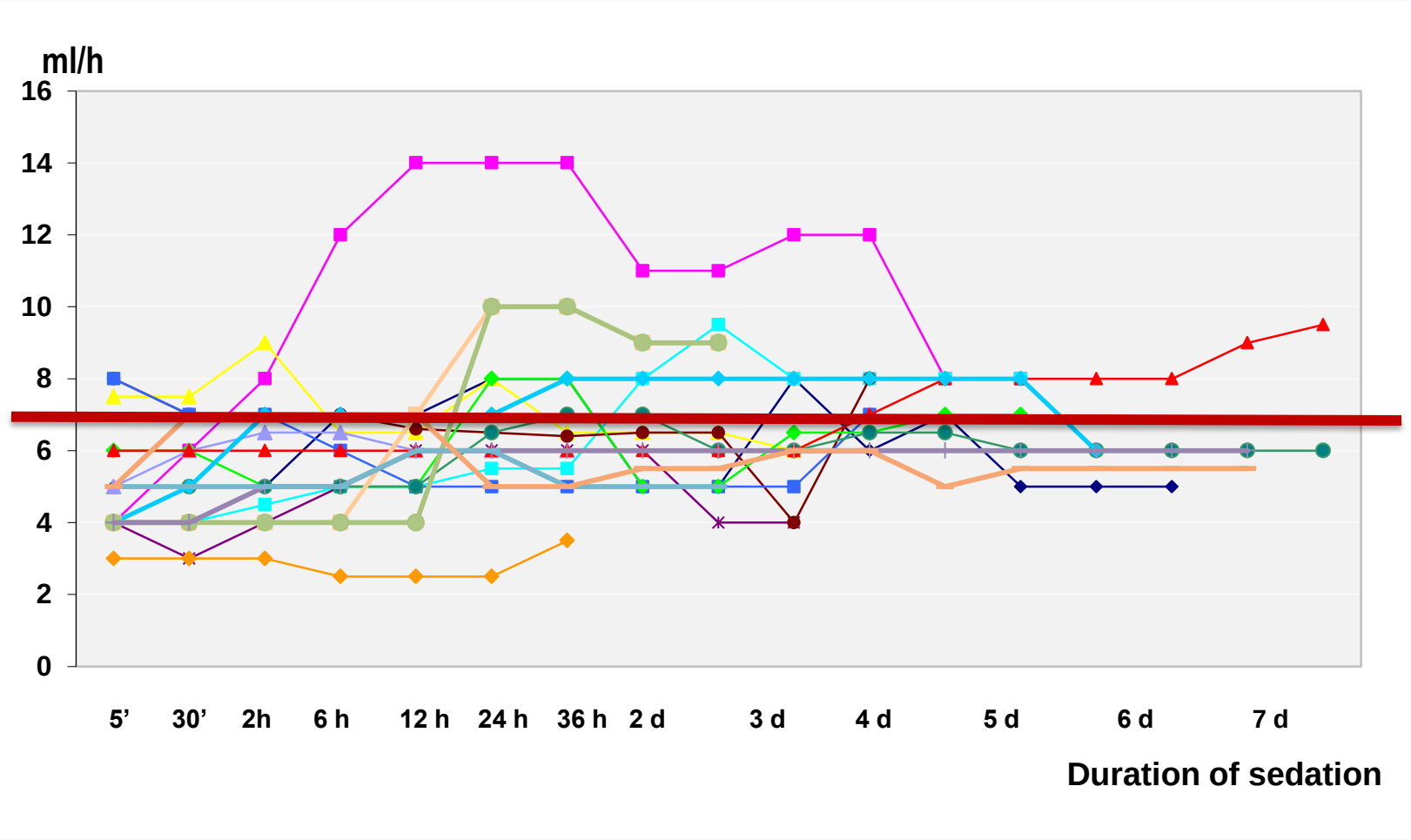
APACHE II	21 [15–25]	28 [21–31]	18 [13–22]
SAPS II	21 [16–28]	25 [22–37]	24 [18–28]
PaO_2/FiO_2 (mmHg)	261 [205–345]	253 [215–360]	295 [263–350]
Duration of sedation (h)	50 [39–71]	57 [35–89]	50 [38–71]
Duration of invasive mechanical ventilation (h)	51 [44–74]	61 [41–66.5]	58 [52–74]
ICU stay (days)	10 [5–16]	12 [7–19]	12 [9–17]


A
Wake up time (min)
600
400
200
0
*
§
Sevoflurane
Propofol
Midazolam
B
33 min
326 min
599 min
Extubation delay (min)
2000
1500
1000
500
0
*
Sevoflurane
Propofol
Midazolam
C
Time with Ramsay score of 3-4 (%)
100
80
60
40
20
0
Sevoflurane
Propofol
Midazolam
D
24h post extubation morphine consumption (mg.kg-1)
2
1.5
1
0.5
0
*
Sevoflurane
Propofol
Midazolam

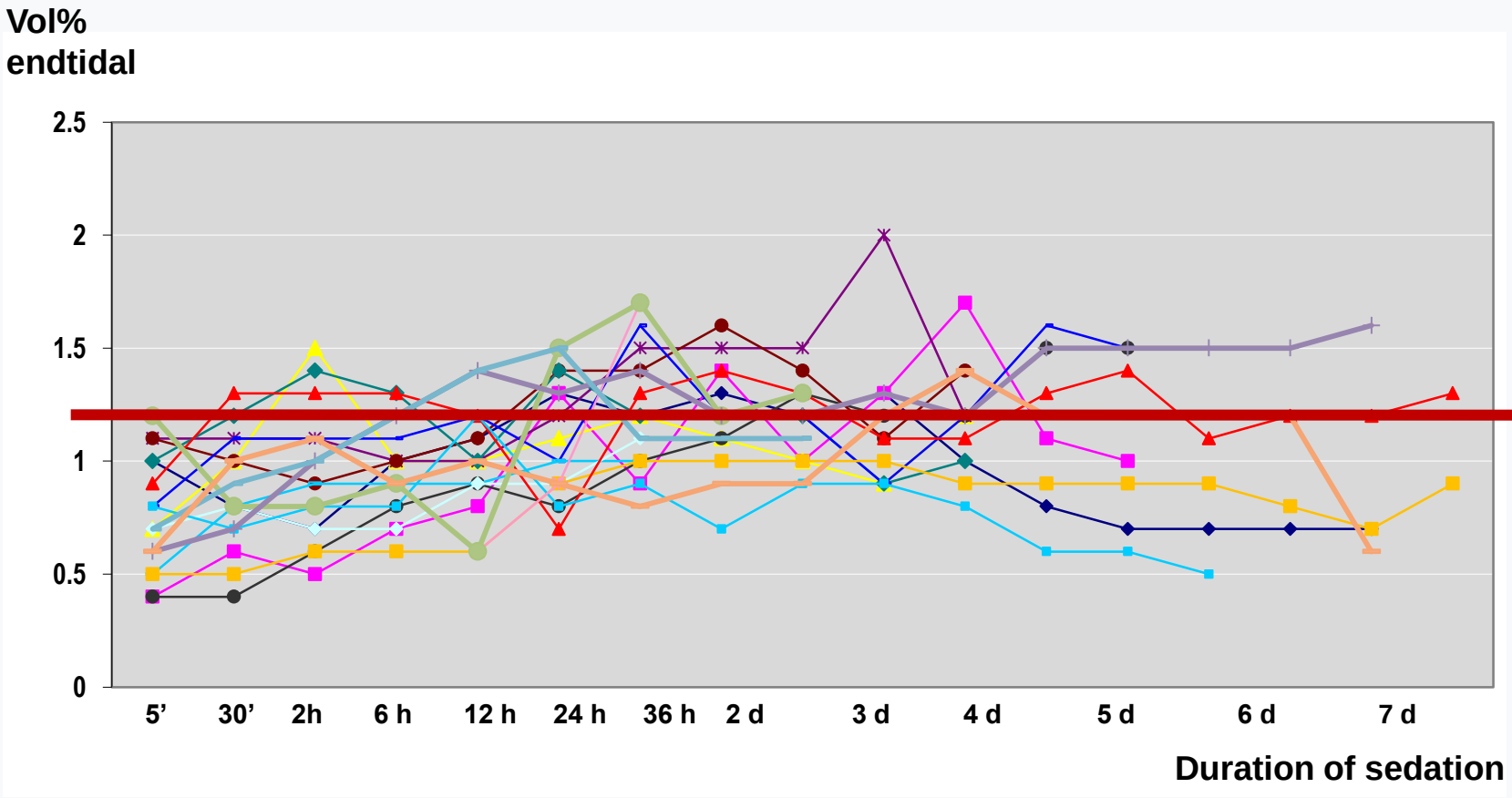
*p < 0.05

Prolonged Inhalational sedation using Sevoflurane

Röhm KD et al. Adv Anaesth Crit Care 2009; 1 (2): 60-3



Röhm KD et al. Adv Anaesth Crit Care 2009; 1 (2): 60-3



0.8-1.5 Vol% endtidal
(≈ 0.4-0.8 MAC)

Metaanalysis: Advantage in extubation time

Landoni G et al. J Cardiothor Vasc Anesth 2016; 4: 1005-14

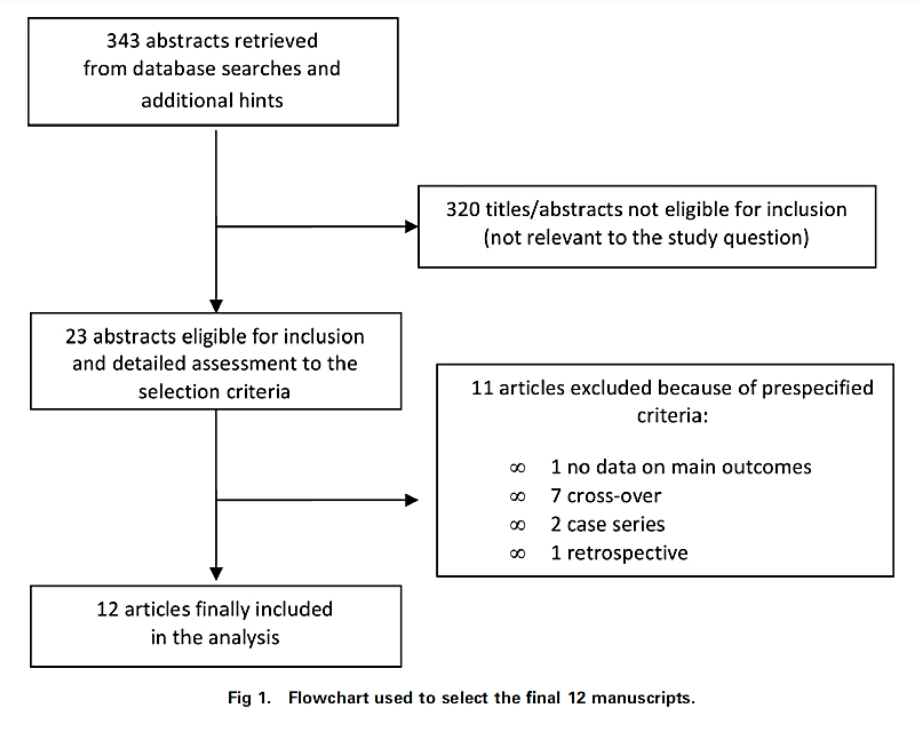
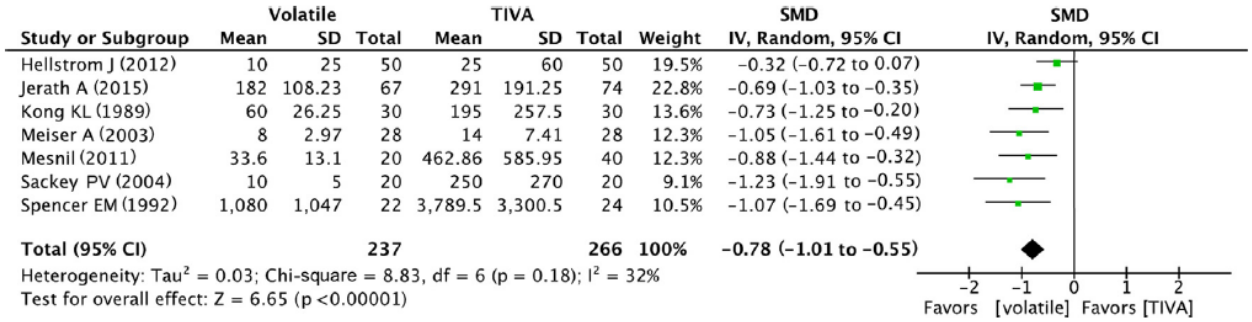


Fig 1. Flowchart used to select the final 12 manuscripts.

Inclusion of any randomized controlled trial on volatile agents in the ICU until 01.06.2015

12 Studies = 934 patients

Extubation time

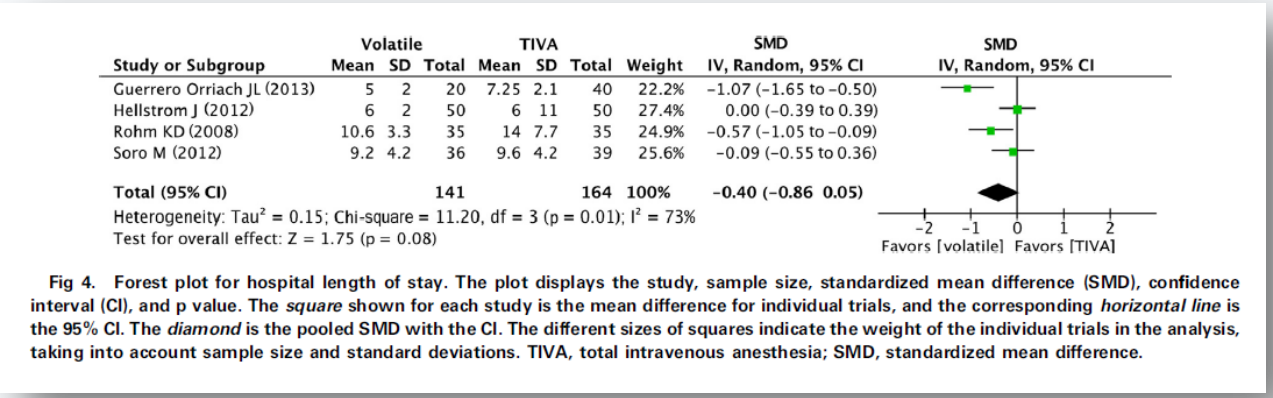


Study or Subgroup	Volatile Mean	Volatile SD	Volatile Total	TIVA Mean	TIVA SD	TIVA Total	Weight	SMD IV, Random, 95% CI
Hellstrom J (2012)	10	25	50	25	60	50	19.5%	−0.32 (−0.72 to 0.07)
Jerath A (2015)	182	108.23	67	291	191.25	74	22.8%	−0.69 (−1.03 to −0.35)
Kong KL (1989)	60	26.25	30	195	257.5	30	13.6%	−0.73 (−1.25 to −0.20)
Meiser A (2003)	8	2.97	28	14	7.41	28	12.3%	−1.05 (−1.61 to −0.49)
Mesnil (2011)	33.6	13.1	20	462.86	585.95	40	12.3%	−0.88 (−1.44 to −0.32)
Sackey PV (2004)	10	5	20	250	270	20	9.1%	−1.23 (−1.91 to −0.55)
Spencer EM (1992)	1,080	1,047	22	3,789.5	3,300.5	24	10.5%	−1.07 (−1.69 to −0.45)
Total (95% CI)			**237**			**266**	**100%**	**−0.78 (−1.01 to −0.55)**

Heterogeneity: $Tau^2 = 0.03$; Chi-square = 8.83, df = 6 (p = 0.18); $I^2 = 32\%$
Test for overall effect: Z = 6.65 (p <0.00001)

Fig 2. Forest plot for time to extubation. The plot displays the study, sample size, standardized mean difference (SMD), confidence interval (CI), and p value. The *square* shown for each study is the mean difference for individual trials, and the corresponding *horizontal line* is the 95% CI. The *diamond* is the pooled SMD with the CI. The different sizes of squares indicate the weight of the individual trials in the analysis, taking into account sample size and standard deviations. TIVA, total intravenous anesthesia.

Hospital LOS



Study or Subgroup	Volatile Mean	Volatile SD	Volatile Total	TIVA Mean	TIVA SD	TIVA Total	Weight	SMD IV, Random, 95% CI
Guerrero Orriach JL (2013)	5	2	20	7.25	2.1	40	22.2%	−1.07 (−1.65 to −0.50)
Hellstrom J (2012)	6	2	50	6	11	50	27.4%	0.00 (−0.39 to 0.39)
Rohm KD (2008)	10.6	3.3	35	14	7.7	35	24.9%	−0.57 (−1.05 to −0.09)
Soro M (2012)	9.2	4.2	36	9.6	4.2	39	25.6%	−0.09 (−0.55 to 0.36)
Total (95% CI)			**141**			**164**	**100%**	**−0.40 (−0.86 0.05)**

Heterogeneity: $Tau^2 = 0.15$; Chi-square = 11.20, df = 3 (p = 0.01); $I^2 = 73\%$
Test for overall effect: Z = 1.75 (p = 0.08)

Fig 4. Forest plot for hospital length of stay. The plot displays the study, sample size, standardized mean difference (SMD), confidence interval (CI), and p value. The *square* shown for each study is the mean difference for individual trials, and the corresponding *horizontal line* is the 95% CI. The *diamond* is the pooled SMD with the CI. The different sizes of squares indicate the weight of the individual trials in the analysis, taking into account sample size and standard deviations. TIVA, total intravenous anesthesia; SMD, standardized mean difference.

No differences in LOS or mortality
Slight improvement of cognitive recovery and memory scores

Safety and Efficacy of Volatile Anesthetic Agents Compared With Standard Intravenous Midazolam/Propofol Sedation in Ventilated Critical Care Patients: A Meta-analysis and Systematic Review of Prospective Trials

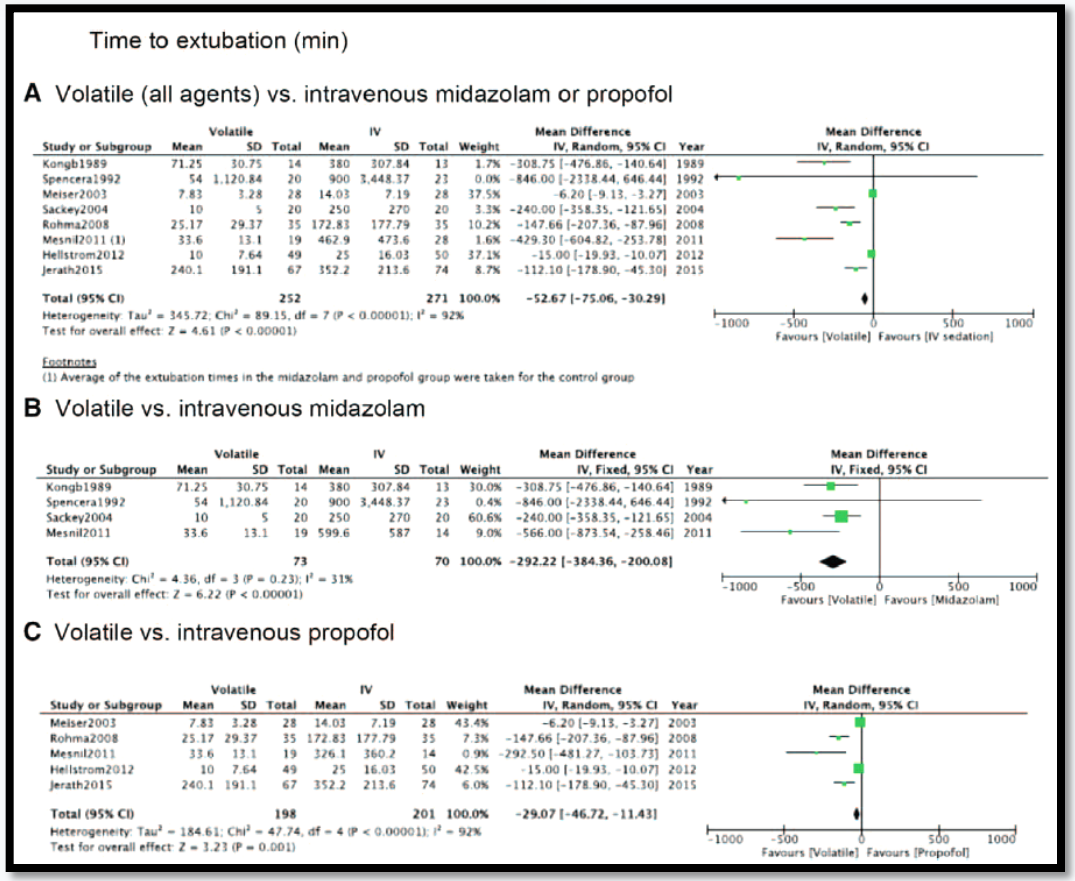
Angela Jerath, FRCPC, FANZCA, MBBS, BSc,* Jonathan Panckhurst, MBChB,† Matteo Parotto, PhD, MD,* Nicholas Lightfoot, FANZCA, MBChB,† Marcin Wasowicz, PhD, MD,* Niall D. Ferguson, FRCPC, MSc,‡ Andrew Steel, FRCPC, FFICM, FRCA, MBBS, BSc,* and W. Scott Beattie, PhD, FRCPC*

Anesth Analg 2016;
DOI 10.1213/ANE.0000000000001634

15 Trials included

8 trials showed reduction in extubation time and duration of mechanical ventilation

No differences in LOS, adverse events, death



Survival after long-term isoflurane sedation as opposed to intravenous sedation in critically ill surgical patients

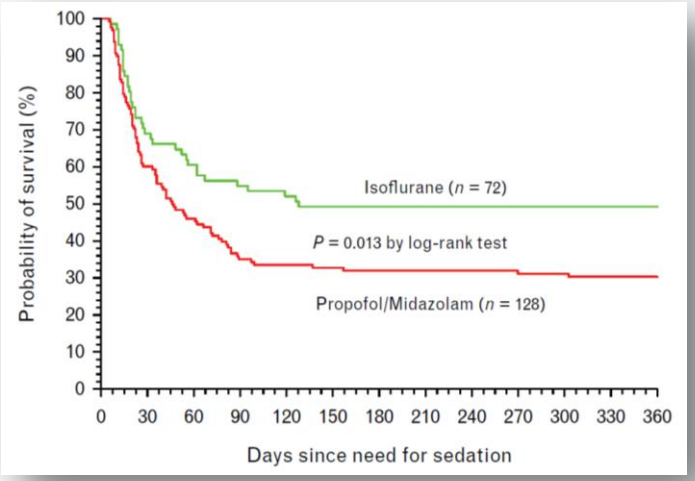
Retrospective analysis

Martin Bellgardt, Hagen Bomberg, Jenny Herzog-Niescery, Burkhard Dasch, Heike Vogelsang, Thomas P. Weber, Claudia Steinfort, Waldemar Uhl, Stefan Wagenpfeil, Thomas Volk and Andreas Meiser

Eur J Anaesthesiol 2016; 33: 6-13

Retrospective Analysis 2005-2010
Mechanical ventilation >96 h

369 patients studied → 200 included
→ 72 isoflurane and 128 propofol/midazolam

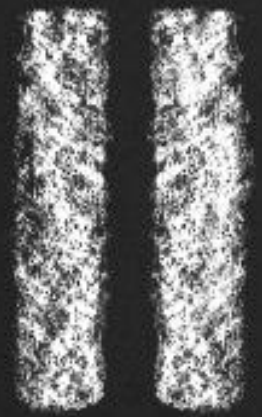


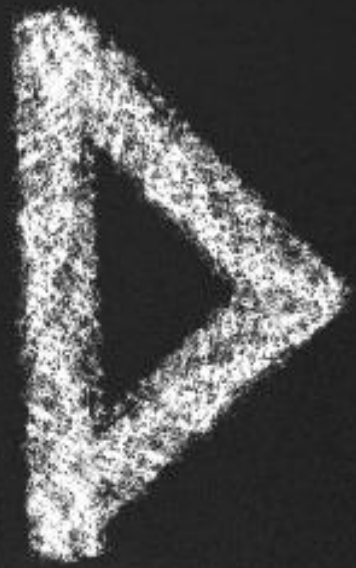
	Isoflurane (*n* = 72)	Propofol/Midazolam (*n* = 128)	*P*
Ventilation			
Invasive ventilation (h)	506 ± 354	431 ± 377	0.17
Ventilator-free days at 30 days (days)	7.4 ± 9.5	7.7 ± 10.4	0.81
Ventilator-free days at 60 days (days)	32.5 ± 29.2	23.2 ± 28.2	0.03
Length of stay			
In ICU (days)	30 ± 20	26 ± 20	0.19
In hospital (days)	60 ± 39	48 ± 39	0.08
Hospital-free days at 90 days (days)	14.7 ± 22.2	13.7 ± 13.4	0.77
Hospital-free days at 180 days (days)	62.1 ± 59.5	44.1 ± 64.8	0.04
Mortality			
Hospital mortality (%)	29 (40)	81 (63)	0.005
365-day mortality (%)	36 (50)	89 (70)	0.013

Data are numbers (%) and for quantitative data, mean ± standard deviation. A *P* value <0.05 was considered as statistically significant.

Summary- Part I

- Inhalational sedation is used since the 80ies
- Volatile anaesthetics have ideal sedative properties
- AnaConDa is the 1st tool to easily administer volatile anaesthetics in the ICU
- Shorter and predictable extubation time
- Reduction in long-term mortality

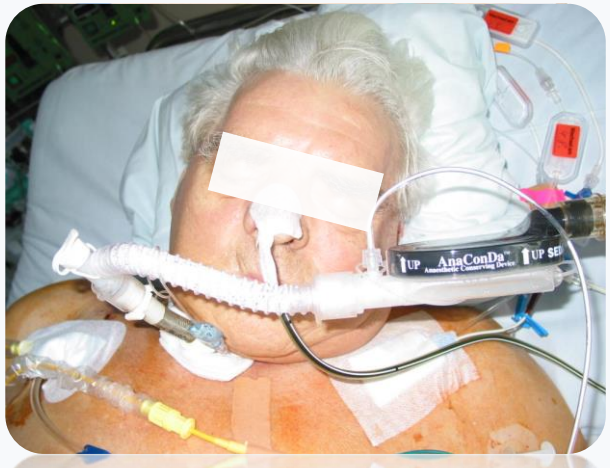




PAUSE PLAY

Content – Part II

- **Indications of inhalational sedation**
- **Neuro & Cardiac protection**
- **ARDS**
- **Paediatrics**
- **Specials…**



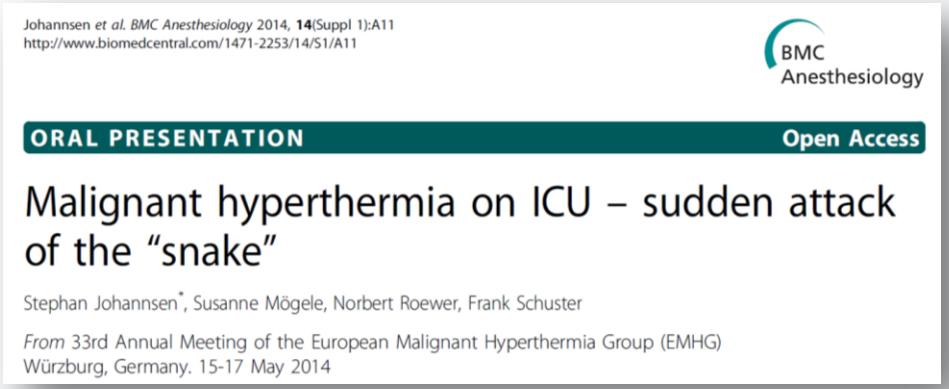
Indications for Inhalational Sedation

NO Inhalational Sedation for which patient group…???

Broncho-pleural fistula (Leakage from the airway)

Muscle disease (muscle dystrophia, atrophia)

History of Malignant hyperthermia



Johannsen *et al. BMC Anesthesiology* 2014, **14**(Suppl 1):A11
http://www.biomedcentral.com/1471-2253/14/S1/A11

BMC Anesthesiology

ORAL PRESENTATION Open Access

Malignant hyperthermia on ICU – sudden attack of the "snake"

Stephan Johannsen*, Susanne Mögele, Norbert Roewer, Frank Schuster

From 33rd Annual Meeting of the European Malignant Hyperthermia Group (EMHG)
Würzburg, Germany. 15-17 May 2014

59-year male

Persistent lumbalgia

Increasing dysnea

ICU admission

Intubation

Bilateral pulmonary infiltrates

Influenza pneumonia?

Initial i.v. sedation with propofol and sufentanil

Antibiotics: moxiflocaxin, piperacillin-tazobactam

Additional sedation necessary on day 4

Sevoflurane via AnaConDa

After 5 h:

Haemodynamic instability, severe acidosis, rapid increase in body temperature

Highly elevated creatine kinase and myoglobine levels, rhabdomyolysis

Discontinuation of sevoflurane

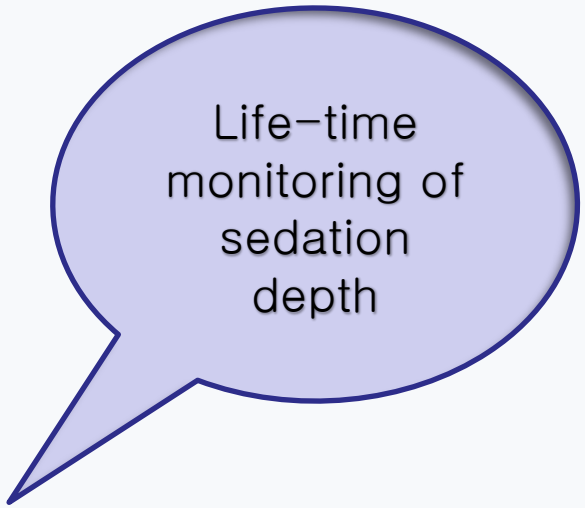
Dantrolene

Gradually improvement in haemodynamic and metabolic situation

Discharge from ICU on day 17

Muscle biopsy after 9 monts (positive for MH)

Indications & Benefits…



- **Consider any patient who needs sedation**

  (most reasonable in sedation > 12 h)
- **Light and deep sedation by adjustment of MAC/inspired VA**
- **Deep and/or difficult sedation (abuse of alcohol/drugs)**
- **Obese patients**

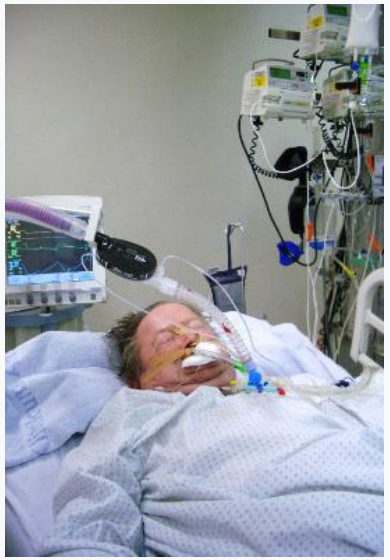
Difficult sedation…

48-year old male, CPR after Bolus avalanche; cerebral oedema, Pneumonia and ARDS; Kinetic therapy
Alcohol abuse

07.02.2017 Intubation after CPR
- Propofol + Sufentanil

„Difficult“sedation
- + Midazolam + Ketanest S + Clonidine

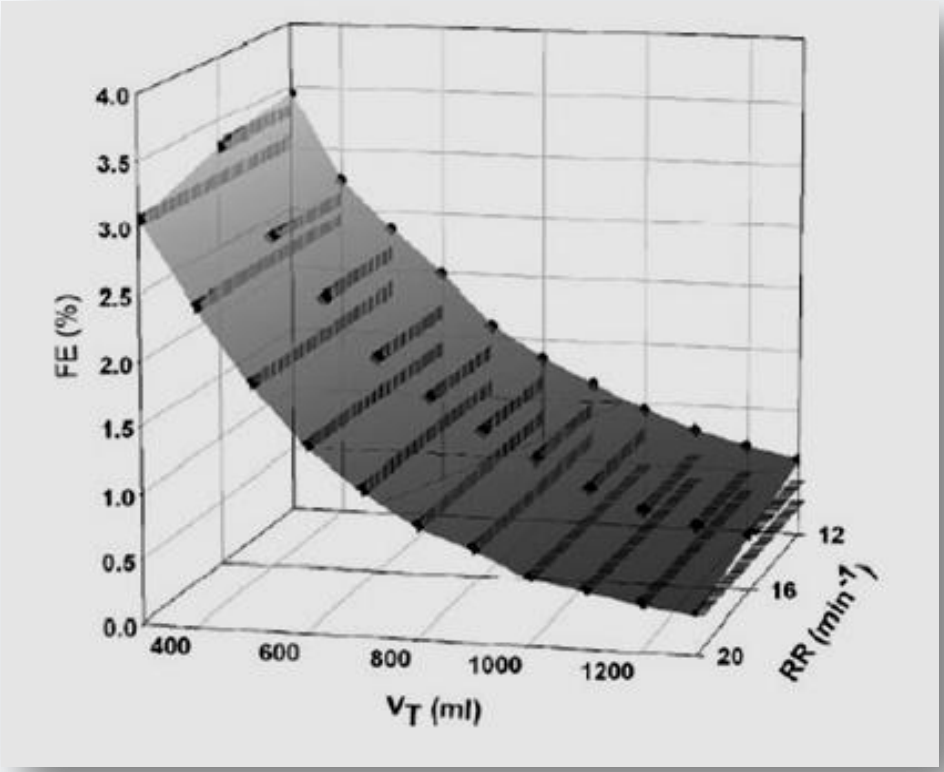
10.02.2017 Fighting the respirator, coughing, eye opening
- Switch to Isoflurane via AnaConDa as single sedation drug

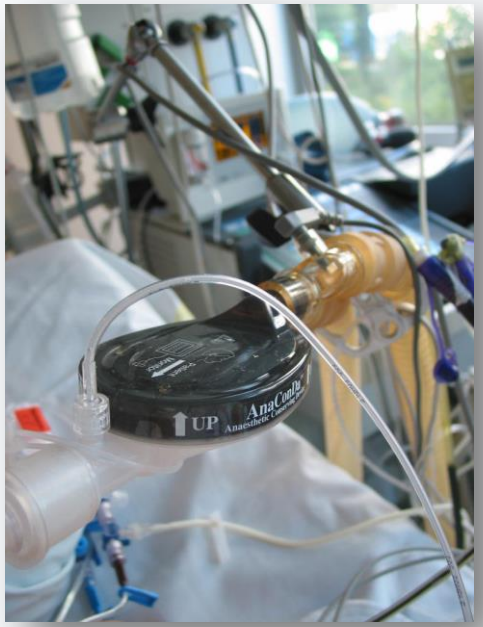


Technical properties

AnaConDa® Reflection Filter: Bench and Patient Evaluation of Safety and Volatile Anesthetic Conservation

Berton J et al. Anesth Analg 2007; 104: 130-4

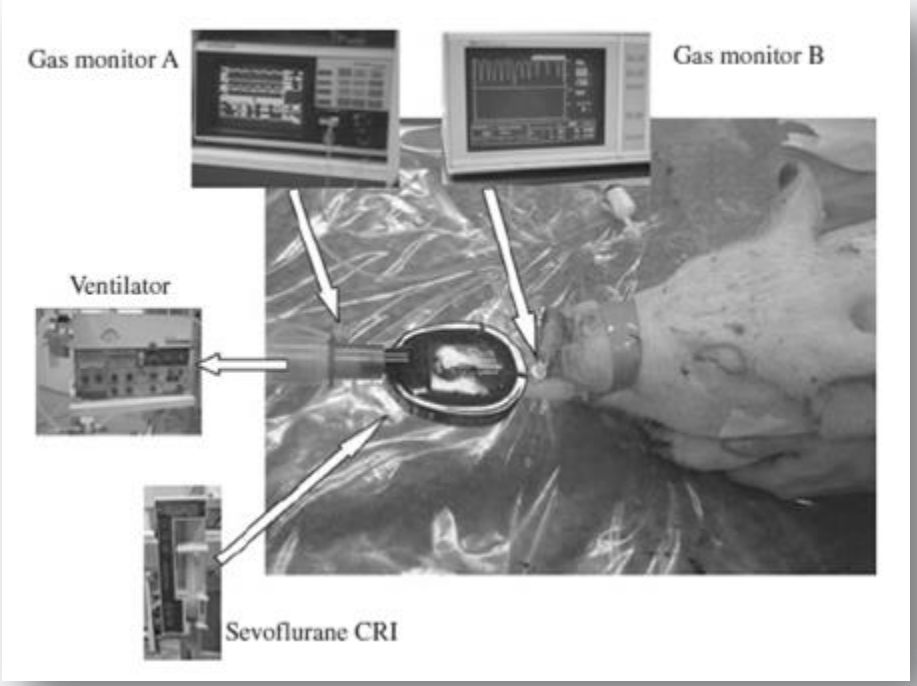




Influence of two different ventilation modes on the function of an anaesthetic conserving device in sevoflurane anaesthetized piglets

Stijn Schauvliege* DVM, Stefaan Bouchez† MD, Lindsey Devisscher* DVM, Tim Reyns‡ PhD, Sandra De Boever‡ DVM & Frank Gasthuys* DVM, PhD, Diplomate ECVAA

Veterinary Anesth Analg 2009; 36: 230-8



Minute volume is inversely proportional to the endtidal Sevoflurane concentration

Comparable technical performance in volume and pressure controlled mechanical ventilation

CO_2 increase with low Vt >> Rebreathing
→ Small AnaConDa (50 ml)

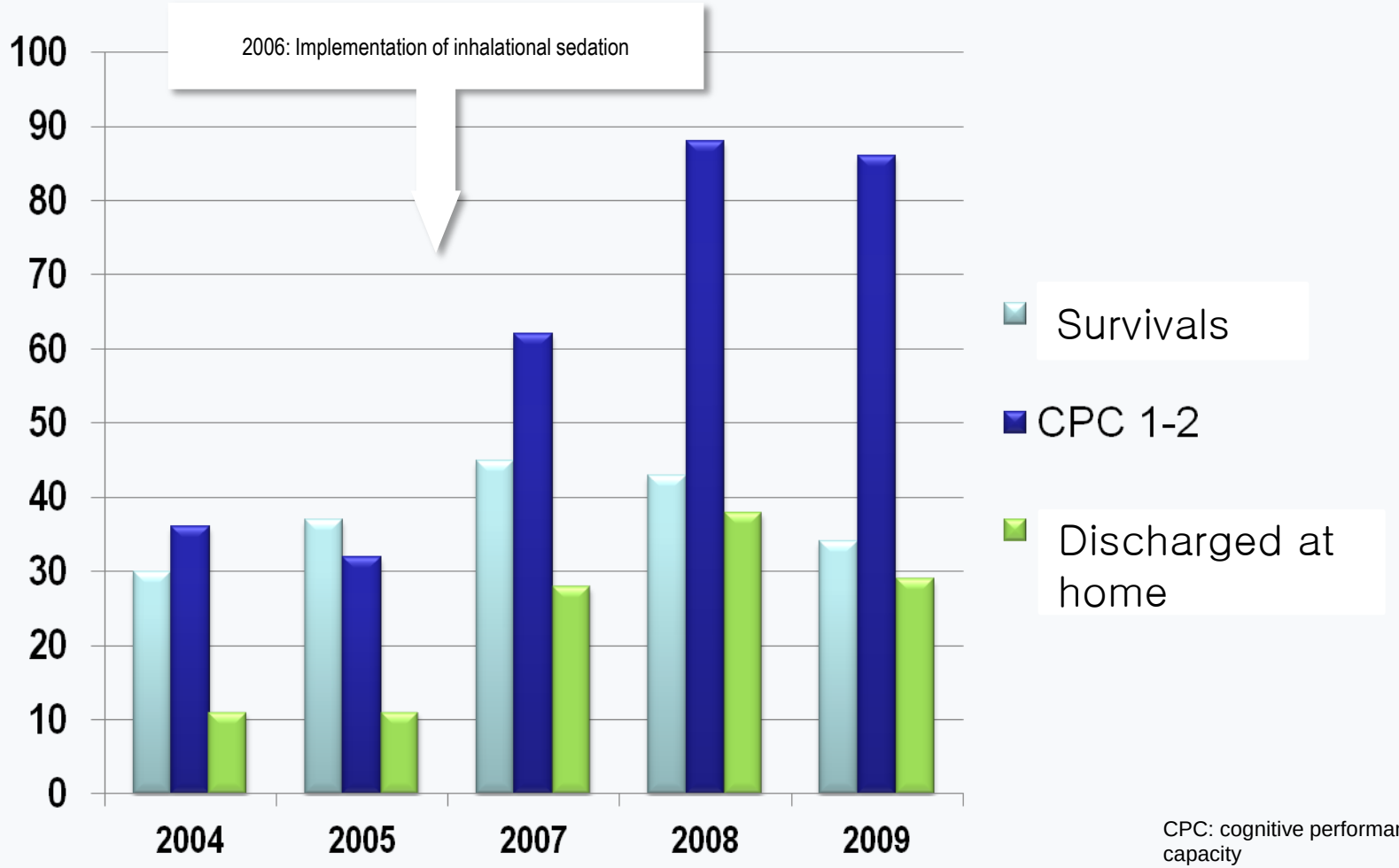
Indications & Benefits…

- Consider any patient who needs sedation
- Light and deep sedation by adjustment of MAC/inspired VA
- Deep and/or difficult sedation (abuse of alcohol/drugs)
- Obese patients

- **Neurological Patients:** **Daily assessment of neurology**

  Hypothermia after ROSC

Study project at the Hospital of St. Marien Amberg
AnaConDay Heidelberg 12/2010
Dr. S. Schmid



CPC: cognitive performance capacity

Inhaled Isoflurane Sedation During Therapeutic Hypothermia After Cardiac Arrest: A Case Series*

Jan Hellström, MD[1]; Anders Öwall, MD, PhD[1]; Claes-Roland Martling, MD, PhD[2]; Peter V. Sackey, MD, PhD[2]

CCM 2014; 42: 161-6

TABLE 1. Patients' Medical History

Variables	Isoflurane Sedation (*n* =12)
Age, mean yr (range)	61 (49/76)
Male sex, *n*	10
Body weight, mean kg (range)	84.2 (54–126)
History of diabetes, *n*	3
History of hypertension, *n*	6
History of angina, *n*	4
History of myocardial infarction, *n*	3
History of coronary artery bypass grafting and/or percutaneous coronary intervention, *n*	4
Out of hospital cardiac arrest, *n*	11
Witnessed arrest, *n*	10
Basic life support provided by bystander, *n*	10
Emergency medical service median response time, min (25th–75th percentile)	7.5 (5–11)
Ventricular fibrillation at start of cardiopulmonary resuscitation, *n*	11
Median return of spontaneous circulation, min (25th–75th percentile)	15 (11.5/23.5)

- 2008-2011
- CPR

- 24 h Hypothermia (34°C)
- Isoflurane 4.2 ml/h = 0.79 Vol%
- Sedation <57 h

→ **Potential postconditioning effects in the reperfusion period**
→ **Quick and deep sedation with Isoflurane, no Shivering**
→ **Early neurological Assessment after Rewarming**

Isoflurane Sedation on the ICU in Cardiac Arrest Patients Treated With Targeted Temperature Management: An Observational Propensity-Matched Study

Alexander Krannich, MSc[1]; Christoph Leithner, MD[2]; Martin Engels, MD[1]; Jens Nee, MD[1]; Victor Petzinka[1]; Tim Schröder, MD[1]; Achim Jörres, MD, PhD[1]; Jan Kruse, MD[1]; Christian Storm, MD, PhD[1]

Crit Care Med 2016;
DOI 10.1097/CCM.0000000000002185

Retrospective analysis; 2010-2015

TABLE 1. Baseline Parameters Used for Matched Pair Analysis and Outcome Results

Variables	Baseline (Matched Parameters) IV	Volatile	p
n	110	110	
Age, mean (95% CI)	61.9 (58.9–64.8)	62.3 (59.6–65.0)	0.827
Time to return of spontaneous circulation, median (IQR)	12.0 (8.0–20.0)	12.0 (8.0–23.5)	0.931
Gender, female, *n* (%)	29 (26.4)	26 (23.6)	0.755
Shockable, *n* (%)	54 (49.1)	46 (41.8)	0.343
Acute Physiology and Chronic Health Evaluation II, median (IQR)	31 (24–36)	29 (23–35)	0.554
Variables	**Results**		
Cerebral Performance Category, *n* (%)			0.599
1	34 (30.9)	40 (36.4)	
2	15 (13.6)	9 (8.2)	
3	2 (1.8)	3 (2.7)	
4	10 (9.1)	7 (6.4)	
5	49 (44.5)	51 (46.4)	
Ventilation duration, median (IQR)	269.0 (122.2–530.2)	170.5 (87.5–323.5)	0.003
ICU stay, median (IQR)	13.0 (6.0–26.7)	8.5 (4.2–16.0)	0.006
Shivering, *n* (%)	32 (29.1)	28 (25.5)	0.650
Paralysis, *n* (%)	44 (40.0)	15 (13.6)	< 0.001
Bedside Shivering Assessment Scale, *n* (%)			0.962
None	78 (70.9)	81 (73.6)	
Mild	10 (9.1)	9 (8.2)	
Moderate	12 (10.9)	10 (9.1)	
Severe	10 (9.1)	10 (9.1)	
Tracheotomy, *n* (%)	32 (29.1)	21 (19.1)	0.115
Norepinephrine, mg/48 hr, median (IQR)	26.5 (13.0–64.0)	39.50 (15.7–77.0)	0.127
Cardiac cause of arrest (%)	60 (54.5)	57 (51.8)	0.787

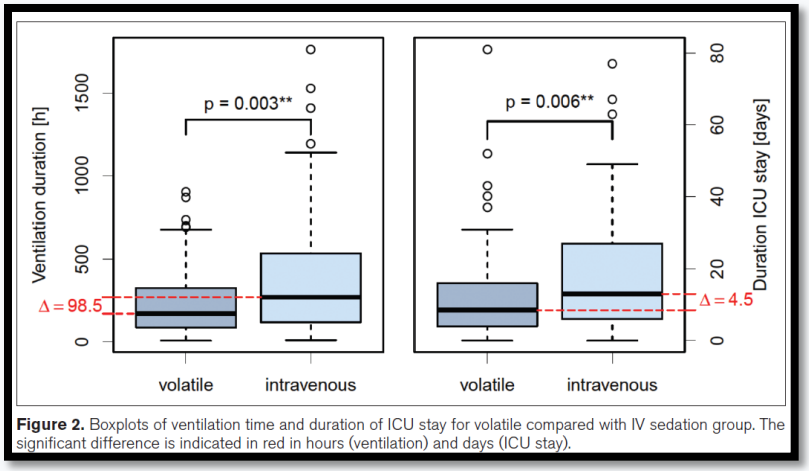


Figure 2. Boxplots of ventilation time and duration of ICU stay for volatile compared with IV sedation group. The significant difference is indicated in red in hours (ventilation) and days (ICU stay).

170 vs. 269 h

8 vs. 13 days

→ **No difference in mortality or coma**
→ **Neurone specific enolase (NSE) after 72 h equal in both groups**

→ **Hypercapnia (6.4%) in VA group**
→ **No differences in tachycardia, re-arrest, ARDS, bleeding**

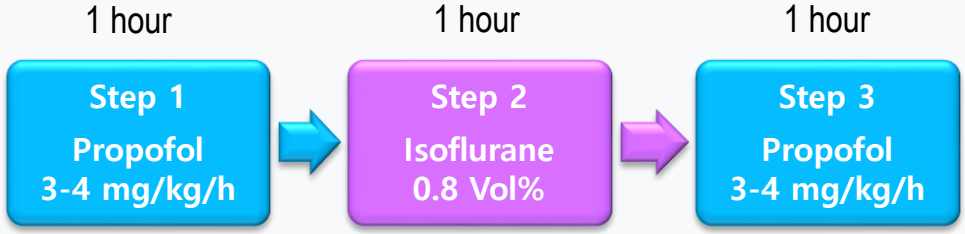
Inhalation versus endovenous sedation in subarachnoid hemorrhage patients: Effects on regional cerebral blood flow*

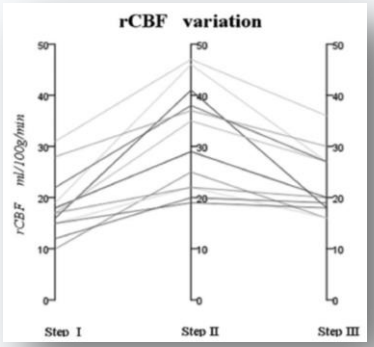
Federico Villa, MD; Cosimo Iacca, RN; Andrea Forastieri Molinari, MD; Carlo Giussani, MD, PhD; Giacomo Aletti, PhD; Antonio Pesenti, MD; Giuseppe Citerio, MD

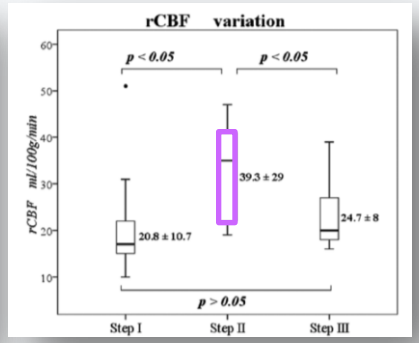
Crit Care Med 2012; 40: 2797-2804

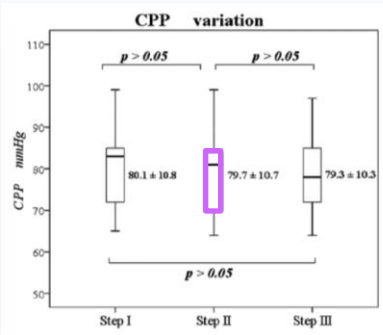
15 Patients

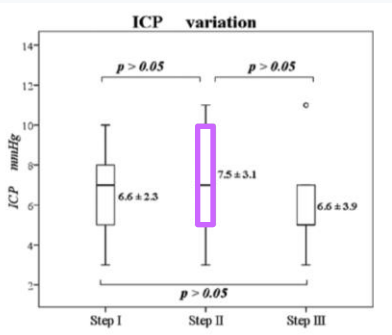
Severe subarachnoid hemorrhage
(<72 h from initial bleeding)
ICP < 18 mmHg



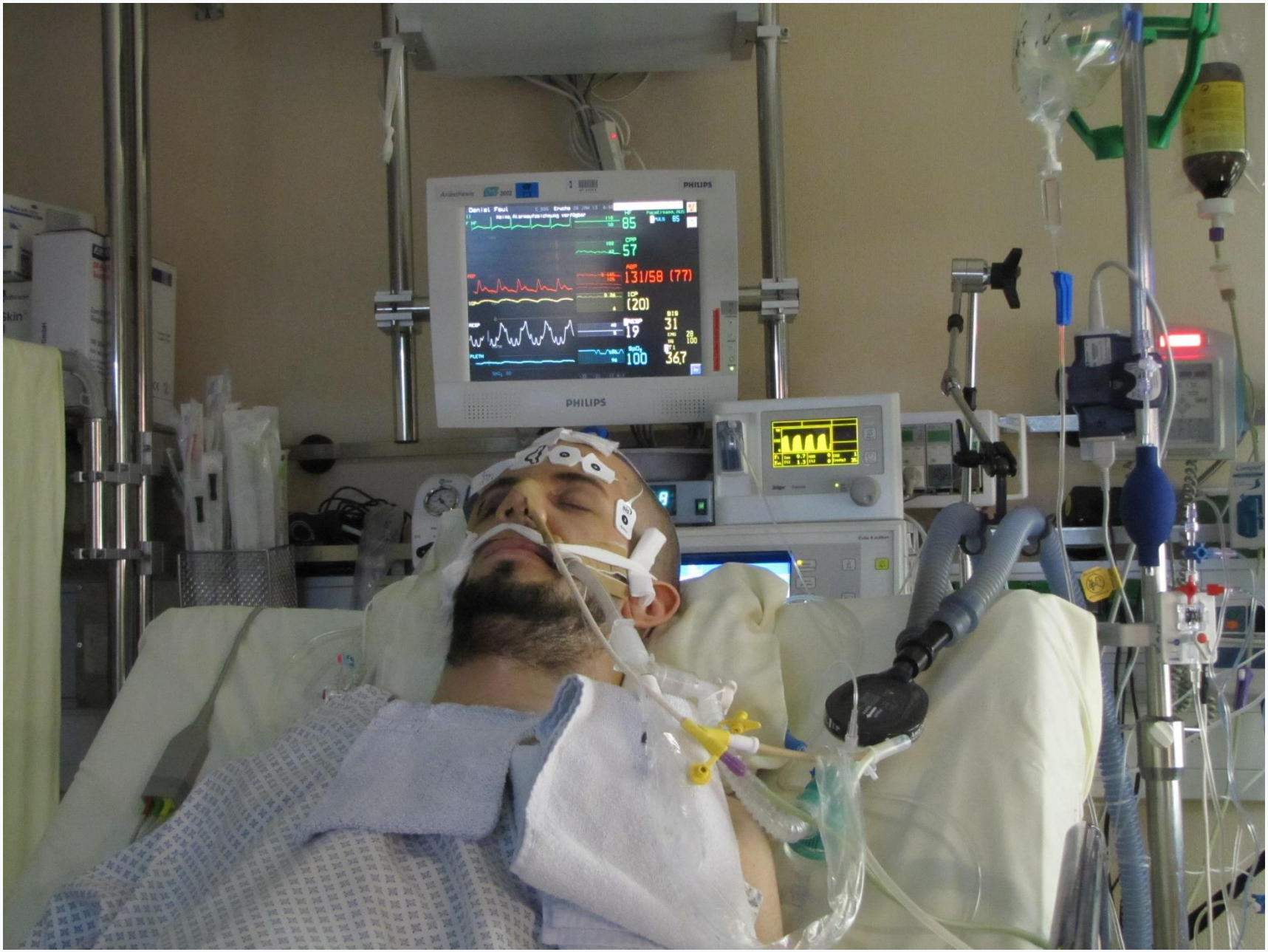








→ Regional cerebral blood flow increased significantly with Isofllurane
→ No change in intracranial pressure or cerebral perfusion pressure


PHILIPS
85
57
131/58 (77)
(20)
19
31
100
PHILIPS

Indications & Benefits…

- Consider any patient who needs sedation
- Light and deep sedation by adjustment of MAC/inspired VA
- Deep and/or difficult sedation (abuse of alcohol/drugs)
- Obese patients
- Neurological Patients: Daily assessment of neurology
  Hypothermia after ROSC

- **Cardiac patients: Aortocoronary bypass grafting, Myocardial infarction, Cardiopulmonary resuscitation**

Anesthesiology 2004; 101:9–20

Choice of Primary Anesthetic Regimen Can Influence Intensive Care Unit Length of Stay after Coronary Surgery with Cardiopulmonary Bypass

Stefan G. De Hert, M.D., Ph.D., Philippe J. Van der Linden, M.D., Ph.D.,† Stefanie Cromheecke, M.D.,‡ Roel Meeus, M.D.,§ Pieter W. ten Broecke, M.D.,‡ Ivo G. De Blier, M.D.,‖ Bernard A. Stockman, M.D.,‖ Inez E. Rodrigus, M.D., Ph.D.#*

De Hert SG et al. Anesthesiology 2004; 101: 299-310

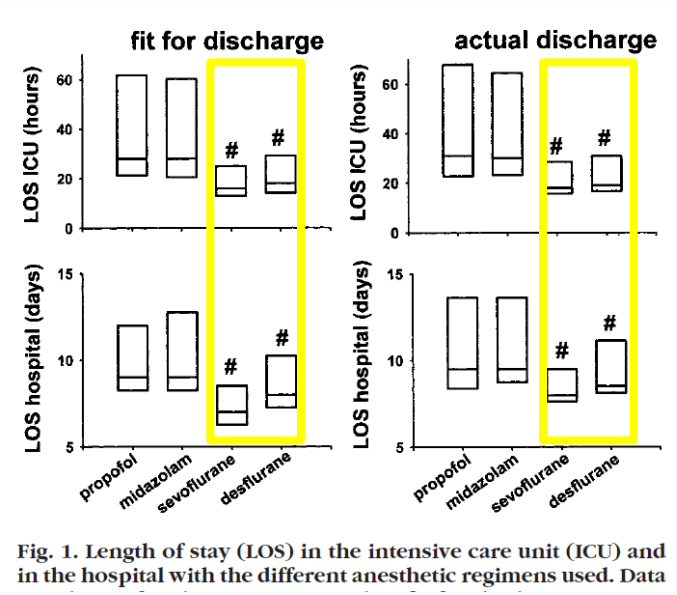
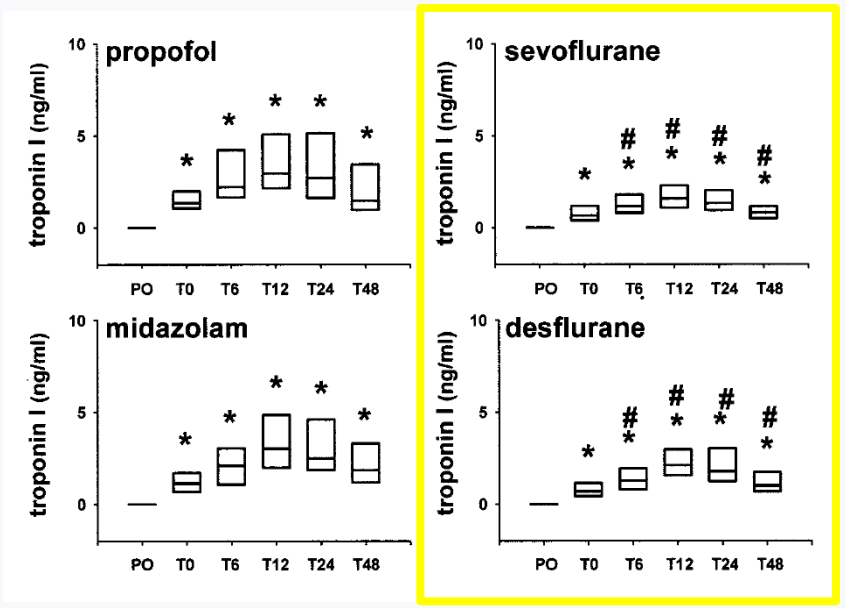


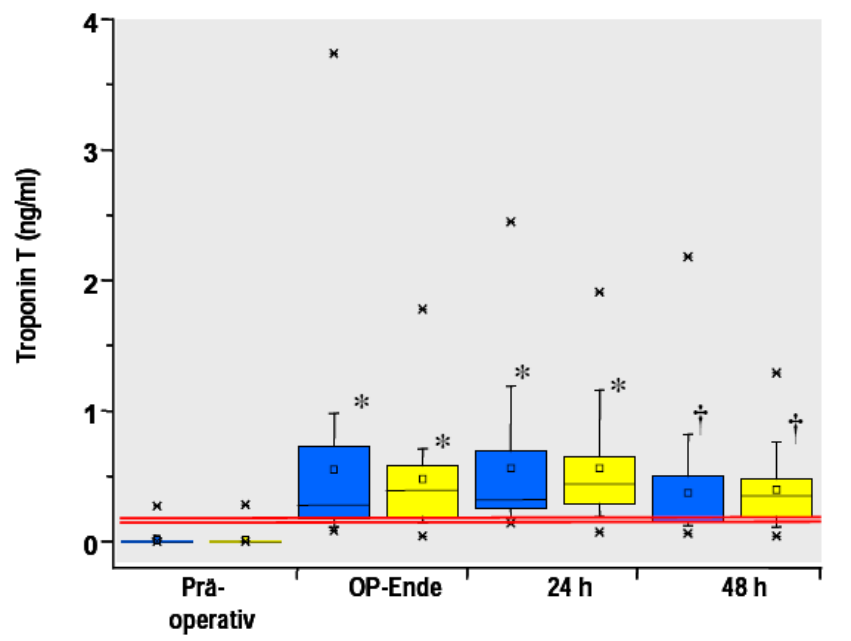
Fig. 1. Length of stay (LOS) in the intensive care unit (ICU) and in the hospital with the different anesthetic regimens used. Data

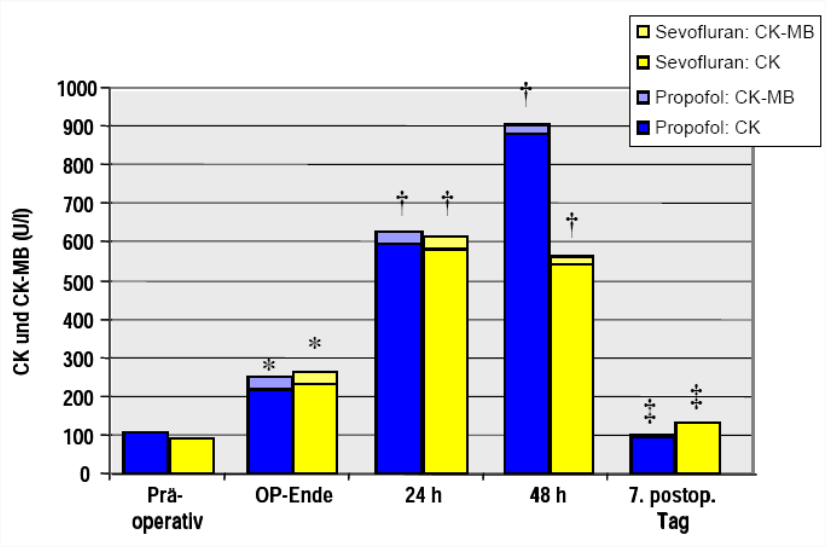


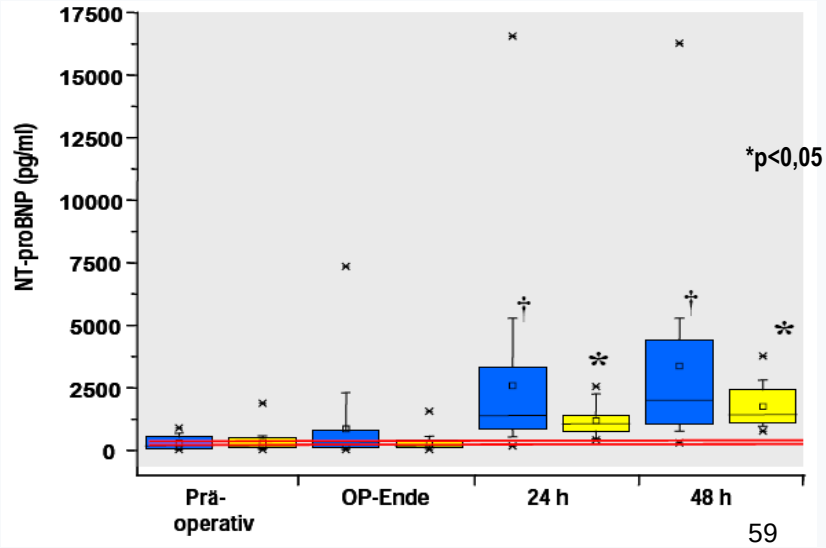
→ LOS hospital + LOS in ICU + Troponin I levels
→ Better postoperative cardiac function

Cardiac protection…???

Röhm KD. Unpublished data

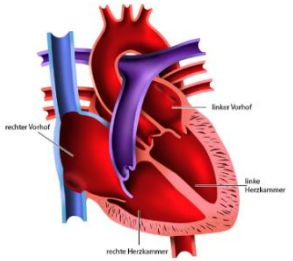






Late pharmacologic conditioning with volatile anesthetics after cardiac surgery

Marc P Steurer[1,2,3†], Martina A Steurer[1,2,4†], Werner Baulig[1], Tobias Piegeler[1,2,7], Martin Schläpfer[1,2], Donat R Spahn[1], Volkmar Falk[5], Pamela Dreessen[1], Oliver M Theusinger[1], Edith R Schmid[6], David Schwartz[7], Thomas A Neff[8†] and Beatrice Beck-Schimmer[1,2*†]



Crit Care 2012; 16: R191

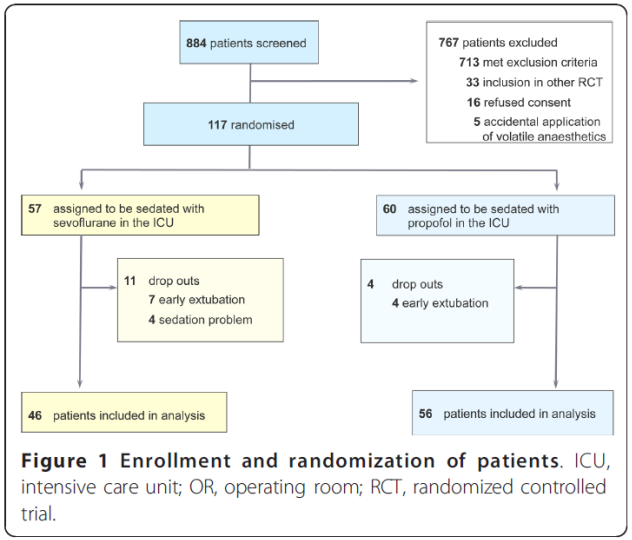


Figure 1 Enrollment and randomization of patients. ICU, intensive care unit; OR, operating room; RCT, randomized controlled trial.

Table 2 Linear regression analysis to compare cardiac markers between the sevoflurane and propofol groups (*n* = 102)

Cardiac marker (U/L)	Unadjusted difference in means (point estimate)	95% CI	Adjusted difference in means (point estimate)	95% CI
Troponin T, 4 hours (μg/L)	-0.3	-0.7, 0.1	-0.1	-0.2, 0.1
CK, 4 hours (U/L)	**-140[a]**	**-250, -30**	-38	-96, 20
CK-MB, 4 hours (U/L)	-2.4	-23.9, 19.2	1.2	-6.4, 8.7
Myoglobin, 4 hours (μg/L)	**-113[a]**	**-187, -39**	-42	-100, 16
Troponin T, POD1 (μg/L)	**-0.4[a]**	**-0.7, -0.1**	**-0.2[a]**	**-0.4, -0.02**
CK, POD1 (U/L)	**-258[a]**	**-434, -83**	**-169[a]**	**-331, -8**
CK-MB, POD1 (U/L)	-4.6	-27.5, 18.3	-1.1	-13.2, 11.0
Myoglobin, POD1 (μg/L)	-107	-217, 3	-48	-157, 60

The model is adjusted for age, blood products, baseline value of corresponding cardiac injury marker on ICU admission, and extracorporeal circulation (ECC) time. The propofol group is the reference. [a]$P < 0.05$, statistically significant.
4 hours, 4 hours after ICU admission; CK, creatine kinase; CK-MB, creatine kinase, heart muscle tissue; POD1, first postoperative day.

Follow-up after 6 months:
→No differences in cardiac or non-cardiac events
→Sevo group required less hospital admissions and drug/interventional/surgical treatment

Bovini JM et al. PLoS One 2015; 10: e0132165

Indications & Benefits…

- Consider any patient who needs sedation
- Light and deep sedation by adjustment of MAC/inspired VA
- Deep and/or difficult sedation (abuse of alcohol/drugs)
- Obese patients
- Neurological Patients: Daily assessment of neurology
  Hypothermia after ROSC
- Cardiac patients: Aortocoronary bypass grafting, Myocardial infarction,
  Cardiopulmonary resuscitation

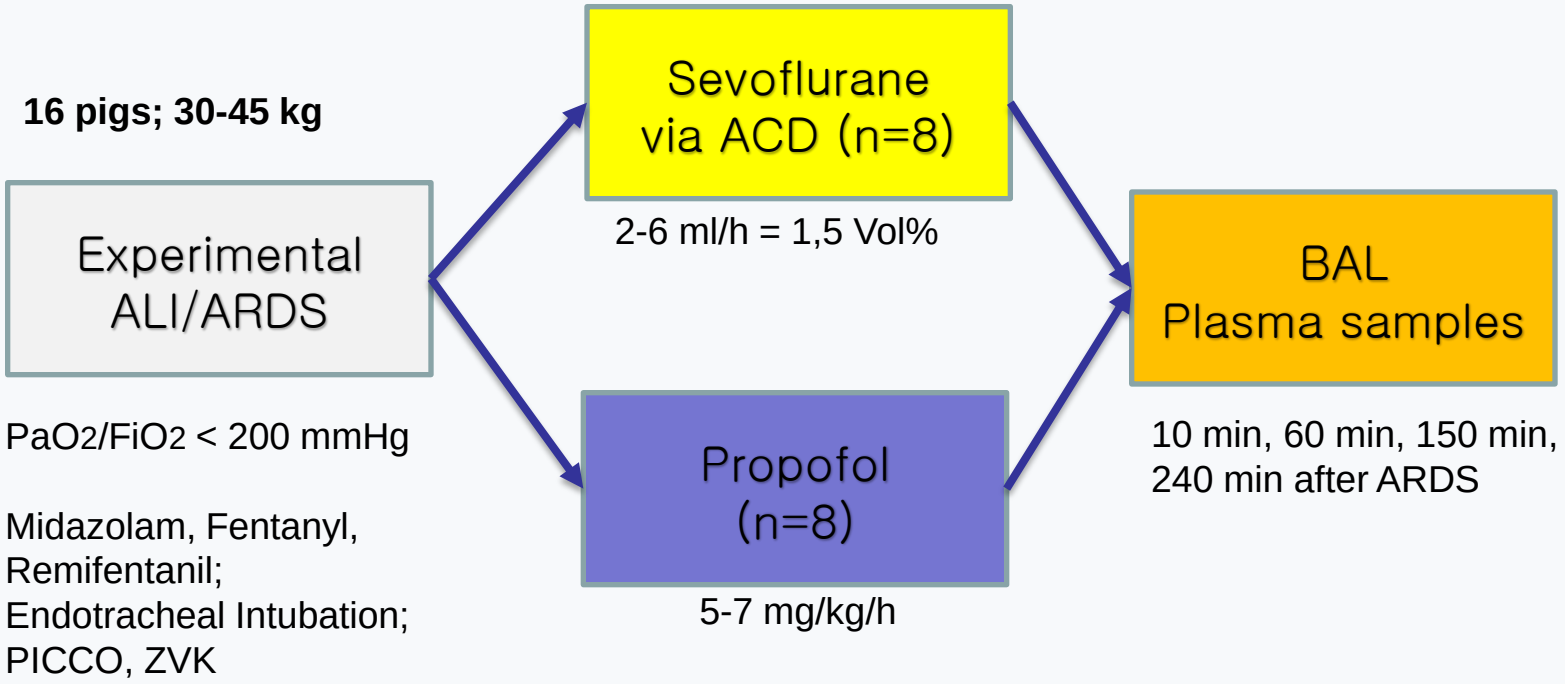
- **Pulmonary diseases: ARDS; Pneumonia; Bronchospasm**
  Status asthmaticus; ECMO??

Sevoflurane, but not propofol, reduces the lung inflammatory response and improves oxygenation in an acute respiratory distress syndrome model

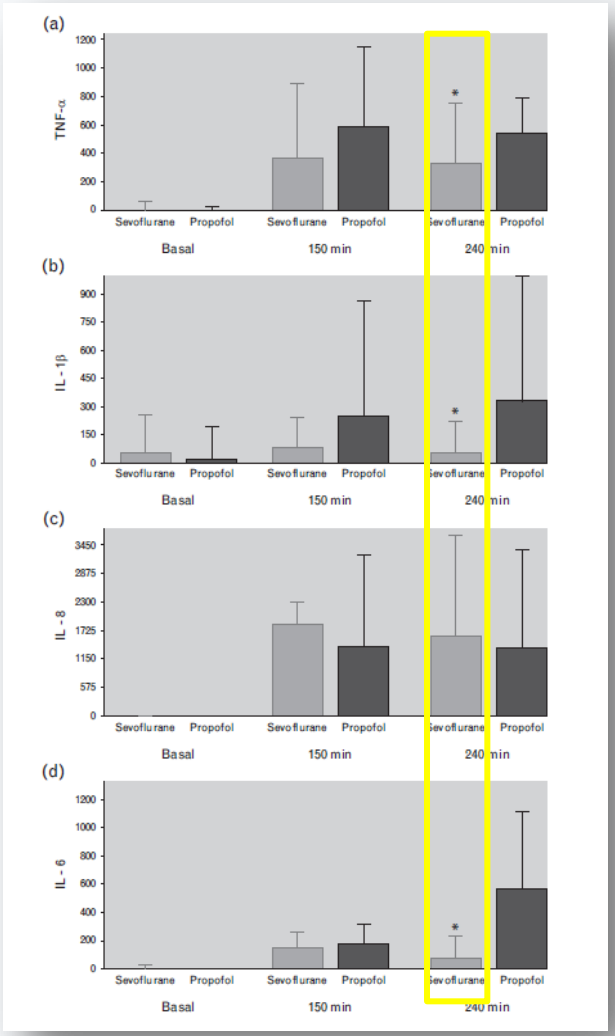
A randomised laboratory study

Carlos Ferrando, Gerardo Aguilar, Laura Piqueras, Marina Soro, Joaquin Moreno and Francisco J. Belda

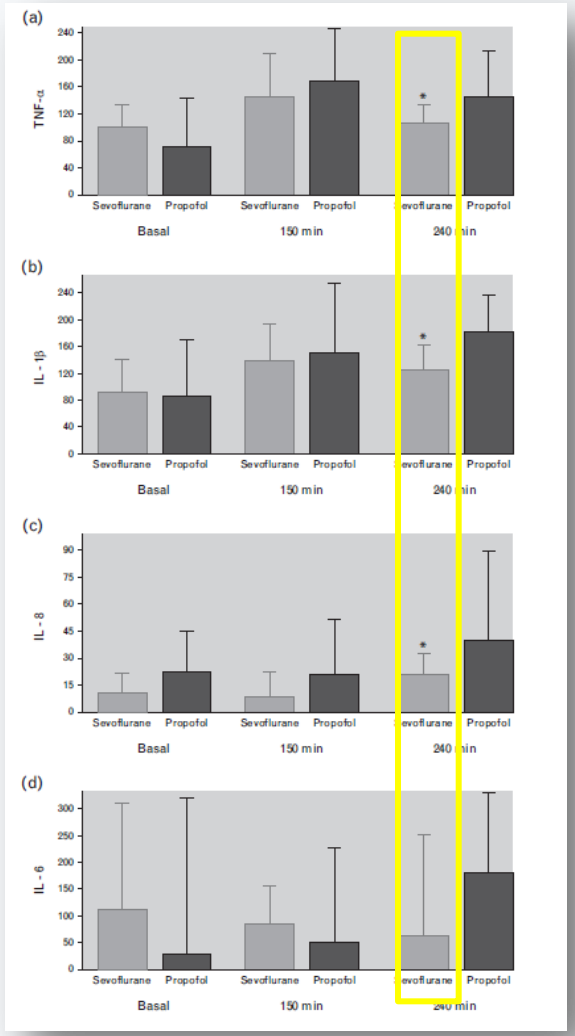
Eur J Anaesthesiol 2013; 30: 455-463



Bronchoalveolar Lavage



Inflammatoric Markers in Plasma



→ **Higher immunmodulatory effects with Sevo vs. Propofol**
→ **Less influence on alveolocapillar permeability**
→ **Better oxygenation**

Sevoflurane sedation for ARDS

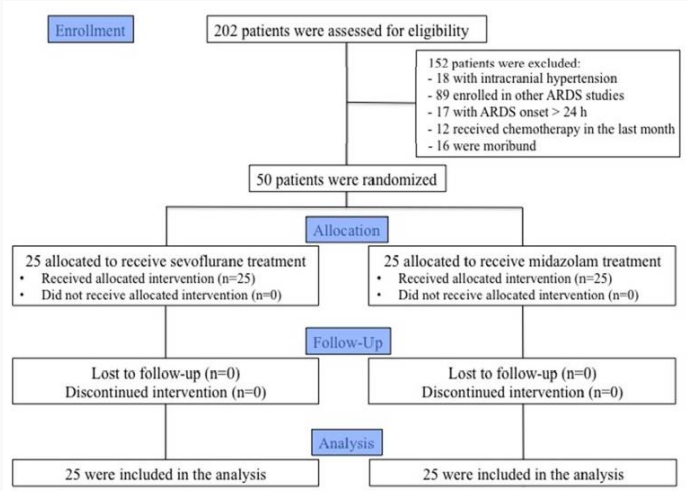
Jabaudon M et al. Am J Respir Crit Care Med 2016;
DOI 10.1164/rccm.201604-0686OC

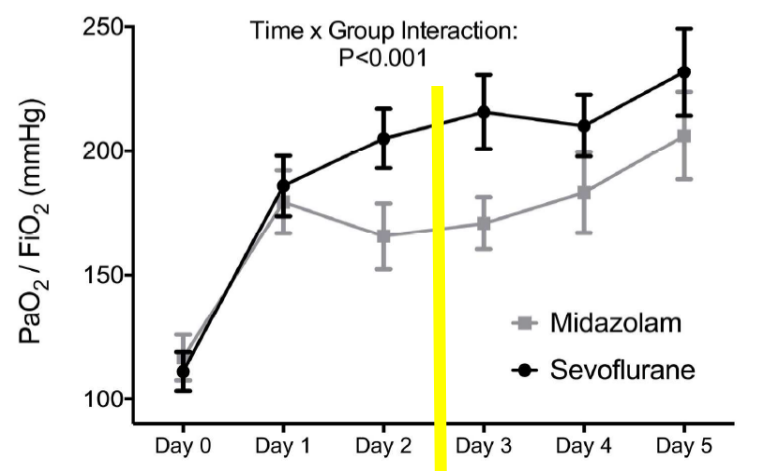
Parallel, open-label single center randomized controlled trial at 3 ICU‘s 04/2014-02/2016

Comparison of Midazolam vs. Sevoflurane in ARDS patients (n=50); 48 h Sedation period

Primary goal: PaO_2/FiO_2

Secondary parameters: Alveolar and plasma levels of cytokines, Soluble form of receptor for advanced glycation end-products (sRAGE)





Improved arterial oxygenation on day 2 and 3 (not day 1,4 or 5)

No differences in duration of mechanical ventilation, LOS in ICU and mortality at 30 d

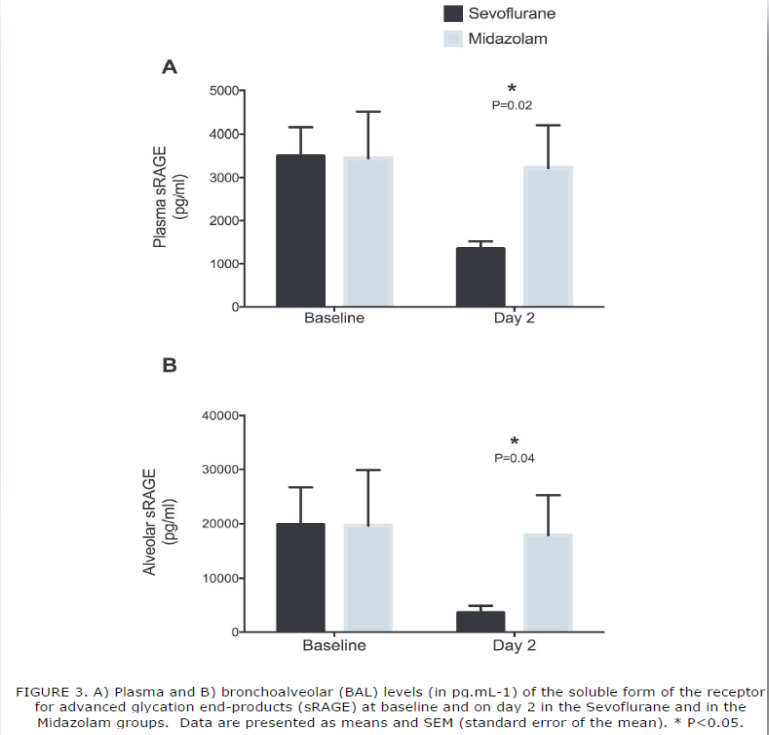


FIGURE 3. A) Plasma and B) bronchoalveolar (BAL) levels (in pg.mL-1) of the soluble form of the receptor for advanced glycation end-products (sRAGE) at baseline and on day 2 in the Sevoflurane and in the Midazolam groups. Data are presented as means and SEM (standard error of the mean). * P<0.05.

Reduction in plasma and alveolar levels of sRAGE and inflammatory cytocines (alveolar and plasma IL-6 and TNFa; alveolar IL-8) on day 2

Extracorporeal Life Support

Laufenberg M et al. Med Klin Intensivmed Notfmed 2016;
DOI 10.1007/s00063-016-0199-z

Case Report:

58 year old female
Exacerbated COPD
NIV → Somnolence

pH	7.076
paO2	115 mmHg
paCo2	123 mmHg

Intubation
Prone position

pH	7.165
paO2	63 mmHg
paCo2	82 mmHg
BIPAP	33/15 mmHg
FiO2	0.8
Vt	450 ml

Implantation of vv-ECMO
(Cardiohelp System, Maquet/Germany)

Sedation with Midazolam + Sufentanil
→Switch to AnaConDa with isoflurane
→Normalization within 6 d and weaning from ECMO, at home 20 d later…

Extracorporal Life Support

Verkoyen K et al. ASAIO 2016;
DOI 10.1097/MAT 0000000000000466

Retrospective, observational, single-center
2008-2014

Comparison propofol vs. Isoflurane in 91 patients requiring ECMO (>24h)
Isoflurane et 0.3-0.5Vol%

Table 1. Characteristics of the patients receiving ECMO > 24 hours (n = 91)

Number of patients (male; %)	91 (77; 85%)
Age (median, range)	54 (16-86)
BMI** (median, range)	29 (19-88)
VV ECMO*	70 (77%)
VA ECMO*	8 (9%)
iLA*	17 (18%)

Table 3. Rates of survival and weaning from ECMO

Survivors	Total	Propofol	Isoflurane	Others
To hospital discharge	45 (49.5%)	24 (26.4%)	20 (22.0%)	1 (1.1%)
To ICU discharge	47 (51.6%)	24 (26.4%)	21 (23.1%)	2 (2.2%)
Weaned from ECMO	57 (62.6%)	27 (29.7%)	28 (30.8%)	2 (2.2%)

Table 5. ECMO-run duration, duration of sedation, length of ICU stay, and length of hospital stay

	ECMO-run duration*	Sedation duration*	Length of ICU stay*	Length of hospital stay*
Propofol	8.4 (1.7-21.4)	15.5 (1.8-181.1)	17.8 (3.5-71.7)	37.5 (3.5-213.8)
Isoflurane	9.2 (1.9-37.1)	12.6 (1.3-78.8)	22.9 (2.3-197.6)	**34.5 (2.3 -105.1)**
Others	8.9 (2.9-14.2)	-	**17.4 (3.4-36.1)**	**19.1 (3.4-58.3)**
P value	**0.863**	**0.176**	**0.621**	**0.712**

* Median (range)

Iso or Sevoflurane?

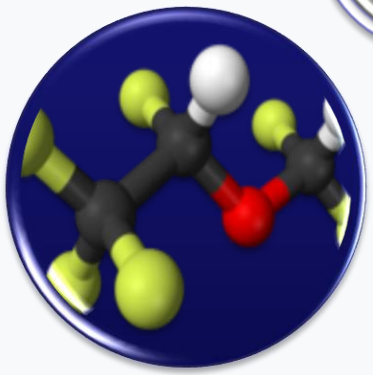
Costs

Extubation time

ICU stay

Changes in syringe pump per day

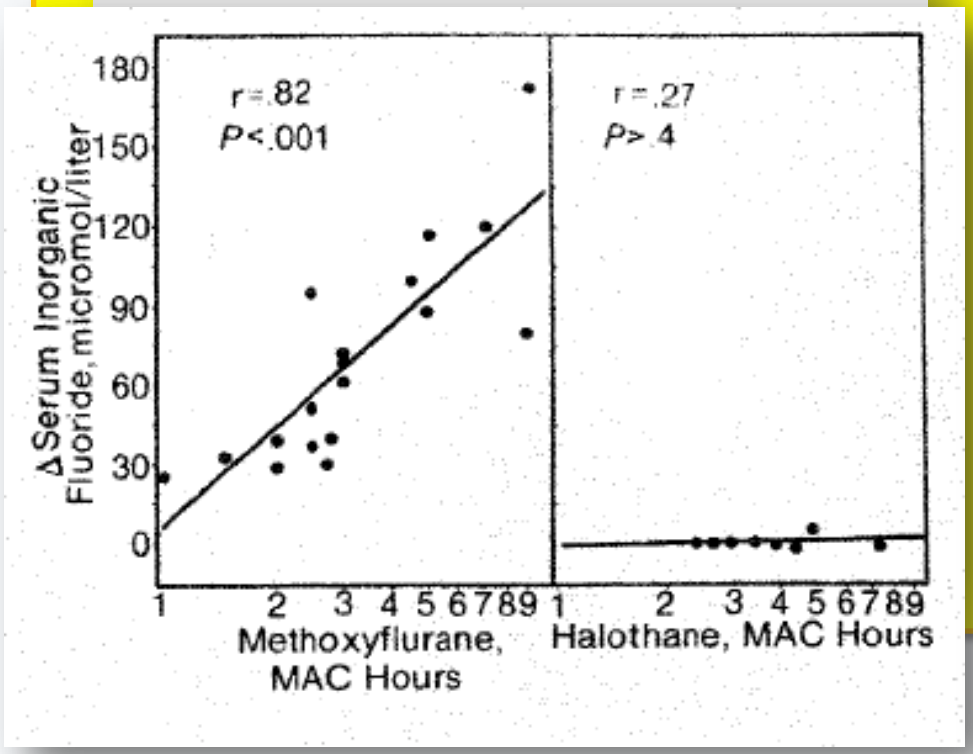
Same sedation qualities



Fluoride impact

Metabolization rate

Sevoflurane and Fluorides



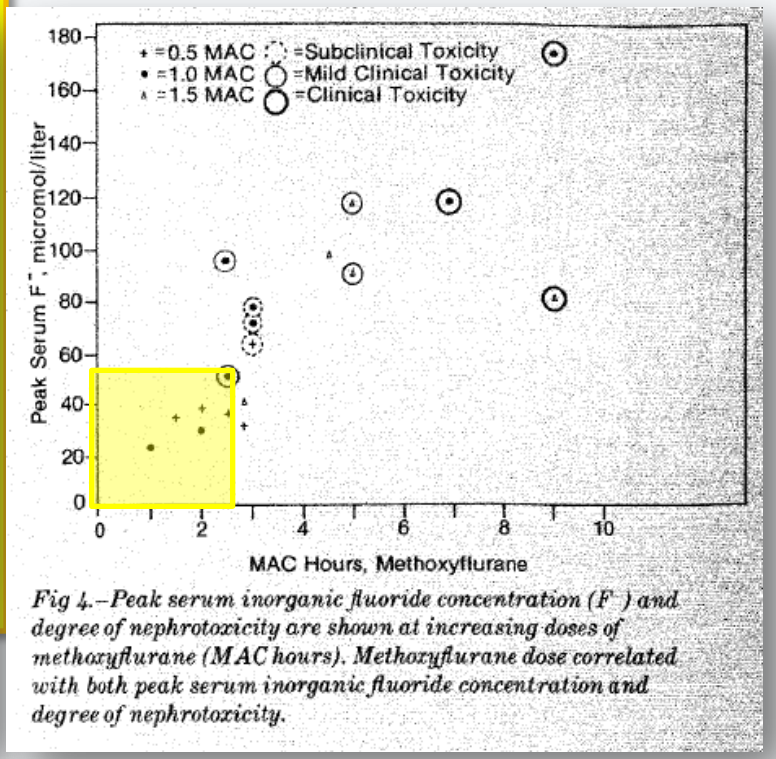


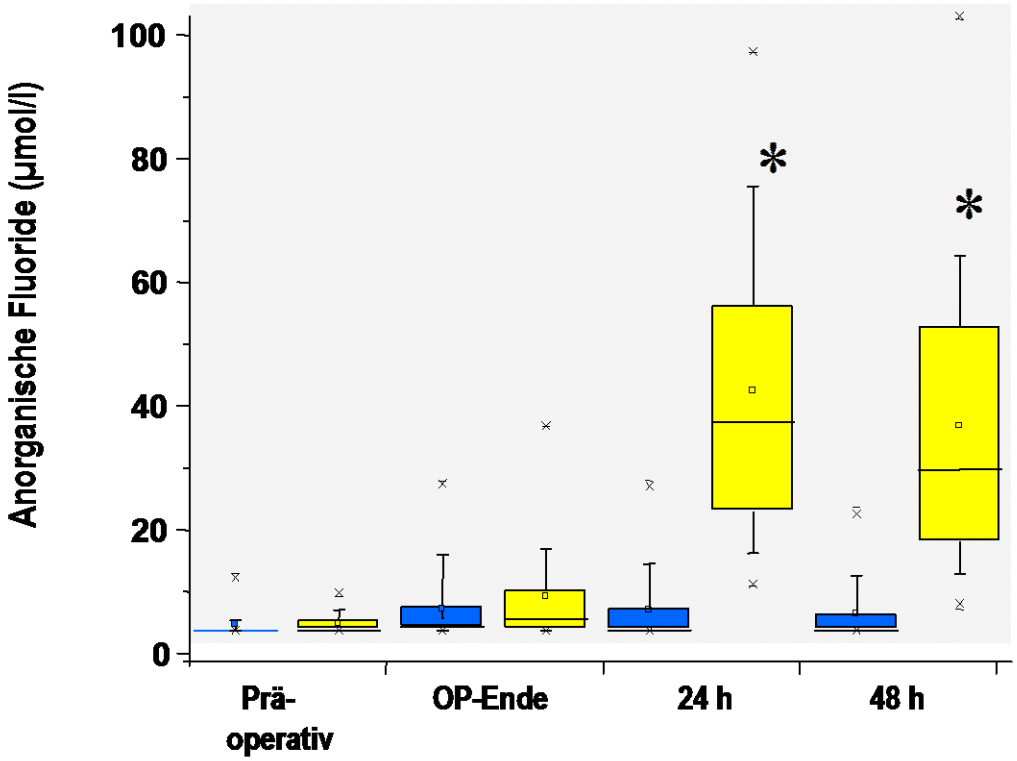
Fig 4.–Peak serum inorganic fluoride concentration (F^-) and degree of nephrotoxicity are shown at increasing doses of methoxyflurane (MAC hours). Methoxyflurane dose correlated with both peak serum inorganic fluoride concentration and degree of nephrotoxicity.

Cousins MJ et al. JAMA 1973; 225 (13)

Renal function

Anorganic Fluorides Short-term sedation

Röhm KD et al. Anesth Analg 2009; 108: 1848-54

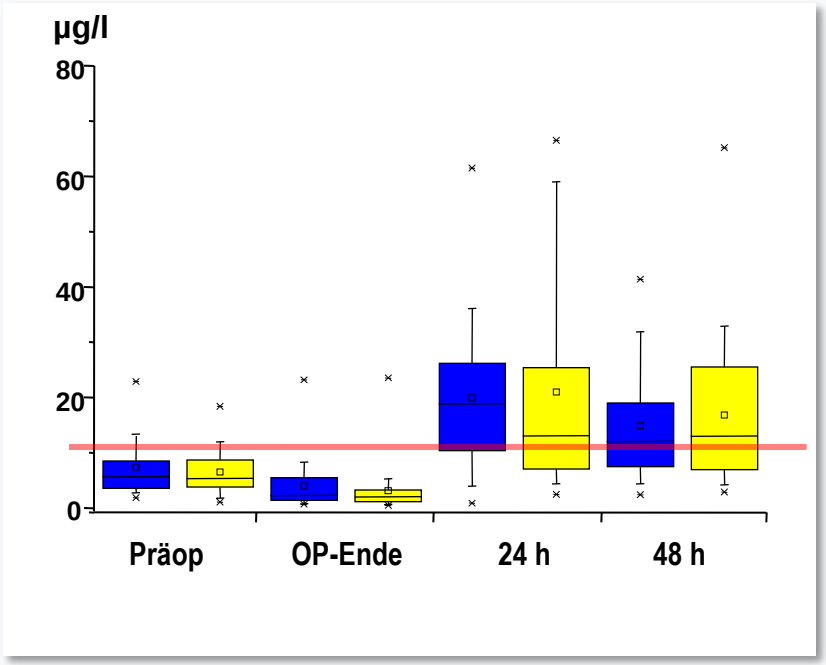


Tubular renal function

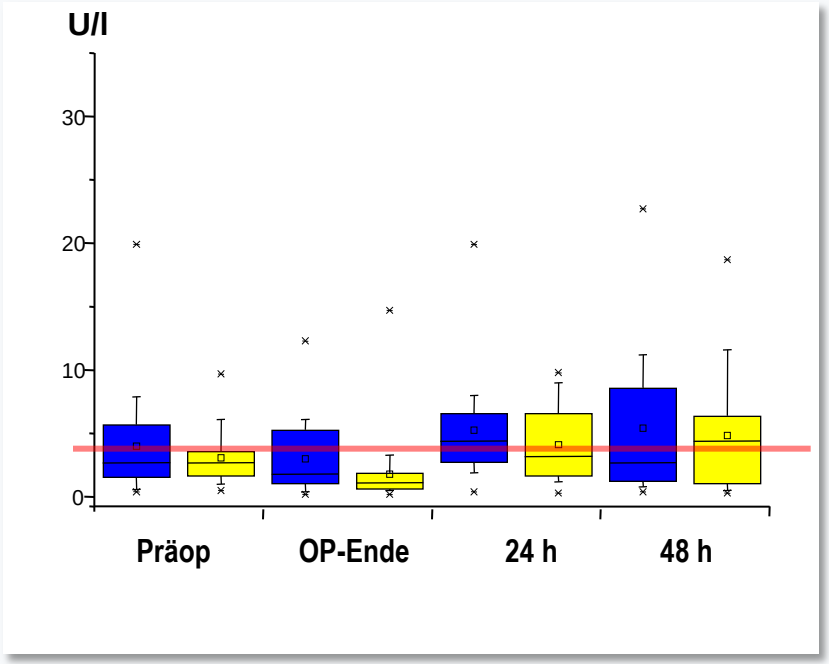
Röhm KD et al. Anesth Analg 2009; 108: 1848-54

Propofol
Sevofluran

Alpha-Gluthation-S-Transferase



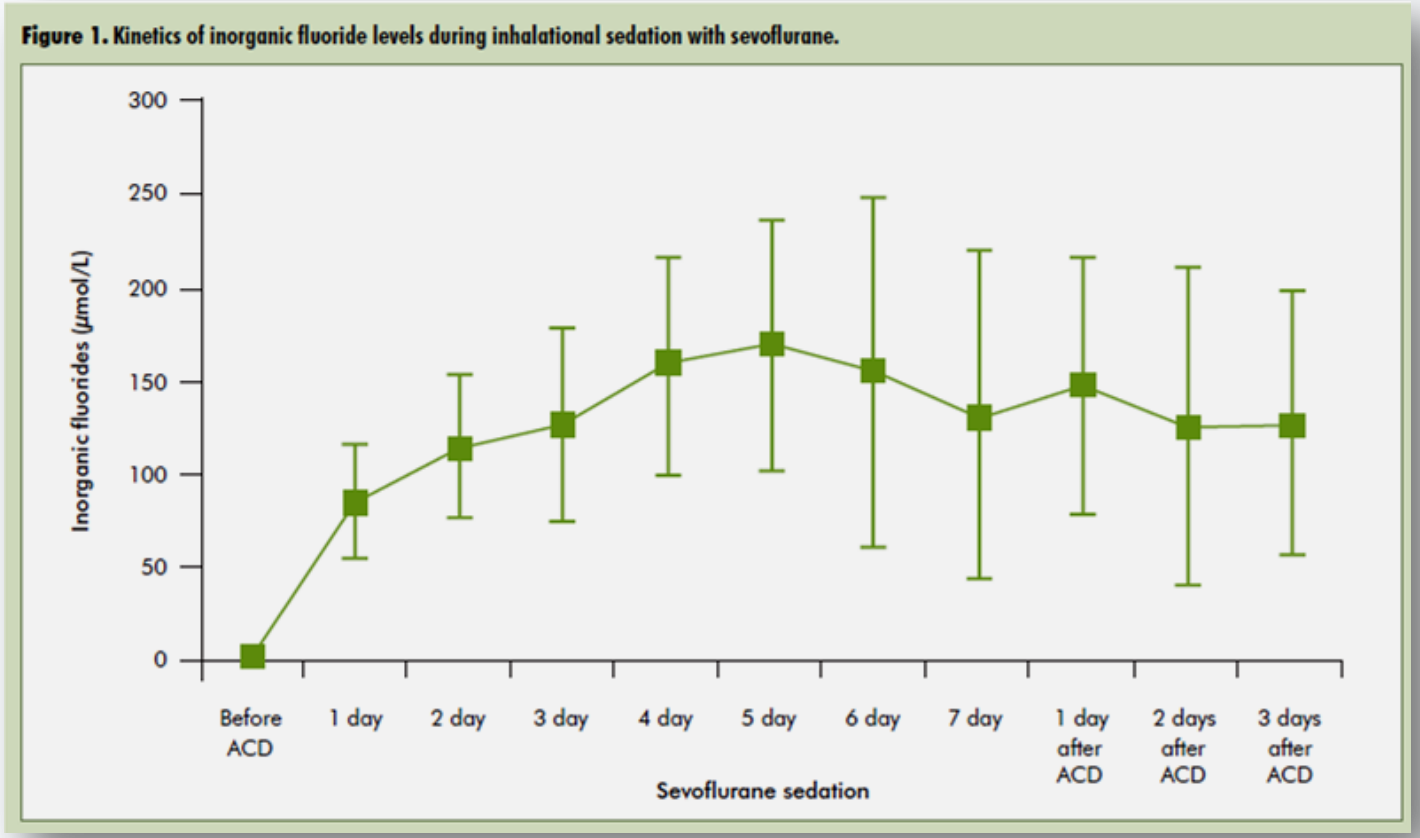
Beta-NAG



Renal function

Anorganic Fluorides Long-term sedation

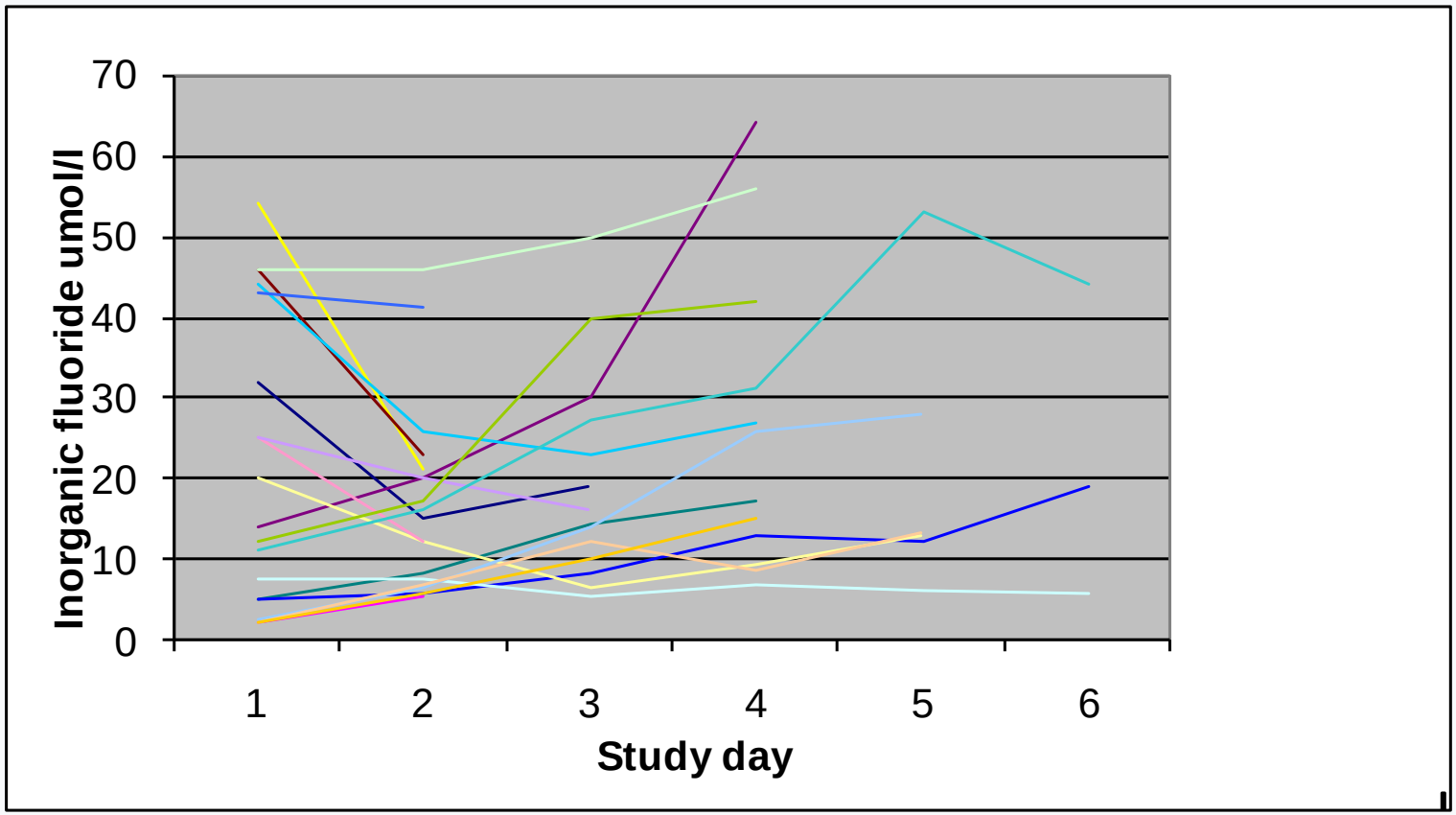
Röhm KD. Adv Anaesth Crit Care 2009; 1 (2): 60-3



Renal function

Isoflurane und Fluorides

Sackey PV et al. CCM 2005; 33: 585-90



Maximal occupational pollution in anaesthesia

(DGAI/BDA-German commission: „Workplace safety in anaesthesia“)

Limits of concentration:

- **Halothane** **5 ppm**
- **Isoflurane** **10 ppm** **(Germany, Schweden; USA 2 ppm; GB 50 ppm)**
- **Sevoflurane** **no limits given**
- **Desflurane** **no limits given**

1999 ASA-Task Force; proposal of NIOSH/OSHA: Desflurane: 2 ppm

	N_2O	Halothane	Enflurane	Isoflurane	Sevoflurane
Denmark	100	5	2	–	–
France	–	2	–	–	–
Germany	100	5	20	–	–
Italy	100	–	–	–	–
Norway	100	5	2	2	–
Sweden	100	5	10	10	–
Switzerland	–	5	–	–	–
USA: NIOSH	25	2	2	2	2
USA: ACGIH	50	50	75	–	–

2 ppm

Hörauf KH et al. Int Arch Occup Environ Health 1997; 69: 134-8

Ambient isoflurane pollution and isoflurane consumption during intensive care unit sedation with the Anesthetic Conserving Device*

Peter V. Sackey, MD; Claes-Roland Martling, MD, PhD; Gun Nise, PhD; Peter J. Radell, MD, PhD

Crit Care Med 2005; 33: 585-90

Patient No.	Study Time, Hrs	Mean End-Tidal Isoflurane Concentration, % (Range)	Mean Isoflurane Consumption, mL/hr
1	89	0.2 (0.11–0.54)	2.1
2	71	0.4 (0.15–0.56)	2.2
3	40	0.5 (0.15–0.82)	5.0
4	62	0.3 (0.12–0.41)	1.6
5	96	0.2 (0.11–0.44)	1.7
6	22	0.3 (0.13–0.75)	0.8
7	60	0.3 (0.11–0.36)	1.7
8	64	0.2 (0.11–0.38)	1.4
9	64	0.2 (0.18–0.56)	1.7
10	12	0.3 (0.13–0.35)	1.6
11	12	0.2 (0.12–0.26)	3.1
12	94	0.4 (0.10–0.65)	2.2
13	22	0.2 (0.10–0.24)	1.7
14	88	0.2 (0.10–0.34)	2.9
15	43	0.2 (0.10–0.34)	2.0

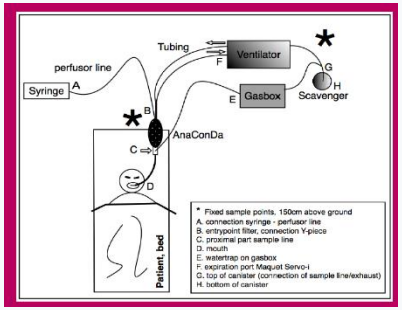
Patient No.	Mean Isoflurane Pollution Level, ppm	Episodes with TWA >2 ppm >10 Mins, No.	Peaks >5 ppm >1 min, No.
1	0.5	1[a]	1[b]
2	0.1		1[c]
3	0.3	1[d]	—
4	0.0	—	—
5	0.0	—	—
6	0.0	—	—
7	0.0	—	—
8	0.1	—	—
9	0.2	—[e]	—[e]
10	0.0	—[e]	—[e]
11	0.0[f]	—	—
12	0.1[f]	—	—
13	0.2[f]	—	—
14	0.3[f]	—	—
15	0.0[f]	—	—

TWA, time weighted average.

[a]Change of Anesthetic Conserving Device (ACD), TWA 3.5 ppm, duration 30 mins, peak 11 ppm; [b] infusion catheter from ACD dropped, >5 ppm for 3 mins, peak 13 ppm; [c] suction, >5 ppm for 2 mins, peak 10 ppm; [d] disconnection of system prior to transport of isoflurane sedated patient for computed tomography scan, TWA 2 ppm, duration 17 mins, peak 5 ppm; [e] no continuous recording due to printer malfunction; [f] no active scavenging of waste gas from ventilator.

The AnaConDa® and Sevoflurane in the ICU:
data on ambient pollution and staff exposure

A.T. Bos MD, Anesthesiologist-Intensivist
Dept. of Intensive Care, VieCuri Medical Center Venlo, the Netherlands



Poster presentation, Amsterdam, Netherlands 2017

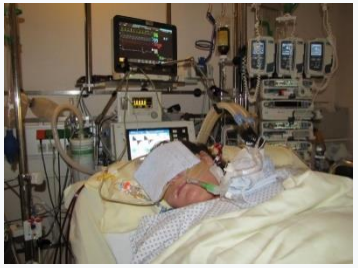
Sevoflurane sample data in a standard single patient ICU room, VieCuri Medical Centre.
Physical data of the ICU room: 52m³, air refreshing rate minimum 6/hr.

Position	Description	Sample time (min)	% exposure limit	Total sample volume (L)	TWA 8hrs (mg/m³)	Conc (ppm)
Nurse 1 shift 1 a)	personal air sampling	484	0,10	23,9	0,0418	
Nurse 2 shift 2 a)	personal air sampling	493	0,10	24,7	0,0404	
Stationary 1 shift 1 b)	stationary, above patients head	465	0,24	23,6	0,0998	
Stationary 1 shift 2 b)	stationary, above patients head	496	0,60	25,9	0,251	
Stationary 2 shift 1 b)	stationary, near scavenger	465	0,26	24,1	0,111	
Stationary 2 shift 2 b)	stationary, near scavenger	500	0,19	25,4	0,0792	
Position A c)	syringe – infusion line	realtime				0,23
Position B c)	AnaConDa® filter – Y-piece	realtime				0,19
Position C c)	AnaConDa® filter - sample line	realtime				1,12
Position D c)	patients mouth	realtime				0,25
Position E c)	sample line – gasbox (watertrap)	realtime				0,23
Position F c)	ventilator exp. port - exhaust	realtime				0,22
Position G c)	top of scavenger canister (confluent of sample line & exhaust)	realtime				0,36
Position H c)	bottom scavenger canister	realtime				0,31

a) personal air sampling, (SKC 226-01 charcoal tube)
b) stationary sampling approx. 150cm above ground, (SKC 226-01 charcoal tube)
c) Realtime measurements, (Miran SapphIRe infrared ambient air analyzer)
Reference: Arbejdstilsynet; grænseværdiliste Bekendtgørelse; **42mg/m³** (5ppm), time weighted average over 8 hrs; ***(1 ppm = 8,33 mg/m³)***
NEN 689 model:

- Exceedance can be ruled out if concentration is <10% of exposure limit
- Possible exceedance if concentration is 10-100% of exposure limit
- **Exceedance; concentration is >100%**

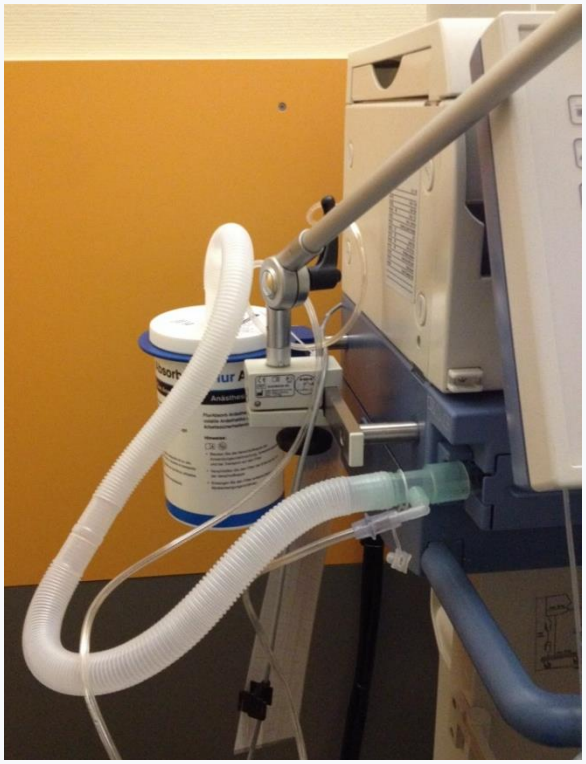
Scavenging systems



- Central gas scavenging?

- Aldasorber
- Novasorb
- CONTRAfluran Filter
  Zeosys Berlin

- FLUR Absorb
  Anaesthetic Gas Filter



Paediatrics

J Anesth (2014) 28:610–612
DOI 10.1007/s00540-013-1751-0

CLINICAL REPORT

Treatment of life-threatening hypercapnia with isoflurane in an infant with status asthmaticus

Yoshiki Masuda · Hiroomi Tatsumi · Kyoko Goto · Hitoshi Imaizumi · Shin-ichiro Yoshida · Tomohiko Kimijima · Michiaki Yamakage

2-year old female child
History of low birth weight, Atrial septal defect, Anal atresia
Diagnosed bronchial asthma at 18 mo of age

Inhalational steroids + β-2 stimulants + i.v. aminophylline
Lost consciousness, hypoxia → intubation

Severe acidosis (pH 6.71; paO_2 185 mmHg; HCO_3- 13.5 mEq/l)
Respiratory physiotherapy

Isoflurane 1.5 Vol%
Restitution within 30 min to normal values
Isoflurane continued with 0.5 Vol% for 2 h
Extubation at 18 h

	Our Case
Age	2
$PaCo_2$ (max)	238
Duration (h)	3
Complications	None
Outcome	GR

Sackey PV. Pediatr Anesthesia 2005; 15:879-85

Morphin, Midazolam
S-Ketamine, Clonidine;
(Propofol, Droperidol)

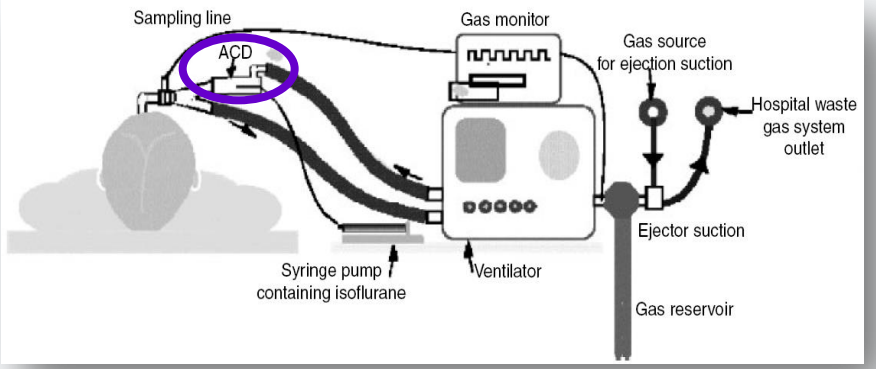
4-year old boy, 20 kg

Abdominal Compartment-syndrom due to intestine perforation;
Severe Sepsis;
Mild liver insufficiency

Isoflurane via AnaConDa

Syringe pump rate: 3-6 ml/h
Isoflurane concentration: 0,3- 0,4 Vol%

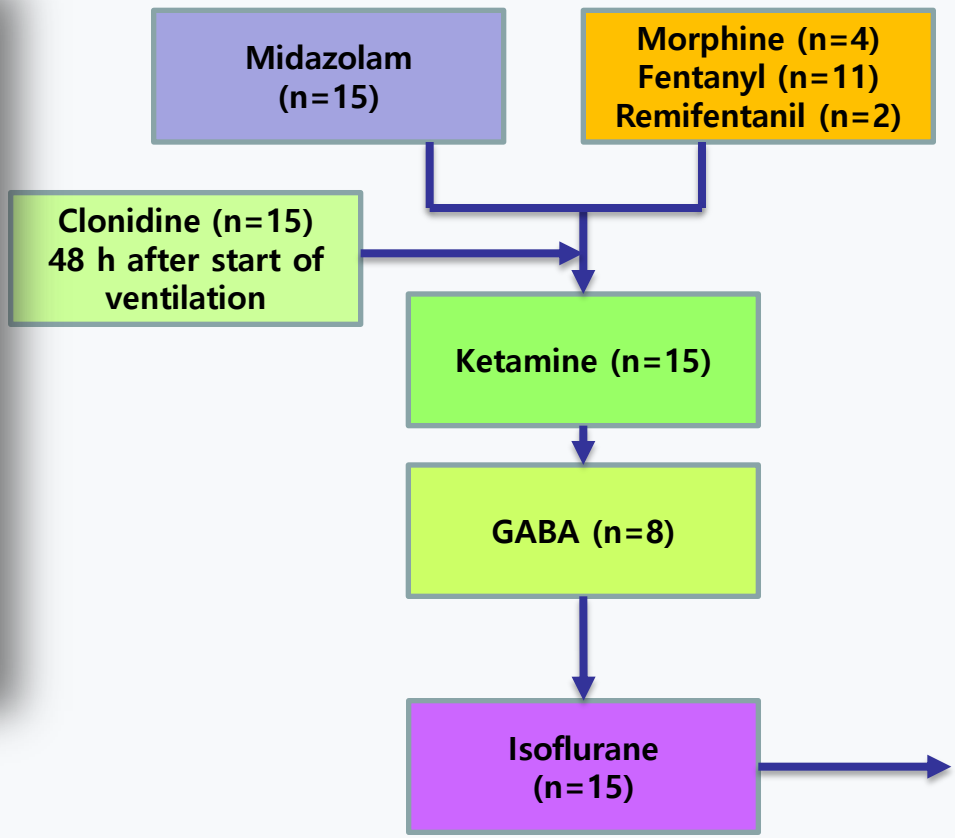
Duration of sedation: 8 days



Experience of inhalational Isoflurane in long-term sedation of critically ill children using a modified AnaConDa-System

Eifinger F et al. Klin Päd 2014; 225: 206-11

Patient no., sex	Age [months]	Diagnosis	Analgesia and sedation before isoflurane inhalation [days]	Isoflurane inhalation [days]
1, m	6.5	double outlet right ventricle, congenital obstructive hypertrophic cardiomyopathia	6.0	6.6
2, m	5.1	double outlet right ventricle, pulmonary valve atresia, SIRS	21.2	4.0
3, m	2.8	univentricular heart, tracheobronchial malacia, Trisomia 21	9.3	6.7
4, m	7.2	congenital obstructive hypertrophic cardiomyopathia, Noonan-syndrome	23.6	7.2
5, f	0.1	total anomalous pulmonary venous connection, phrenic nerve paresis, SIRS, SCID	29.5	5.8
6, m	27.0	hypoplastic left heart syndrome, SIRS	2.3	1.0
7, m	2.5	hypoplastic left heart syndrome, bilateral phrenic nerve paresis	8.2	18.0
8, f	11.7	formerly VLBL infant (27th GA), pulmonary hypertension, subglottic stenosis	2.5	2.2
9, f	8.0	formerly VLBL infant (25th GA), pulmonary hypertension, SIRS	2.6	21.0
10, f	7.2	formerly VLBL infant (23th GA), pulmonary hypertension, partial pneumonectomy	2.4	11.4
11, f	7.4	formerly VLBL infant (29th GA), pulmonary hypertension	7.6	1.1
12, f	7.5	floppy infant (35th GA)	6.1	1.3
13, m	33.2	SIRS, purpura fulminans, ARF	11.0	8.0
14, m	26.7	esophageal alkali burn	1.9	3.8
15, m	31.9	common type of acute lymphoblastic leukemia, SIRS	11.0	10.5
	11.8 (±2.4)		9.7 (±1.1)	7.2 (±1.4)

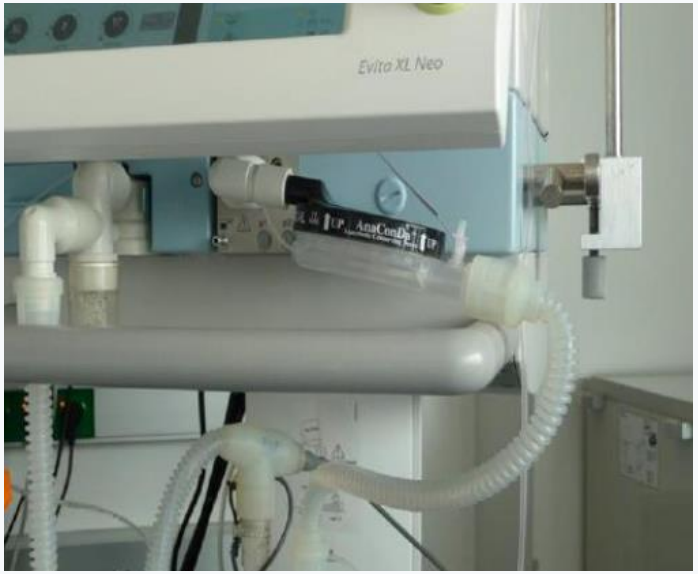


Setup of AnaConDa in the inspiratory limb

Start Isoflurane: **3-10 ml/h**
Isoflurane-Bolus: **0.3 ml**

Isoflurane consumption: 9.1 ± 1.1 ml/h

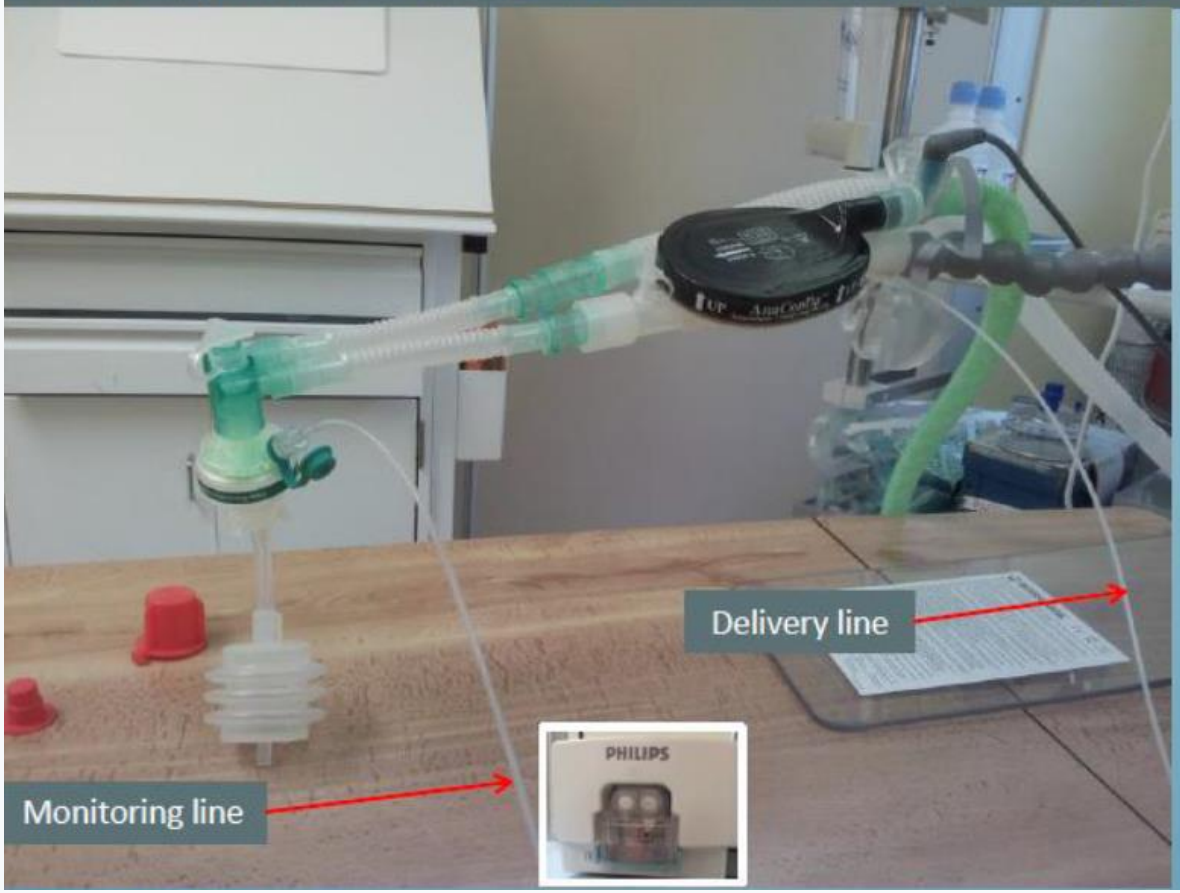
Isoflurane endexpir.: 0.9 ± 0.12 Vol%



→ **More frequently spontaneous breathing**
→ **Reduction of analgesics and Co-Sedatives**
→ **No change in haemodynamics**

→ **Isoflurane via AnaConDa as an additional option in difficult sedation and/or critically ill children**

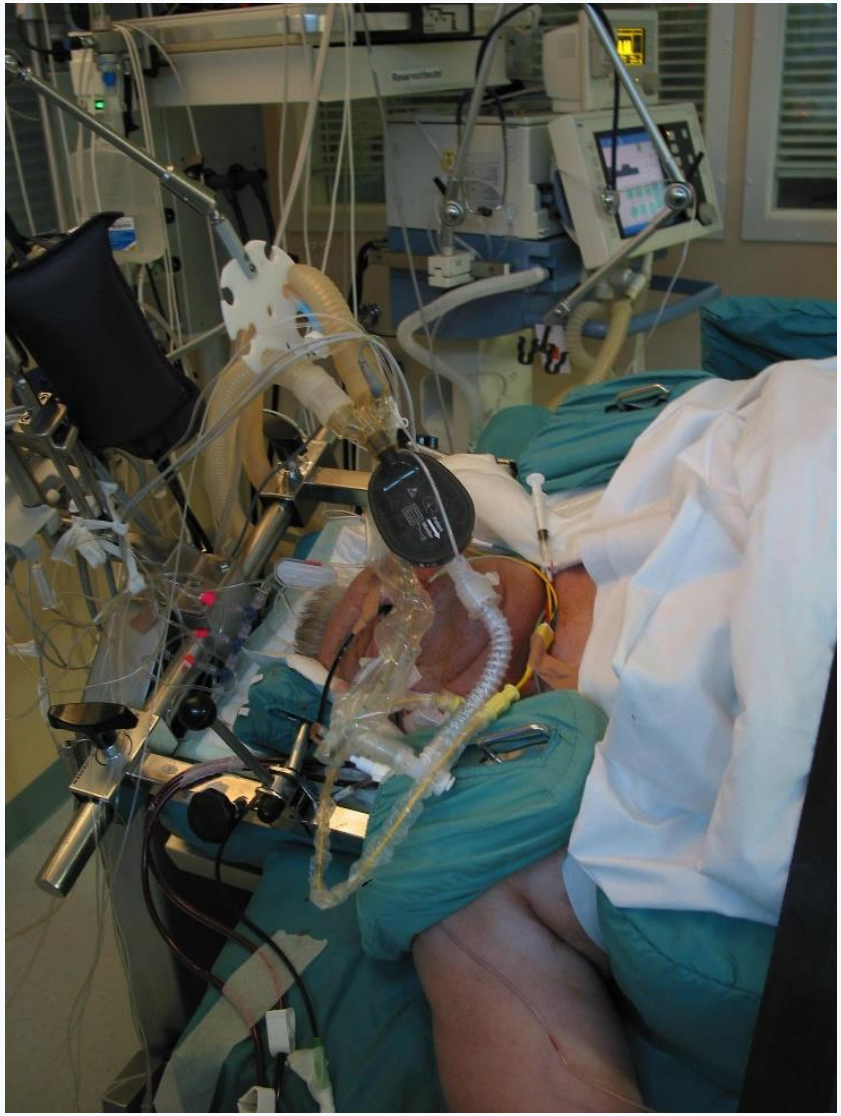
1. Remove the Anaconda device from the box and insert into the INSPIRATORY LIMB of the Evita XL ventilator, prior to the end module, with the arrows in the direction shown
2. Attach the HME filter to the Y-piece of the ventilator
3. Attach one end of the monitoring line to the HME filter and the other end to the port of the gas analyser module on the Philips gas bench
4. Ensure the circuit is occluded with the use of a 'dummy lung'
5. The delivery line attached to the Anaconda device will be attached to the delivery syringe in due course

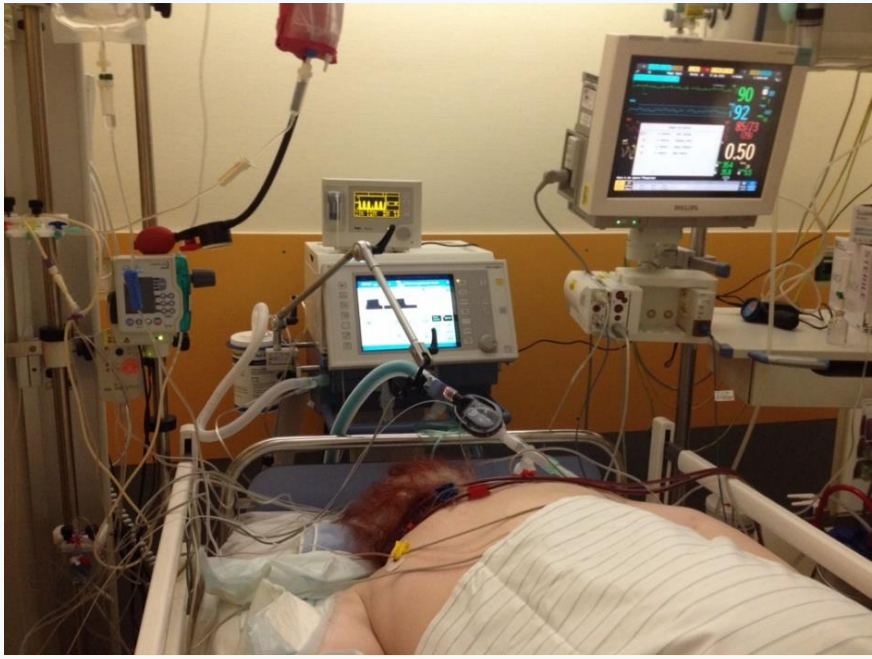


Ensure the anaconda is inclined down towards the patient to help minimise saturation of the device with secretions and condensation

A paediatric circuit should only be used with the Anaconda for patients up to 20kg – after 20kg an adult circuit is required

Do not use the humidifier unless instructed to by the on-call Intensivist

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92
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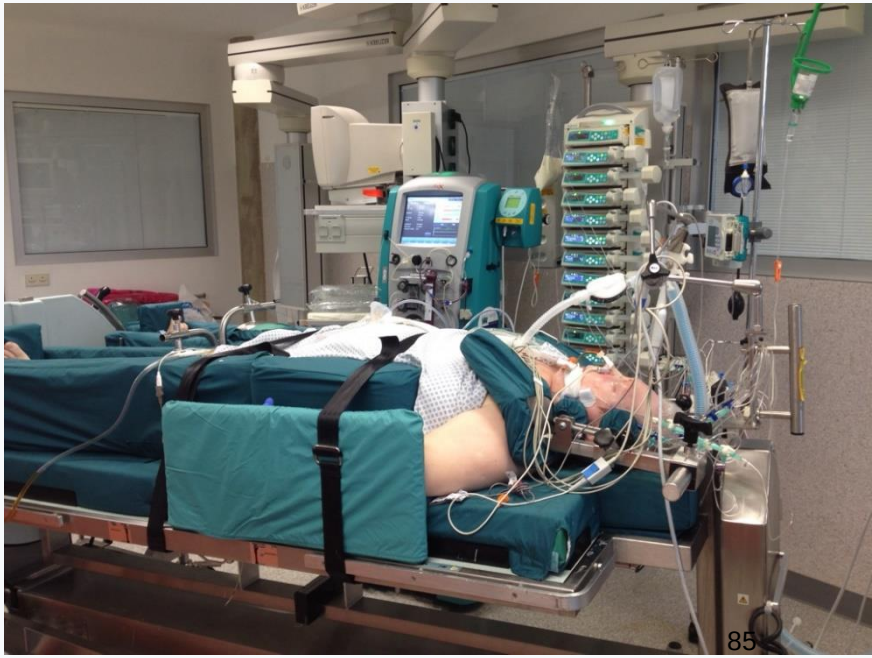
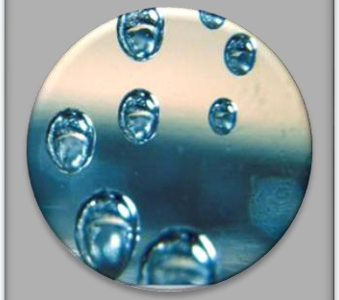


New challenges

AnaConDa: **100 ml dead space**
Vt >350 ml

SMALL AnaConDa:
50 ml dead space
Vt >175-200 ml

ARDS, small patients & children…



Consider inhalational sedation as a new option (PAD-Guidelines)

Choose isoflurane or sevoflurane

Gas monitoring & Scavenging

Place AnaConDa in the ventilator circuit

Iso 3 ml/h
Sevo 5 ml/h via syringe pump

Bolus 0.5 ml

Summary

- Shorter wake-up times and extubation
- Realtime monitoring of sedation depth
- Short and long-term use without tolerance or severe side-effects to date
- Less ventilator days
- Reduced mortality
- Promising in special patient groups in terms of neuro-/cardioprotection and immune modulation
- VA are part of German S3-sedation guidelines and non-benzodiazepine sedatives

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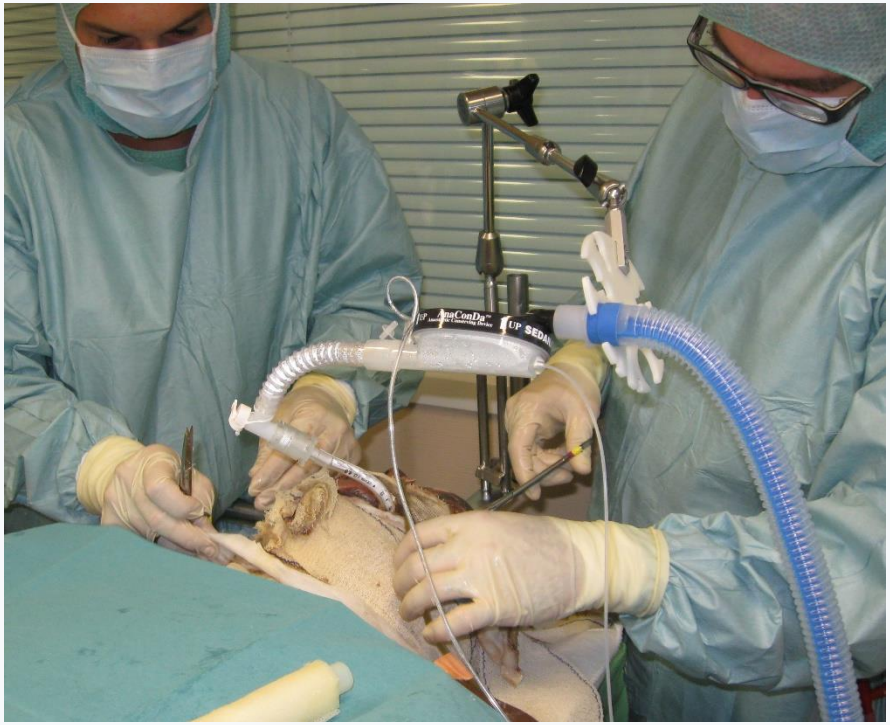

Thank you!