Volatile vs. Intravenous
(Comparisons, Intracranial Surgery)

- In patients with tumors comparing:
  - Propofol/Fentanyl
  - Isoflurane/N_2O
  - Fentanyl/N_2O

- No differences in mean ICP or brain condition.
- MAP and CPP was lower with Iso/N_2O.
- Emergence was more rapid with Fentanyl/N_2O.

Todd MM et. al., Anesthesiology 1993; 78:1005-1020

Volatile vs. Intravenous
(Comparisons, Intracranial Surgery)

- In patients with mass lesions comparing Sevo/Fentanyl with Propofol/Remifentanil:
  - No difference in brain condition
  - No difference in recovery variables
  - More hypotension in the TIVA group.

Magni G et. al., J Neurosurg Anesthesiol 2005; Vol 17 (3):134-8

* No benefit to using ultra-short opioid

Volatile vs. Intravenous
(Comparisons, Intracranial Surgery)

- Compared to Propofol:
  - Des and Iso 0.5 and 1.0 MAC increased CSFP (5 and 4 mm Hg) and decreased CPP (12 and 15 mm HG)
    Talke P et. al., Anesthesiology 1996; 85:999-1004
  - Sevo 0.5 and 1.0 MAC increased CSFP (2 mm Hg) and decreased CPP (11-15 mm Hg)
    Talke P et. al., Anesthesiology 1999; 91:127-30
- Propofol infusion, Isoflurane, or Isoflurane switch to Propofol at dural closure:
  - No differences in hemodynamic or recovery variables.

Talke P et. al., Anesth Analg 2002; 95:430-5

Volatile vs. Intravenous
(Comparisons, Intracranial Surgery)

- In elective tumor patients, comparing Sevo/Remi to Propofol/Remi, no difference in:
  - Time to reach Aldrete score = 9
  - Time to eye opening
  - Time to extubation
  - Incidence of shivering, PONV, pain
  - *Hypotension more frequent with Sevo

Lauta E et al, J Neurosurg Anesthesiol 2010; 22:110-118

The two techniques are comparable!

Volatile vs. Intravenous
(Comparisons, Intracranial Surgery)

- Tumor patients combining Fentanyl, comparing Propofol with Iso and Sevo, Propofol infusion was associated with:
  - Lower ICP (7 mmHg vs 12 or 11)
  - Higher CPP (80 mm Hg vs 60 or 63)
  - Lower dural tension than Iso (not Sevo)
  - Less cerebral swelling after opening dura

*No difference in ICP or CPP between Iso and Sevo

Petersen KD et. al., Anesthesiology 2003; 98:329-36

Volatile vs. Intravenous
(Does Remifentanil Help?)

- Elective craniotomy comparing Sevo-Remi, Sevo/Fentanyl, and Propofol/Remi:
  - No difference in – Time to Aldrete score = 9
    - Brain relaxation scores
    - Use of osmotic diuretics
  - Less PONV with Propofol
  - Higher cost (23%) and postoperative analgesic requirements with Remi groups

Citerio G et al, Eur J Anaesthesiol 2012; 29:371-379

And Since we're Talking About Cost…

- Current UCH acquisition costs for:
  - Desflurane - $140.05
  - Sevoflurane - $127.37
  - Isoflurane - $10.91
  - Propofol 20 ml - $2.14
  - Propofol 50 ml - $5.34
  - Fentanyl 5 ml - $0.99
  - Sufentanil 100 mcg/2ml - $3.53
  - Remifentanil 1 mg - $43.83

CBF, ICP, CBV, or CPP?

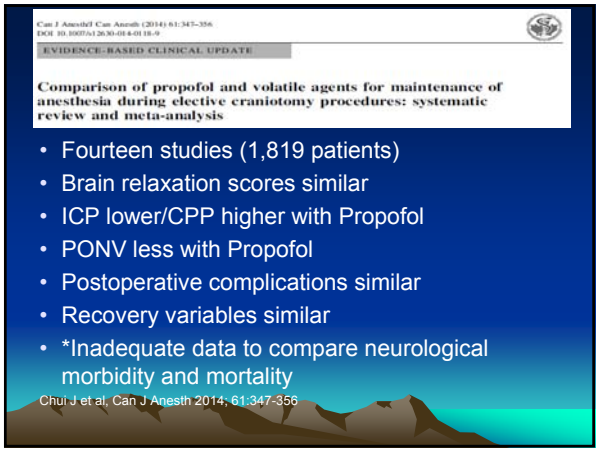
- CPP = MAP – ICP
- Want to maintain CPP = 70 – 90 mm Hg
- ICP affected by intracranial volume
- Intracranial volume has 4 components:
  - Tissue volume
  - CSF volume
  - Fluid compartment (edema)
  - Blood volume (arterial and venous)
- CBF reflects arterial volume – how much does this really affect total CBV?

Compare 3 Opiates, 5 Hours, 70 kg:

- Fentanyl – 8mcg/kg load, 1.25mcg/kg/hr:
  Total 1007 mcg = ~$4
- Sufentanil – 1mcg/kg load, 0.3mcg/kg/hr:
  Total 175 mcg = ~$7
- Remifentanil – 1mcg/kg load, .25mcg/kg/min:
  Total 5320 mcg = ~$227
- Propofol – 2mg/kg load, 150 mcg/kg/min:
  Total 612 mg = ~$65

CBF, ICP, CBV, or CPP?

- Approximately 10% of CBV is in the arterioles and capillaries – the compartment which reacts to CO_2 and anesthetic agents
  Schmidek HH et. al., Neurosurgery 1985; 17:663-78
  Heistad DD et. al. in Handbook of Physiology; American Physiologic Society, 1983
- Comparing 1.4% Iso, 0.8% Hal, or 2.2% Enf:
  Halothane: ↑CBV (11%), ↑ICP (stable)
  Enflurane: ↑CBV (9%), ↑ICP (continued to rise, even after Enf off)
  Isoflurane ↑CBV (10%), ↑ICP (only for 20 min, then returned to baseline)
  Fentanyl: ↓CBV (8%), ↓ICP (only for first 20 min, then returned to baseline)
  Artru AA, Anesthesiology 1983; 58:533-9
  Artru AA, Anesthesiology 1984; 60:575-9


Can J Anesthl Can Anesth (2014) 61:347–356
DOI 10.1007/s12630-014-0118-9

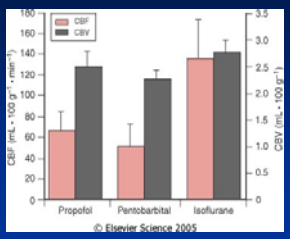
EVIDENCE-BASED CLINICAL UPDATE

Comparison of propofol and volatile agents for maintenance of anesthesia during elective craniotomy procedures: systematic review and meta-analysis

- Fourteen studies (1,819 patients)
- Brain relaxation scores similar
- ICP lower/CPP higher with Propofol
- PONV less with Propofol
- Postoperative complications similar
- Recovery variables similar
- *Inadequate data to compare neurological morbidity and mortality

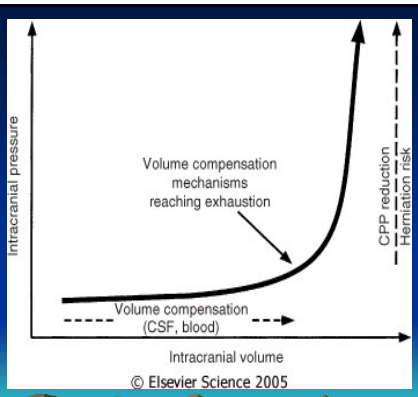
Chui J et al. Can J Anesth 2014; 61:347-356

CBF, ICP, CBV, or CPP?



- In rats though CBF was 2.0-2.6 times greater with Iso than Prop or Pento, CBV was only 10-18% greater with Iso

Todd MM and Weeks J, J Neurosurg Anesthesiol 1996; Vol 8 (4):296-303



- Drummond JC and Patel PM in Miller's Anesthesia, 6th Ed, p. 2128

Volatile vs. Intravenous Agents
(Is One Really Better?)

- It depends on how you define "better"
  - Quicker emergence (short term outcome)
  - Ease of titration/administration
  - Hemodynamic stability
  - Brain conditions
  - Long term outcomes (no data)

What About Dexmedetomidine?

- Decreases both CBF > $CMRO_2$
- Can reduce MAC by up to 90%
- Opioid sparing effect
- Moderate doses do not interfere with neuromonitoring
- Decreases intracranial pressure
- Significantly attenuates hypertensive response to intubation and Mayfield pin placement

Published Opinions

- Overall, TIVA is similar to volatile anesthetics with regard to hemodynamic stability, emergence times, extubation times, early cognitive function, and adverse events. … Our institutional experience with TIVA in these patients has shown a subjective improvement in brain relaxation and surgical access to the operative site. … The impact of TIVA…in a study group with severely elevated ICP has yet to be evaluated.

Cole CD et al. Neurosurgery 2007; (ONS Suppl 2):ONS369-378

What About Dexmedetomidine?

- Increases cardiovascular stability
- ETT may be removed earlier in one study
- BUT – it is not an anesthetic and use may confuse bispectral index monitoring

Bekker A, Sturaitis MK, Neurosurgery 2005;57:(ONS Suppl 1)
Tanskanen PE et al, Br J Anaesth 2006;97:658-65
Bekker A et al, Anesth Analg 2008;107:1340-7
Osman I et al, EAJM 2010;42:61-5
Soliman RN et al, Middle East J Anaesthesiol 2011;21:325-34

Inhalational or intravenous anesthetics for craniotomies?
Pro inhalational
Kristin Engelhard and Christian Werner

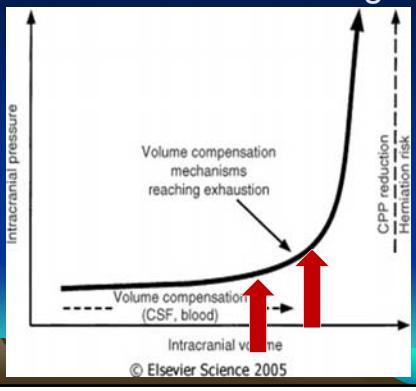
Both, sevoflurane and propofol are generally suitable for neurosurgical interventions. The decision to choose either of the two anesthetics should be made on the basis of exact knowledge of their advantages and disadvantages. In patients with no intracranial hypertension the use of sevoflurane might be more reasonable, because cerebral blood flow is improved compared with propofol. When intracranial pressure is high (e.g. large tumor) propofol reduces the intracranial volume and thereby facilitates the surgical approach.

Curr Opin Anaesthesiol 2006; 19:504-508

My Opinion

- For all agents, the ultimate condition of the patient will be determined by the sum of the effects of the chosen agent on CBF, $CMRO_2$, vascular tone, MAP, CO, CSF formation/reabsorption, and CBV.
- The preponderance of evidence is that intravenous agents (Propofol, Barbiturates, Etomidate, Benzodiazepines, synthetic opiates (phenylpiperidine)) have *less deleterious, and more salutary effects that are more predictable on intracranial dynamics than volatile agents*, especially if MAP is maintained.

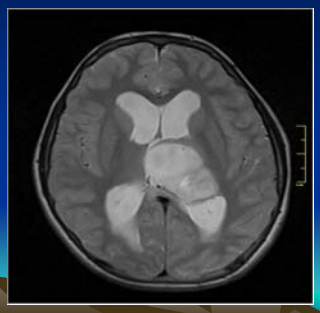
Where Are We Starting?



My Opinion

- Isoflurane, Sevoflurane, and Desflurane are similar, though the edge goes to Sevoflurane, and their ultimate effects on ICP/CPP are less predictable.
- There is no overwhelming evidence that one technique is superior to any other in terms of short term recovery profile, if the agents chosen are properly administered.
- Choose your poison (agents) wisely given the goals of anesthesia and surgery, and the condition of the patient such as……

On The Other Hand, This is a Totally Different Animal



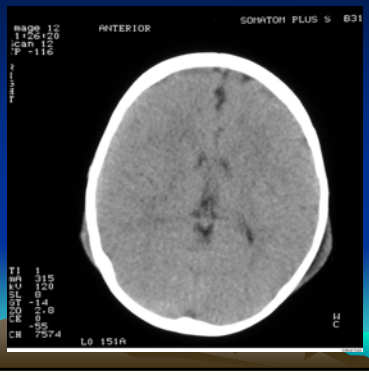
- If the patient is wide awake, appearing for elective surgery, and is well-compensated in terms of intracranial dynamics:

  Either volatile or TIVA are appropriate taking care to avoid bad things like –

  - Hypotension (remember CPP)
  - Hypertension
  - Hypoxemia
  - Hypercarbia
  - Inadequate anesthesia at critical points

  Remember – it's more important how you do it, than what you use.

As Is This:



And This:

My Opinion

- If the patient has signs or symptoms of high ICP (altered mental status, head injury, ventriculostomy/ICP monitor in place, midline shift on CT/MRI, etc.):
  - -Management of the ICP/CBF/CBV/CPP is critical
  - -TIVA is preferable, at least until the dura is opened and the effects of anesthetics on the brain bulk can be assessed directly
  - -Keep a very close eye on CPP (>70 mm Hg)

Lower Limit of Autoregulation - Human

Author	Hypotensive Technique	CBF Method	LLA Mean (Range)
McCall[9]	Hydralazine	K-S/N2O	<64 (33–80)
	Veratrum viride	K-S/N2O	<57 (40–72)
Moyer, *et al.*[6]	Hexamethonium	K-S/N2O	>62 (53–80)
	Trimethaphan	K-S/N2O	>57 (44–75)
	Pendiomide	K-S/N2O	<61 (54–72)
Strandgaard[8]	Trimethaphan/tilt	1/A-VDO2	73 ± 9
Waldemar, *et al.*[10]	Trimethaphan/lower body negative pressure ± captopril	1/A-VDO2	79 (57–101)
Larsen, *et al.*[11]	Lower body negative pressure/labetalol	1/A-VDO2	79 (53–113)
		CBFVmca	91 (41–108)
Olsen, *et al.*[12]	Labetalol/lower body negative pressure	1/A-VDO2	88 (76–101)
Olsen, *et al.*[13]	Lower body negative pressure/labetalol	1/A-VDO2	73 (60–100)
		A-NIRS diff	79 (73–101)

Data are presented as mean values with ranges (when available) or standard deviations.

* The subjects were 42 pregnant women near term, 24 of whom had toxemia of pregnancy.

K-S/N20 = Kety-Schmidt technique using nitrous oxide as the tracer; CBFVmca = mean CBF velocity in the middle cerebral artery; 1/A-VDO2 = the constancy of cerebral metabolic rate was assumed and that CBF was determined by the formula CBF = a constant × 1/(arterial-jugular venous oxygen content difference); A-NIRS = the constancy of cerebral metabolic rate was assumed, and a decrease in CBF was inferred when the arterial to regional saturation difference (the latter determined by near infrared spectroscopy) increased; ± = the LLA was not identified, but that CBF was unchanged from the control value at the MAP indicated; > = the LLA was not identified, but that CBF was less than the control value at the MAP indicated.