CSF Overdraiange – Too much of a good thing

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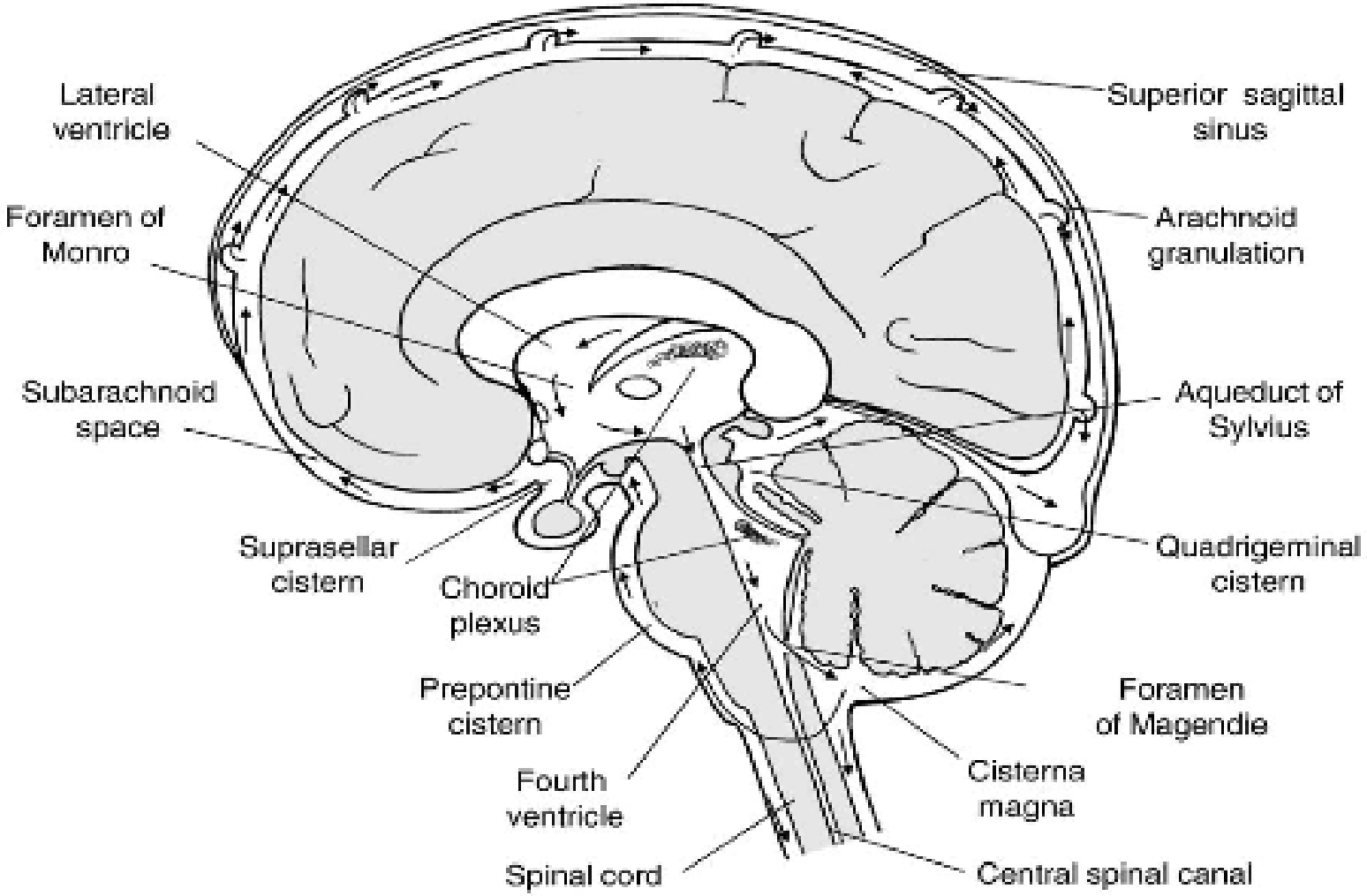
Normal CSF Physiology

- CSF Volume in adult: 150 ml
- CSF Turnover in 24 hours: 500 ml
- CSF secretion rate: ~ 20 ml/hr ~ 500 ml/day in adults

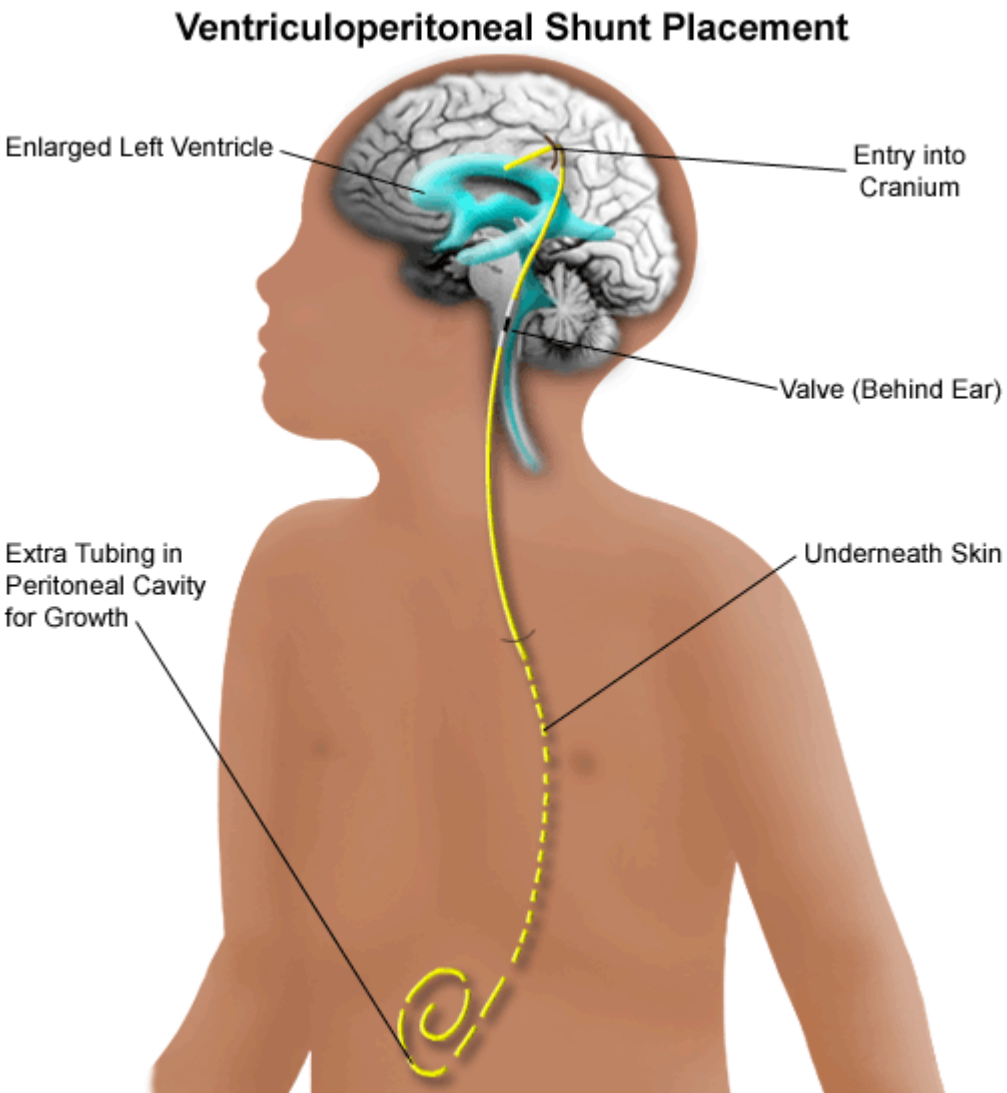
CSF Flow

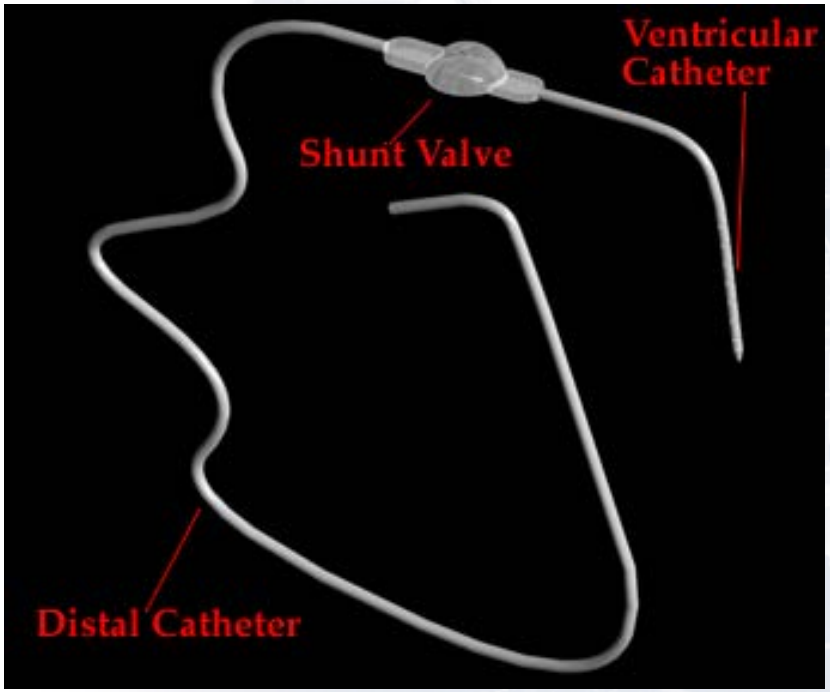

Lateral ventricle
Foramen of Monro
Subarachnoid space
Suprasellar cistern
Chorold plexus
Prepontine cistern
Fourth ventricle
Spinal cord
Superior sagittal sinus
Arachnoid granulation
Aqueduct of Sylvius
Quadrigeminal cistern
Foramen of Magendie
Cisterna magna
Central spinal canal

Shunt complications

- Shunt obstruction ~ 50%
- Shunt infection ~ 15-20%
- Shunt overdrainage ~ 10%

Shunts





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Monroe-Kellie doctrine

$$V_{intracranial} = V_{brain} + V_{blood} + V_{csf}$$

Good compliance in children – brain ISF increases – slit ventricles

Poor compliance in adults (stiff brain) – blood vessels (veins) expand – subdural hematoma

CSF flow through shunts

- With simulation invitro of an upright posture (+30 cm differential) flow through conventional differential pressure shunt valves is un-physiologic - 25 to 3000 ml/hr
- Normal CSF production is ~ 20 ml/hr
- For a typical medium pressure valve – 200 ml/ hr for a 25 cm differential.

Symptoms

- Headaches
- Dizziness, ringing in the ears, hearing loss
- Paradoxical worsening gait and cognition

If severe –

- Confusion, seizures, coma – subdural hematomas or shunt obstruction

Headaches

- Positional –
  - worse when upright
  - relived by lying down in a short time
- Worse with exercsie or maneuvers that induce a Valsalva
- Worse towards the end of the day
- Intermittent high pressure headaches followed by low pressure headaches
  - (eg: blowing a balloon)

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Hearing and Balance problems

- Decreased hearing
- Pressure sensation in the ears – like swimming under water
- Ringing in the ears
- Dizziness
- Constant sensation of floating or walking as if drunk

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NPH patients with overdrainage

- May have positional headaches but more commonly ….
- Paradoxical return of symptoms of NPH
  - worsening gait and balance
  - Worsening memory and confusion

If untreated and severe

- Signs of subdural hematoma (bleeding around the brain)
- Signs of slit ventricle syndrome
- Signs of shunt obstruction

Risk factors for overdrainage

- Height increase - gravity
- Low shunt settings
- LP shunts
- VA shunts

Findings on testing

- CT – subdural hygromas/hematomas when severe overdrainage; none if mild or moderate
- MRI – enhancement of dura; sagging of brainstem,tonsillar herniation in LP shunts (iatrogenic “Chiari”)
- Nuc. Med. Shunt patency: Rapid egress of radiotracer from shunt
- ICP Monitoring – negative pressures with upright positioning

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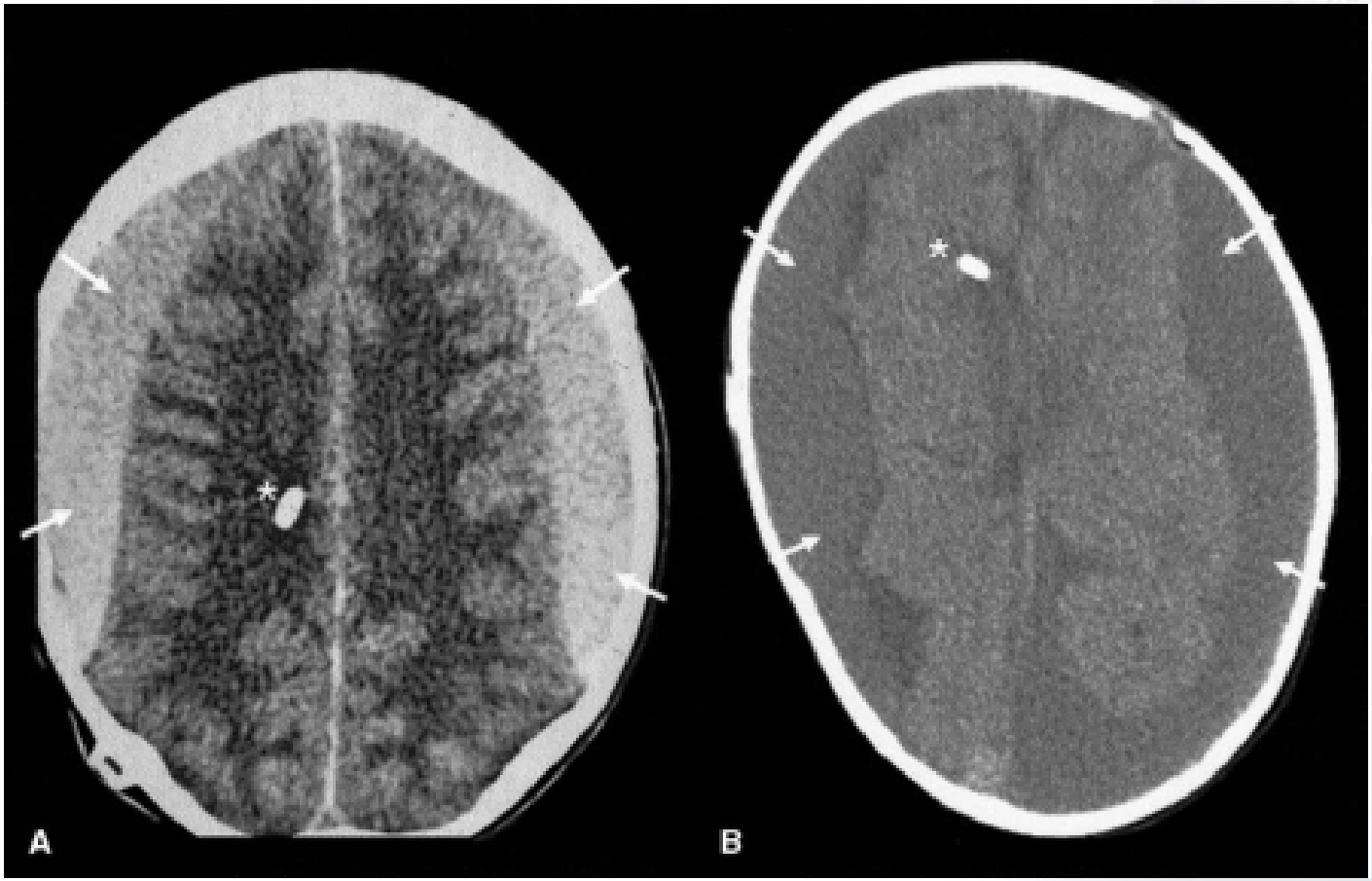
Bilateral subdural hematomas from CSF overdrainage

Bilateral subdural hematomas



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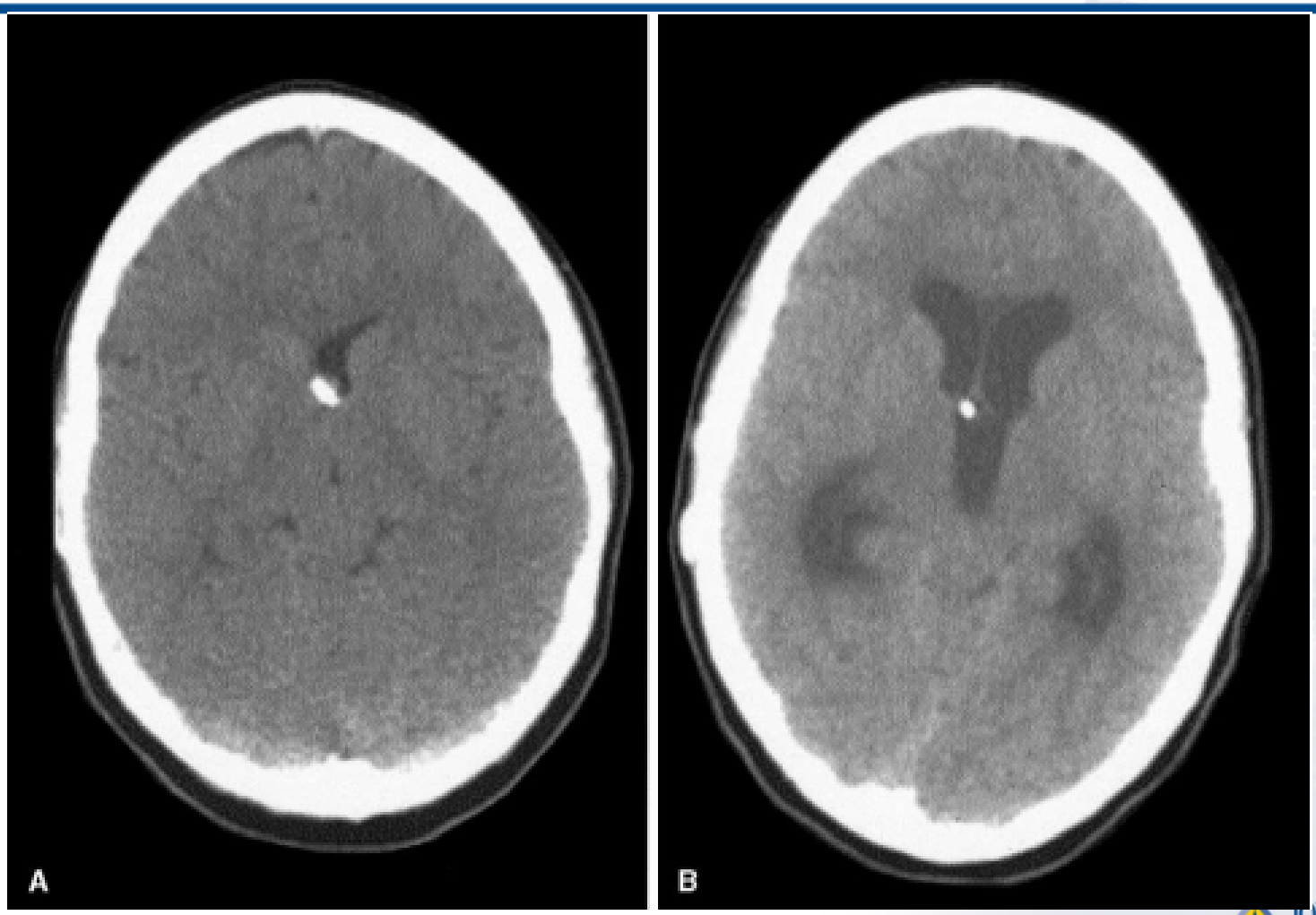
CT for assessing shunt function



Slit Ventricles

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Slit Ventricle syndrome

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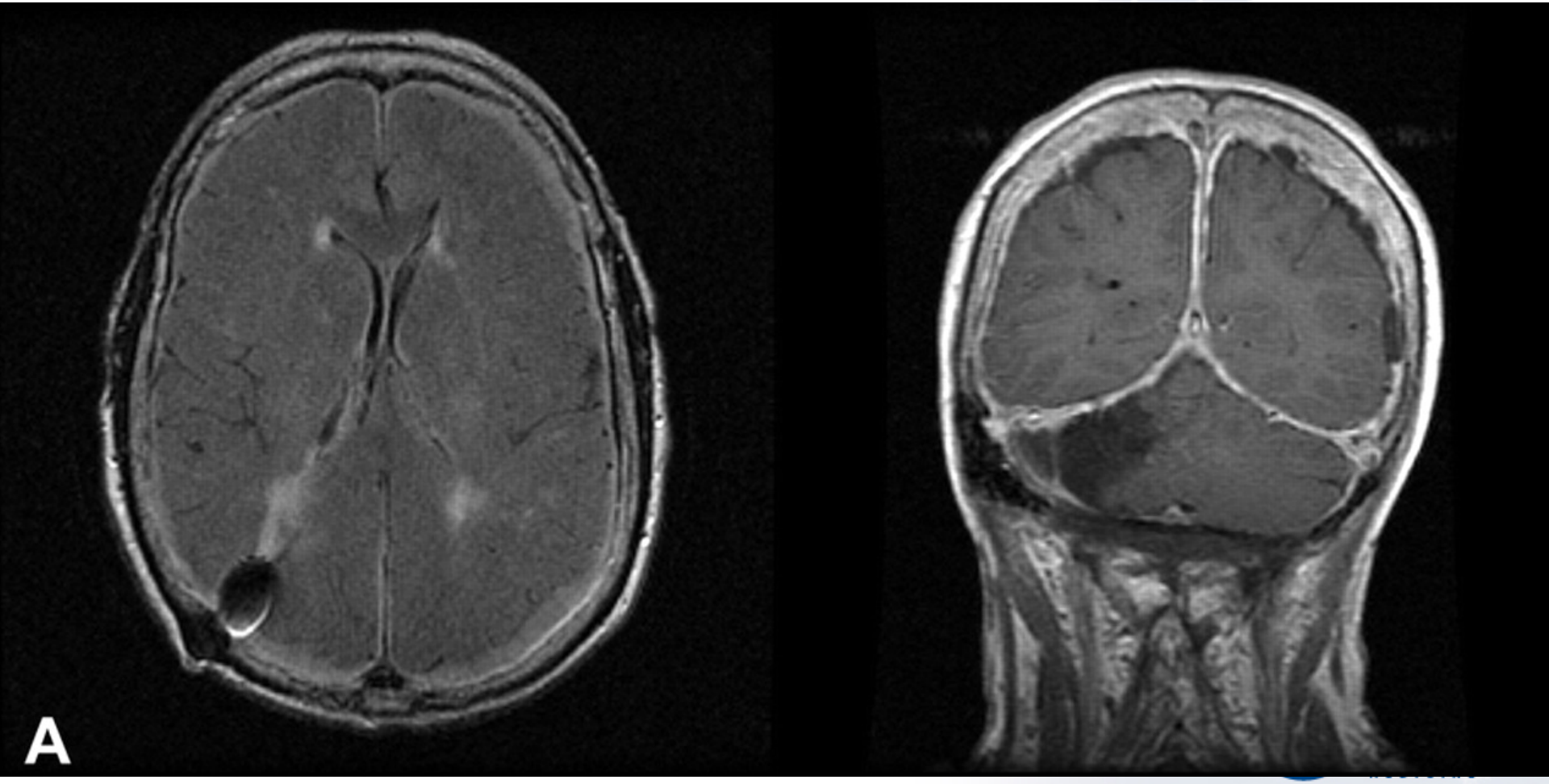
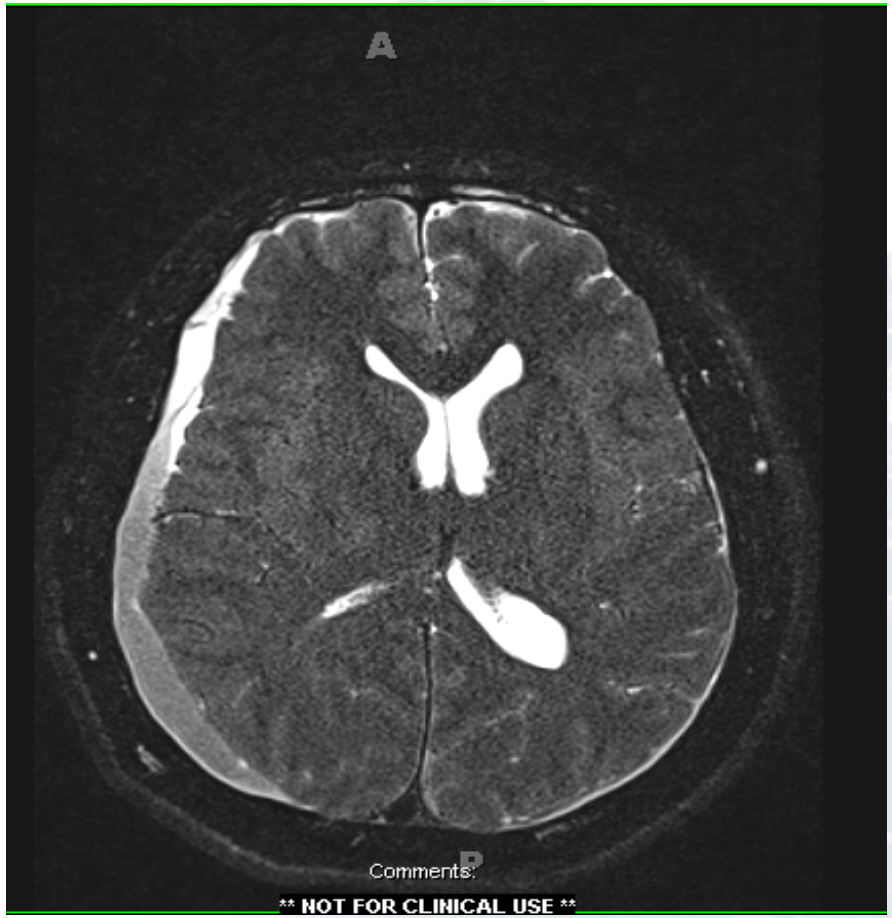
MRI appearance in intracranial hypotension due to CSF overdrainage



CSF Overdrainage in LP shunts



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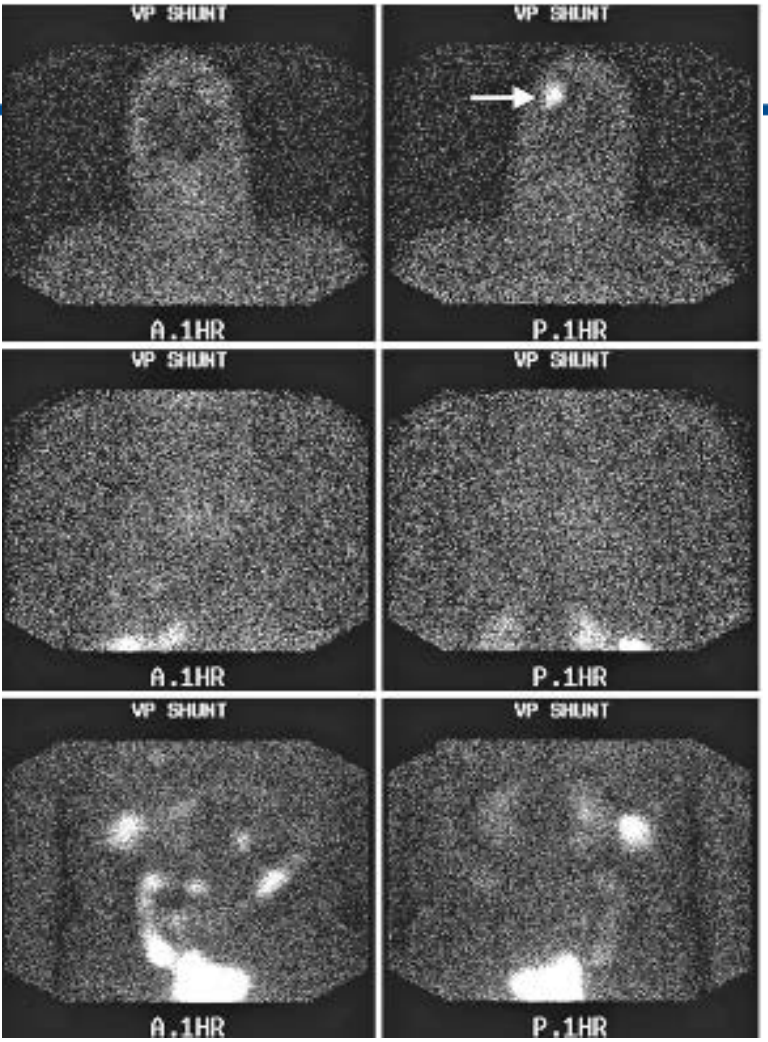
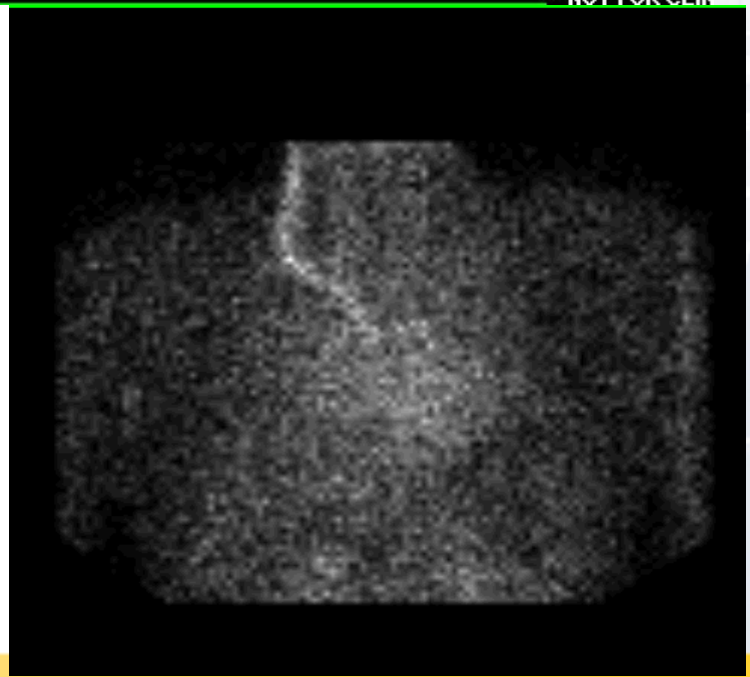
Shunt Patency Study

- Assess proximal catheter patency by aspirating 0.5 cc CSF
- Occlude distal catheter
- Inject radio-isotope
- Flush with appropriate CSF
- Image for 20 minutes; ambulate and image 2 hours later if no flow





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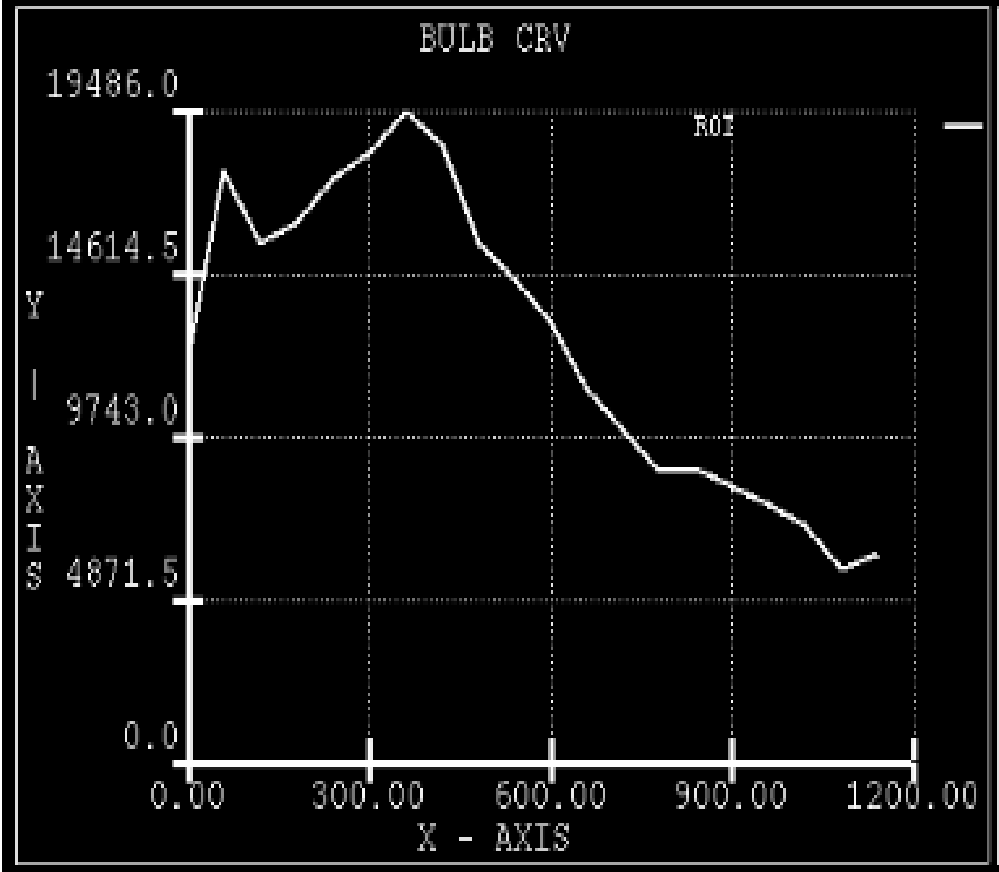
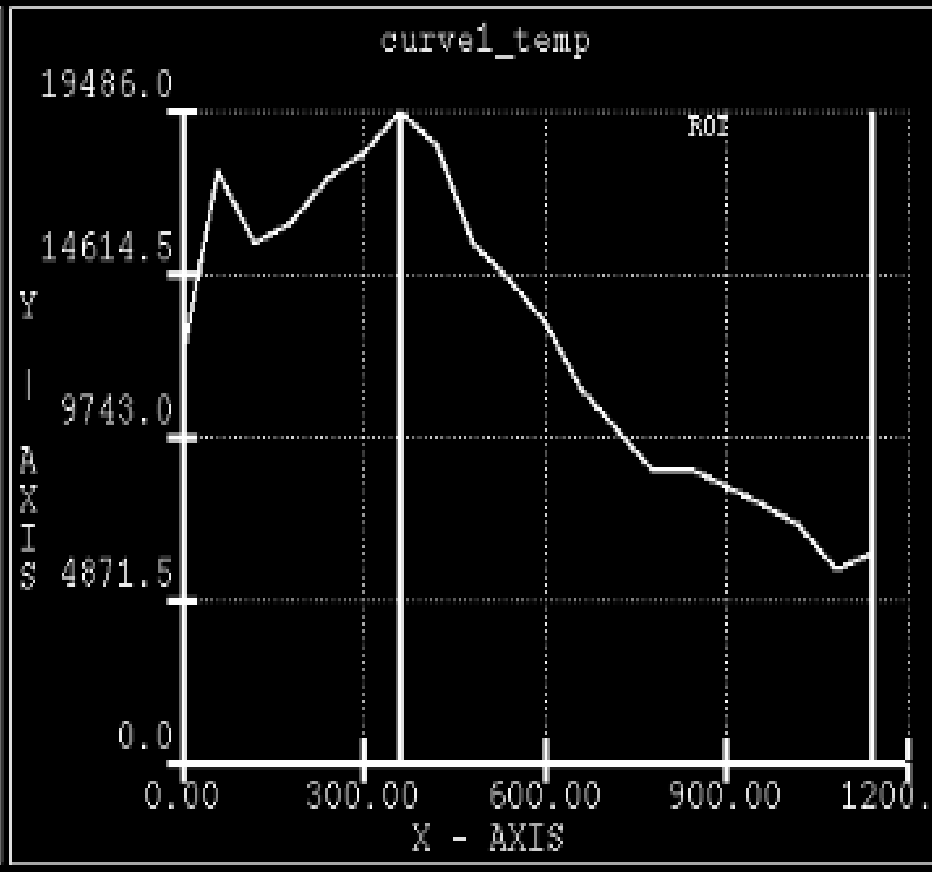
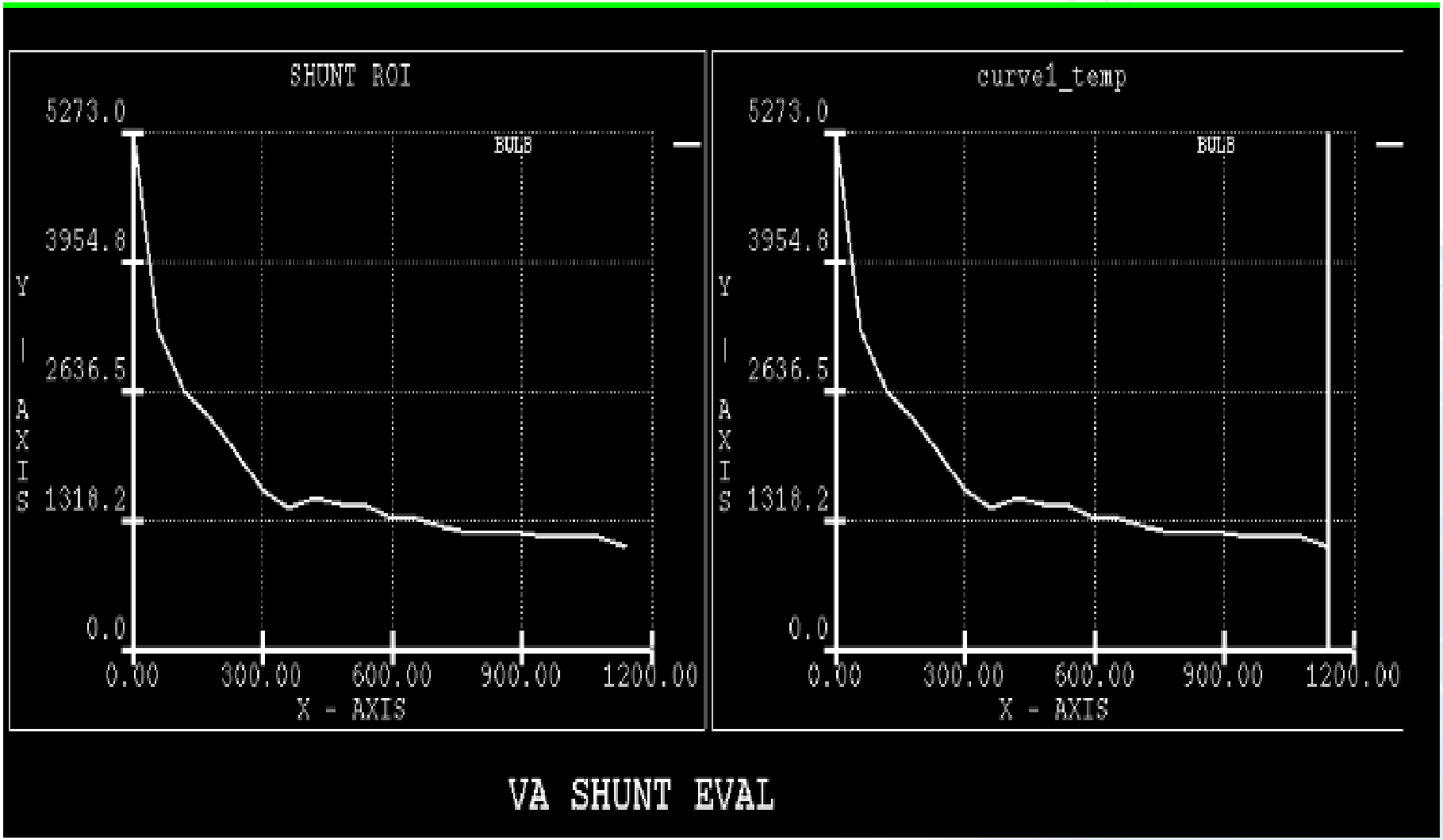


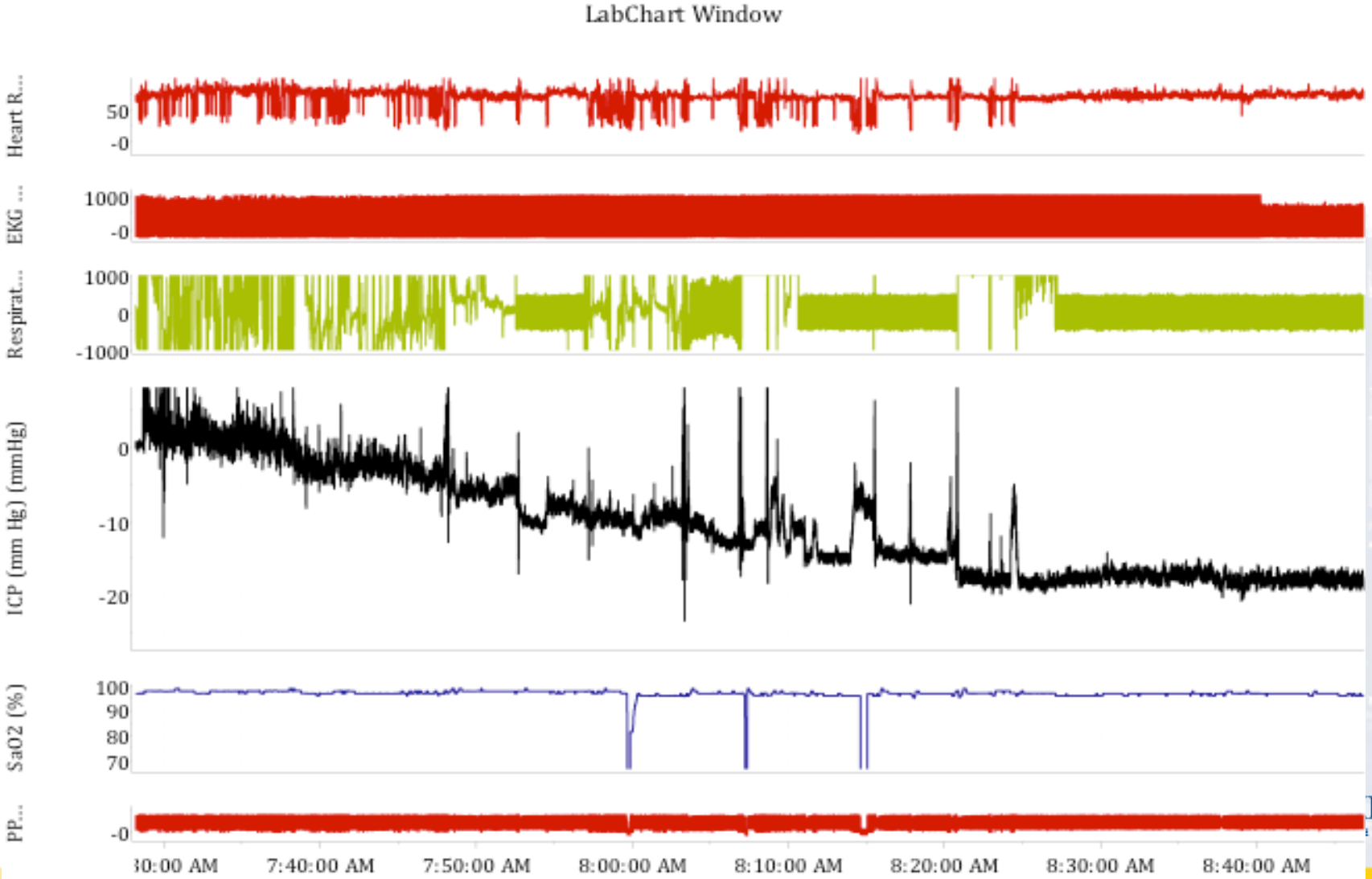


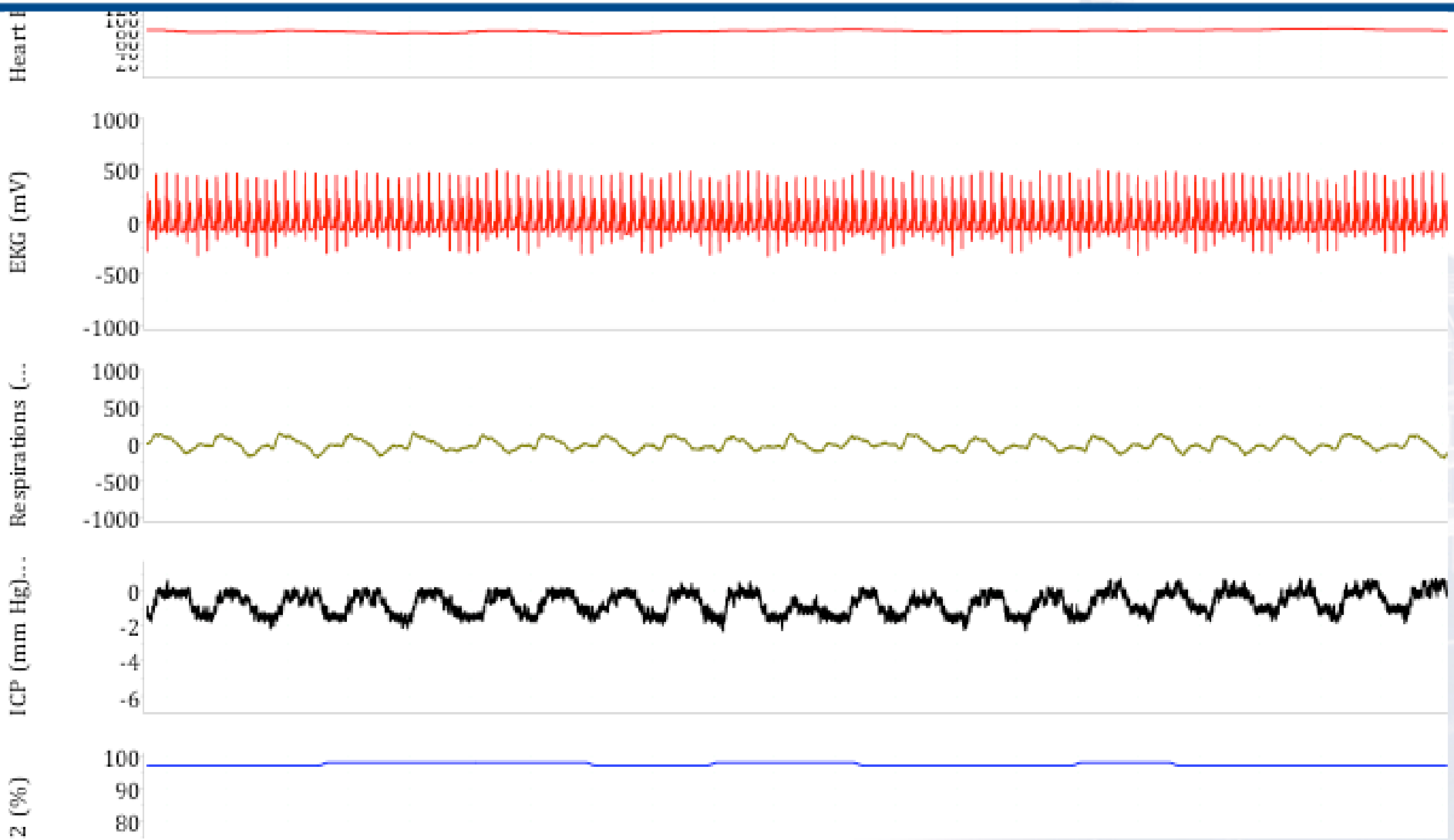
VA SHUNT T1/2= 7 MINS

T ½: 2 minutes


SHUNT ROI
5273.0
3954.8
2636.5
1318.2
0.0
Y - AXIS
BULB
0.00
300.00
600.00
900.00
1200.00
X - AXIS
curve1_temp
5273.0
3954.8
2636.5
1318.2
0.0
Y - AXIS
BULB
0.00
300.00
600.00
900.00
1200.00
X - AXIS
VA SHUNT EVAL

ICP changes with position




Heart
EKG (mV)
1000
500
0
-500
-1000
Respirations (...
1000
500
0
-500
-1000
ICP (mm Hg)...
0
-2
-4
-6
2 (%)
100
90
80

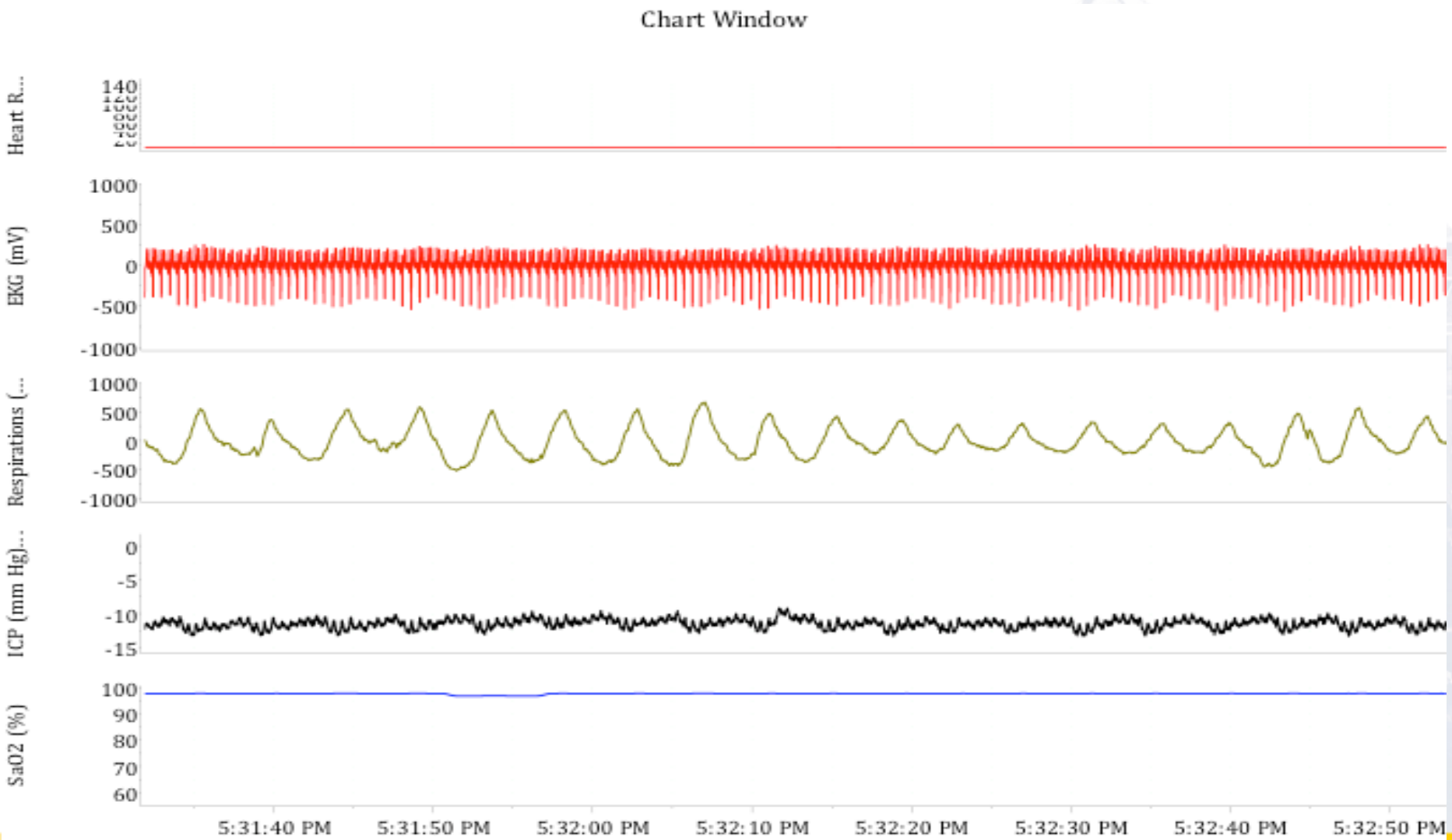
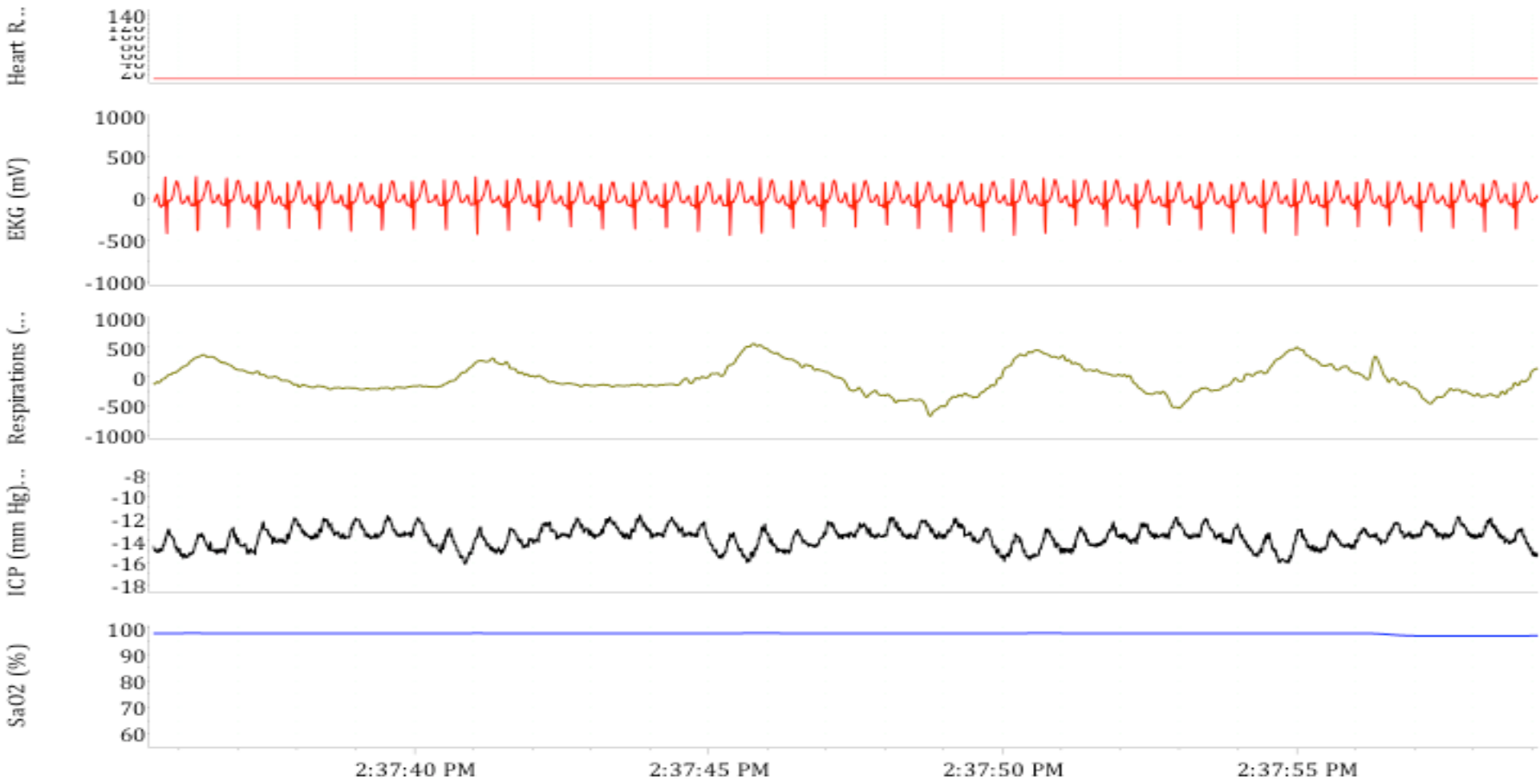


Chart Window
Heart R...
140
EKG (mV)
1000
500
0
-500
-1000
Respirations (...
1000
500
0
-500
-1000
ICP (mm Hg)...
0
-5
-10
-15
SaO2 (%)
100
90
80
70
60
5:31:40 PM
5:31:50 PM
5:32:00 PM
5:32:10 PM
5:32:20 PM
5:32:30 PM
5:32:40 PM
5:32:50 PM

Chart Window



Treatment options

- Increase shunt settings if programmable
- Add a resistive device – siphon regulatory device
- Replace with a shunt that offers higher resistance to CSF flow
- Replace with a shunt that is flow regulated as opposed to pressure regulated
- Is a shunt still needed – removal ± ETV

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Programmable shunts

- Higher shunt settings – higher opening pressures for the valve – more resistance to siphoning
- Needs to be done gradually over several weeks to months
- Risk of underdrainage and return of symptoms

Siphon control devices

- Add variable resistance (low in children; more in taller thin adults)
- Some are activated by upright posture; some by negative pressures when there is too much siphoning of CSF
- Implanted distal to the shunt
- Position crucial for effective operation

Shunt replacement

- Replace with fixed shunts with higher opening pressures or preferably with programmable shunts

- Replace with a flow regulated valve in contrast to a pressure regulated valve; but higher incidence of shunt obstruction

Is the shunt still needed ?

- Shunt removal ± ETV
- Stepwise – shunt ligation, monitoring of ICP and imaging
  - If ICP normal and no progressive ventriculomegaly – remove shunt
  - If ICP increases and ventriculomegaly associated with aqueductal stenosis - ETV

Ideal shunt valve

- H. Pornroy –

  "…an ideal valve should be flow controlled. Such a valve would have to continuously determine the formation rate and the rate of outflow through natural channels and regulate the flow through the valve so as to remove only the excess fluid."