Decompressive craniectomy : rationale, indications and outcome

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Background

Decompressive craniectomy(DC) has been used as a final option in the management of refractory intracranial hypertension caused by severe head injury, cerebral infarction, subarachnoid hemorrhage, intracerebral hematoma and so on.

Pathophysiology : decompressive effects

(Kerr FWL; 1968)

Decompressive craniectomy (DC) is a method of "giving room to the swelling brain" and can be " a life-saving procedure."

Mechanism by which DC decreases compression of brain stem structures and minimizes herniation .

Aims of Decompressive Craniectomy

- Reduce ICP
- Improve blood flow
- Reduce damage to surrounding brain tissue
- i.e. reduce secondary brain injury

Indication Criteria for Decompressive Craniectomy

INDICATION

① **coma or semicoma (GCS < 9)**

② **pupillary abnormalities, but respond to mannitol**

③ **supratentorial lesion with midline shift on CT**

④ **refractory ICP despite best conventional therapy**

⑤ **age:** initially < 80 years , now **≦ 70 years**

(Of patients who were > 70 years, 75% were dead)

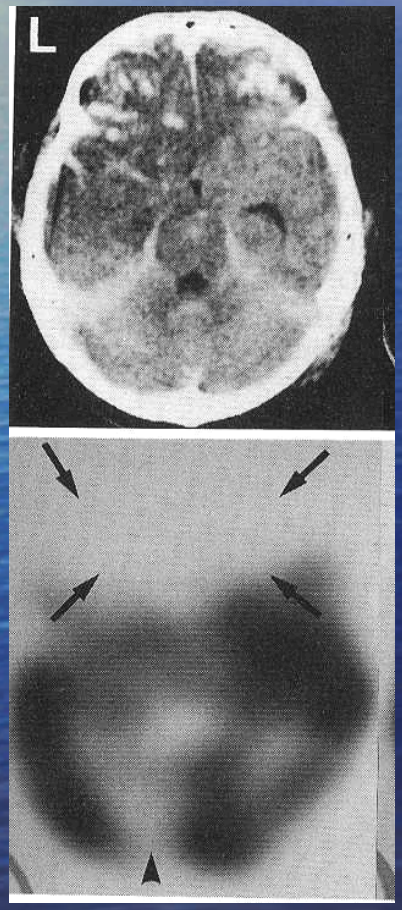
CONTRAINDICATION

fatal brain stem damage :

GCS < 4 or fixed and dilated bilateral pupils

Increase in a focal CBF in the decompressed brain related to the beneficial effect in patients (Yamakami & Yamaura, 1993)

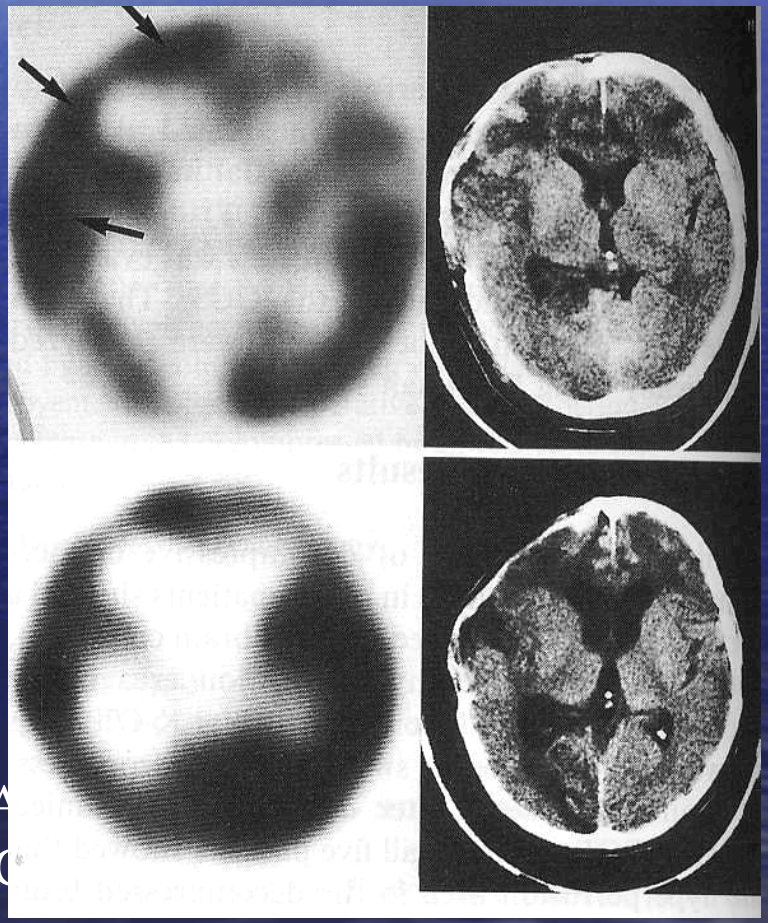
Pre-DC



Post-DC

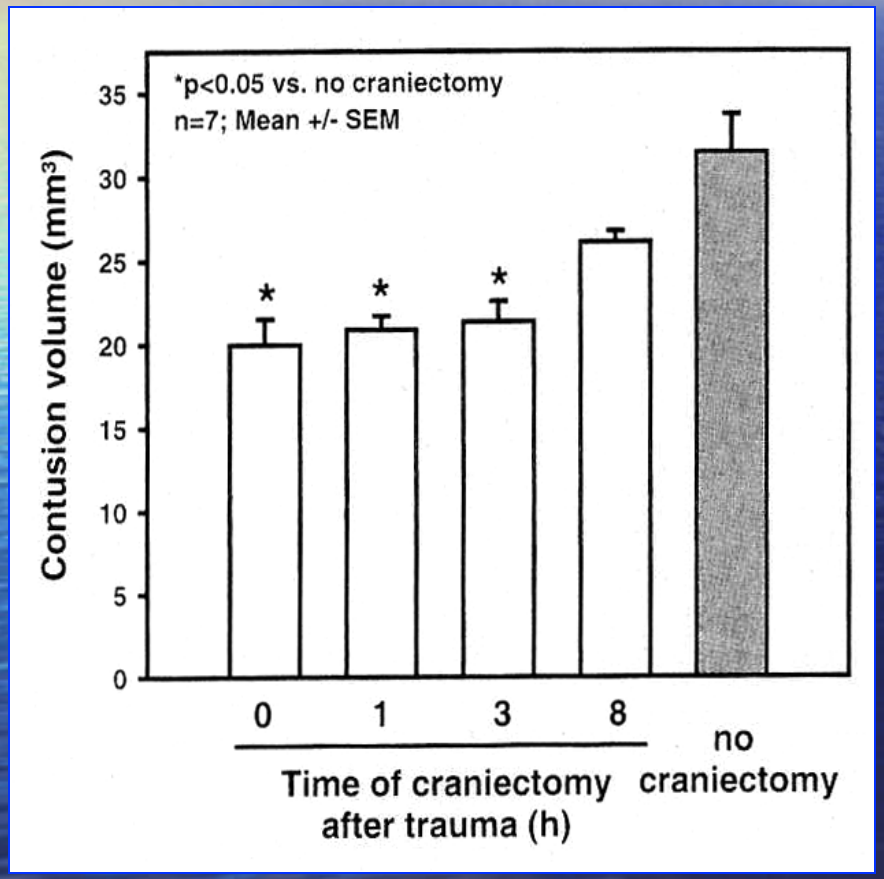
8 days

25 days



^{99m}Tc-HMPA
SPEC

Early DC prevents secondary brain damage



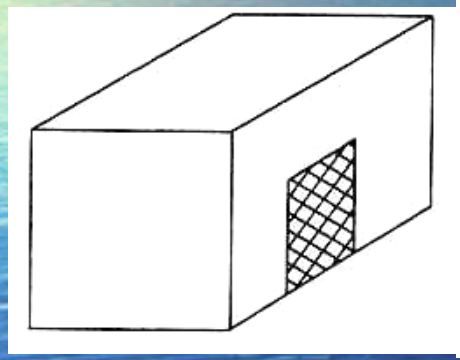
Early DC reduces brain edema formation by more than 50% and prevents secondary brain damage when performed early enough (i.e., during the first 3 h after trauma).

(Zweckberger K, et al.; 2006)

History of decompressive craniectomy (DC)

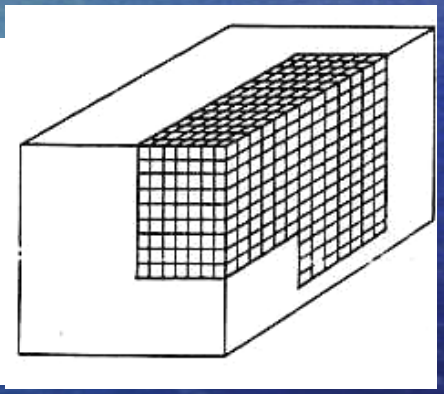
A variety of operative techniques of DC

Subtemporal craniectomy



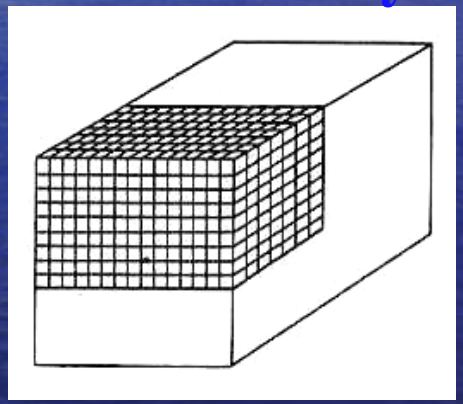
Cushing (1905)

Hemicraniectomy



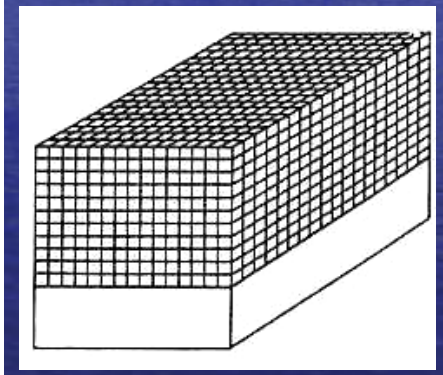
Ransohoff (1971)

Bifrontal craniectomy

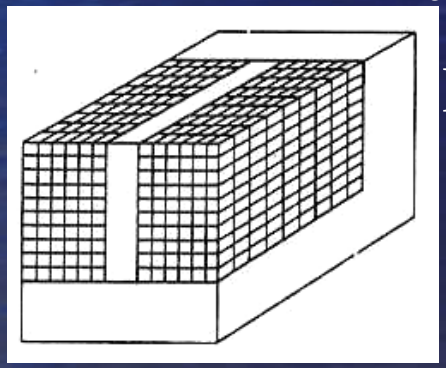


Kjellberg (1971)

Total calvariectomy



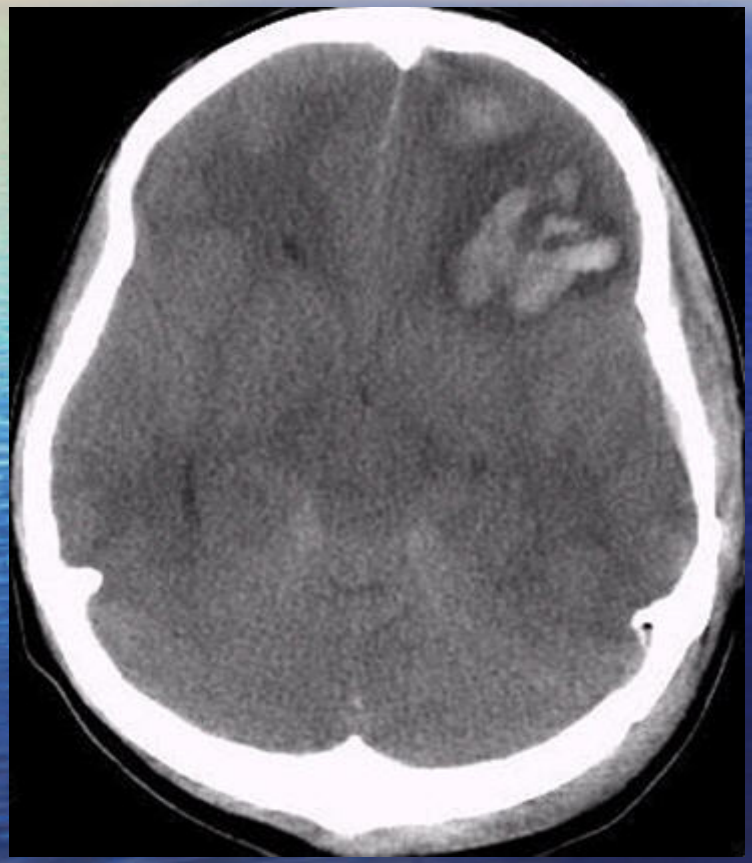
Miyazaki (1973)

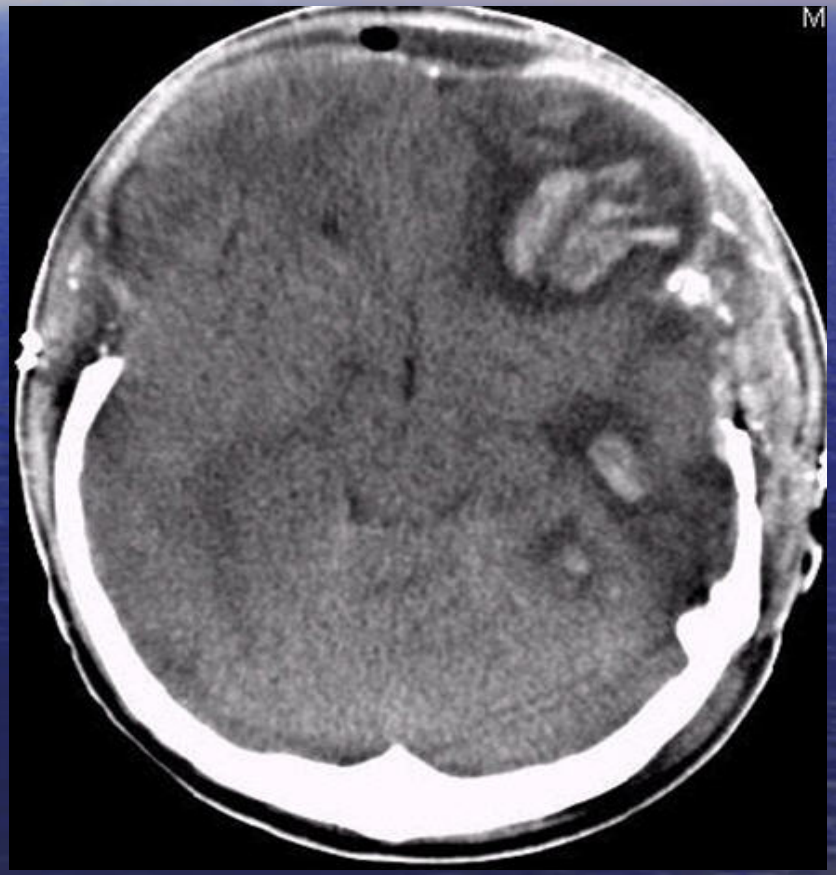


Bilateral frontotemporo-parietal craniectomy

Makino (1975)
Guerra (1999)

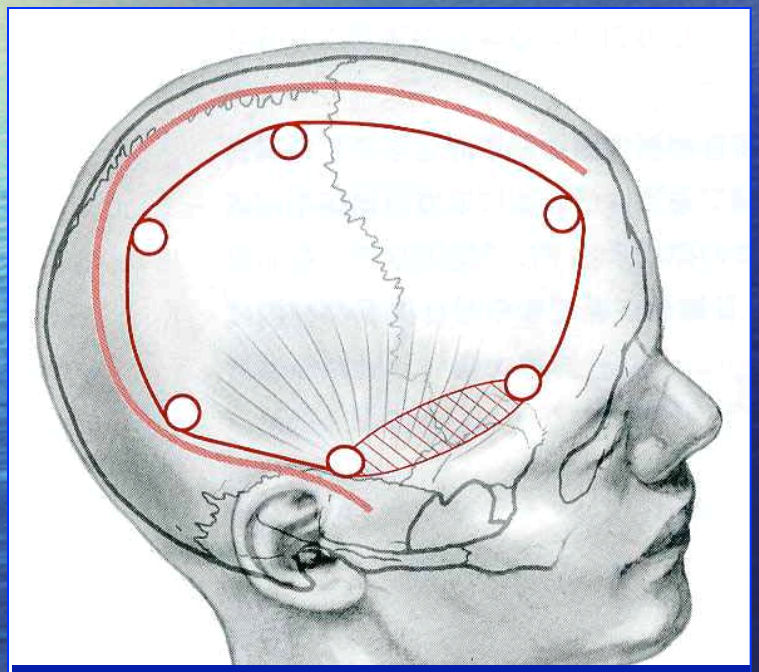
Before and after…



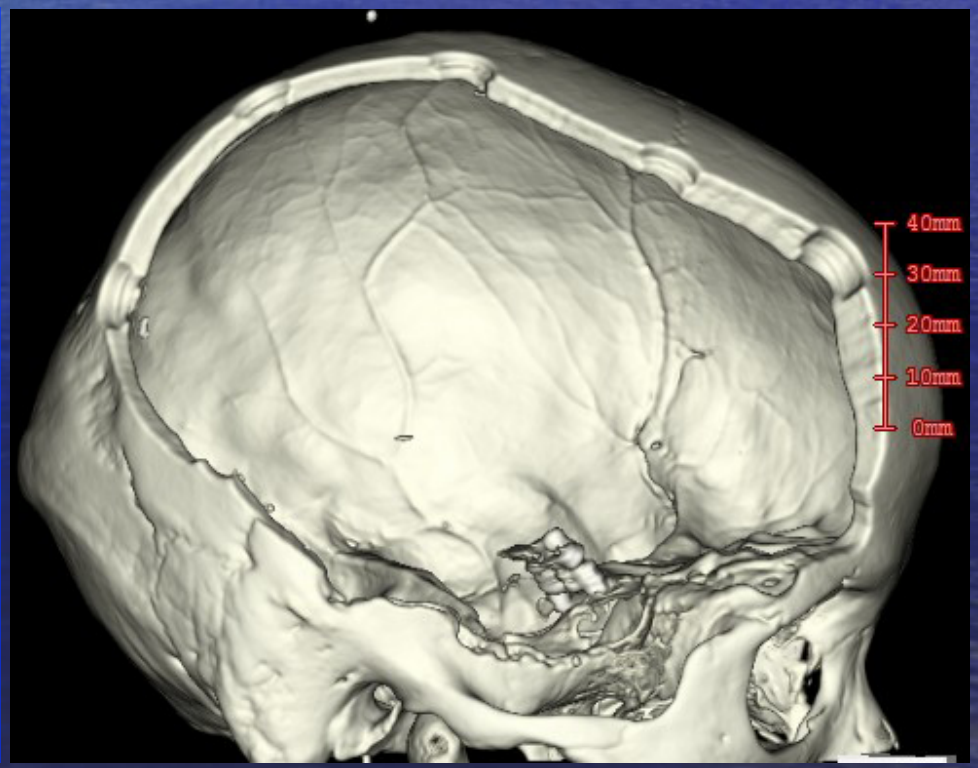


Surgical Technique for DC

Large (10 × 15 cm) frontotemporoparietal craniectomy with the lower margin from the middle cranial fossa



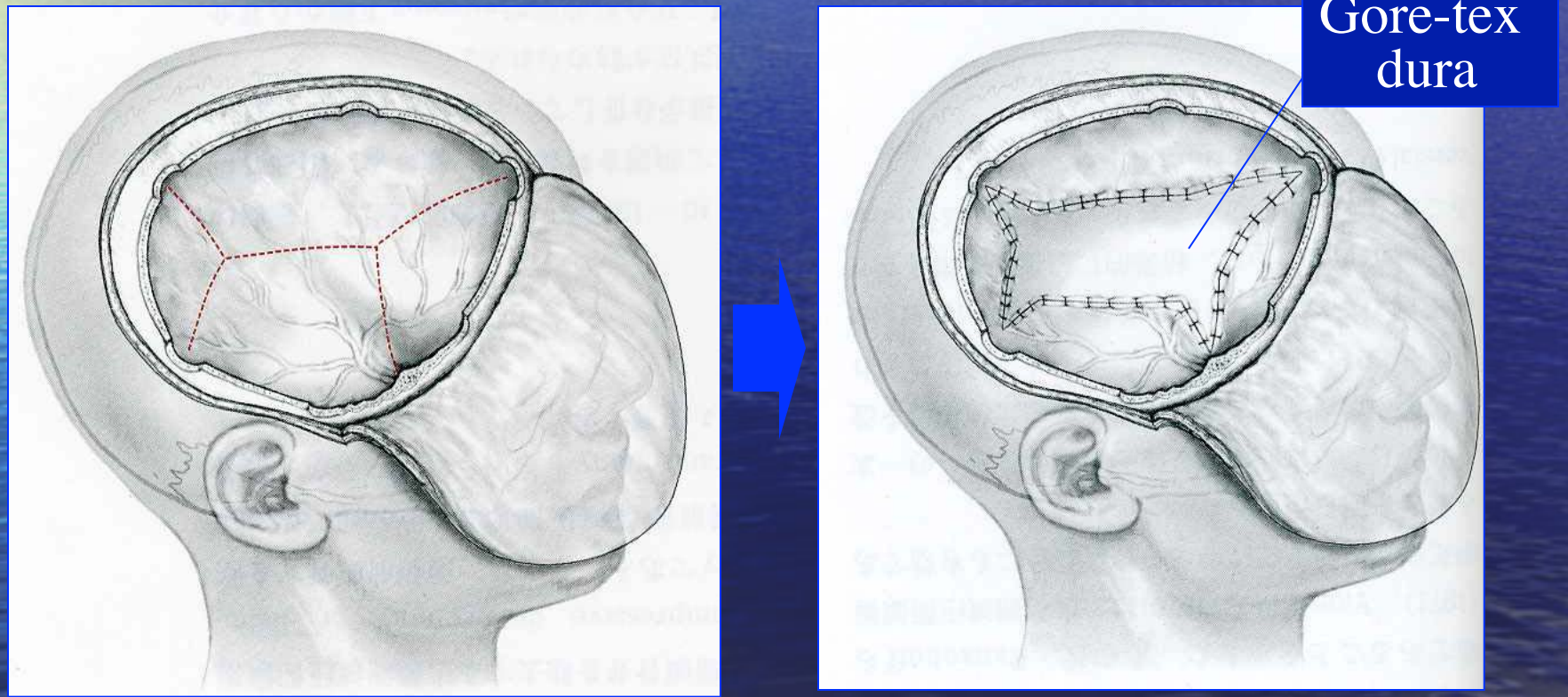
skin incision & craniectomy



(Shima K, 2004)

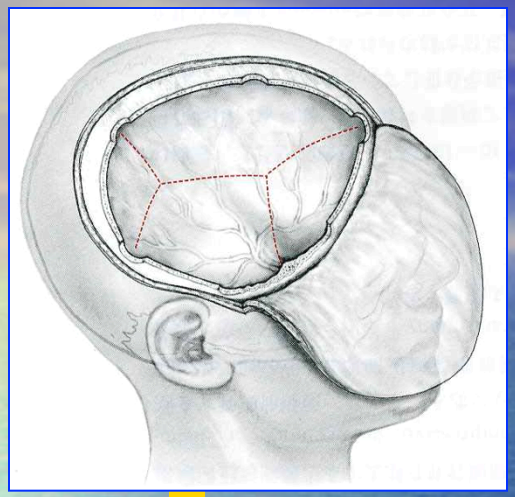
Surgical Technique for DC (2)

dural incision **standard duraplasty**

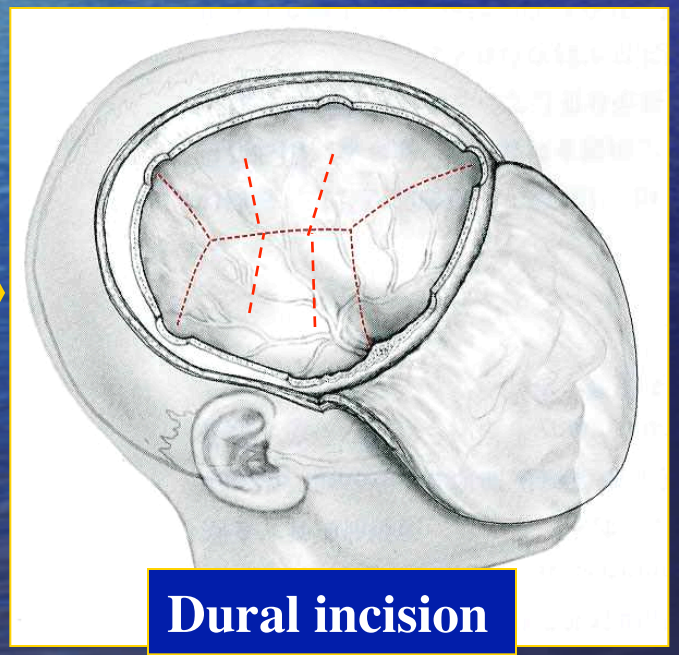


(Shima K, 2004)

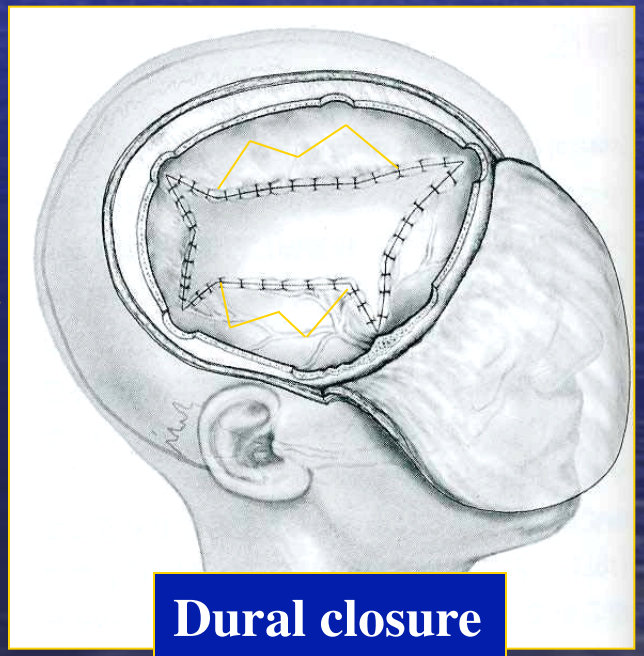
Surgical Technique for DC (3)



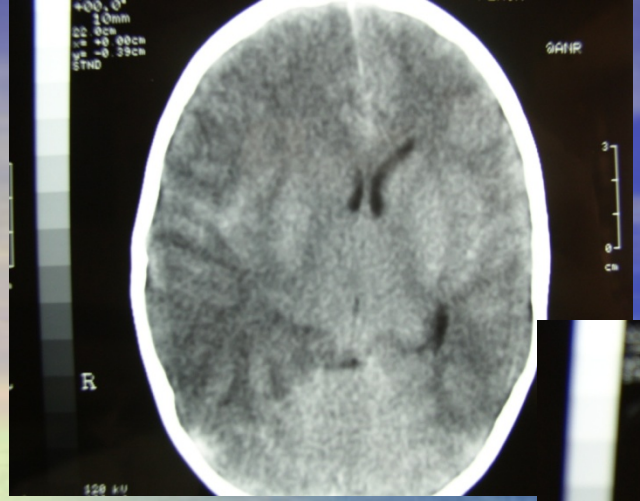
In the event of massive cerebral swelling, extensive duraplasty with internal decompression is performed.



Dural incision



Dural closure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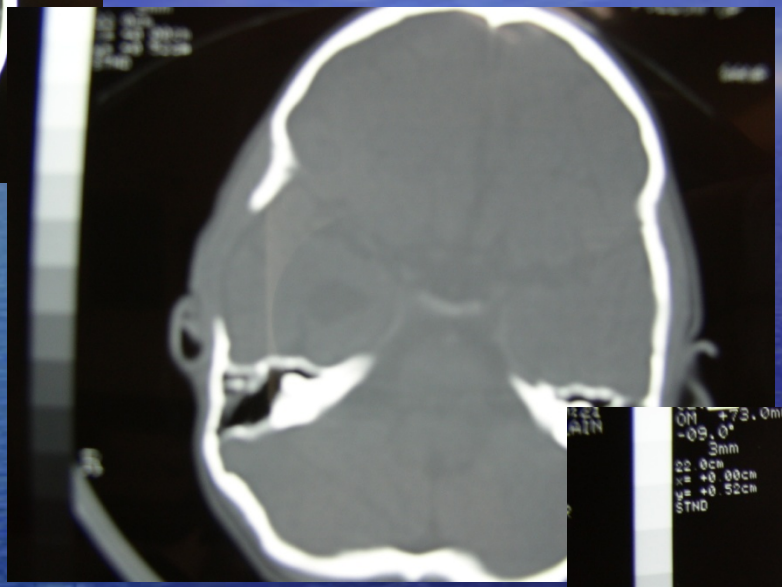

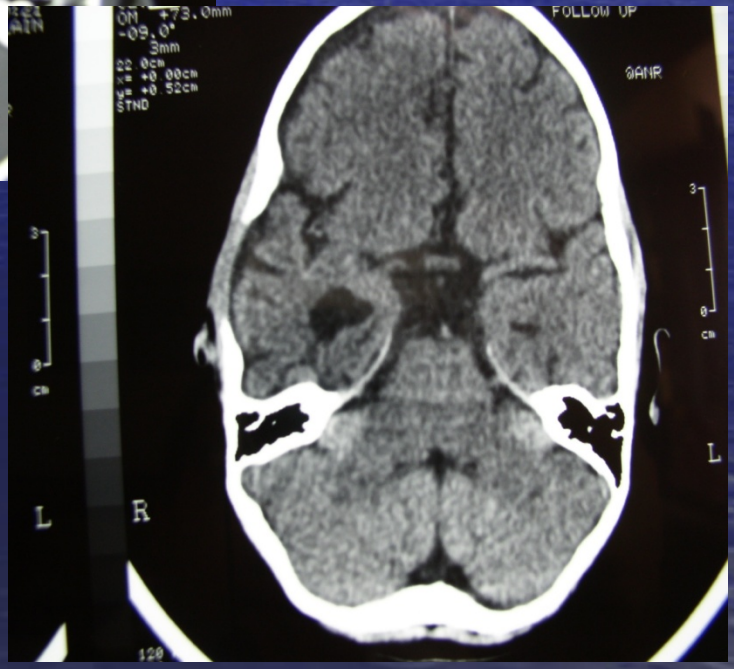
+73.0mm
-09.0°
3mm
STND
FOLLOW UP
9ANR
L
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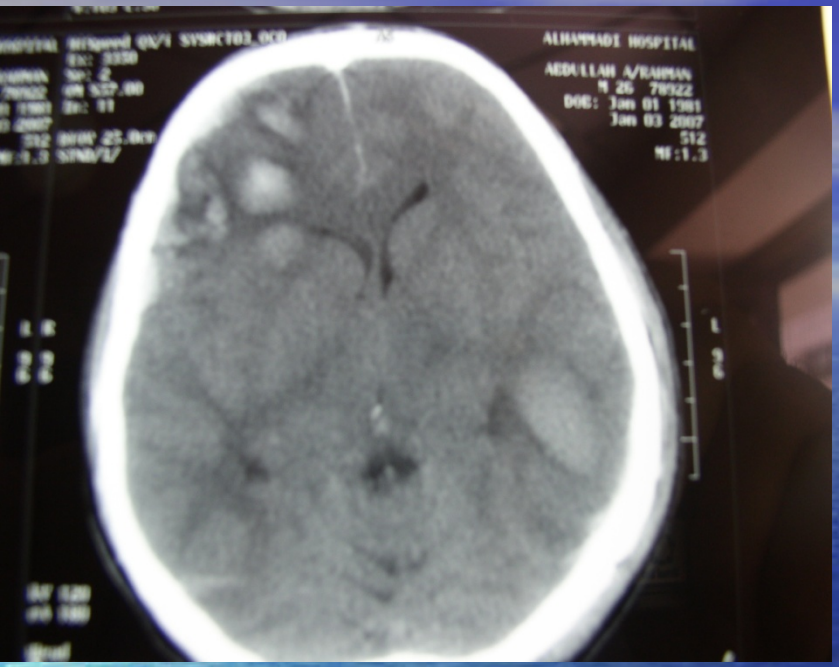
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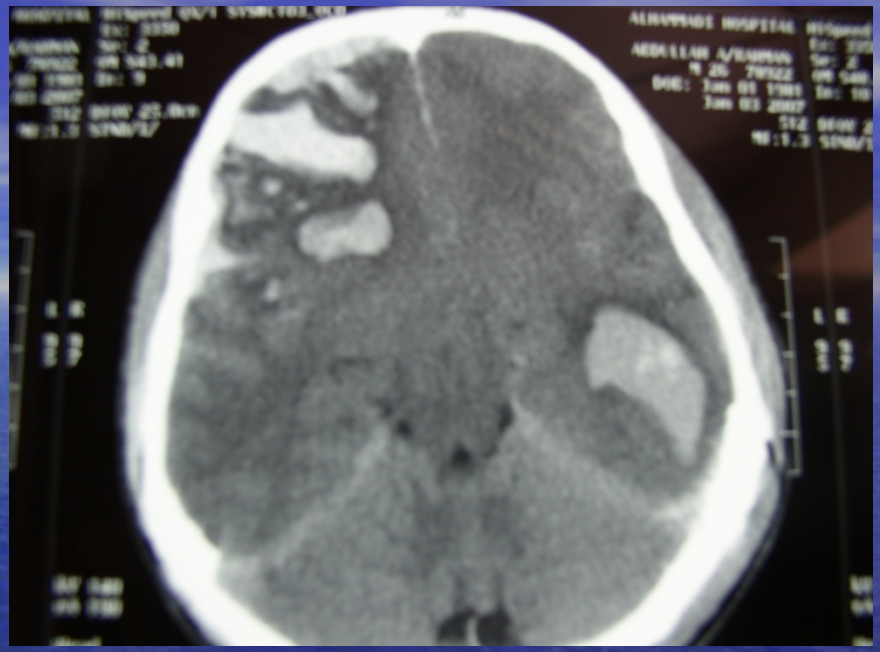
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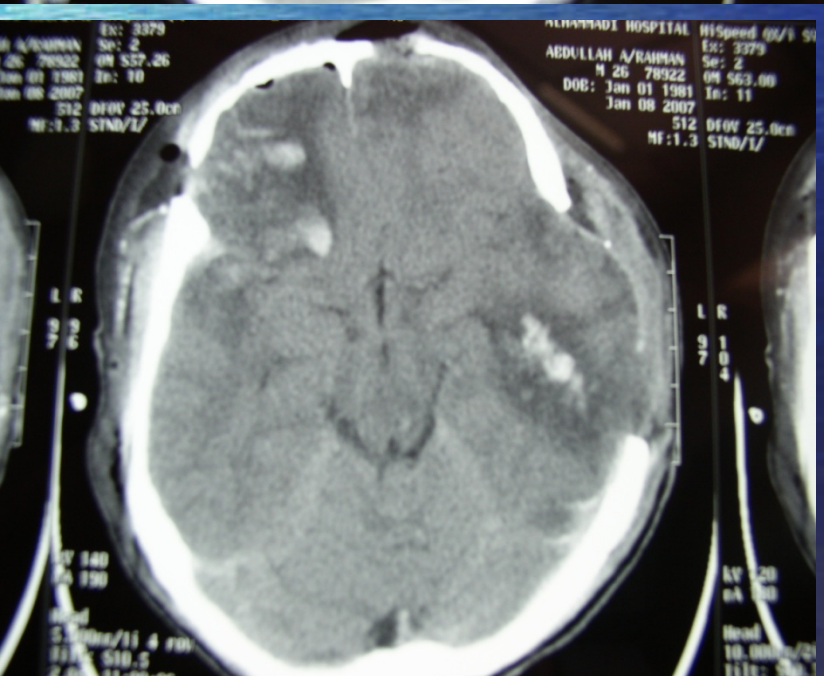
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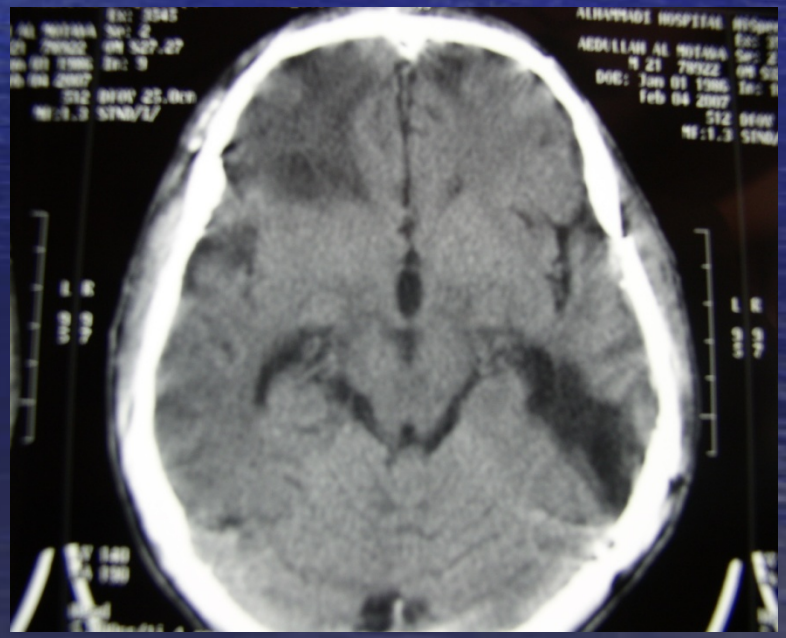
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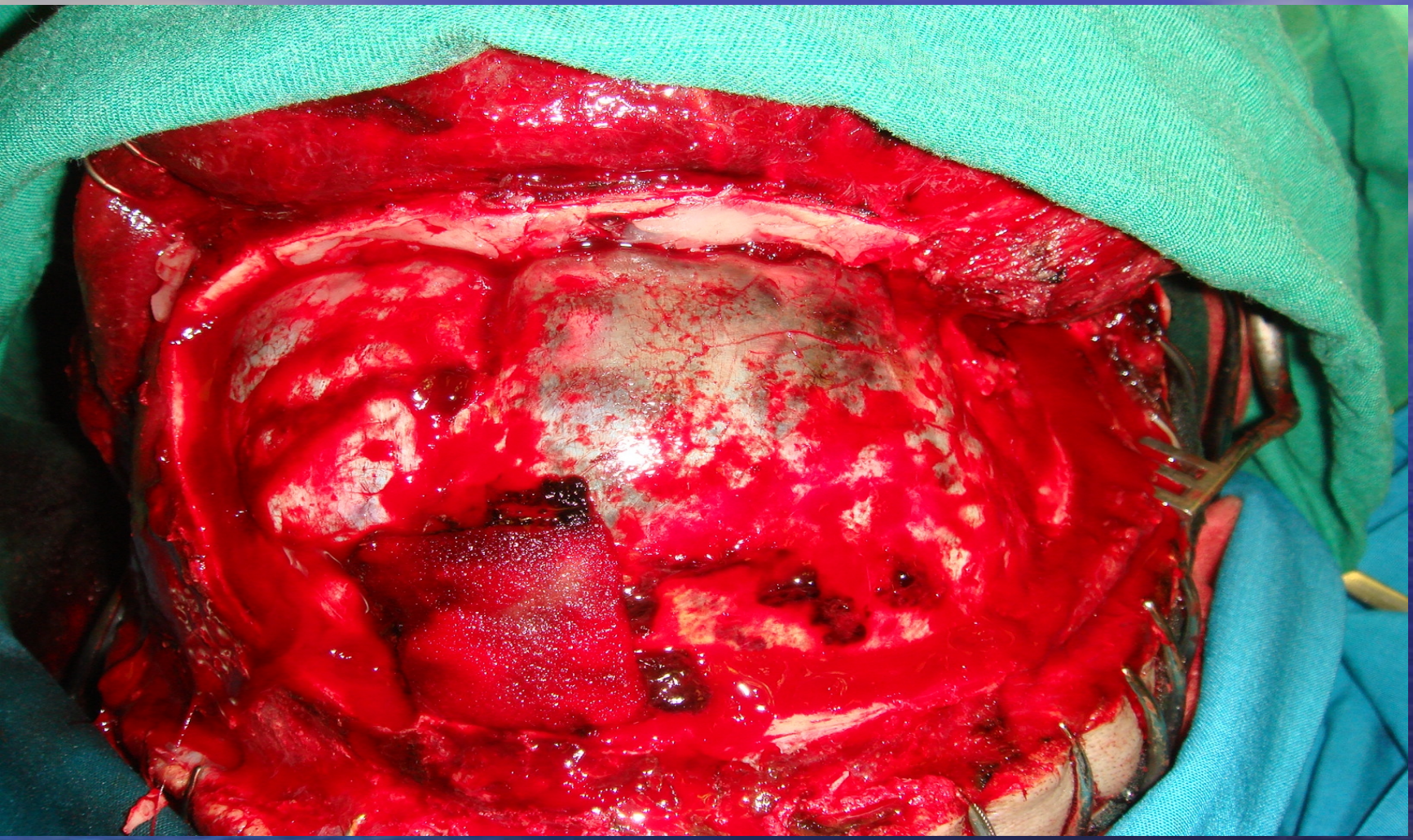

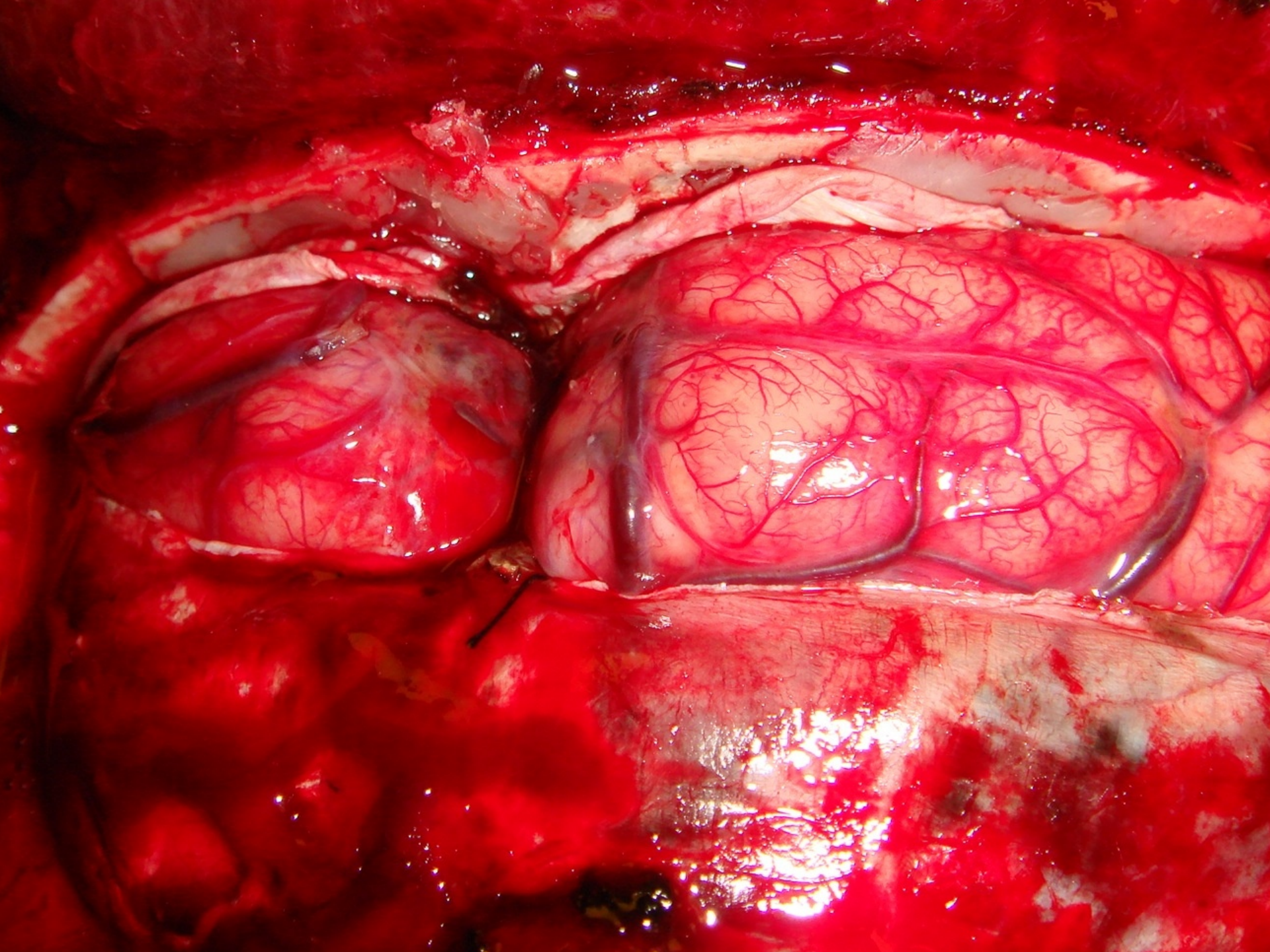

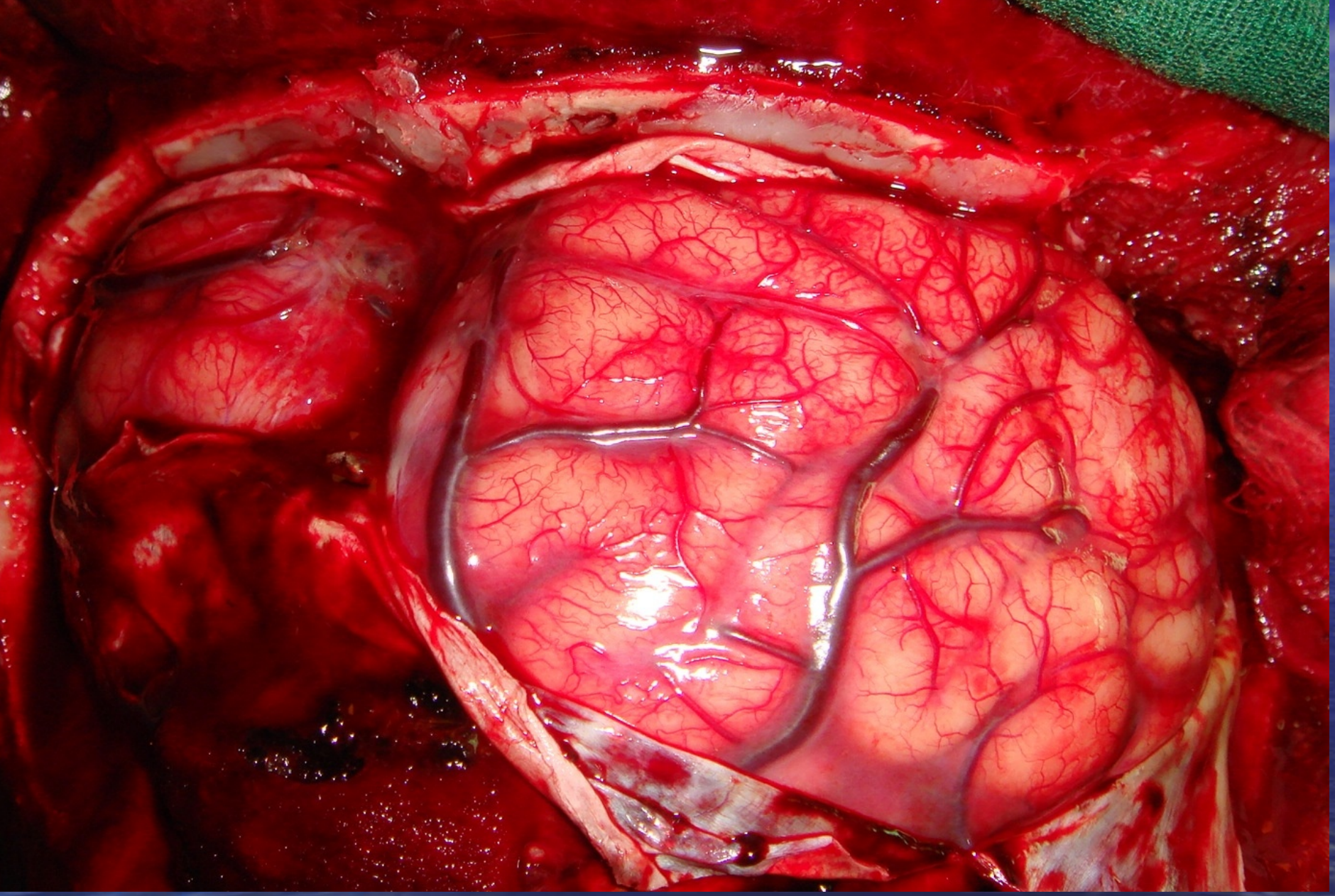

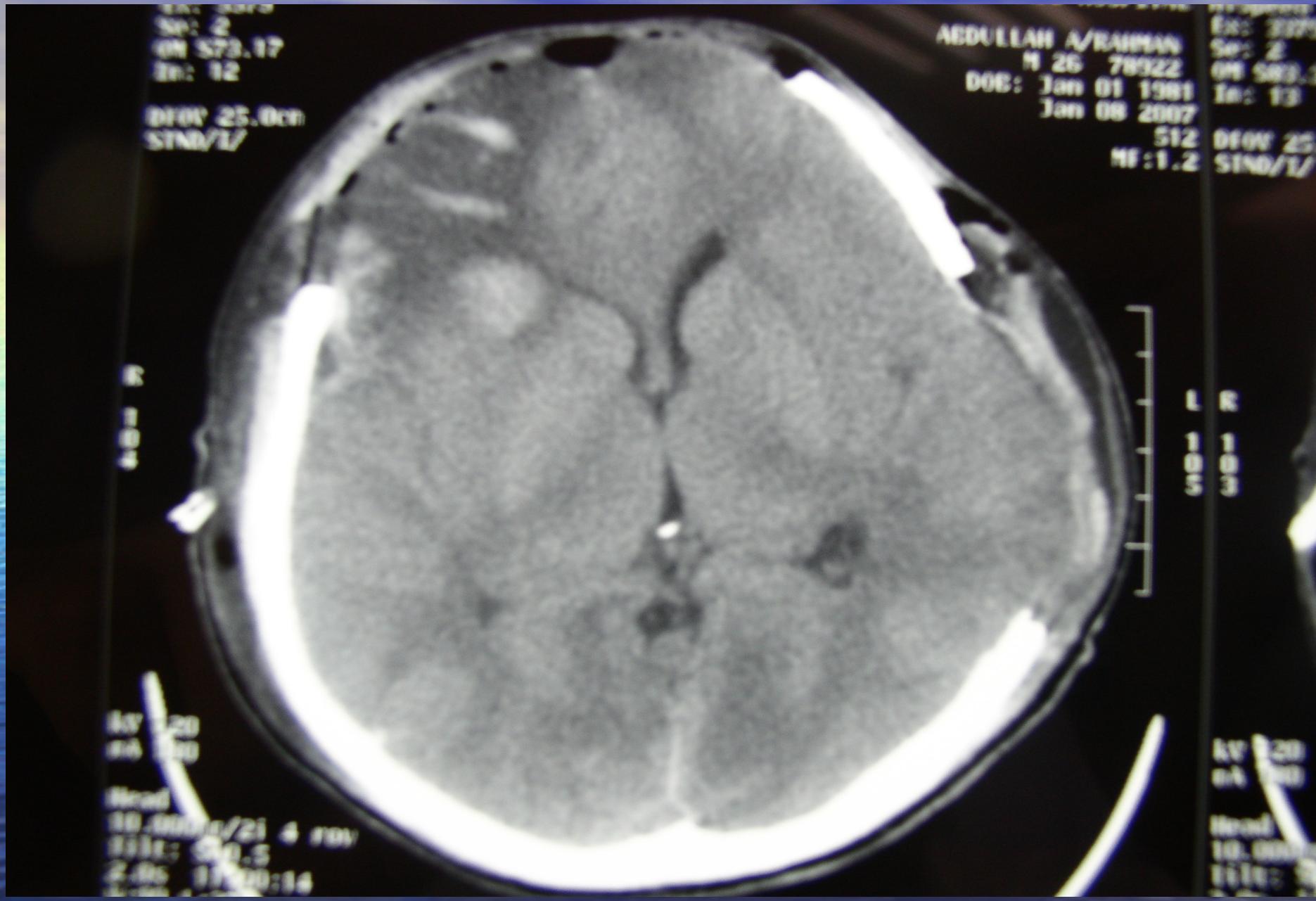
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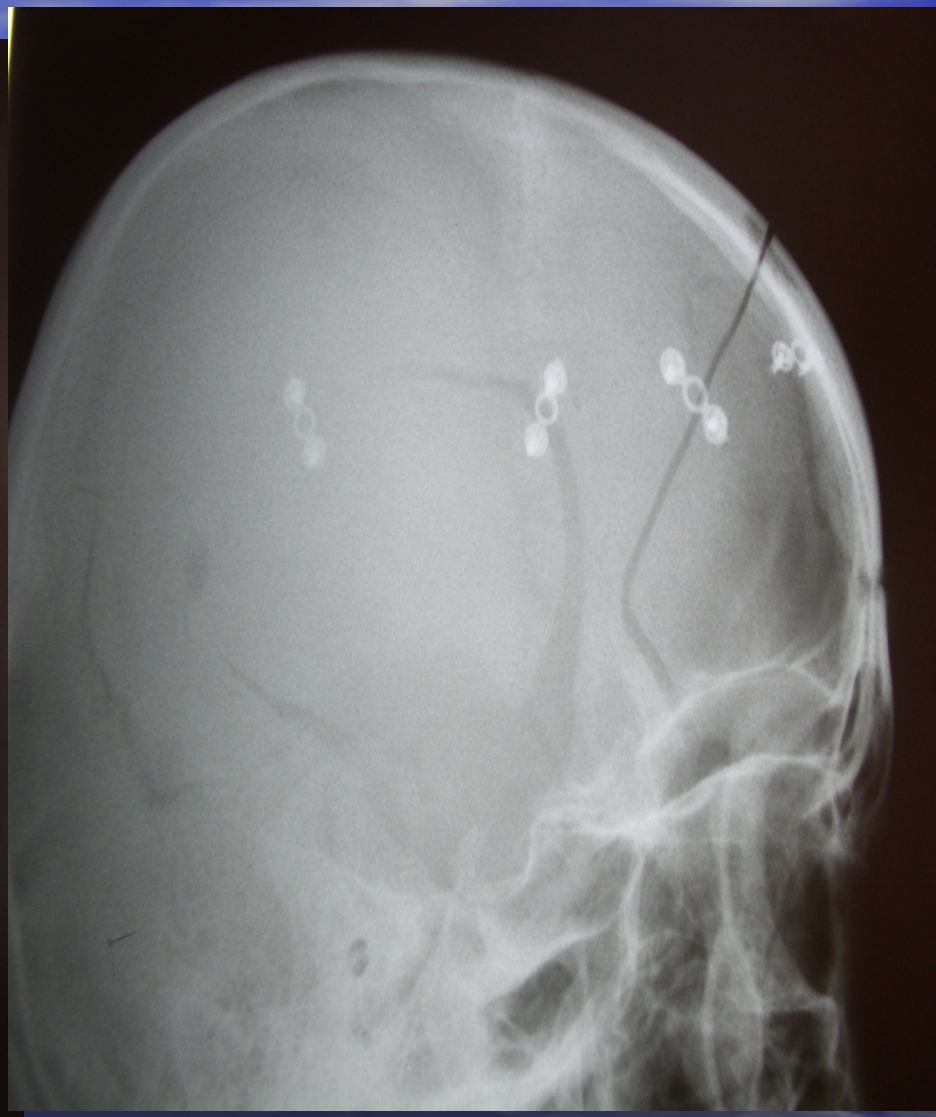

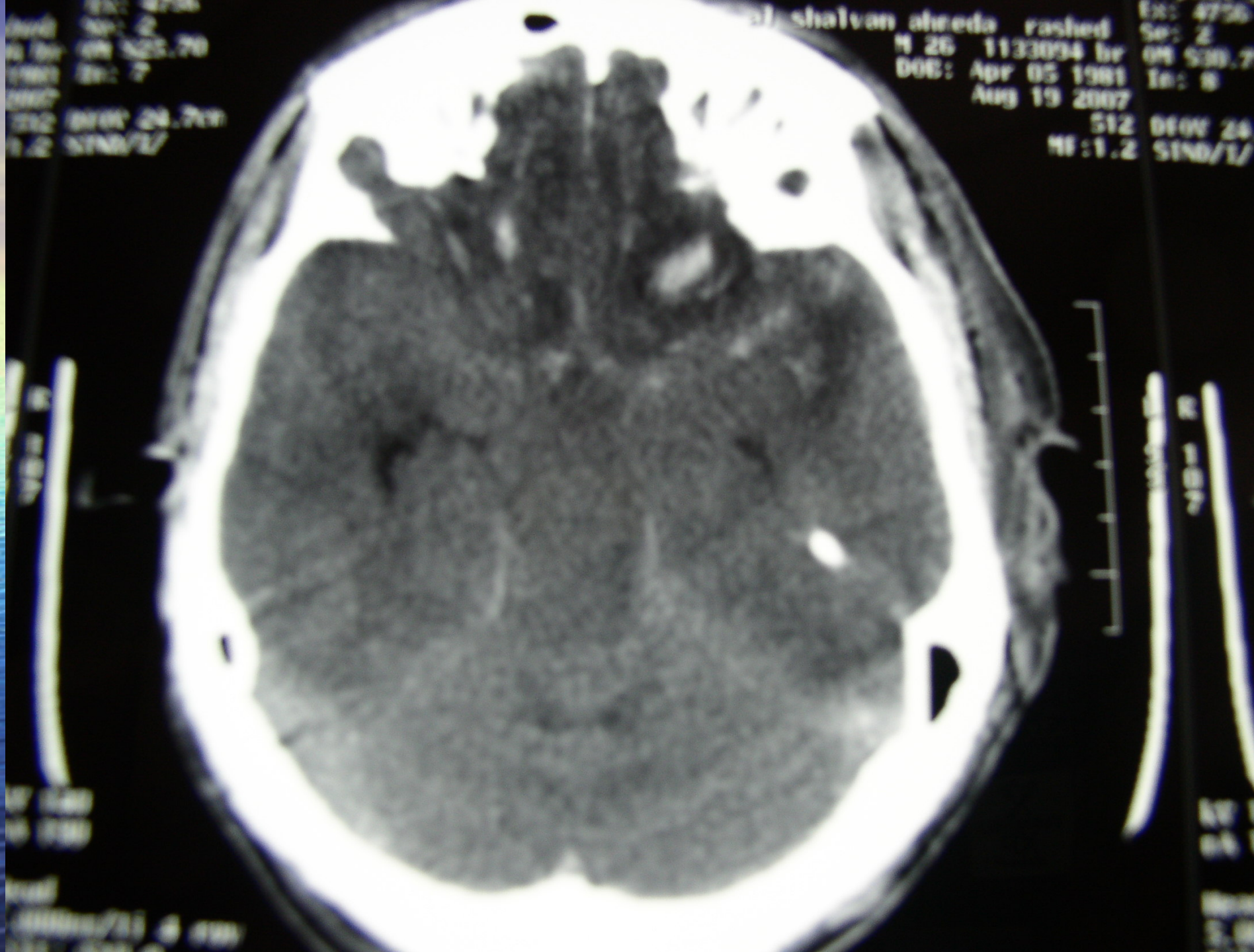
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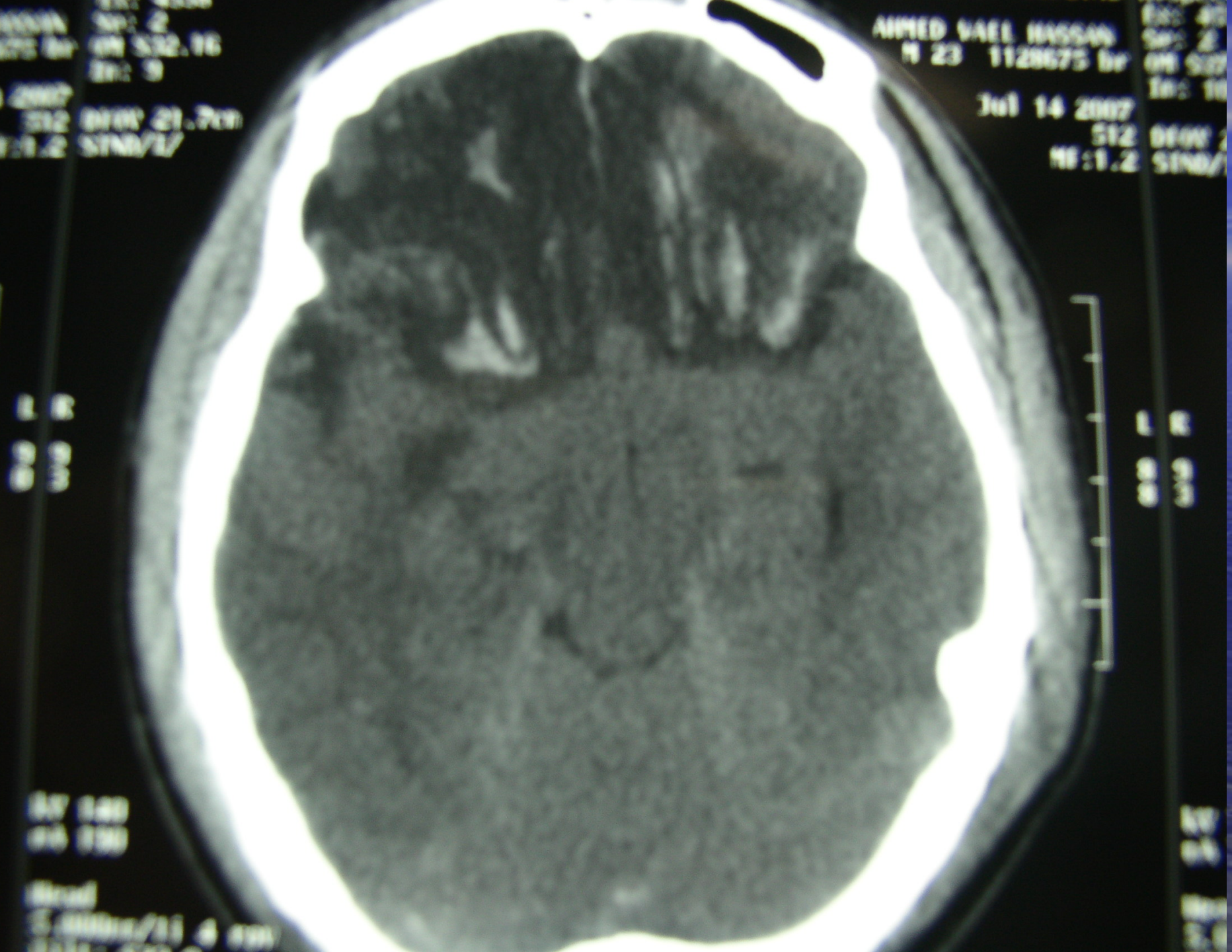
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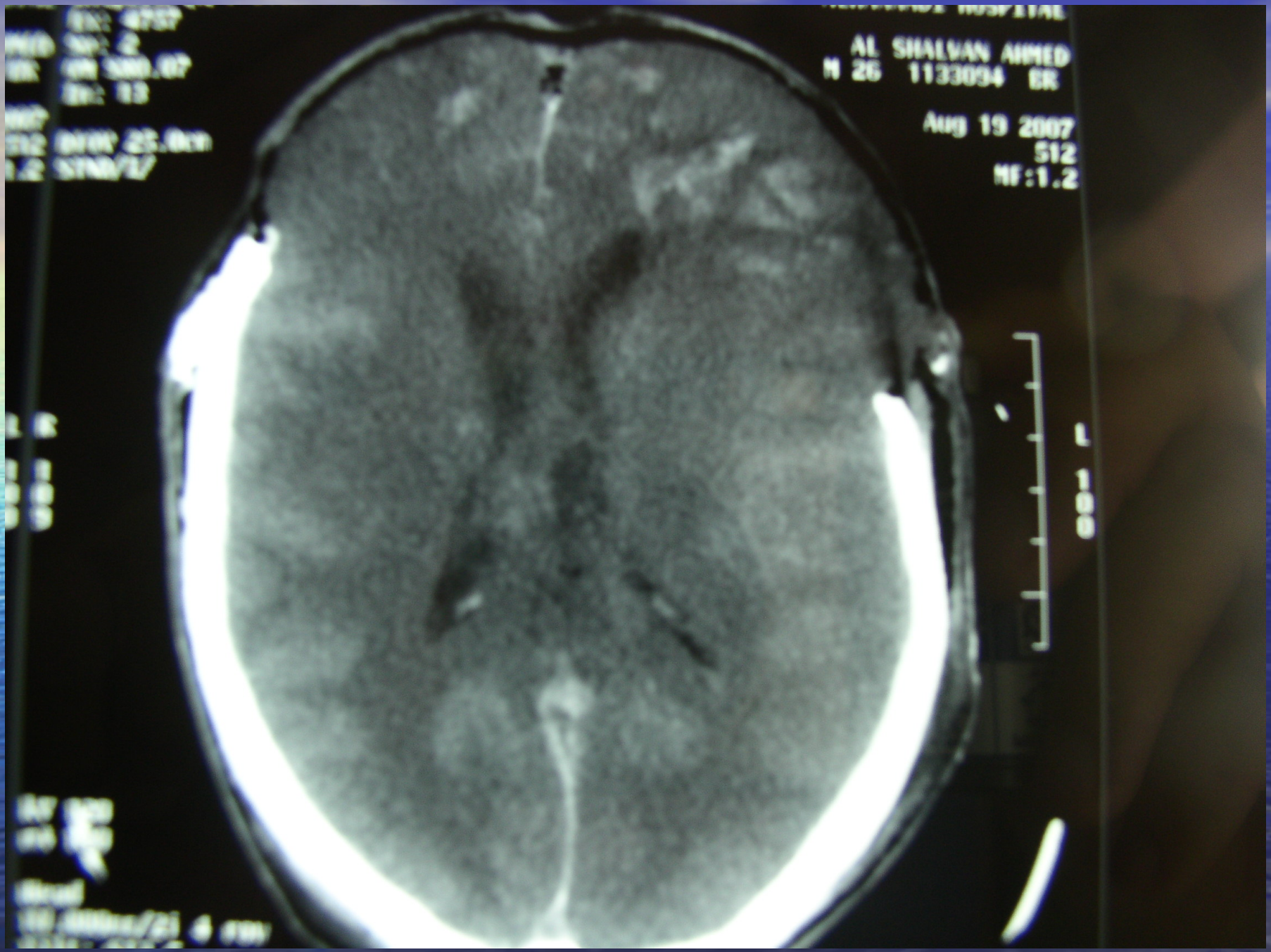
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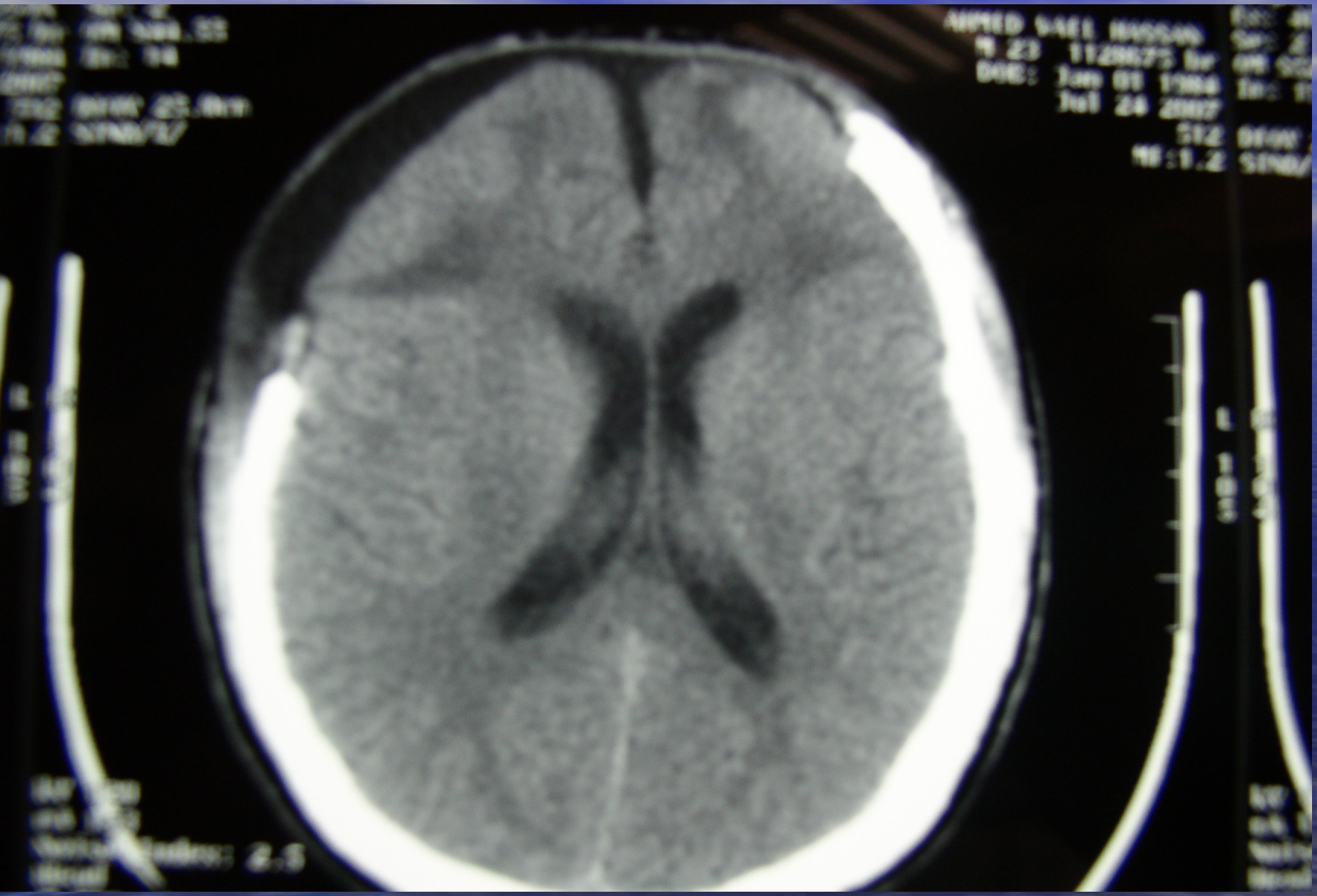
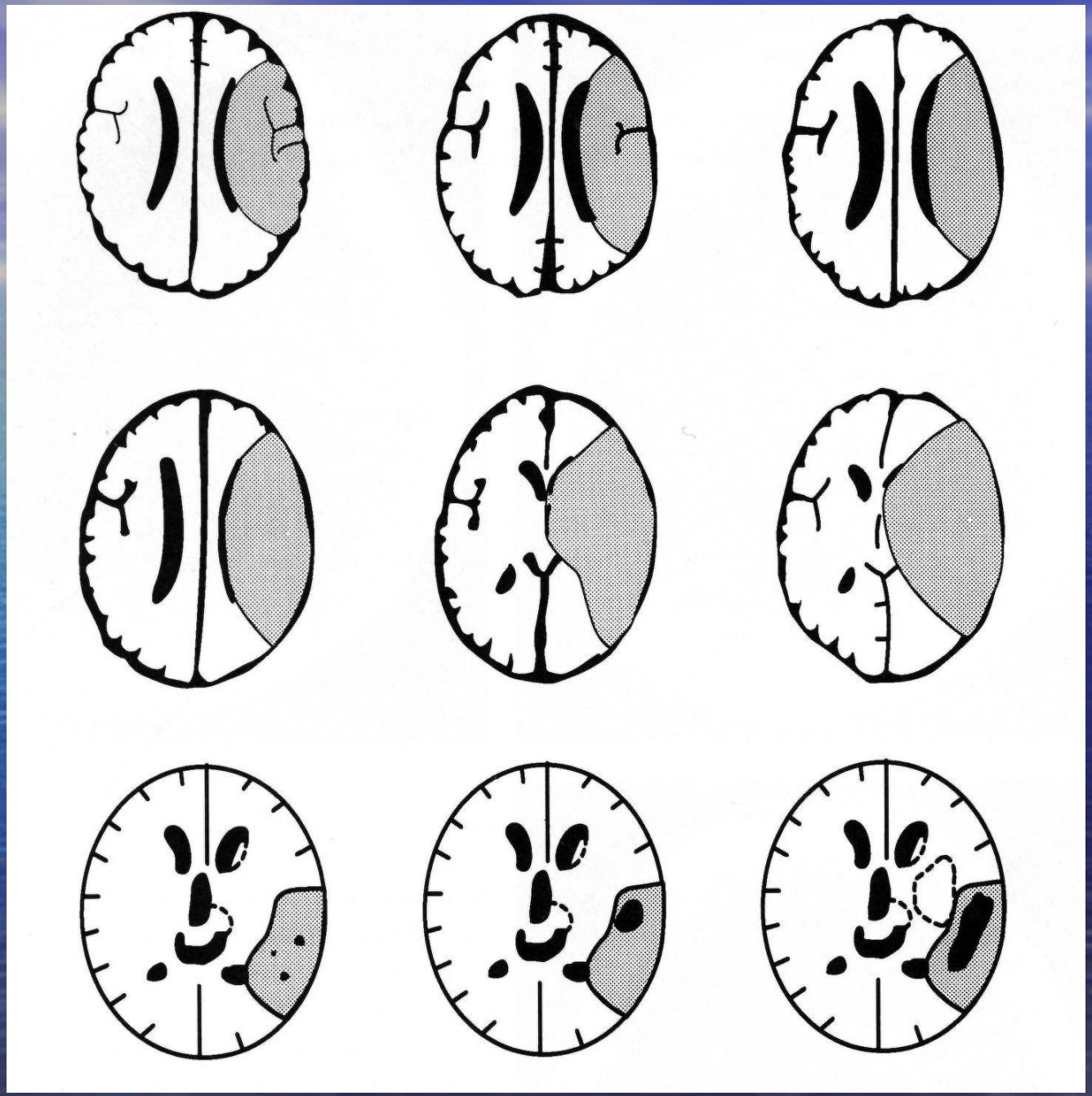


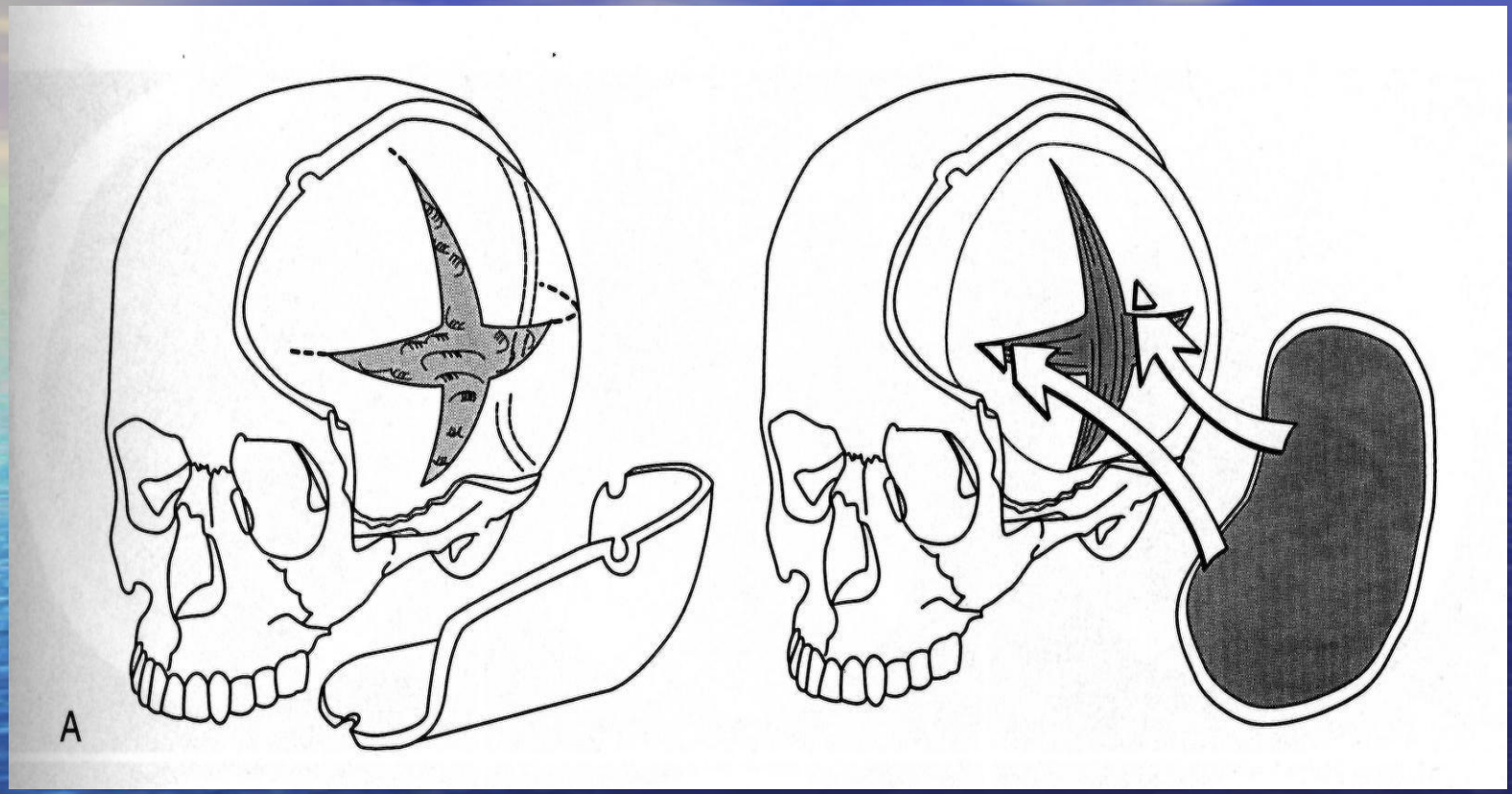
Malignant Middle Cerebral Artery Infarction Syndrome (MMCAIS)

How Common

Study	MMCAIS	
Ng L et al 1970	45 /353 supratentorial infarcts	12.74%
Berrouschot J et al. 1998	53/221 supratentorial infarcts	23.9%
Kasner S et al, 2001	201/ 12000 stroke patients	1.675%
Qureshi AI et al 2003	59 /1214 supratentorial infarcts	4.859%
Wang KW et al 2006	40/418 MCA infarct	9.5%

Reported between 5 to 10% of Acute Ischaemic Stroke.

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What are the causes of sudden deterioration in AIS?

Weimar C et al. *Arch Neurol* 2005

- 256/ 1964 patients (13%) had NIHSS ≥1 point after 48 to 72 hour
- 127 (6.5%) patients and 43 patients (2.2%) were intubated
- Attributable to
  - Progressive stroke (33.6%)
  - Increased ICP (27.3%)
  - Recurrent cerebral ischaemia (11.3%)
  - Secondary parenchymal haemorrhage (10.5%)
- Worsening of the NIH-SS ≥4: sensitivity 68.9%, specificity 68.4%
  - Internal carotid occlusion [OR 3.323 (2.008 – 5.501), $p<0.001$]
  - Middle cerebral artery (M1) occlusion [OR 3.019 (1.979 – 4.604), $p<0.001$]
  - territorial infarction [OR 1.917 (1.246 – 2.948), $p = 0.003$]

Malignant Middle Cerebral Artery Infarction Syndrome

- Large hemispheric infarction involving >50% of MCA territory associated with a massive cerebral oedema and brain-stem herniation
- Caused by complete/ near complete occlusion of either internal carotid artery (ICA trunk) or proximal middle cerebral artery

Can we predict brain oedema?

- Kasner S et al, 2001
  - Hypertension, heart failure, ↑ WBC
  - CT - > 50% hypodensity and additional vascular involvement
- Hofmeijer J et al 2008
  - Infarct size > 66%
  - additional vascular involvement
- Thormalla G et al 2003
  - Quantitative analysis of early DWI & PWI can predict MMCAI

MMCAIS

- Dense pyramidal signs (initial)
- Neurological deterioration < 24-72 hr[1] due to elevated ICP leading to brain stem herniation
- Very high mortality despite maximal medical treatment
  - 70% (37/ 53) died in NICU (33/37 died within first 5 days)[2]
  - 78% (35/45) died within 1 week[1]

1. NG K et al. *Stroke* 1970
2. Berrouschot J et al. ICM 1998

Decompressive Hemicraniectomy (DH)

- 1st described by Kocher in 1901 for the treatment of TBI
- 1st reported by Rengachary S et al.[1] for the treatement of MMCAIS in 1981
- Removal of an ipsilateral bone flap ≥ 12 cm in diameter and including parts of the frontal, parietal, temporal and occipital squama plus Duraplasty
- To relieve ICP
- Inadequate craniectomy size is associated with parencymal haemorrhage ± infarction and increased mortality[2]

1. Rengachary S et al *Neurosurgery* 1981: vol 8/3, 321-328
2. Wagner S et al. *Journal of Neurosurgery*, May 2001, vol./is. 94/5(693-6)

Current Evidence on efficacy of DH in management of Malignant Middle Cerebral Artery Infarction Syndr0me

Does decompressive hemicraniectomy improve outcomes in management of malignant MCA infarction syndrome?

- Survival (mortality)
- Functional outcomes: impairment, disability, quality of life. Dependency = GOS 2 or 3, mRS 4 to 5, BI < 60.
- Can we predict malignant brain oedema?
- Timing: when to operate?

Comparative Studies

- Schwab et al – 63 pts, Early (<24 hr, b/4 MLS) vs. Late (>24 h), early mortality was 16%vs. 34.4% and BI 68.8 vs. 62
- Cho et al – 52 pts, (<6h vs. > 6 h vs. Medical), early mortality (7.8% vs. 36.7% vs. 80%), better BI (70)and GOS (4)
- 6 studies compared DH with medical Rx. Early mortality was 4.8% - 21% in DH whereas 42-83% in Medical groups

Different outcomes in non-randomised studies

- Age
- Timing of surgery – before or after signs of brain herniation
- Additional vascular territory involvement

Systematic Reviews

- Cochrane (Morley N et al, 2002) – no RCT evidence to support DH (reviewed non-randomised studies from 1971-2001)
- Hofmeijer J et al (CCM 2003; 31/2: 617-25) - 2 large non-randomised studies showed promising results in terms of reduction in mortality and functional outcome

Summary of Evidence

- Decompressive Hemicraniectomy if performed early (< 48 hr) improve survival and functional outcome in patients (< 60 yr) with malignant MCA infarction [RCT confirms the results of observational study)
- Level of evidence 1^{+}, Grade B
- Recommended by National Clinical Guideline for Stroke, 4.6.1.k, 3rd edition July 2008

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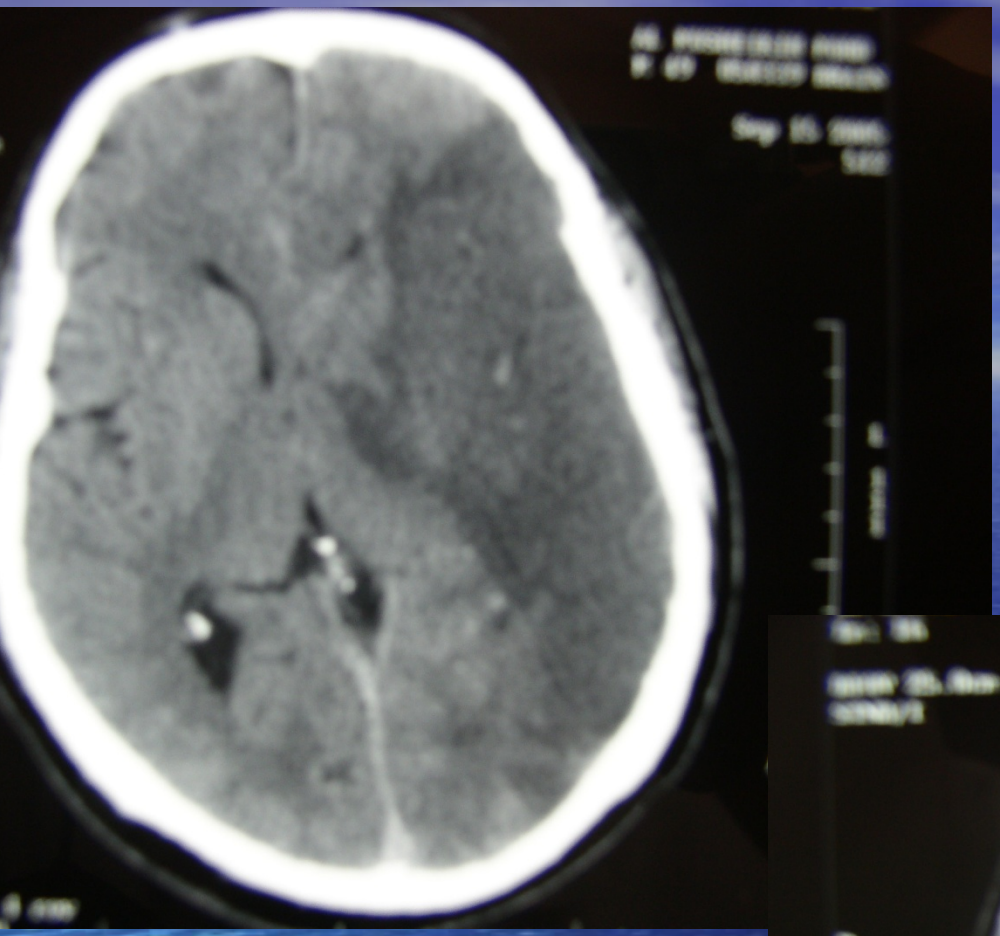

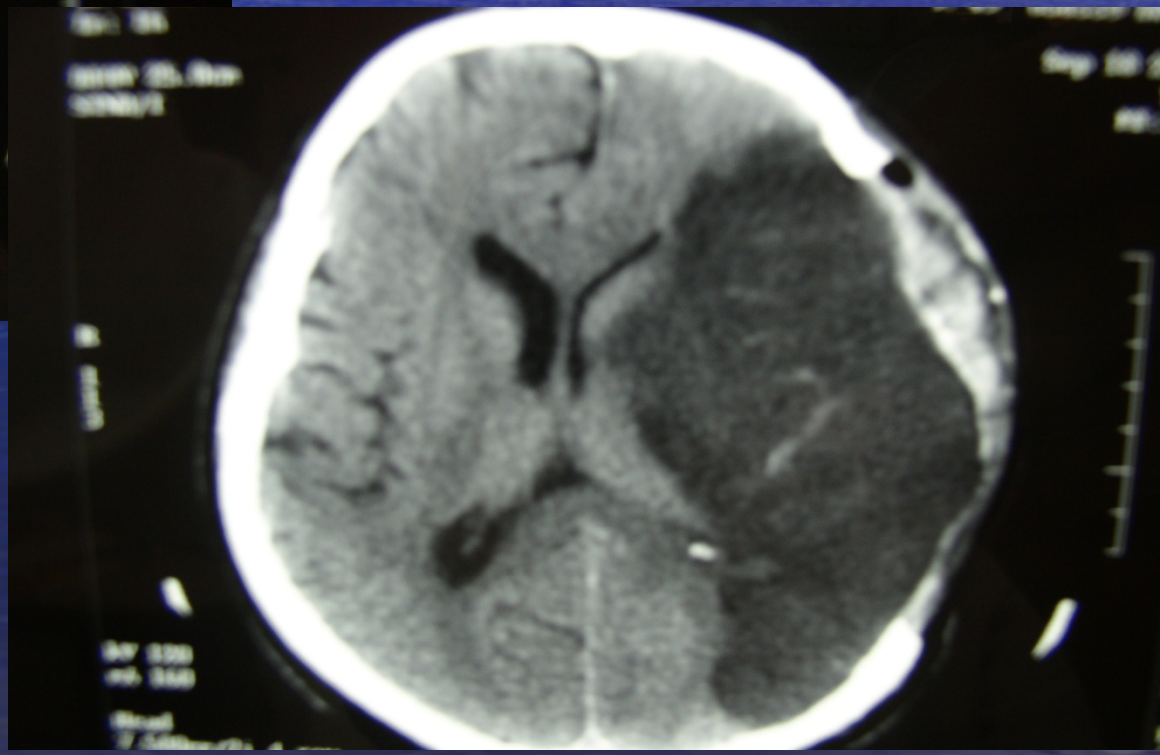

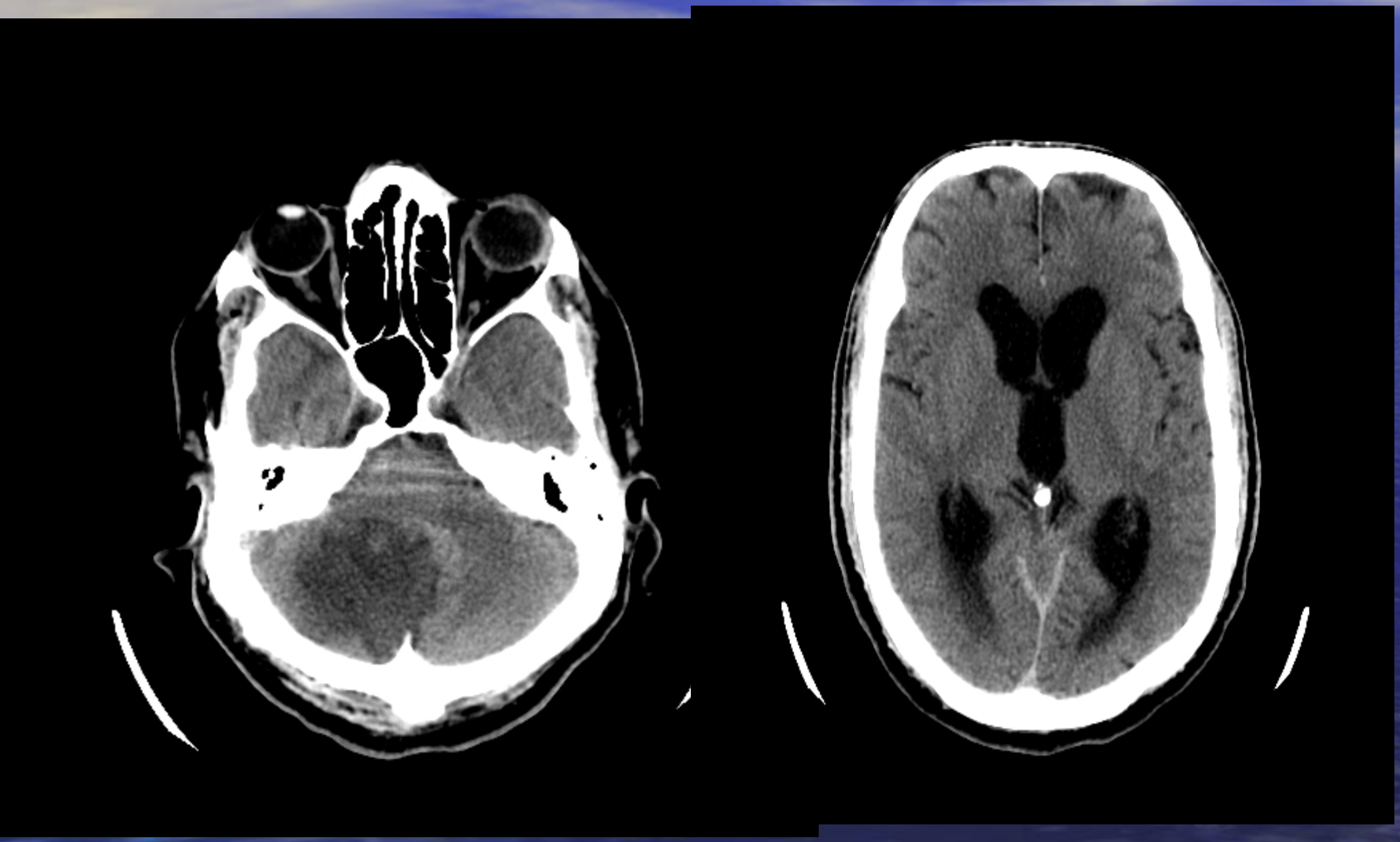

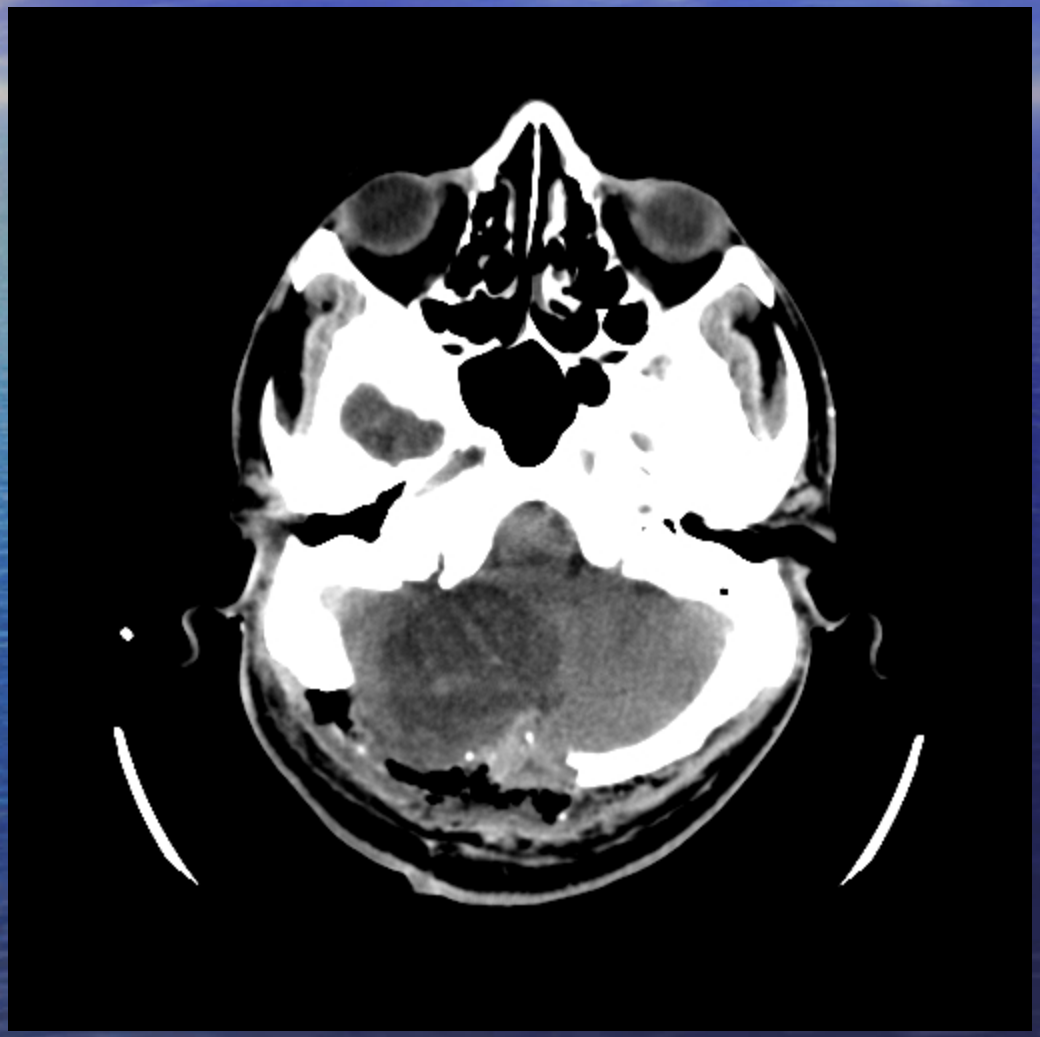

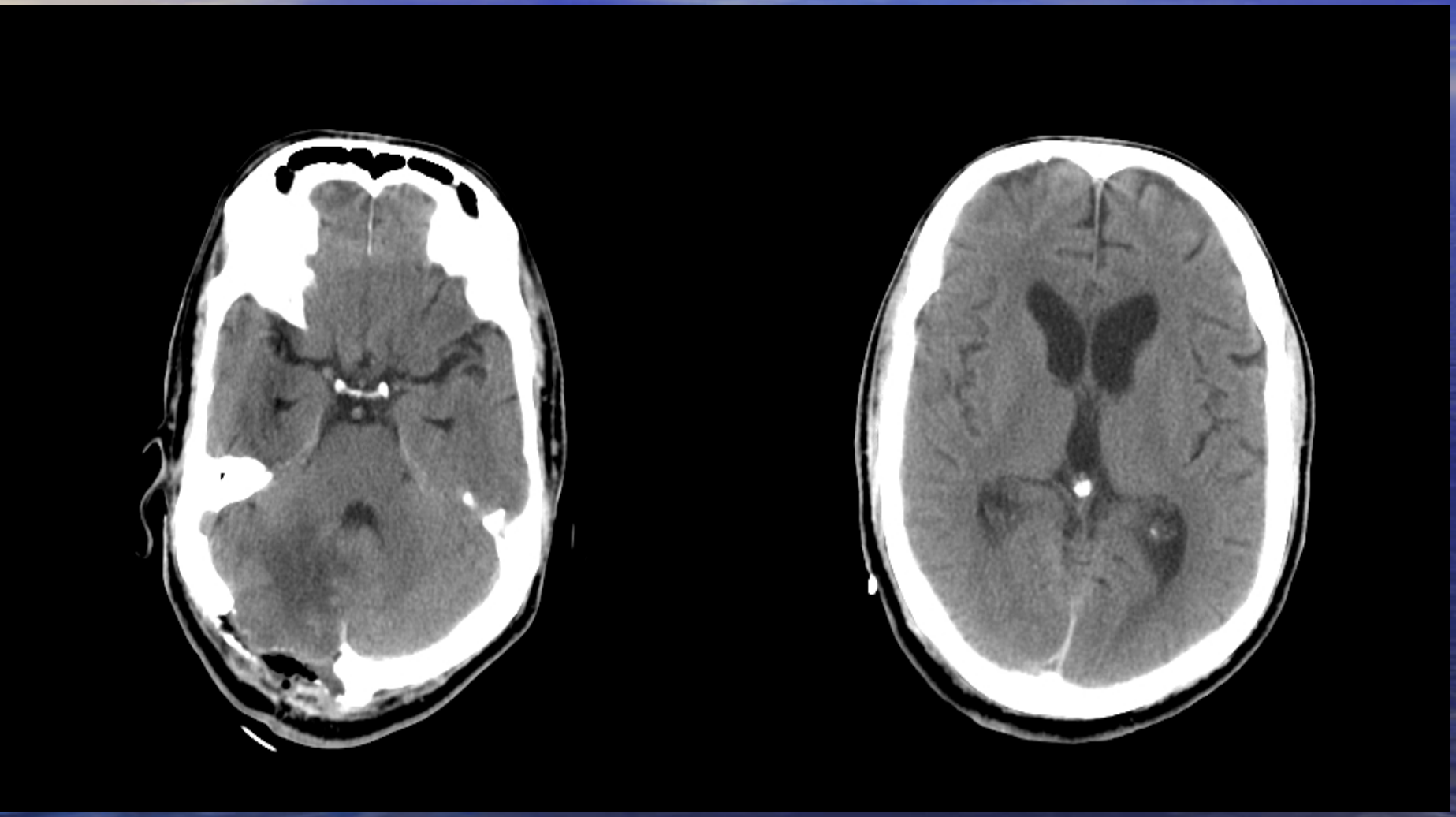

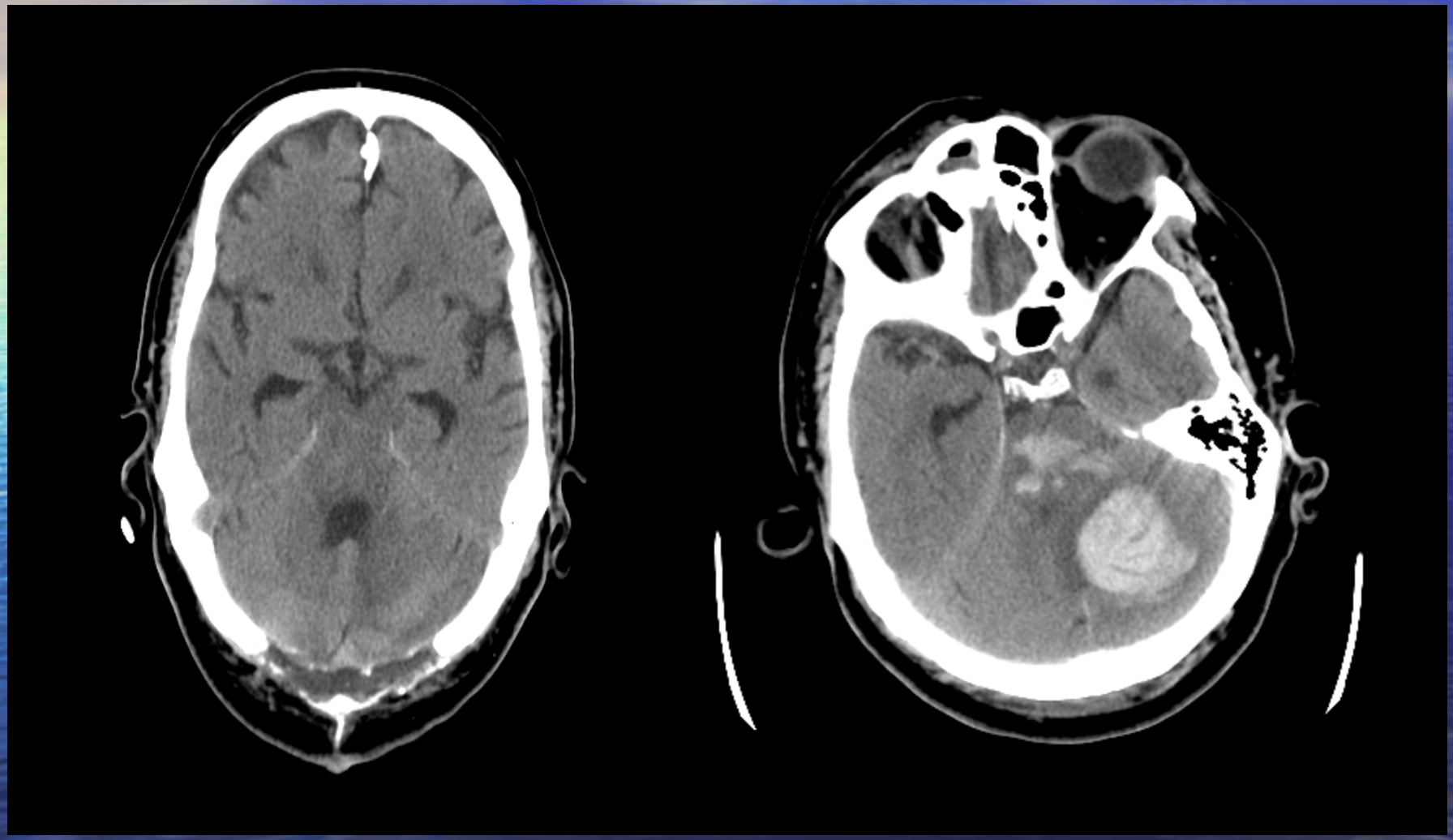

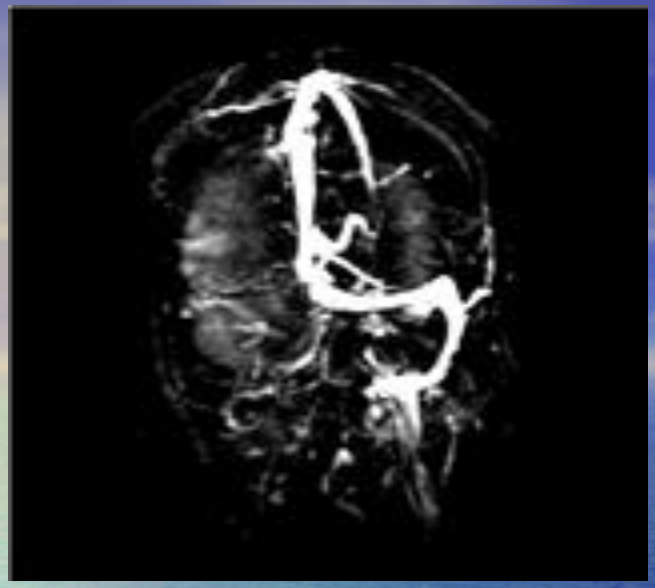

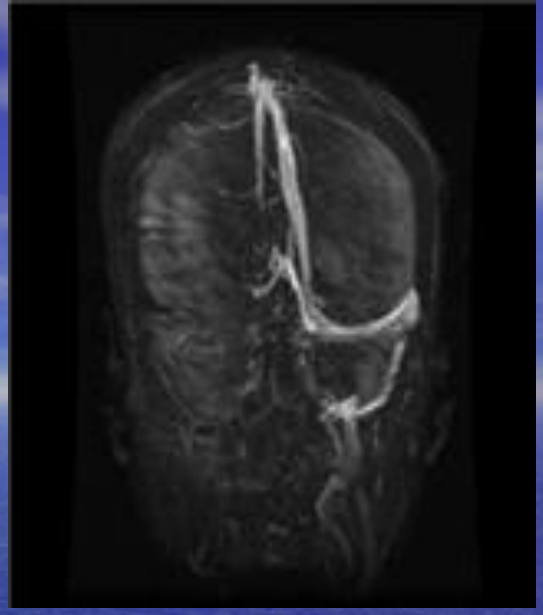

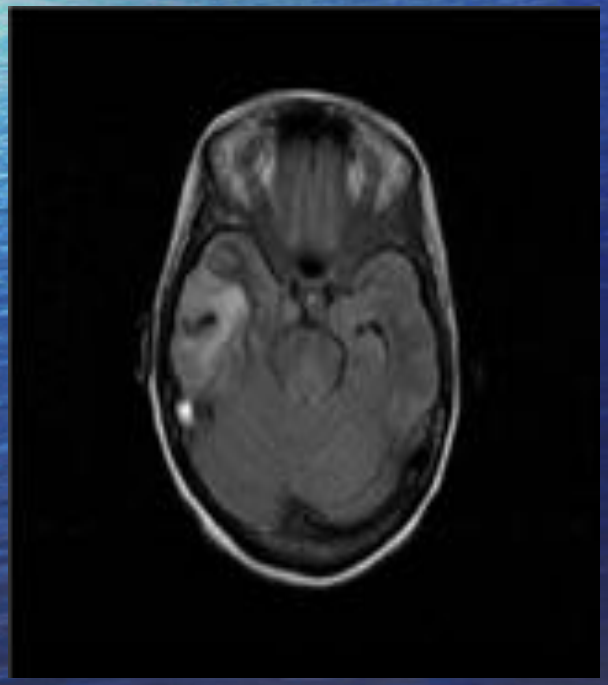

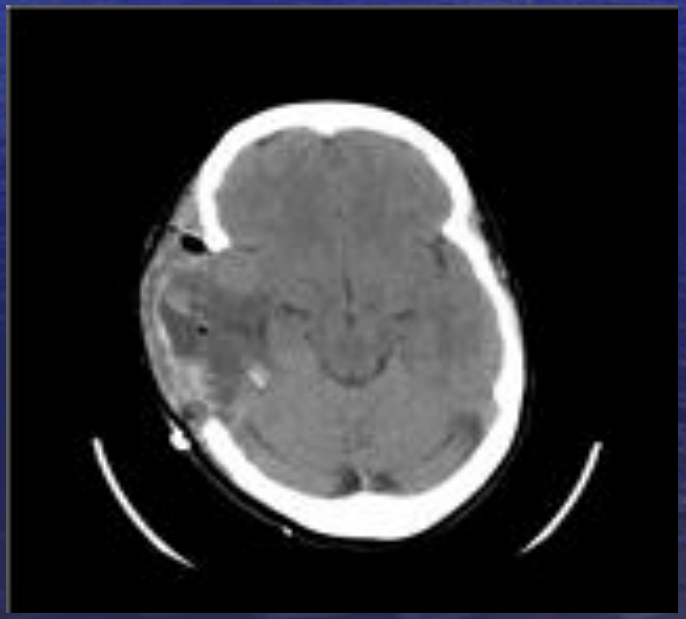

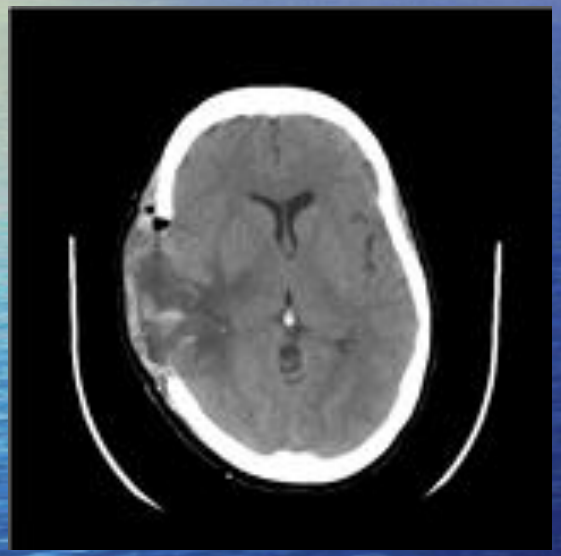

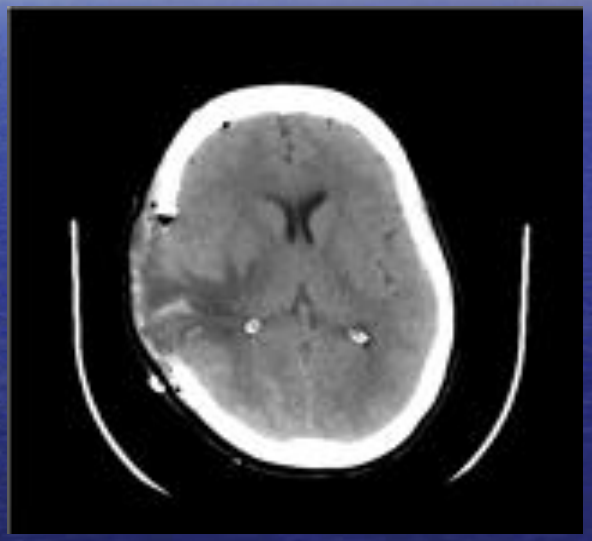

The Cochrane Database of Systematic Reviews

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The Cochrane Collaboration Volume (1), 2006

Decompressive craniectomy for the treatment of refractory high intracranial pressure in traumatic brain injury

Sahuquillo, J; Arikan, F

- There is no evidence to support the routine use of secondary DC to reduce unfavourable outcome in adults with severe TBI and refractory high ICP. In the pediatric population DC reduces the risk of death and unfavourable outcome.

- However, the results of non-randomized trials and controlled trials with historical controls involving adults, suggest that DC may be a useful option when maximal medical treatment has failed to control ICP

Brain Trauma Foundation
www.braintrauma.org

- Bifrontal decompressive craniectomy within 48 hours of injury is a treatment option for patients with diffuse, medically refractory posttraumatic cerebral edema and resultant intracranial hypertension

Decompressive Hemicraniectomy (DH)

- 1st described by Kocher in 1901 for the treatment of TBI
- 1st reported by Rengachary S et al.[1] for the treatement of MMCAIS in 1981
- Removal of an ipsilateral bone flap ≥ 12 cm in diameter and including parts of the frontal, parietal, temporal and occipital squama plus Duraplasty
- To relieve ICP
- Inadequate craniectomy size is associated with parencymal haemorrhage ± infarction and increased mortality[2]

1. Rengachary S et al *Neurosurgery* 1981: vol 8/3, 321-328
2. Wagner S et al. *Journal of Neurosurgery*, May 2001, vol./is. 94/5(693-6)

“Management of refractory intracranial hypertension such as decompressive craniectomy should be proactive rather than reactive.”

Thank you for your attention !