MR Imaging of Hypoglycemic Encephalopathy

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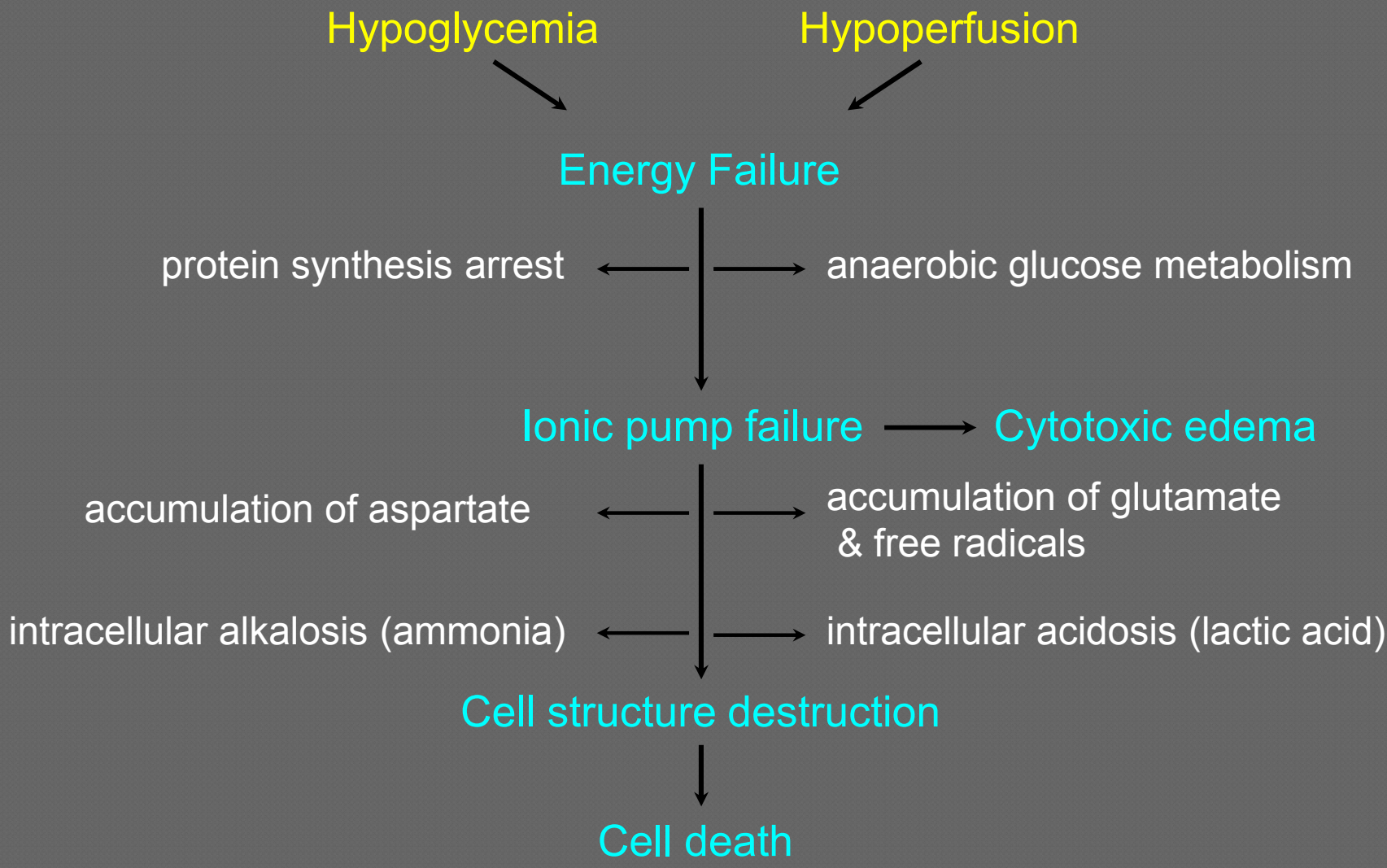
- Cerebral blood flow dynamics are tightly regulated to provide nutrients and oxygen to the dependent CNS.

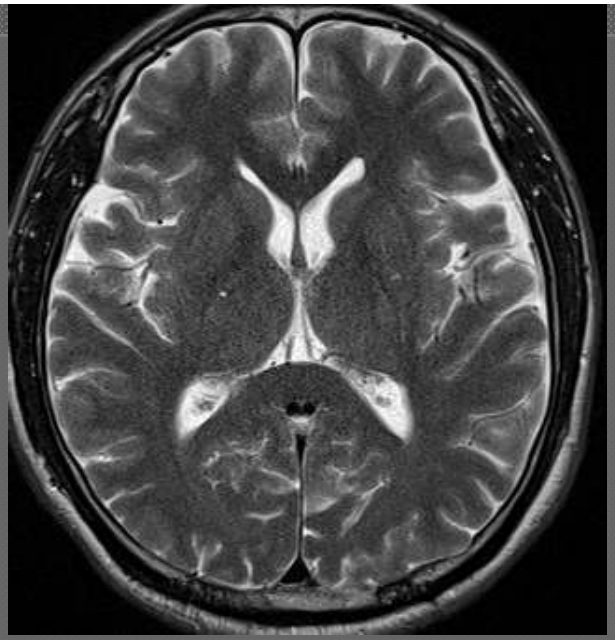
- Impairment of any one of these factors can result stroke (sudden development of neurologic deficit caused by cell death).

- Stroke may diverse spectrum of precipitating event such as vascular occlusion, hypoxia, hypertension, anemia, hypoglycemia, hemorrhage.

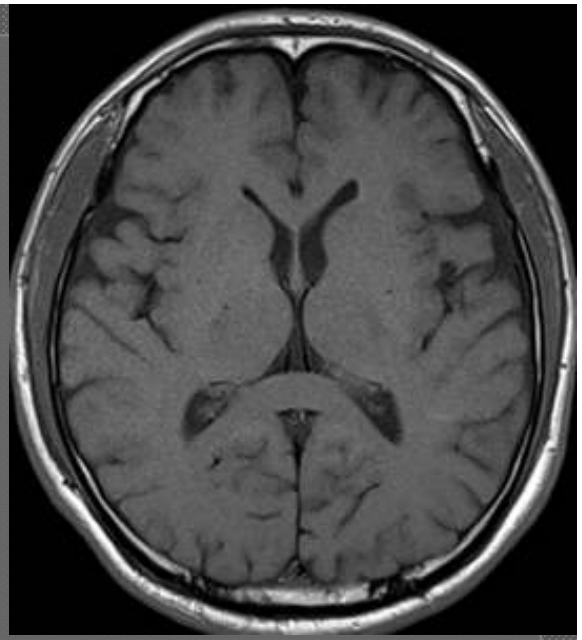
Biochemical change



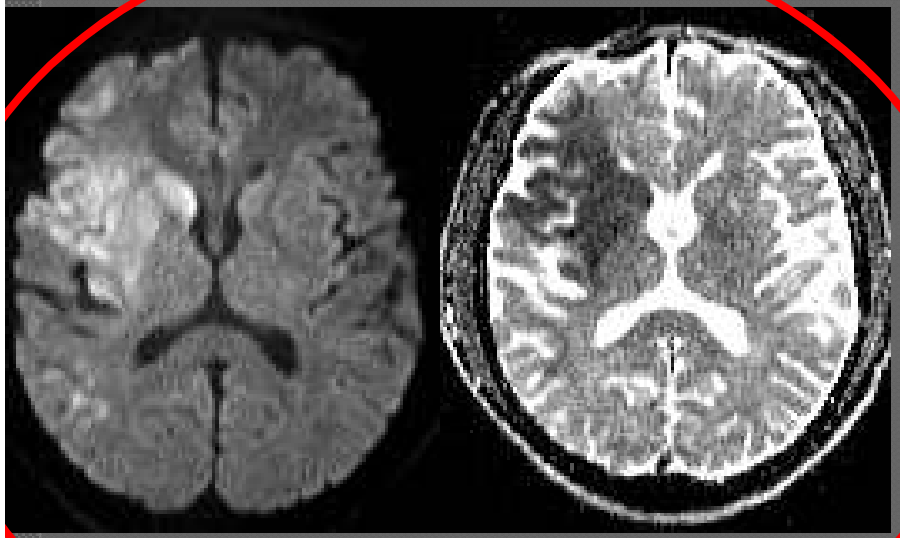
CT



MRI T2 강조영상

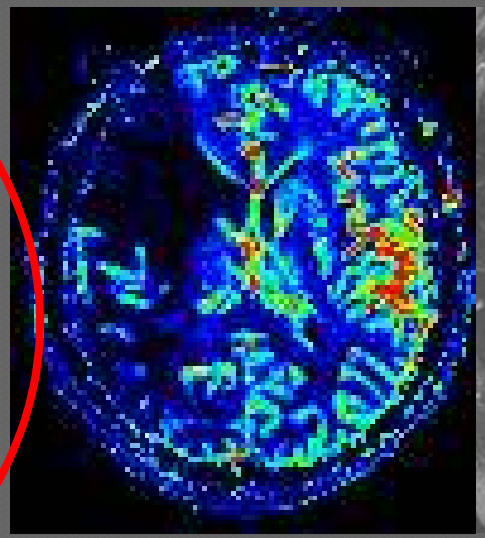


T1 강조영상

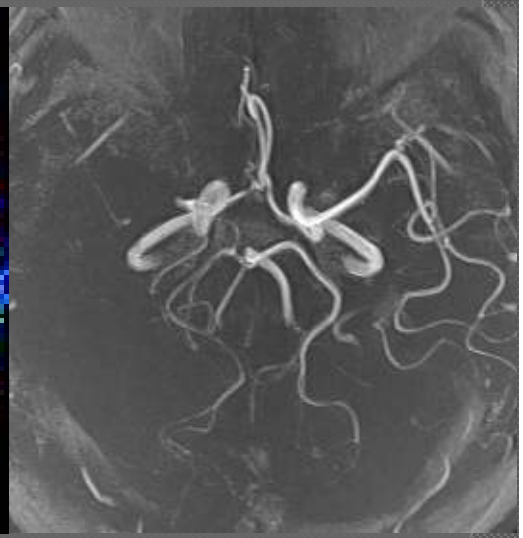


확산강조영상

현성확산계수영상

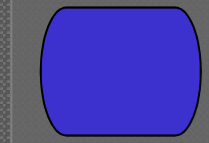


관류강조영상



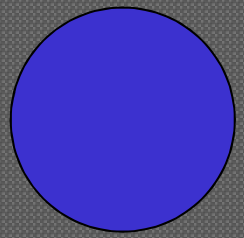
MR 혈관조영술

Normal Brownian random water motion in normal state



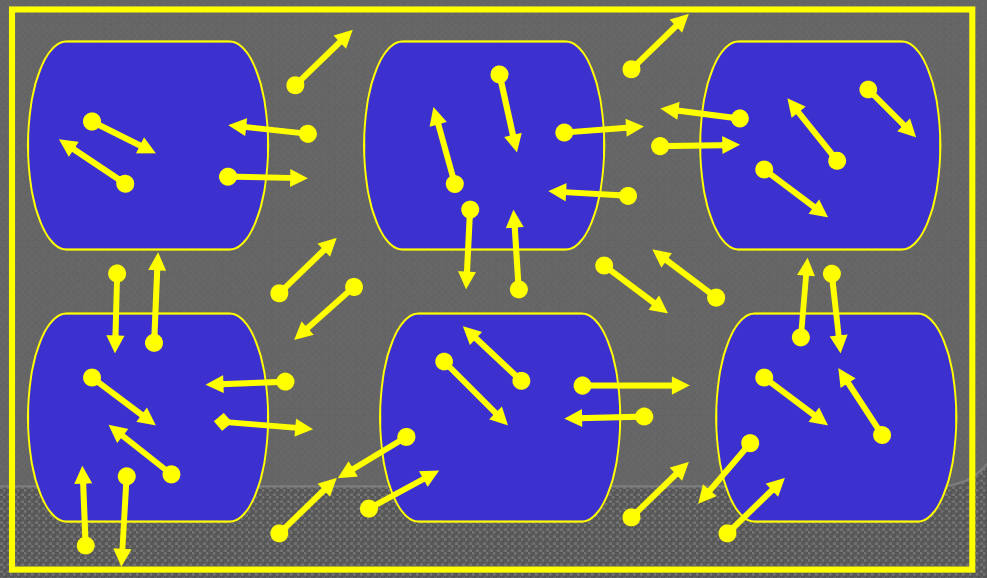
Normal cell

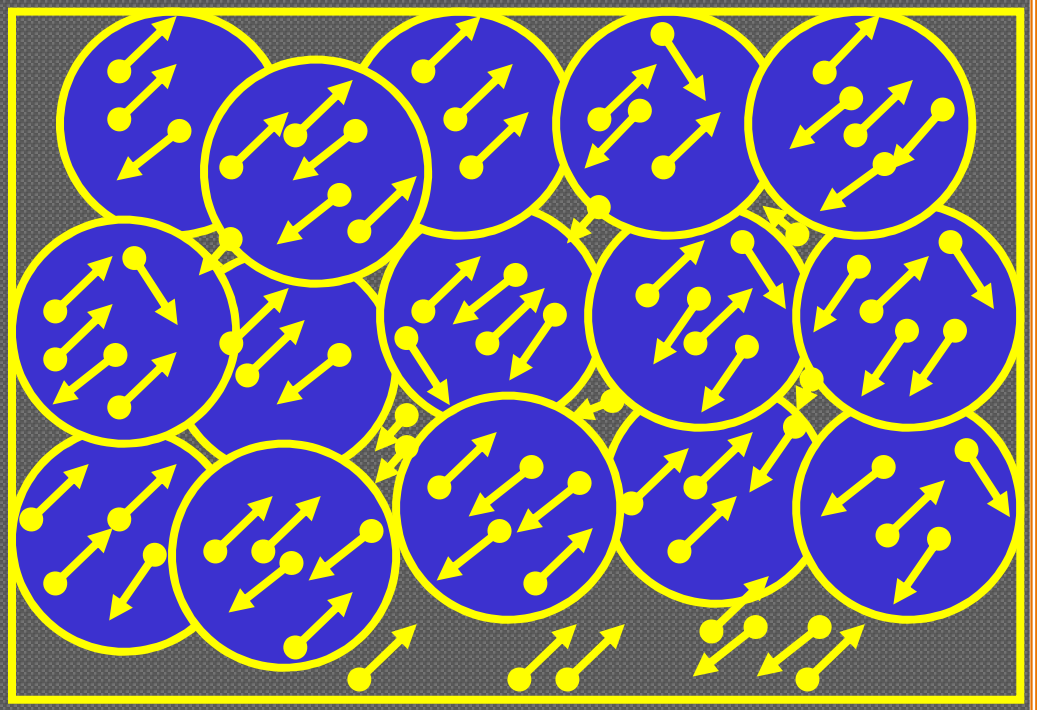
Water molecule



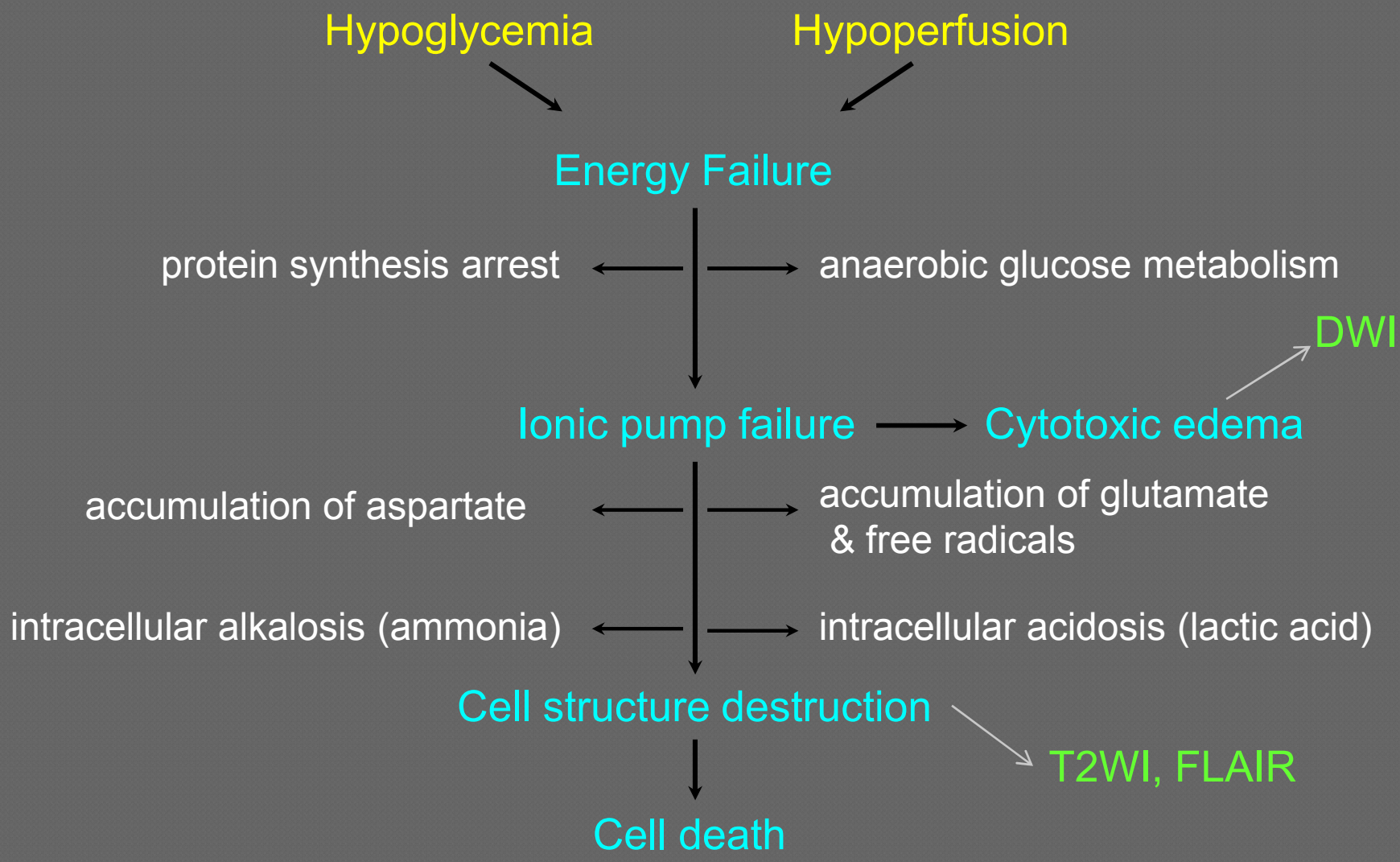
Swollen cell

Restricted motion of water molecules due to cellular swelling and contraction of the interstitial compartment.





Biochemical change



- Diffusion-weighted MR imaging (DWI) detects change in water diffusion with cellular dysfunction and primarily identifies early ischemic changes in stroke.

- DWI is high when diffusion is restricted, as seen at cytotoxic damage.

- DWI is useful for evaluating hypoglycemic cerebral lesion.

- Not so many cases were reported, but most of them suggested followings :

Gray matter is considered to be more vulnerable to hypoglycemic injury.

: Cerebral cortex

Basal ganglia

Hippocampus

- Selective white matter involvement limited to the splenium of the corpus callosum, internal capsule, and corona radiata.

Clinical features in 17 patients with hypoglycemic encephalopathy

Patient no./age (year)/sex	DM (year)	Clinical manifestations	Blood glucose level at presentation (mg/dL)	Days to MR	Outcome
1/71/F	+ (25)	Coma	40	1	PVS
2/80/F	+ (1)	Semicoma	33	1	PVS
3/81/F	−	Stupor	29	1	PVS
4/80/F	+ (20)	Stupor	33	1	PVS
5/57/M	+ (5)	Coma	16	1	PVS
6/53/F	+ (1)	Drowsy	22	1	Motor impairment
7/80/F	+ (20)	Coma	30	1	PVS
8/78/F	+ (20)	Stupor	32	1	PVS
9/65/F	+ (20)	Coma	15	1	PVS
10/59/F	−	Stupor	24	1	PVS
11/51/M	+ (10)	Stupor	35	1	PVS
12/72/F	+ (20)	Coma	29	1	PVS
13/69/F	+ (18)	Stupor	34	1	PVS
14/32/F	−	Coma	33	1	PVS
15/76/F	+ (30)	Coma	34	1	PVS
16/60/M	+ (7)	Stupor	19	1	Recover
17/91/M	+ (5)	Drowsy	24	1	Recover

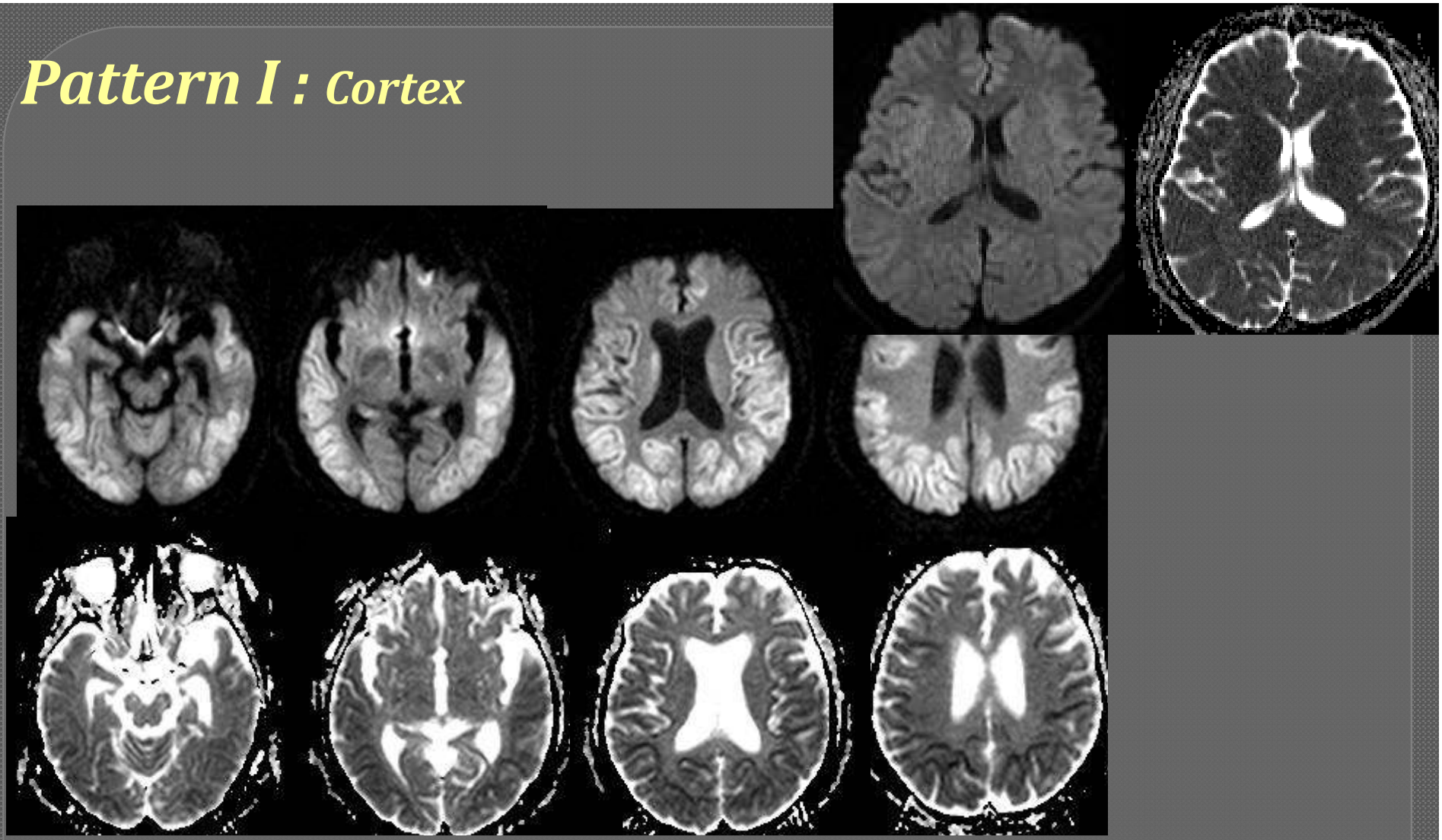
Lesion distribution on diffusion-weighted MR images in 17 patients with hypoglycemic encephalopathy

Patient no.	Cortex	Deep gray matter	White matter	Lesion distribution
1	•		•	Bilateral, symmetrical
2	•		•	Bilateral, symmetrical
3	•		•	Bilateral, symmetrical
4	•	•	•	Bilateral, symmetrical
5	•	•	•	Bilateral, symmetrical
6	•	•	•	Bilateral, symmetrical
7	•	•	•	Bilateral, symmetrical
8	•	•	•	Bilateral, symmetrical
9	•			Bilateral, symmetrical
10	•	•		Bilateral, symmetrical
11	•	•		Bilateral, symmetrical
12	•	•		Bilateral, symmetrical
13			•	Bilateral, symmetrical
14			•	Bilateral, symmetrical
15			•	Bilateral, symmetrical
16			•	Bilateral, symmetrical
17			•	Unilateral

Pattern I
- selective gray matter involvement

- 4 patients among the 17 subjects were included in this group.
- Nobody were recovered.

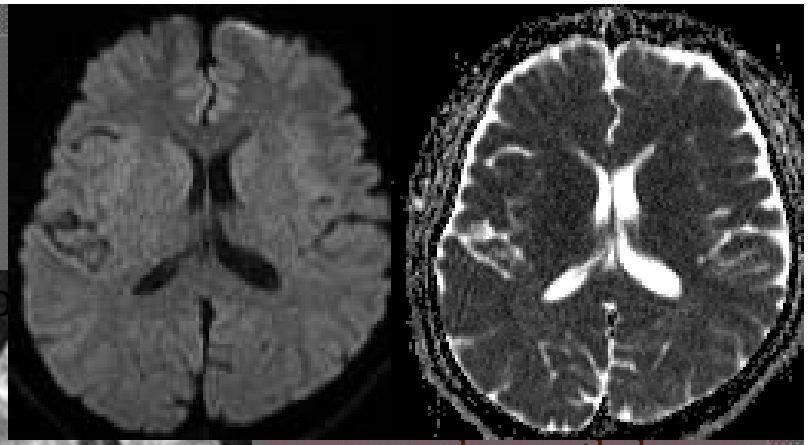
Pattern I : Cortex

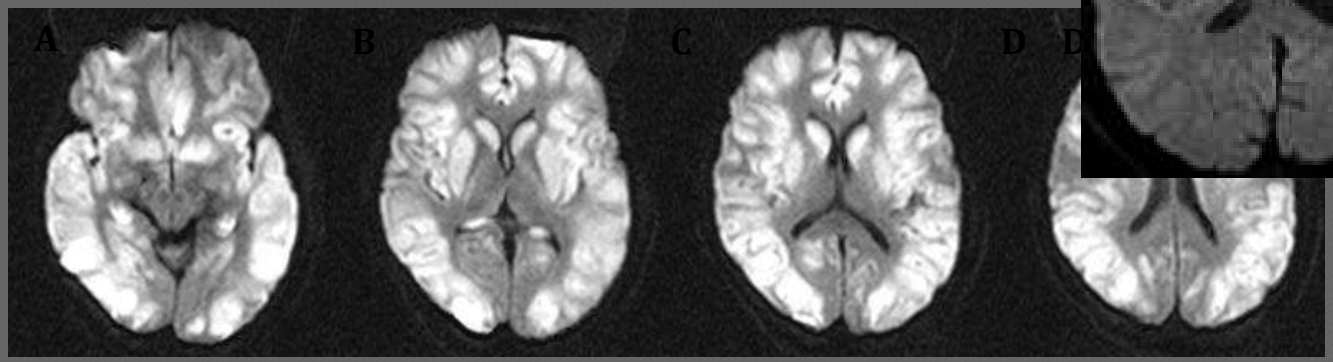


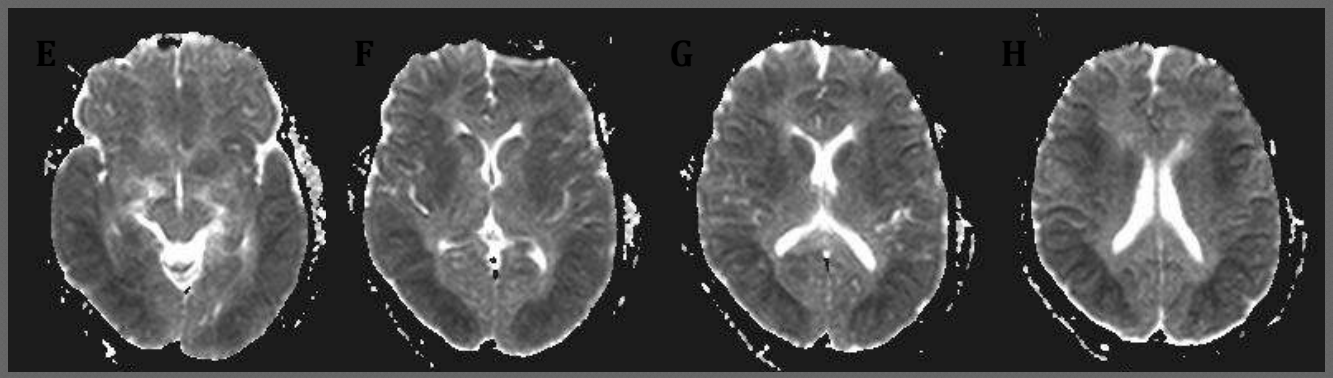
- A 65 years old woman who had DM with insulin use.

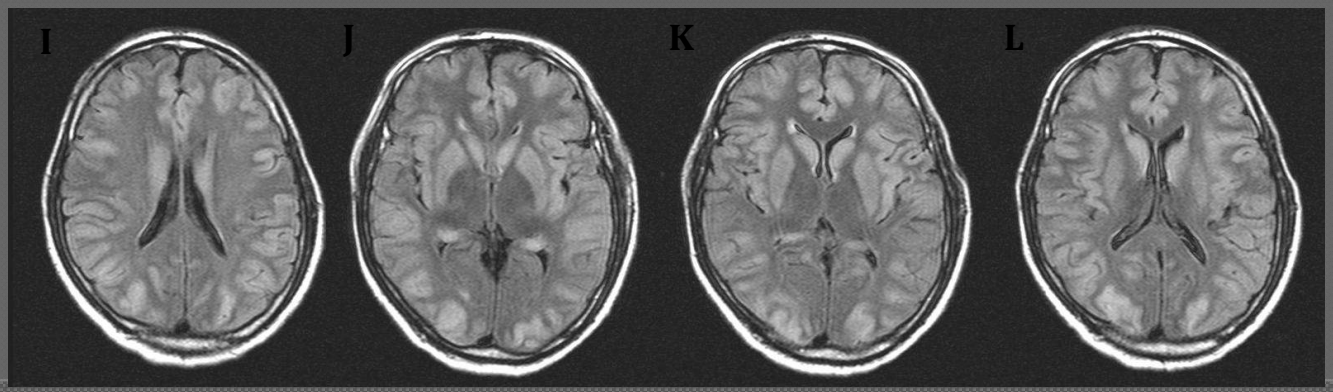
  Her husband injected insulin to her in the morning and went out. She was found in a coma state in the evening. The initial blood glucose level at the point of admission was 15mg/dL. She discharged without recovery.

Pattern I : Cortex + deep GM









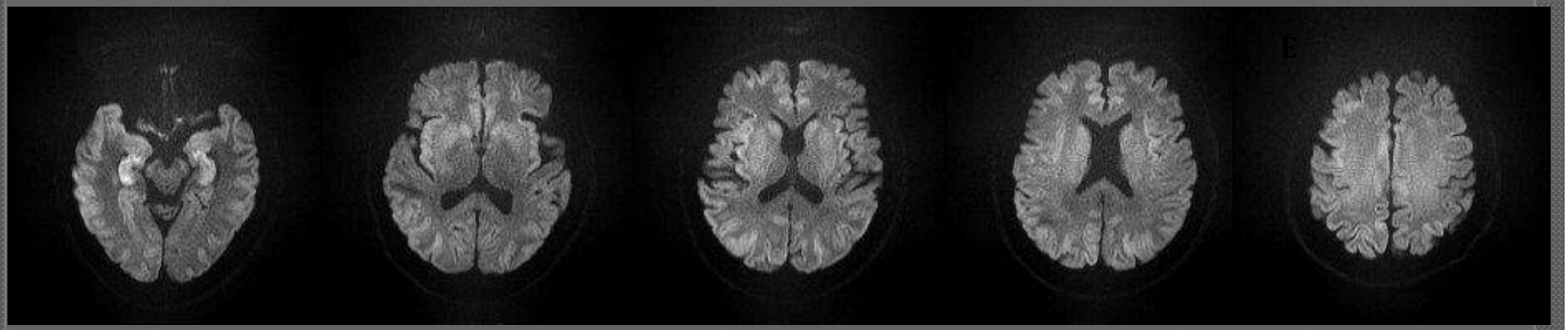
pump and recently he frequently fell in hypoglycemia. Initial blood glucose level was below the 35mg/dL and the probable hypoglycemic time was 26 hours. He remained as vegetate state.

A - D (DWI), E - H (ADC)
I – K (FLAIR)
: Extensive involvement of bilateral symmetric restricted diffusion at the both cerebral cortexes, basal ganglia and some subcortical white matters.

Pattern II
- both gray and white matter involvement

- 8 patients of the 17 subjects were included in this group.
- Nobody were recovered.

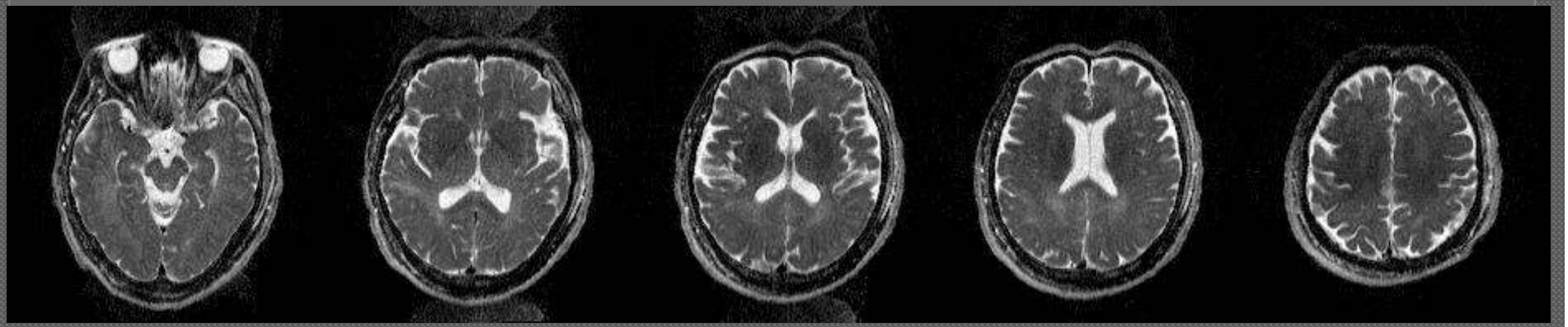
Pattern II : Cortex + BG + white matter



- A 57 years old man who had diabetes mellitus with insulin use was found coma state at his home. initial blood glucose level at the point of admission was 16 mg/ml. He discharged without recovery.

A - E (DWI) and F – J (ADC)

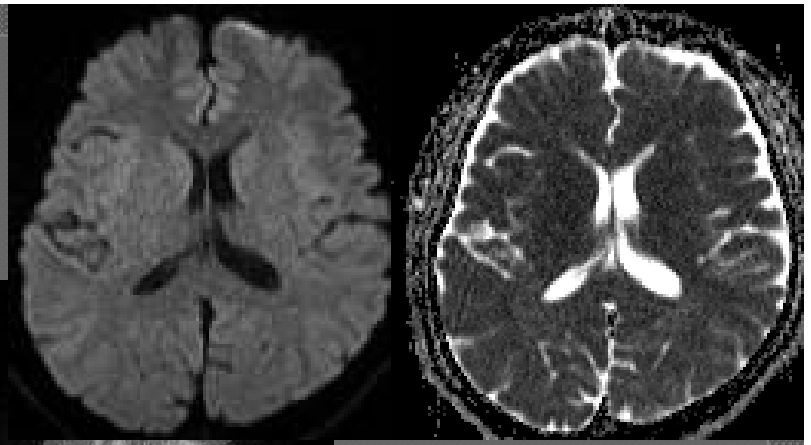
: Restricted diffusion areas at both cerebral cortexes, basal ganglia, hippocampus, periventricular white matter and centrum semiovale.

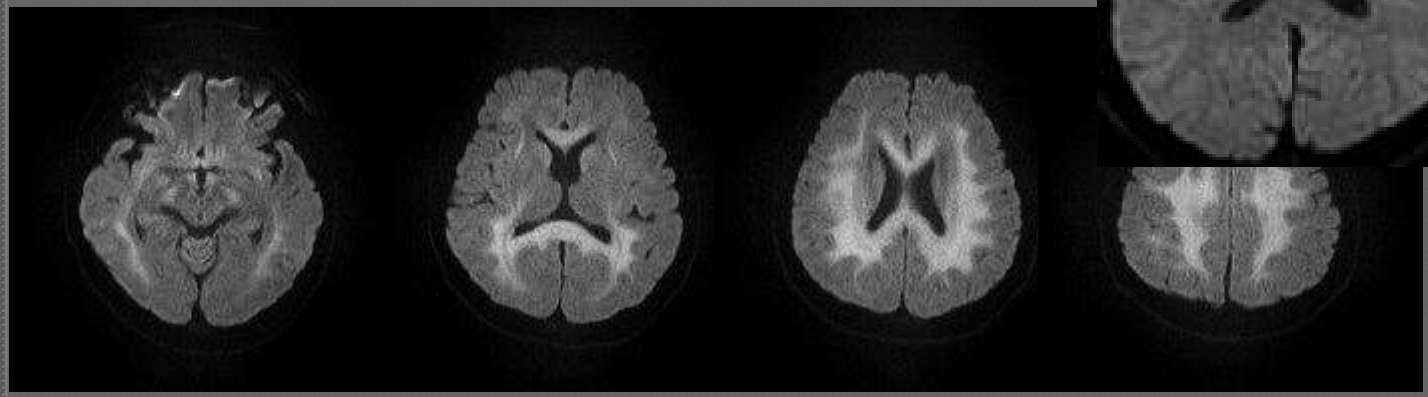


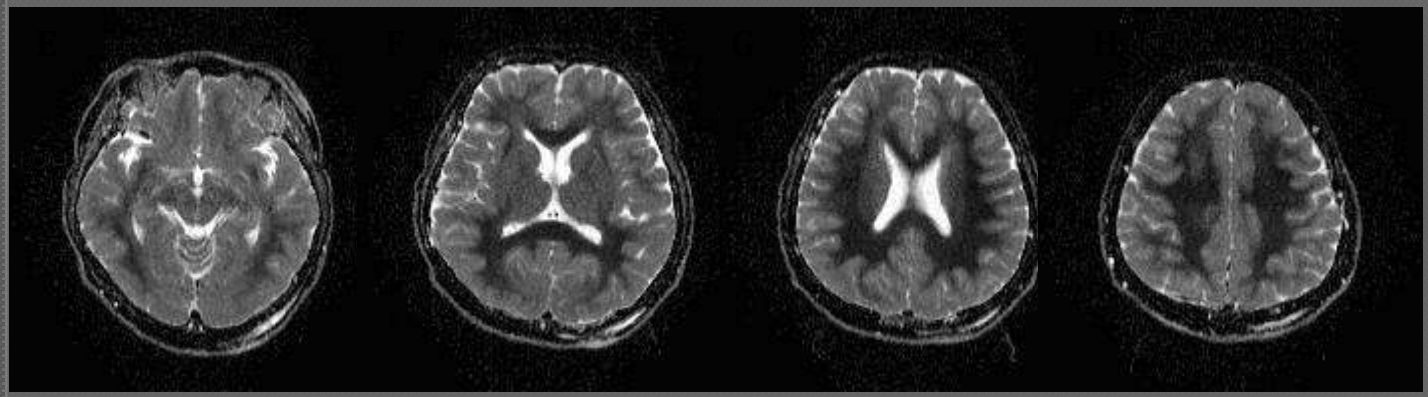
Pattern III
- selective white matter involvement

- 5 patients among the 17 subjects.
- Two patients with a unilateral white matter abnormality and a localized splenial abnormality recovered without neurological deficits.

Pattern III : Cerebral WM





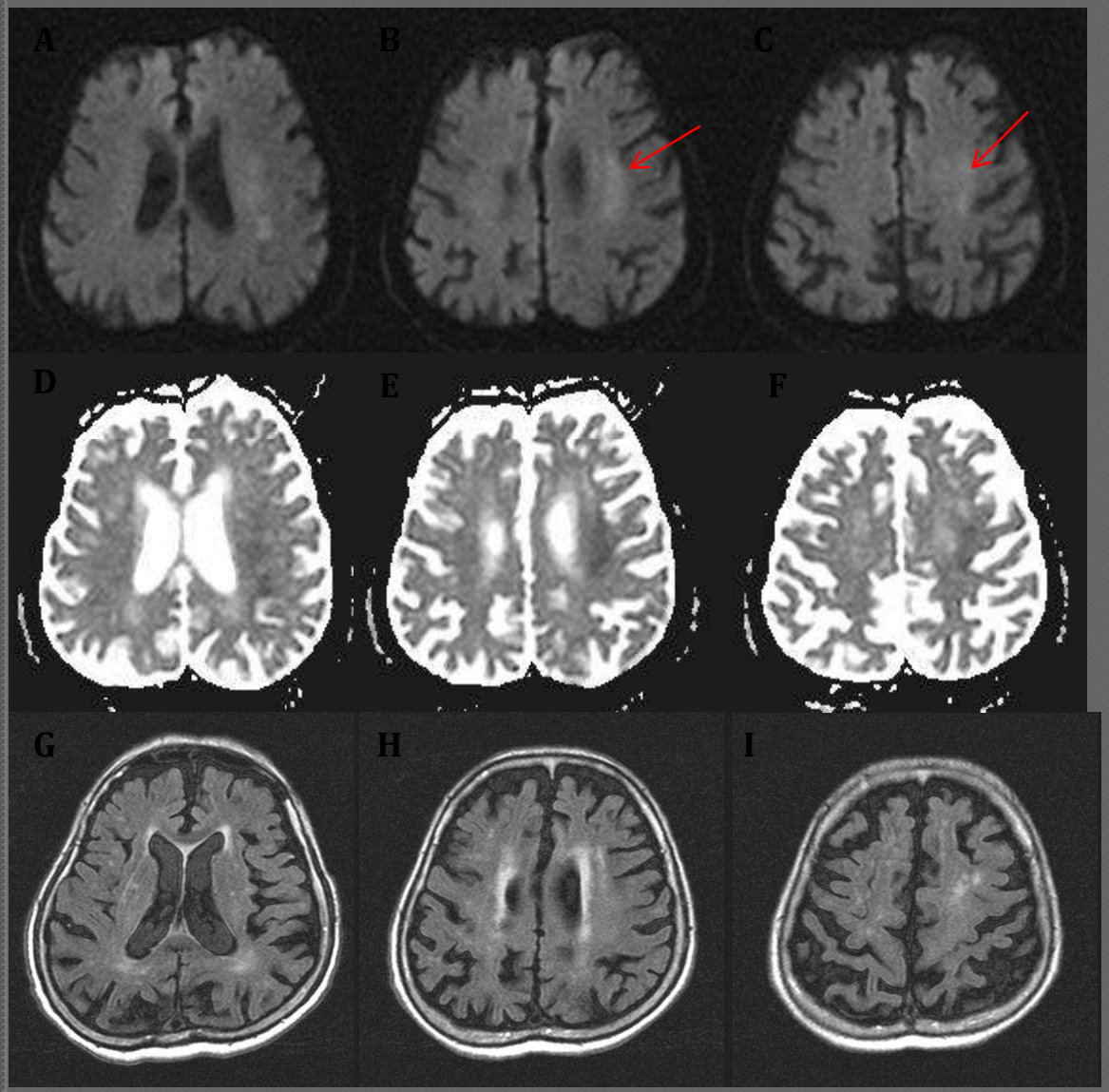


bilateral, symmetric area of restricted diffusion at the both cerebral deep white matters including the periventricular deep white matter, centrum semiovale, corpus callosum, internal capsule, and cerebral peduncle.

- A 32 years old woman without no medical disease was found stupor mentality.

  Initial blood glucose level at the point of admission was 19mg/ml. She discharged without recovery.

Pattern III : Cerebral WM



- A 91 years old man with DM was found as drowsy mentality. Initial blood glucose level was below the 24mg/ml and the probable hypoglycemic time was 10 hours.
- **He recovered completely.**

A-C (DWI), D-F (ADC)
: Bilateral asymmetric area of restricted diffusions at the both periventricular deep white matters and centrum semiovale.

G –I (FLAIR)
: FLAIR image show high signal intensity at the corresponding area of restricted diffusion.

Pattern III : Cerebral WM

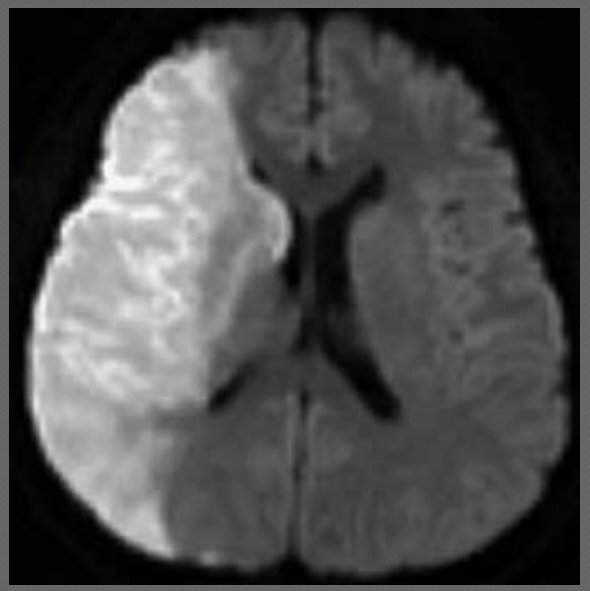
- A 60-year-old diabetic man was found in a stuporous state 12 h affter he was last seen. Glucose level was 19 mg/dL at presention.
- **He recovered completely.**

DWI(a) shows hyperintense lesion in the splenium of the corpus callosum with reduced ADC values (b).

Conclusion

- White matter was more sensitive to hypoglycemia that previously thought.
- There was no specific association between the patterns of injury and clinical outcomes whether the cerebral cortex, deep gray matter and/or white matter were affected.
- Diffuse and extensive injury observed on the DWI predicts a poor neurological outcome in patients with hypoglycemic injuries.

Ischemia?
Hypoglycemic encephalpathy?

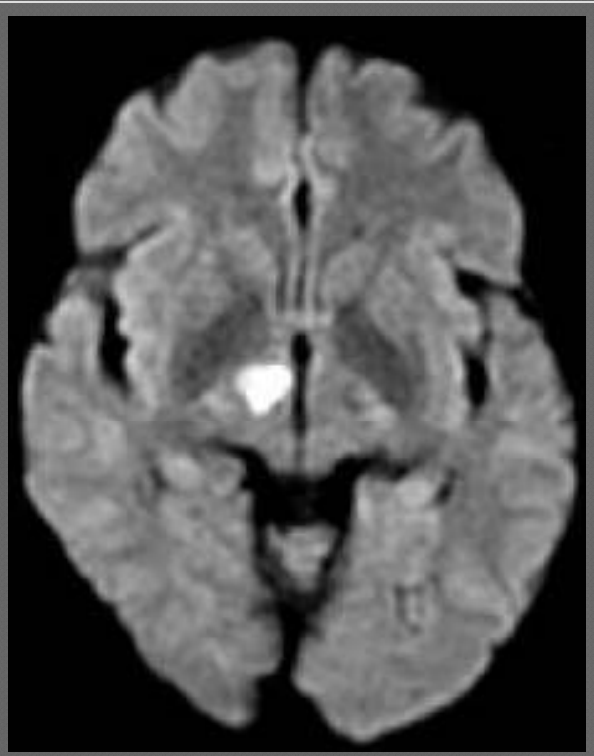


R MCA infarction

Hypoglycemic encephalopathy

Hypoglycemic Encephalopathy : Dose not conform to the typical cerebral arterial distributions and overlapped across multiple lobes.

Ischemia ?
Hypoglycemic encephalpathy?



- The *cerebellum, brain stem* , and thalamus are usually spared in hypoglycemic encephalopathy.

: The protein synthesis in the cerebellum and brain stem remains relatively unaffected because of the greater activity of the glucose transport mechanisms.

: The adenosine triphosphate level is higher in the thalamus

Summary

- Acute Neurologic Deficit
  → diffusion MRI

- Hypoglycemic Encephalopathy
  → high SI on DWI
  : bilateral symmetrical
  : gray matter
  : white matter

- Diffuse extensive involvement
  → poor prognosis