MOYAMOYA DISEASE
Introduction

• A chronic occlusive cerebro-vascular disease affecting arteries around the ‘circle of Willis’ & formation of extensive collaterals at the base of the brain

• Presents with ischemic and hemorrhagic symptoms

• Characteristic angiographic finding
History

• First described in Japan- Takeuchi & Shimizu (1957)

• Spontaneous occlusion of the ‘circle of Willis’- Kudo (1968)

• Moyamoya means ‘puff of smoke’

• Coined by Suzuki and Takaku in 1969
Epidemiology

- Highest incidence in Japan (0.35/lakh)
- Incidence in Western countries - 1/10\textsuperscript{th} of Japan
- F:M = 2:1
- Bimodal age distribution: larger peak in 1\textsuperscript{st} decade & smaller peak around 30-49 years
- 10-15\% have familial form
Etiology

• Multifactorial: genetic predisposition and environmental stimuli

• Genetic loci: chromosome 3, 6, 8 & 17
Associated conditions

- Immunologic: Grave’s disease/thyrotoxicosis
- Infections: Leptospirosis and tuberculosis
- Hematologic disorders: Aplastic anemia, Fanconi anemia, sickle cell anemia, and lupus anticoagulant
Associated conditions 2

- Congenital syndromes: Apert syndrome, Down syndrome, Marfan syndrome, tuberous sclerosis, Turner syndrome, NF-1 & Hirschsprung disease

- Vascular diseases: Atherosclerosis, coarctation of aorta, fibromuscular dysplasia & hypertension
Associated conditions 3

- Others: Head injury, Head neck irradiation for optic glioma, pituitary tumor, craniopharyngioma.

- These are not causative, but warrant consideration during treatment.
Patho-physiology 1

- Smooth muscle hyperplasia of vessel wall & luminal thrombosis
- Fibro cellular thickening of intima,
- Attenuation of media
- Disruption of internal elastic lamina
- No evidence of inflammation or arteriosclerosis
Patho-physiology 2

- Site: supra-clinoidal ICA, ACA & MCA
- Rare involvement of PCA & BA
- Extra-cranial involvement: STA
- Role of pleuripotent peptides, enzymes & receptors: primary or secondary
Clinical features

Symptoms

- Ischemic
- Hemorrhagic
Pediatric population

- Ischemic symptoms: 70-80% cases
- Stroke or TIA: 6% of childhood strokes
- Occurs in watershed areas
- Precipitating factors:
  - Hyperventilation
  - Dehydration
Pediatric population 2

• Features:
  ▶ Hemi paresis
  ▶ Speech disturbance
  ▶ Cognitive impairment
  ▶ Seizure
  ▶ Subtle deficits: developmental delay, syncope, personality changes, visual disturbance
Pediatric population 3

- Hemorrhage: IVH, intraparenchymal or subarachnoid
- Headache
- Choreiform movements
Adult population

- Hemorrhage: 66% cases
- Intra or periventricular bleeding
- Annual rebleeding rate 7%
- High morbidity & mortality
- Sources:
  - Fragile collateral vessels
  - Micro aneurysms in the circle of Willis
  - Periventricular pseudo aneurysms
  - Saccular aneurysms in vertebro-basilar system
Adult population

• Ischemic symptoms predominate in Western world
• Low morbidity and mortality
• Pregnancy and delivery increase the risk
Imaging

- Angiography: Gold standard
- MRI & MRA: steno-occlusive carotid lesion and basal Moyamoya
- Plain CT: helps in acute stage
- Cerebral blood flow studies: xenon enhanced CT, PET, SPECT
Angiography

- Suzuki & Takaku staging:
  - Stage 1: Narrowing of carotid fork
  - Stage 2: Initiation of Moyamoya
Angiography 2

- Stage 3: Intensification of Moyamoya
- Stage 4: Minimization of Moyamoya
Angiography 3

- Stage 5: Reduction of Moyamoya

- Stage 6: Disappearance of Moyamoya
Angiography 2

• Types:
  - Basal Moyamoya
  - Ethmoidal Moyamoya
  - Vault Moyamoya
Management

• No definite treatment available
• Medical treatment: not effective
• Aspirin
• Anticoagulants
• Calcium channel blockers
• Steroids
Surgical management

• Aim:
  ➢ Augment cerebral blood flow
  ➢ Improve cerebral hemodynamics

• Methods:
  ❖ Direct revascularization
  ❖ Indirect revascularization
  ❖ Combined
Surgical management 2

• Criteria for revascularization:
  1. Symptomatic patients with good neurological status
  2. Infarction <2cm on CT & all previous hemorrhages resolved completely
  3. Angiographic stage II to IV
  4. Timing: > 2 months after the most recent attack
Direct revascularization

- Indicated when donor & recipient vessel diameter >1mm
- Immediate selective perfusion of ischemic area
- Chance of hyper perfusion syndrome
- Usually done in adults
Direct revascularization 2

- STA-MCA bypass- Donaghy & Yasargil (1967)
- STA-ACA bypass
- STA- PCA bypass
Indirect revascularization

- Aimed at stimulating neovascularization
- Extent of revascularization unpredictable
- Useful in pediatric population
Indirect revascularization 2

- Encephalomyosynangiosis (EMS): implantation of temporalsis muscle on lateral brain surface and secured to dura

- Encephaloduroarteriosynangiosis (EDAS): dissected STA is laid onto the cortical surface
Indirect revascularization 3

- Ribbon EDAS: pedicle of galea inserted into interhemispheric fissure
- Autogenic omentum transplantation as free graft
Peri-operative care

- Adequate hydration
- Normo-capnia
- Analgesia
- Normo-thermia
Follow-up

• Clinical evaluation & angiography after 6 months
• Angiography after 1 year
• MRA annually from second year
Assessment of revascularization

• Qualitative:
  ➢ Matushima grading on DSA-
    ✤ Grade-A: good revascularization- >2/3\textsuperscript{rd} of MCA territory
    ✤ Grade-B: fair- 1/3 to 2/3\textsuperscript{rd} of MCA territory
    ✤ Grade-C: poor- slight or no collateral formation
Assessment of revascularization

• Qualitative:

  ➢ Doppler grading after EMS:
    ❖ Grade 1: no vessel formation
    ❖ Grade 2: 1-4 vessel formation
    ❖ Grade 3: >4 vessel formation
Assessment of revascularization

- Quantitative:
- Study published in Neurosurgery in March 2012
- Quantitative assessment of RV on DSA
- Revascularization of MCA territory against supratentorial area of the ipsilateral hemisphere
- Best result following combined procedure
Prognosis

- Benign course in 75-80%
- Rebleeding occurs in 30-65%
- Revascularization reduces rebleeding & TIAs
- Unilateral disease progresses to bilateral involvement in 7-27%
Future prospects

• Role of endothelial progenitor cells

• Role of cytokines and growth factors

• Quantitative assessment of RV
AIIMS data

• Ten-year experience of 44 patients with Moyamoya disease from a single institution
• Published in Journal of Clinical Neurosciences in April 2010
• Adult population predominates: 59% vs. 41%
• Hemorrhagic symptoms more common: 68% vs. 32%
AIIMS data 2

- Revascularization done in 11 patients: 9 indirect & 2 combined
- No new episode in revascularized patients
- In conservatively managed 19 patients 7 developed new episodes
- In hospital mortality: 3 patients with hemorrhagic symptoms died
Conclusion

• The unpredictable and relentless course of the MMD, coupled with irreversible nature of deficits once present dictates a need for early diagnosis, prompt treatment and regular follow-up