EC – IC BYPASS INDICATIONS AND TECHNIQUES

History of revascularization

Author (year)	Event
Kredel , 1942	EDAMS
Woringer & Kunlin, 1963	CCA-ICA bypass with saphenous vein graft
Donaghy & Yasargil, 1968	STA – MCA bypass
Loughheed 1971	CCA- IC ICA bypass
Kikuchini & Karasawa1973	EC-IC bypass for moyamoya
Karasawa , 1977	Encephalomyosynangiosis for moyamoya
Story , 1978	ICA-MCA bypass, saphenous vein graft
Sundt , 1982	Saphenous vein graft for posterior circulation
EC/IC bypass study group, 1985	No benefit of STA-MCA bypass in reducing ischemic events compared to best medical therapy
COSS ,2010	Study stopped for futility

Revascularization

- Indirect :
  - Promote new capillary network formation
  - Revascularization with time
  - Flow augmentation , smaller volume of flow
  - Recipient vessel size not important
  - Ischemic brain unable to accommodate a higher flow

- Direct
  - Vessel to vessel anastamosis
  - Immediate revascularization
  - Flow augmentation/ replacement
  - Recipient vessel size > 1mm (ideally > 1.5 mm)

Indirect revascularization

- EMS (encephalomyosynangiosis)
- EDAS (encephaloduroarteriosynangiosis)
- EDAMS (encephaloduroarteriomyosynangiosis)
- Omental graft
- Multiple burr holes

Direct revascularization

- STA
  - STA – MCA anastamosis
- Arterial / venous graft
  - PETROUS ICA – SUPRACLINOID ICA
  - CERVICAL ECA/ICA – MCA
  - CERVICAL ECA/ICA – SUPRACLINOID ICA
  - Bonnet graft (opposite STA – Saphenous graft- MCA)

Revascularization

- Decision about direct/ indirect
- Decide on donor vessel
- Decide on conduit
- Decide on recipient
- Technique of anastamosis

Revascularization

Direct

- Immediate flow required (vessel sacrifice)
- The brain can handle the high flow rates
- Availability of acceptable recipient vessel

Indirect

- Immediate flow not required (3- 4 months to mature)
- Collaterals may not develop in 40 – 50 % adults
- Mass effect of muscle (aphasia)
- Revascularized area dependent on craniotomy size and site (only local revascularization)
- No acceptable recipient

Donor vessel

- STA (superficial temporal artery)
- MMA (middle meningeal artery)
- ECA (external carotid artery)
- ICA (internal carotid artery)
- OA (occipital artery)
- VA (vertebral artery V3 segment)

Conduit

- Pedicled grafts
  - STA ≥ 1mm
  - OA
  - MMA
- Free arterial graft
  - Radial ≥ 2.4mm
  - Other arteries
- Free venous graft
  - GSV ≥ 3mm

J Neurosurg 102:116–131, 2005

Flow characteristics of grafts

- Low resistance circulation, vein grafts not a disadvantage
- Low flow vessels
  - STA, OA, MMA
  - < 50ml/min flow at time of anastamosis
- High flow grafts
  - Radial artery
    - 50-150 ml/min at anastamosis
  - Saphenous vein graft
    - 100-250 ml/min at anastamosis

Vein Vs arterial graft

Arterial graft

- Better suited to high pressure flow
- Short term patency rates are better (98% at 6 W)
- Length is a limitation
- No valves
- Lumen approximates that of recipient
- May not always be available (incomplete palmar arch)
- Recipient ≥ 2 mm

Venous graft

- Larger diameter, higher flow rates
- Lower short term patency rates (93% at 6 W)
- Length is not a limitation
- Almost always available
- Valves present
- Lumen larger than recipient
- Higher procedure related complications
- Children < 12 years
- Recipient ≥ 2.5 mm

Neurosurgery 69:308–314, 2011

Graft flow characteristics

High flow > 50 ml/min

- Proximal vessel sacrifice
- Flow replacement
- Large area to be revascularized

Low flow (< 50 ml/min)

- No vessel sacrifice
- Flow augmentation
- Small area to be revascularized
- Brain can not handle high flows

Recipient vessel

- M1 tolerates temporary occlusion poorly (lenticulostriate perforators)
- Implant into a bifurcation
- Implant into a 2.5 mm vessel MCA
- If M1 segment short , MCA unsuitable recipient, use supraclinoid ICA if aneurysm infraclinoid
- If supraclinoid ICA used as recipient collateral from ACA essential (temp PCA occlusion required)
- Suturing started at the heel end

Anastomotic technique

- Hand sewn (commonest)
  - Require proximal and distal clamping of the recipient
- Non occlusive anastamosis
  - Expensive , learning curve, larger recipient vessel size, patency rates comparable, similar complication rates
    - ELNA (Excimer Laser assisted Non occlusive Anastamosis)
    - C-Port xA Distal Anastomosis System

STA – MCA bypass

- STA
  - Parietal branch preferred (frontal has collaterals with ophthalmic)
  - Location of craniotomy
    - Junction of the anterior 2/3 and posterior 1/3 of a line joining lateral canthus to ipsilateral tragus
    - A line perpendicular to this
    - Craniotomy 3-5 cm in diameter 6 cm above this line
  - Anastomose to temporal M4 branches
    - Avoid ischemia to frontal branches during occlusion
    - Good collaterals with PCA
    - More consistent good M4 branches

Neurosurgery 61:ONS-74–ONS-78, 2007

Radial artery harvest

- Radial artery graft
- Allen's test
- Expose at wrist between FCR and brachioradialis tendon
- Follow upwards between Pronator Teres and brachioradialis

J Neurosurg 102:116–131, 2005

GSV harvest

- Expose at ankle 1 cm anterior and cranial to medial malleolus
- Follow upwards to medial aspect of leg
- Harvest appropriate length
- Can also be harvested in the thigh (drains into CFV 3 cm below inguinal ligament)

J Neurosurg 102:116–131, 2005

Anastomosis

- Meticulous haemostasis (heparin administration)
- Distension of graft to prevent spasm
- Vein graft ***<u>not reversed</u>***
- Intracranial anastomosis performed first
- Arterial graft retro/ preauricular route
- Venous graft retroauricular route
- Deliver graft without torsion

Hand sewn anastomosis

- Fish mouthing of graft end before anastamosis
- Teardrop arteriotomy of recipient
- Ensure no air in graft (back bleeding/ flushing)
- Verify flow through graft (Doppler/ angiography)
- Bone flap placed without compromising graft

Indications for bypass

- Cerebral ischemia
- Moyamoya disease
- Aneurysms
- Skull base tumors

Bypass after major vessel sacrifice

- Selective approach: only if test occlusion is positive
  - 22% risk of TIA, infarcts
    - Neurosurgery 35:351–363, 1994.
  - TIA 10% ,stroke rate of 5% and mortality of 5% after ICA occlusion following test occlusion
    - Neurosurgery 36:26–30, 1995
  - A high flow bypass if fails test occlusion, low flow if passes
    - Spetzler RF . Comments Neurosurgery 62[SHC Suppl 3]:SHC1373–SHC1410, 2008
- Universal approach: irrespective of test occlusion results
    - Neurosurgery 62[SHC Suppl 3]:SHC1373–SHC1410, 2008

Moyamoya disease

- Rationale for surgery
  - Augment blood flow
  - Improvement in CBF has been demonstrated
  - Reduction in further ischaemic events
  - Reduction in hemorrhagic events
- Indications for surgery
  - History of infarct/ haemorrhage
- Regions to be addressed
  - MCA territory : EDAS,EDAMS, STA – MCA bypass
  - ACA territory : multiple burr holes, STA – ACA bypass, vascularized dural flap

Moyamoya disease

- Indirect revascularization
  - EMS,EDAS,EDAMS, EDMAPS (Neurosurgery 66:1093-1101, 2010)
  - Encephalo – galeo – synangiosis
  - Multiple burr holes
  - Omental graft
- Direct revascularization
  - STA – MCA bypass
  - STA – ACA bypass (technically difficult, poor results)
  - A higher incidence of symptomatic hyperperfusion with direct revascularization as compared to atherosclerotic disease

Aneurysms

- Only level III evidence available
- Sacrifice of parent vessel or a major branch
- As a temporary measure during prolonged temporary clipping of complex aneurysm
- Aneurysms requiring bypass
    - Giant / blister aneurysms
    - Absence of a neck (fusiform or saccular-fusiform) aneurysms
    - Severe atherosclerosis or calcification in the neck
    - Extensive thrombosis
    - Critical branch origin from neck or sac
    - Symptomatic dissecting aneurysm
    - Blister aneurysm

Cranial base tumors

- Facilitates tumor removal with better patient outcome and tumor removal
- Allows surgeon to focus on cranial nerve preservation
- High morbidity and mortality
- Performed by few centers
- Being used less frequently (GKRS)

Cerebral ischemia

(occlusive cerebrovascular disease not amenable to carotid endarterectomy)

- EC – IC bypass study 1985
- Not effective preventing ischemia
- Reduction in bypass
- Criticism
  - Only half of the patients received antiplatelet agents at entry into study
  - No evaluation preop for **cerebrovascular hemodynamic status**..
  - Both the patient and the therapist were **not blinded**
  - **Randomization-to-treatment bias** could have occurred
  - **No angiographic determinants for entry**.
  - A large percentage of patients had **no symptoms between** the angiographic **demonstration of ICA occlusion and randomization**.
  - large number of patients underwent **surgery outside the study**.
  - A high percentage of patients had **tandem lesions**

COSS study

- Inclusion criteria
  - Complete occlusion of an ICA
  - TIA or ischemic stroke in the hemispheric territory of an occluded internal carotid artery in the preceding 120 days
- Outcome measures
  - Surgery arm
    - Death or stroke 30 days from surgery
    - Ipsilateral stroke within 2 years
  - Medical arm
    - Death or stroke 30 days from randomization
    - Ipsilateral stroke within 2 years
- Results
  - Study stopped on 24 June 2010 for futility

Present status of revascularization

- Cerebral ischemia:
    - most RCT have shown no benefit
- Moyamoya disease:
    - only class III evidence of benefit
- Complex aneurysms :
    - class III data. Evidence of benefit
    - IC – IC bypass, lower morbidity, comparable patency rates
- Skull base tumors:
    - class III evidence of benefit
    - alternative strategies for treatment of residual disease,