EARLY EXPERIENCE WITH SURGICALLY INACCESSIBLE WIDE-NECKED INTRACRANIAL ANEURYSM EMBOLISED WITH GUGLIELMI ELECTRICALLY DETACHABLE COILS AND ELECTROTHROMBOSIS

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ABSTRACT

We describe our early successful experience with Guglielmi Electrically Detachable Coils (GDC) and electrothrombosis in treating a surgically inaccessible wide-necked intracranial aneurysm in a Chinese patient. The precautions taken to prevent unnecessary complications while performing this technique was also described. It provides a serious alternative to other less ideal types of embolising agents and direct surgery in treating patients with these difficult-to-treat aneurysms.

Keywords: *wide-necked intracranial aneurysm, embolisation, Guglielmi detachable coils, electrothrombosis*

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INTRODUCTION

It has been estimated that approximately 2% of the entire population harbours an intracranial aneurysm[1]. Saccular aneurysms from the anterior circulation are frequently encountered. Multiplicity of cerebral aneurysms are not unusual and have a reported incidence of 19%[2]. As such, complete visualisation of the intracranial vasculature is necessary.

Most intracranial saccular aneurysms are found in patients between the ages of 4 and 60 years. Males are commonly affected before the age of 40 years whereas females show strong preponderance after the age of 40 years. The overall ratio of female to male is 3:2. Also recurrent bleeding is more common in females than in males[2].

We describe our experience in one patient using the recently developed Guglielmi Detachable Coils (GDC) and electrothrombosis for aneurysm occlusion. This is the first case of intracranial aneurysm to be treated utilising this technique in the South East Asian region and this was confirmed by the manufacturer of the GDC.

Endovascular treatment of intracranial aneurysms is an established therapeutic alternative to direct surgery in selected cases. The obvious advantages of this approach is the avoidance of general anaesthesia, craniotomy and brain manipulation.

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Of the varied embolisation materials used to obliterate the aneurysm, the very soft electrically detachable platinum coils are much less traumatic when compared to balloons. These coils are able to adapt to the shape of the aneurysm without increasing the intra-aneurysmal pressure significantly[3]. This property reduces the risk of aneurysm rupture during embolisation.

Apart from the physical properties of the thrombogenic platinum coil[4], the added electrothrombosis process ensures the formation of a stable clot within the aneurysm.

We describe the technique and highlight the precautions that need to be taken when performing endovascular occlusion of intracranial aneurysm utilising this recently developed Guglielmi detachable coils and electrothrombosis.

CASE REPORT

A 59-year-old Chinese woman presented to our Department with an acute onset of headache, profound dizziness and vomiting. There was no significant past medical history of note.

Clinically, our patient was conscious and alert. While in the hospital, the highest recorded blood pressure reading was 130/80 mmHg.

Computerised tomography of the head revealed acute subarachnoid haemorrhage in the interhemispheric fissure. Three vessel angiography confirms the presence of two aneurysms, one located at the anterior communicating artery (AcoA) and the other, at the right carotico-ophthalmic artery (COA). The carotico-ophthalmic artery aneurysm has its fundus pointing superiorly and medially towards the dorsum. This aneurysm was demonstrable only in one view.

The following day, our patient had left peritonal craniotomy and clipping of the AcoA aneurysm with a Sugita 1.5 cm length clip. An associated small pool of blood at the AcoA area was seen. The AcoA aneurysm was presumed to be the most likely source of bleed at that time.

Post-operatively, she was well and a repeat angiogram showed completed obliteration of the AcoA aneurysm.

The other inferiorly located right carotico-ophthalmic aneurysm was not easily accessible via direct surgery and due to the patient's reluctance for a second craniotomy on the right side, she was scheduled for treatment by endovascular embolisation a month later.

Our patient was readmitted and angiogram performed

Fig 1 – Example of continuous flush setup
(Courtesy of Target Therapeutics)

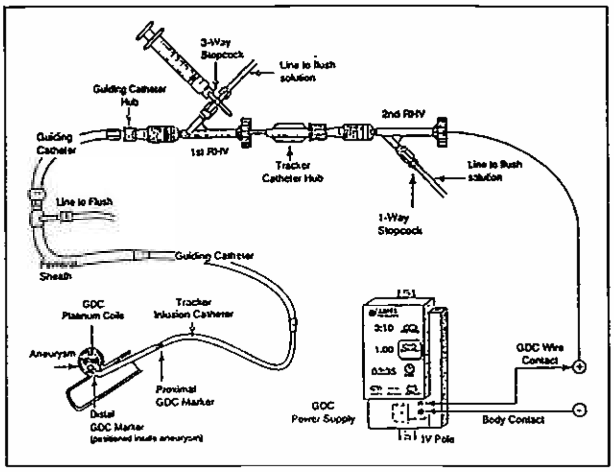
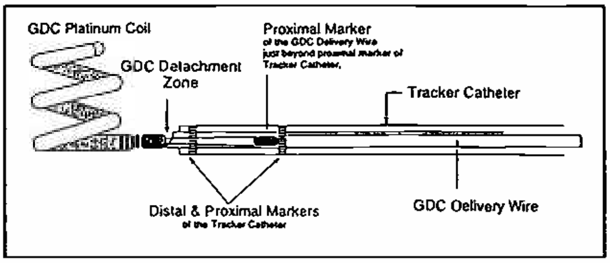


Fig 2 – Optimal alignment of radiopaque markers
(Courtesy of Target Therapeutics)



revealed the right wide-necked COA aneurysm had remained very much the same. Embolisation was attempted with the mechanical detachable Tungsten 5 mm/150 cm and Tungsten 3 mm/8 cm length coils which were found to be too large and too small respectively. During the procedure, washed out of the smaller coil from the aneurysm sac occurred before detachment. The coil was successfully retrieved without any neurological sequelae.

A decision was then made to have the patient scheduled for GDC embolisation.

PROCEDURE

The patient was admitted for GDC embolisation. Neuroleptic analgesia of fentanyl 0.05 mg and dormicum 5 mg were given prior to the embolisation of the aneurysm.

During the entire procedure, our patient was awake and was able to converse with both the neurosurgeon and the radiologist. The transfemoral approach was used to introduce a 5F guiding catheter into the right carotid artery. Then a Tracker microcatheter (Target) was advanced coaxially through the 5F guiding catheter with the aid of a steerable guidewire into the aneurysm sac.

The tip of the microcatheter is shaped to form a slight curve to allow easy entry into the aneurysm which is almost perpendicular to the parent artery.

The steerable guidewire is removed and an intra-aneurysmal angiogram performed to ensure that the microcatheter is positioned properly.

The detachable platinum coil with its stainless steel delivery wire is introduced through the microcatheter. The platinum coil while in the microcatheter adopts a straight shape which allows easy advancement towards the aneurysm.

As soon as the platinum coil emerges from the microcatheter tip, it folds and forms a circular pattern conforming to the shape of the aneurysm. This characteristic ensures that no unnecessary stress is applied onto the aneurysm wall.

The platinum coil in the aneurysmal sac is ready to be detached when the platinum/stainless steel wire junction zone is 3 mm beyond the tip of the microcatheter. The catheter and coil delivery wire markers can both be visualised under fluoroscopy. The position of the platinum/stainless steel junction zone should not extend too far beyond the tip of the microcatheter because when the coil is detached by electrolysis, the stainless steel delivery wire might perforate the fragile aneurysm wall.

On occasion, migration of the coil into the parent vessel may occur. In our patient the coil had to be withdrawn and repositioned in several instances. This would not have been possible with the other types of coils.

When the coil was suitably positioned in the aneurysmal sac, electrothrombosis and electrolysis of the detachable platinum coil was initiated.

Positive direct electric current was applied to the proximal end of the stainless steel delivery wire using a proprietary battery-operated current generator. The negative ground pole was connected to a hypodermic needle (size 20G or 22G) inserted at the groin of the patient. As most hypodermic needles are silicone coated, we roughed its surface with a surgical blade to improve conduction of electricity.

In our patient, electrolysis with detachment of the platinum coil occurred within a minute. The current applied was 0.5 mA and voltage recorded was about 2.5V. The stainless steel delivery wire was then withdrawn under fluoroscopy.

During the electrolysis process, the patient may experience slight discomfort at the site of the ground needle (groin). This can be corrected by reducing the default current setting of the GDC power supply. Switching current ranges as suggested by the manufacturer has no effect on the functionality of the unit but may increase detachment time.

The positive electric charge applied to the proximal end of the detachable coil, attracts negatively charged red blood cells, white blood cells, platelets and fibrinogen resulting in electrothrombosis.

The first coil delivered into the aneurysm should be as large as possible to create a supporting (basket) framework. Subsequent coils should "filled the basket" but caution should be exercised in the repositioning of additional coils since visualisation of the catheter tip and individual coils may be compromised by the coil mass.

Our patient required more than one coil to pack the aneurysm. After detachment of the first coil, it was evident that it would be difficult to locate the distal marker of the microcatheter and the platinum/stainless steel junction of the second coil in the aneurysm. The Tracker microcatheter has 2 radiopaque markers, one at the distal tip and another which is 3 cm proximal to the first. There is also a proximal marker on the delivery steel wire 2.8 cm before the platinum/stainless steel junction. The suitable position for detachment occurs when the proximal marker on the delivery steel wire is just at or distal to the proximal radiopaque marker on the microcatheter. This would ensure that the platinum/stainless steel wire junction is about 2-3 mm distal to microcatheter tip. These proximal markers allow safe delivery of coils subsequent to the first coil.

A third coil was introduced but partial migration of the coil into the carotid artery occurred even though a smaller size coil was used.

A post-embolisation angiogram showed near total obliteration of the aneurysm with a tiny residual neck remaining. No parent vessel occlusion was noted.

Our patient returned home the following day with a follow-up check angiogram scheduled 4 weeks later.

Fig 3 – Right carotid arteriogram. Medially pointing periclinoid carotid aneurysm (▲)

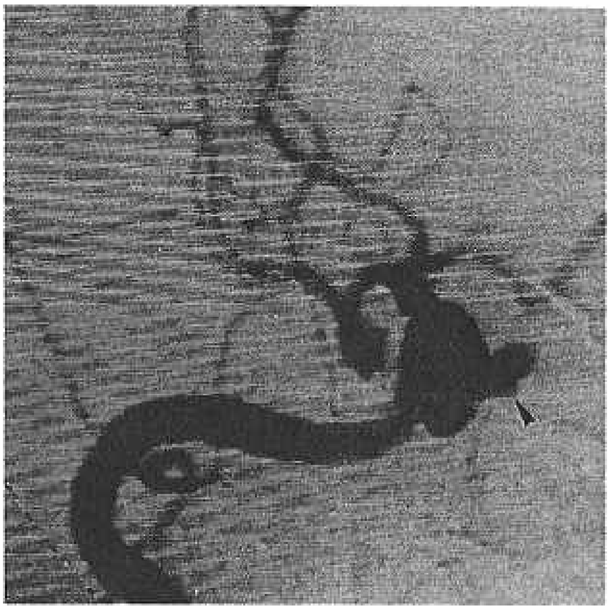


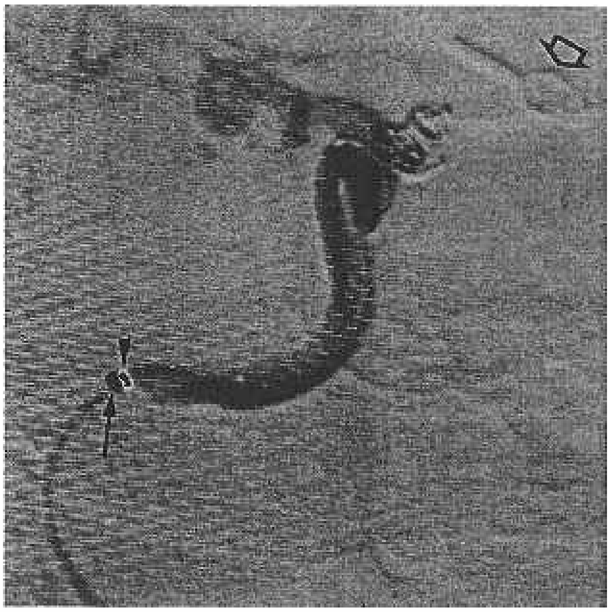
Fig 4 – Right carotid arteriogram. The first GDC successfully detached in the aneurysm. (▲)

MATERIALS

1. Emboli Material
a. Guglielmi Detachable Coil (GDC)
   - Soft detachable platinum coil 4 – 40 cm in length soldered to a stainless steel delivery wire
   - Target GDC – 18 Guglielmi Detachable Coil 6 mm Helix/ 20 cm
   - Target GDC – 18 Guglielmi Detachable Coil 5 mm Helix/ 20 cm
   - Target DGC – 10 Guglielmi Detachable Coil 5 mm Helix/ 10 cm

2. Delivery System
a. 5F polyethylene guiding catheter
b. Guidewires
   - Target Dasher – 10 steerable guidewire
   - Target Dasher – 14 steerable guidewire

Fig 5 – Correct position for the 2nd GDC to be detached is when the proximal marker on the delivery steel wire (▲) is just at or distal to the proximal radio-opaque marker on the microcatheter (↑). Sugita aneurysm clip (⇧).



c. Infusion Microcatheters
   - Tracker – 38 infusion catheter 120 cm
   - Tracker – 18 infusion catheter with 2-tip markers 150 cm
   - Tracker – 10 infusion catheter with 2-tip markers 155 cm

3. Continuous pressurised flushing with heparinised saline to decrease friction of the advancing coil through the Tracker catheter, eliminate clot formation and crystallisation of infusate around the GDC detachment zone.

4. High quality, digital subtraction, fluoroscopic road mapping is mandatory in order to achieve safe catheterisation of the aneurysm and correct placement of the GDC coils.

DISCUSSION

The packaging design necessitates the operator to withdraw the GDC and its introducer sheath from the dispenser coil slowly and smoothly. Otherwise, the GDC may be removed, leaving the introducer sheath inside the dispenser coil. The GDC without the introducer sheath is easily damaged.

The delicate nature of the microcatheter, guidewire and GDC means extreme care should be taken at every stage of the procedure to prevent any malfunction of the coil/delivery system and trauma to the vessel/aneurysm.

As in all endovascular procedures, catheter, guidewire or GDC should never be advanced or withdrawn against resistance. On occasion, this may lead to perforation of the vessel/aneurysm, dislodge a clot or damage to the catheter, guidewire or GDC.

The use of appropriate GDC size coaxially through the Tracker 2-tip marker microcatheter cannot be overemphasised. Inappropriate use as in our patient, withdrawing the GDC-10 coil coaxially through a Tracker 18 2-tip marker microcatheter resulted in the GDC-10 coil folding back on itself and jamming tight at the tip of microcatheter. Eventually, the entire GDC coil and microcatheter had to be replaced.

During the procedure, one must be meticulous in ensuring all connections are secured so that air is not introduced into the system during continuous flushing.

Three cases were reported from a Japanese study in which thromboembolic complications occurred during or after embolisation of cerebral aneurysms with the platinum microcoils. The authors stressed the need for perioperative management of fibrinolytic and coagulation activity in order to prevent thromboembolic complication and to obtain successful result. In addition, continuous flushing helps to prevent thrombus formation and crystallisation of infusate around the GDC detachment zone[5].

It is recommended that the GDC should preferably not be used with non-platinum coils as this tends to prolong the time required for the electrolytic detachment process of the coil.

During the attachment of the polarity lead to the end of the delivery wire, the position of the proximal marker on the delivery wire may shift with respect to the proximal marker on the Tracker microcatheter. This can be checked under fluoroscopy to ensure that the delivery wire/Tracker microcatheter are in optimal position for detachment.

Also, care should be taken to ensure that the polarity leads are not inverted as this will prevent the GDC from being detached.

The choice of Guglielmi detachable coil for embolising certain intracranial aneurysms is dependent upon their morphology, location or patient's general medical condition.

Recommendation of the use of Guglielmi detachable coils in obliteration of intracranial aneurysms includes small-necked aneurysms and those patients with wide-necked aneurysms that are surgically inaccessible or are of high surgical risk[6].

For wide-necked aneurysm, GDC is the coil of choice. In the case of non-detachable free coils, once the coil is pushed out from the microcatheter, there is little or no way in predicting the behaviour of the coil. These include the unpredictable position of the coil, the conformation of the desired configuration and the compactness of the coil within the sac.

The non-detachable free coil does not allow correction for mal-alignment and the retrieval of coil when it punctures through the parent vessel. Also, the inherent design increases the chance of migration into the parent vessel as compared to GDC.

Mechanical Detachable Coils (MDC) and Interlocking Detachable Coils (IDC) on the other hand, provide the advantage of better control over the behaviour of the coils. During the embolisation process, if the coil fails to conform to the desirable configuration, it can be retrieved into the catheter and packing can be repeated. When the coil is satisfactorily placed, it can be detached by pushing the locking device out from the catheter, thus freeing the coil. However, in our experience, premature detachment of coil within the microcatheter can occur, particularly when repeated withdrawing of the coil becomes necessary. GDC with the coil/delivery system can avoid all the above problems and accompanying complications.

Occlusive efficiency is a function of compactness and overall mass. In order to choose the optimum size GDC for any given lesion, examination of pre-embolisation angiograms is required. The appropriate coil size should be chosen based on the aneurysm diameter and the size of the neck. Selection of a coil diameter smaller than 100% of the aneurysm diameter may result in migration.

Multiple embolisation procedures may be required to achieve the desired occlusion of some aneurysms. Clinical data demonstrate that 25% of patients treated will require additional embolisation procedure at a later date.

Generally, complete occlusion is seen with aneurysms with narrow neck. On the other hand, for those with wide neck, complete occlusion is more difficult as was the case with our patient.

Animal studies had been performed to evaluate the long-term histologic changes in experimental canine aneurysms obliterated with Guglielmi detachable coils. Results revealed complete obliteration and recanalised aneurysms were excluded from the parent circulation by an endothelialised layer of connective tissue[7].

The long-term effect of the GDC on the extravascular tissues has not been established so care should be taken to retain this device in the intravascular space.

The added advantage of platinum coils is that these are Magnetic Resonance Imaging (MRI) compatible and induce no significant MRI artifacts[8]. Therefore, follow-up of these patients can be made with Magnetic Resonance Angiogram instead of the traditional invasive angiography.

CONCLUSION

In our patient, GDC embolisation has proven to be a viable alternative to conventional coil embolisation and direct surgery. Limitations of the exacting neurosurgical skills required to ensure successful clipping of aneurysm in or around the cavernous sinus, lack of anaesthetic support to perform temporary shut down of carotid circulation on one side, and the aneurysm was seen only in one view as well as the patient's reluctance for further cranial surgery made this wide-necked carotico-ophthalmic artery aneurysm inaccessible to surgery. Otherwise, the surgical approach would be that as described by Parkinson and Dolenc[9,10].

The ability to remove, reposition and detach a coil was the most significant advantage of the coil design which is crucial to the safe practice of interventional neuroradiology.

Our initial experience with the GDC system suggests that it is both safe and effective in the treatment of wide-necked aneurysm and aneurysms that are surgically inaccessible.

We look forward to a long-term angiographic and clinical follow-up to ascertain the long-term efficacy of this technique in our Asian population.

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