Subarachnoid Haemorrhage: A Comparison Between Coiling and Clipping

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Abstract

Introduction
A subarachnoid haemorrhage is defined as bleeding into the subarachnoid space. It is usually caused by the rupture of an intracranial aneurysm, although it has other causes including trauma and malignancies. The main factors that increase the likelihood of a subarachnoid haemorrhage are excessive alcohol consumption, hypertension, smoking and lack of exercise. The trademark symptom of a subarachnoid haemorrhage is a sudden, severe headache situated at the back of the head. Other symptoms include collapse, neck stiffness and focal neurological deficit. Treatment of aneurysms, both those ruptured and not, is associated with high rates of complications that may cause morbidity and mortality. The two main treatments are coiling and clipping.

Aims
The aim of this piece is to compare and contrast the two techniques used to resolve an intracranial haemorrhage. This will include evaluating rates of complications and the effectiveness & efficiency of both coiling and clipping. Reasons for the complications and ways to reduce their incidence will be considered.

Method
Information for this piece was found using medical databases (e.g. PubMed) and library books (e.g. by Maurice-Williams).

Discussion
Clipping is a form of neurovascular surgery. It involves opening the cranium (craniotomy) to gain access to the aneurysm/haemorrhage. A clip is positioned on the neck of the aneurysm that will close to isolate the dilatation from general circulation. Coiling is a form of endovascular surgery. A coil is introduced into the femoral artery via a catheter. It is passed into the aneurismal sac where it will detach to separate the aneurysm from general circulation. Both of these operations may have unintended consequences including infection, epilepsy, delayed cerebral ischaemia and re-bleeds. The rates of these complications differ in those treated with a clip and those with a coil; generally coiling is associated with few risks, particularly in the short term.

Future Study
Potential improvements made to this piece in a subsequent study may include a discussion of the best ways to prevent the occurrence of subarachnoid haemorrhages, including surgery, drug treatment and lifestyle choices. Alternatively, a new study could focus more on the occurrence of complications and optimal ways to treat them.

Limitations
Problems regarding the writing of this piece included the availability of some articles and the availability of comparable statistics.

Conclusion
Coiling is superior to clipping due to its lower rates of complication. Its inferior rates of re-bleed in the long term are a cause for concern however and so the treatment plan for each patient should be decided on a case by case basis due to a number of interplaying factors (e.g. age of patient).

Introduction
A subarachnoid haemorrhage (SAH) is defined as bleeding into the subarachnoid space. It is responsible for up to 5% of strokes within the UK, although it causes 25% of all stroke-related deaths. SAHs are an important source of morbidity and mortality in the UK: around 9.7 people per 100,000 will suffer a SAH every year, with females at greater risk than males. Of these, 15% die before reaching hospital, and a further 50% will die within 30 days. Morbidity rates for survivors are around 30%; this can vary from anxiety and depression to cognitive impairment that can severely impact quality of life. Recent studies suggest only modest improvements in the incidence and outcomes of SAHs have been achieved in the last few decades.

SAH’s can be categorized as either aneurismal or traumatic. Traumatic causes account for fewer than 10% of cases compared to 85% of SAH cases linked to aneurismal. Other rare causes, such as borreliosis, cerebral arteriovenous malformations and cervical meningiomas, account for the remaining 5%.
Modifiable risk factors of SAH include smoking (odds ratio of 3.2), excessive alcohol consumption (odds ratio 1.5), exercise (relative risk ratio of 0.5) and hypertension (odds ratio of 2.9). The importance of these modifiable risk factors is emphasized by studies suggesting they cause 66% of haemorrhages, comparing to only 10% that are attributed to genetic susceptibility.

Intracerebral aneurysms can be defined as saccular, fusiform or dissecting, commonly forming in and around the circle of Willis, particularly the anterior and posterior communicating arteries. The risk of rupture is proportional to the diameter of the aneurysm, although the majority of ruptures occur in small-diameter aneurysms as they are much greater in number than large-diameter ones. It should be emphasized that not all intracranial aneurysms burst or cause any symptoms; as many as 2% of the general population have an intracranial aneurysm but are unaware of it.

When an aneurysm bursts, the flow of blood into the subarachnoid space causes an immediate rise in the intracranial pressure (ICP) that is large enough to obstruct cerebral perfusion. This is responsible for the loss of consciousness experienced by many who suffer a SAH. Resultant ischemia due to a decline in perfusion does not always result in cerebral infarction; instead it depends on many factors including the extent of the fall and duration in perfusion and the competence of homeostatic measures. The brain normally receives about 50ml of blood per minute. It is only when perfusion falls to around 10ml of blood per minute do neurons sustain permanent damage.

Homeostatic measures employed by the body to correct the situation including plugging the haemorrhage and draining leaked blood, allowing perfusion to return to normal levels very shortly. Cerebral oedema occurring due to fluid accumulation within damaged cells (cytotoxic oedema) or cerebrospinal fluid (CSF) leakage into the interstitial space (vasogenic oedema) exacerbates the raised ICP and negatively impacts efforts to correct it.

Furthermore, the explosive exit of the blood from the vessel causes focal damage to the anterior hypothalamus. With regards to of this, 80% of individuals suffering a SAH also suffer from metabolic, endocrine and systemic disturbances due to the impact on hypothalamic activity.

The clinical manifestations of a SAH are numerous and varied. Different individuals may experience completely different symptoms depending on the location and severity of the haemorrhage. The most common symptom is a sudden, severe ‘thunderclap’ headache at (or radiating to) the occiput. Symptoms of meningeal irritation, such as photophobia and neck stiffness, are common. Other features include reduced (or absent) consciousness, vomiting and seizures. Signs of SAHs commonly manifest themselves in the eyes. Rising ICP may cause brain herniation, suggested by the loss of the pupillary light reflex and an isolated dilated pupil. Rising ICP can also result in an intracerebral haemorrhage, which may be seen on fundoscopy as papilloedema. The presence of papilloedema does not necessarily mean an intracerebral haemorrhage has occurred as papilloedema is also seen (in up to 24% of patients) in its absence due to clots from the SAH blocking CSF flow or absorption. Despite this, SAH-associated intracerebral haemorrhage, called Terson’s syndrome, is particularly important to detect, not only because it is associated with severe cases of SAHs, but also as it may cause serious complications if not treated, namely blindness. It affects around 13% of all patients. The severity of SAH can be classified using the Glasgow Coma Scale (GCS) or the Hunt and Hess scale.

Following an indicative history and examination, patients with suspected SAH immediately undergo a CT scan. The sooner the CT is performed, the more sensitive it is. The presence of a SAH is confirmed, imaging of the intracranial circulation is indicated, such as a CT angiography or digital subtraction angiography (DSA). This also allows for locating the aneurysm site. Occasionally, MRI scans are used, particularly if the presentation is very late onset.

This piece will assess and contrast the two methods of treating aneurysms: coiling and clipping. The procedures and outcomes of both techniques will be evaluated. A decision will be made based on the resources assessed which of the two treatments is preferable, in terms of outcome and risk of complication.

**Methods**

Key words were entered into a medical database called Pubmed. Limitations, including language...
The principle of treating intracranial aneurysms is to isolate the dilation from general circulation without impacting surrounding structures. This can be done, as mentioned above, using a surgical clip or coil.

Clipping

Clipping is a neurosurgical technique first employed by Walter Dandy in 1937 used to treat intracranial aneurysms; both those that have burst and those that have not. It involves accessing the aneurysm via a craniotomy and attaching a titanium clip onto the neck of the aneurysm. This operation is usually performed within 3 days of the initial bleed, although the timing of the operation has proven controversial. Modern clips work using a spring mechanism; once the clip is positioned, its wings can gently tighten around the neck of the aneurysm like a noose. Before the introduction of such a mechanism, the surgeon would manually close the clip, increasing potential liability to the bursting of the aneurysm as well as damage to surrounding structures. This is particularly important considering it is during the attachment of the clip that rupture is most likely. Following the application of the clip, it is common for the surgeon to puncture the aneurysm to confirm its complete occlusion from the parent vessel, although this practice has its obvious risks and is not universally performed.

Coiling

Coiling is a form of endovascular treatment that was first introduced in the 1990s as an alternative to clipping. In contrast to the open-surgery required in clipping, this form of procedure requires only a small incision in the groin. The platinum coil, known as a Guglielmi Detachable Coil, after its inventor, Dr. Guido Guglielmi, is introduced into the femoral artery via a catheter. It is then passed through the arteries, under X-ray fluoroscopic guidance, until it reaches the aneurysm, where it is positioned. The coil is subsequently detached from the catheter to occupy the sac of the aneurysm. This results in haemostasis of that precipitates the formation of a thrombus. This thrombus will occlude the aneurysm/rupture in a manner similar to the clip.

Complications

Direct comparison between the two procedures is difficult, particularly as some aneurysms/haemorrhages are considered more suitable for neurosurgery (e.g. wide-necked aneurysms) rather than endovascular surgery and vice versa. Patients who undergo endovascular (coiling) and neurosurgical (clipping) treatments are at risk of unintended consequences, as is the case with all medical procedures. Complications for both procedures are the same, although the frequency of complications differs.

Infections

Infection is a concern during any surgical procedure. The incidence of infection of the wound following craniotomy (for the application of a clip) is 2-3%; this risk increases if multiple surgeries are needed. Common infection-causing organisms are staphylococcus albus or staphylococcus aureus. Early recognition followed by antibiotics usually resolves the infection but if symptoms do not subside, the affected area is resected. Whilst risk of infection is also present in the key-hole surgery technique employed in coiling, it is smaller. This is because risk of infection increases with hospital duration: patients who received a clip had a median hospitalization duration of 16 days (or 24 days in more severe cases) compared to those that received a coil, who were hospitalized for a median of 12 days (or 20 days in more severe cases). Furthermore, patients who received clipping for their aneurysm/haemorrhage are at added risk of infection bearing in mind the risk of infection is proportional to the duration of surgery.

Anaesthesia

Longer times under general anaesthetic elevate risks associated with sedation. This risk is hence elevated in clipping when compared with coiling.

Intracranial Haemorrhage
Re-bleeding from the aneurysm may occur because of arterial pulsations displacing poorly attached clips/coils leading the aneurysm to burst16. It is associated with the size of the aneurysm and the severity of the case43. Re-bleeding is common; 15% of patients have significant clinical deterioration within the hours of treatment that is suggestive of re-bleed44. Significantly, it may occur in patients treated both endovascularly or neurosurgically; which out of the two is associated with greater chance of re-bleeding was subject to a multinational study called the International Subarachnoid Aneurysm Trial (ISAT)45. This study concluded that for the first 7 years following the operation, coiling was associated with lower probabilities of re-bleeding. Beyond the first 7 years, clipping was more successful in preventing re-bleeds45. This has called into question the mentality of giving coils to younger, fitter patients38. Additionally, the high mortality rate of early (within 30 days) re-bleeding associated with coiling (1.4% risk of early re-bleed with 100% mortality rate)46 compared poorly with the mortality rate associated with early bleeding following clipping (2% risk of early re-bleed with 37.5% mortality rate) from another study47.

Epilepsy

Epilepsy, a family of neurological disorders characterised by seizures48, is another serious complication of a SAH. It is most likely to appear in the immediate period following treatment, particularly in more severe cases16. Classen J et al discovered 7% of SAH patients developed epilepsy in addition to a further 4% having a one off fit that was not considered epileptic49. Interestingly, while there was little variation between the proportion of patients suffering seizures/epilepsy and the type of treatment they received for a ruptured haemorrhage (clipping 10.7% versus coiling 11.1%), clipping was associated with a 48% greater risk of epilepsy/seizure when used to treat an intact haemorrhage in comparison to coiling50. Although the relationship between SAHs and epilepsy is well known, it is not fully understood why coiling and clipping increase its incidence. Many mechanisms have been suggested, most prominently the additional risk generated by clipping due to “exposure of the intracranial space (and) the temporal and frontal lobes” while coiling caused epilepsy because “oedema (due to) thrombosis of the aneurysm”50 51 52. Crucially, much of this data includes one-off seizures and not fulminant epilepsy. Therefore, the actual chance developing epilepsy, which may severely limit quality of life, is not as high as first thought, although the difference in risk between coiling and clipping is clearly not one to be ignored.

Delayed Cerebral Ischaemia

Delayed cerebral ischaemia (DCI) is a complication that can progress into cerebral infarction. It affects up to 30% of SAH patients, usually 4-10 days following the initial rupture53. As such, it can cause life-long morbidity and even death. It’s most common sign is a deterioration of consciousness, which can be detected using the GCS54. Whilst its pathogenesis is unclear, to the point that defining DCI is of dispute, it has been linked to arterial vasospasm55. This is view is enhanced by angiographic evidence of the peak period of vasospasm is also 4-10 days following initial rupture16, although recent trials linking the two together have been disappointing (e.g. reducing rates of vasospasm had little impact on rates of DCI)56. The ISAT study found that DCI was more common after clipping than after coiling51. It is more complicated than this however as patients treated early for their SAH (within 4 days), the outcome of DCI was worse in patients who received endovascular rather than neurovascular treatment57. This is very significant because, as stated above, the majority of neurosurgeons will position a clip usually within the first three days.

As with other complications, the immediate risks of clipping seems greater than with coiling, although long-term risks are greater in coiling. Numerous studies have been made regarding how to reduce the incidence of DCI. Some suggest the presence of a clot shown on CT within the subarachnoid space greatly increases the risk of DCI and removing it prior to treatment has a positive effect on outcomes58 59. Another trial has shown delaying surgery until after 2 weeks from the initial burst can also have a positive effect, avoiding the period of peak vasospasm60.

It has been suggested the reason clipping and coiling can cause DCI is because they aggravate the narrowing and distortion of the vessel following spasm. The distortion will see vessels distal to the affected vessel receive different amounts of blood due to Coanda effect, which is the tendency of fluids to stick to nearby surfaces. Therefore, some vessels will carry disproportionately higher volumes of blood while others will carry volumes low enough to cause ischaemia61.

Recovery Times

There is a striking difference between the recovery
times of clipping and coiling. One study showed that it took 1 year for 50% of surgically treated to feel back to normal following surgery, where as the median was only 27 days for endovascularly treated patients62. Another important factor affecting recovery times was the number of complications. In this regards it was again proven that coiling was superior to clipping, as patients treated surgically were 2.26 times more likely to have complications while in hospital compared with coiled patients63.

Cost

Another, often not discussed, aspect regarding the clipping versus coiling debate is the economic side. This is especially relevant when considering the current economic situation, where health expenditure is being scrutinized more closely. Despite shorter hospital stays, cost of coiling exceeds that of clipping64. Cost of clipping is mostly determined by the cost of the coil, which contributes almost half of the entire operation cost (€5300 cost of coil, cost of operation €10,370). Clips on the other hand, cost €530 against total operative costs of €8865. Instead, the majority of its costs are determined by the days spent in hospital and the need for further care65. While this may not matter too much to a patient in the UK who has their expenses covered by the NHS, it may matter more in another country where there is no free health care, such as the USA, where clipping has a median cost of $42,070 compared to the median cost of $38,166 for clipping63.

Future Study

A future study comparing the effectiveness of coiling and clipping could extend on this piece to see how coiling and clipping compared with conservative/drug treatment with a view to preventing the rupture of an intracranial aneurysm, or even their formation. Furthermore, for a SAH, complications could be researched in more detail, including their pathophysiology, impact and treatment, as well investigating new methods used to reduce their occurrence, such as administering nimodipine following a SAH66. The study can also be expanded to include case reports of individuals being treated for SAH, following them as they recover, providing first hand experiences of the difficult recovery period.

Limitations

One of the difficulties encountered when writing this piece was the complexity of some of the content in the journals and books used. Some had to be read repeatedly to properly understand what was being conveyed. Another problem was that comparable statistics between coiling and clipping in the same study were sometimes difficult to find.

Conclusion

The introduction of coiling in the 1990s revolutionised treatment of SAH. The established method of correcting intracranial haemorrhages and aneurysms that had been accepted for decades has now been virtually discarded in some centres. Whilst the issue of cost is a minor area of discussion, it is nonetheless an important one when considering strained NHS resources. The cheaper costs of clipping may appeal in such times. Direct clinical comparison between the two techniques is difficult; particularly as coiling is a relatively new method of treating intracranial aneurysms. Coiling has been shown to offer superior results in terms of complications, particularly in the short-medium term. Infection, re-bleed, epilepsy (for intact aneurysms) and DCI were all less frequent in patients who were treated endovascularly. Conversely, it has been argued the clips are more effective in the long term at achieving their intended purpose; sealing a SAH and preventing their re-emergence. As such, clipping offers a more complete ‘cure’ to a SAH or intact aneurysms; hence it may be more prudent for younger, fitter patients63. The permanence of clipping means the stressful and indeed dangerous ordeal of an aneurysm and its treatment need not be repeated for a greater number of patients. However, it can also be argued its higher risk of causing a severely restraining disability (or death) negates the benefits of a sealed aneurysm. Since the same complications are present for both coiling and clipping, is it better to invest time and resources into improving the rate of complications of coiling or improving the long-term effectiveness of coiling?

The ISAT trial, which first established coiling superiority, has notable limitations, including its focuses on aneurysms suited equally to coiling and clipping. These limitations matter as this trial has formed the basis for the coiling-clipping debate. Despite this, many articles concur with the view of clipping superiority. Whilst the long term effects of coiling have yet to be thoroughly studied in a similar manner to clipping, the supposed deficit in long-term results is not believed to be sufficiently significant to relegate coiling from its position as first-line therapy.
In spite of this, clipping should not be discarded and remains an extremely useful practise, especially as the use of coiling for some aneurysms is not recommended.

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Illustrations

Illustration 1

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