Cerebrovascular embolisation units

A report by the

National Health Technology Advisory Panel

November 1990

Australian Institute of Health

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This report was prepared by the National Health Technology Advisory Panel and finalised at the first meeting of the interim Australian Health Technology Advisory Committee. Any comments or information relevant to the subject matter of the report would be welcome. Correspondence should be directed to:

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October 1990

CEREBROVASCULAR EMBOLISATION

ISBN 0 642 15824 X

Australian Institute of Health

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EXECUTIVE SUMMARY

- Cerebrovascular embolisation (CVE) is a technique, often used in association with other procedures, in which blood flow in vascular malformations within the brain is reduced or eliminated by introduction of amorphous vascular occluding agents (AVOA's).

- CVE is a complex procedure, demanding high levels of skill and integration of specialties. Technical development continues to be significant. The Panel accepts that it provides a useful approach to the management of small numbers of patients who are at significant risk of major neurological deficit or death.

- The Panel has considered a proposal from Western Australia that a national CVE unit be established at Royal Perth Hospital, with an estimated eventual caseload of 80 per year.

- The Panel notes that the group at Royal Perth Hospital has developed considerable expertise in CVE, in part based on its own research, and has treated a number of patients from Eastern States as well as from Western Australia.

- However, the Panel also notes that CVE is being undertaken in Sydney and Melbourne, and that this activity, the additional cost of transporting patients to Perth and a probable increase in workload, provide arguments against a single national unit in Western Australia. The Panel suggests that a more appropriate option is for two units to be recognised as national centres, and that they maintain close liaison.

- Possible national workload for CVE units might eventually be between 100 and 200 cases a year, at a cost of perhaps $M1 to 2. There would be offsetting savings through avoidance of other medical procedures and hospitalisation which untreated patients would otherwise require.

- Some additional funding will be required for both the national units. This has not been quantified, but the Panel notes that existing centres evidently have essential equipment and facilities in place.

- The Panel notes that limited availability of AVOAs has presented a problem to those undertaking CVE in Australia, and that a mechanism is required whereby AVOA's can be made available promptly and without unreasonable conditions of use to national centres.

The Panel recommends that:

- Two national centres for cerebrovascular embolisation procedures be recognised, one at Royal Perth Hospital and the other on the Eastern Seaboard. Two groups, at the Royal Prince Alfred and Royal North Shore Hospitals in Sydney and at the Royal Melbourne Hospital, have both expressed interest in gaining such recognition.

- Close contact is maintained between the two centres which should routinely collect and publish data on their cases.

- Urgent action is taken by the Commonwealth Department of Community Services and Health in consultation with appropriate professional bodies to ensure that amorphous vascular occluding agents, catheters and other necessary consumables are readily accessible to the two centres.

- The need for further CVE facilities be kept under review, bearing in mind the need to concentrate expertise in this area.

At its meeting in May 1990, the Australian Health Ministers Advisory Council (AHMAC) requested NHTAP to report urgently on a proposal that a national cerebrovascular malformation embolisation unit be established at Royal Perth Hospital. A detailed paper supporting the proposal had been presented to AHMAC(1).

In this report, the Panel has considered a number of issues related to cerebrovascular embolisation (CVE), many of which were addressed in the paper from Western Australia and in a subsequent discussion paper (2). These include the nature of the technique, its relationship to other therapeutic approaches, its efficacy, possible caseload and implications for other centres in Australia.

NATURE OF THE TECHNOLOGY.

Arteriovenous malformations (AVM's) consist of variable sized masses of twisted blood vessels. Blood flow through these is abnormally high, permitting blood to bypass normal capillary vessels. AVM's are associated clinically with headaches, bruit, seizures, intracranial hemorrhage and progressive neurological deficit.

Embolisation is a technique applied to many areas of the body to eliminate or substantially reduce abnormal vascular flow. The proposal from Western Australia refers to a subset of these procedures, those used for cerebrovascular abnormalities such as AVM's. To an extent there is overlap with embolisation at other sites in the sense that some of the technologies that have been developed are of relevance to several areas.

The major feature of embolisation is the introduction of amorphous vascular occluding agents (AVOA's) into the vessels being treated. AVOA's act by eliminating or slowing the blood flow through either mechanical obstruction or thrombus formation. Thomson(3) has listed AVOA's that have been used in Australia (Table 1).

Linked to the use of AVOA's is the need for appropriate catheters, some using detachable balloons, with which to introduce these materials. The Panel understands that this is an area which is undergoing rapid development and that since mid-1988 there have been several significant technical advances, the impact of which has still to be fully assessed. One of the most important is the availability of catheters with small diameter, soft guide wire which can be manouvered through tortuous blood vessels into the brain without causing damage while enabling the radiologist to retain torque control.

These recently developed catheters include the Tracker micro-catheter marketed by Target Therapeutics and the Magic catheter by BALT. Cost per catheter is of the order of $450 to $650.

TABLE 1
AVOAs THAT HAVE BEEN USED IN AUSTRALIA

A. **Absorbable materials**
   Gelfoam (Upjohn - surgical gelatin sponge)
B. **Particulate agents**
   Ivalon (Unipoint - PVA granules)
   Terbal (Mallinckrodt - PVA granules)
   Avitene, Angiostat (Stenning, CRX Co - microfibrillar collagen paste)
   Lydura (Ingenor - Lyophilised Dura Mater)
   Silastic spheres (Cook - silastic microspheres)
C. **Fluids**
   Anhydrous alcohol
   Polymerane (Mallinckrodt-Hydroxyethyl methacrylate)
   Ethibloc (Johnson and Johnson - Alcoholic prolamine)
   Bucrylat (Ethicon - isobutyl-2-cyanoacrylate monomer)
   Avacryl (CRX Co - n-butyl cyanoacrylate monomer)
   Silicone Rubber (Dow-Corning)
D. **Mechanical devices**
   Gianturco Coils (Cook - steel with Dacron threads)
   Amplatz Spiders (Cook - steel umbrella)
   Detachable Balloons (Cook, Mallinckrodt, Ingenor - latex rubber)
   (Interventional Therapeutics Co - Silastic)

Source: K. Thomson, Royal Australasian College of Radiologists

An earlier approach was the use of flow-directed calibrated leak balloon catheters, usually in conjunction with adhesive agents. The group in Perth has, over a period of some years, developed its own approach to catheters and balloon design, and these materials are usually manufactured in-house. The cost of materials is very low (perhaps $25-50 per catheter) but with savings offset by the cost of staff time used in design and manufacture. The Perth group considers that use of their own catheters gives them an advantage over using available commercial materials, which do not always meet their requirements.

In the approach, used by the Perth group, developed in the USA by Hieshima and co-workers, the balloon is inserted into the vessel using a catheter and then dilated to shut down flow. Contrast medium is used during dilation to enable visualisation and AVOA's, such as adhesive materials, introduced. Placement of the balloon is difficult and dependent on flow in the vessel.

There are varying opinions on the best approach to take with regard to AVOA's. The method favoured in Perth is to use adhesive material - cyanoacrylate - to occlude the vessel, sometimes supplementing with micro-coils and silk sutures. As noted in the Western Australia submission, this procedure is technically difficult and requires substantial expertise and a dedicated team. The approach most commonly taken in Sydney has been to use a mixture of polyvinyl alcohol (PVA) particles, ethanol and a colloidal preparation (Avitene) to induce occlusion. Micro coils and silk sutures are often used to provide mechanical restriction and help thrombosis.

There is an opinion in some centres (Hallinan, personal communication) that the PVA - alcohol - Avitene cocktail gives a larger margin of safety, for example through reducing the risks of premature venous occlusion. Intravenous thrombosis is induced with Avitene and the PVA particles are held with mechanical obstruction. If there is escape to the circulation, the AVOA's are readily absorbed by the lungs. However, while the use of this approach appears to be safer, it provides a less permanent embolisation. Occlusion using cyanoacrylate glue is more comprehensive.

ApSimon has advised that while new glues, liquid embolising agents and solid particulate agents are being developed, cyanoacrylate glue will hold its place for several years but may ultimately be replaced by better technologies. He considers that currently cyanoacrylate glue is the best technique for the closure of high flow fistula, the reduction of large malformations to a size suitable for radiosurgery and the long term reduction of high flow in malformations unsuitable for surgical excision or radiosurgery(2).

Embolisation using the PVA/microfibrillar collagen/ethanol mixture yields good temporary devascularisation prior to total surgical removal. Malformations treated by this method will recanalise progressively over a 1.5 to 3 month period if not surgically removed. Use of micro-coils alone is not effective.

Spetzler and Zabramski(4) have reported a strategy for the surgical management of large AVM's involving a stepwise reduction in flow using pre-and intraoperative embolisation followed by complete excision. This is useful in dealing with situations where the brain surrounding the AVM is ischemic, due to vascular steal, and there is increased risk of hemorrhage and swelling associated with excision.

Areas of Application

Thomson has listed applications of CVE as shown in Table 2. A focus for attention is treatment of inoperable arteriovenous malformations (AVM's) but application of the technique is wider than that and appears to be growing. Hallinan (personal communication) has noted that other applications of embolisation include epistaxis, meningioma, other benign tumours (e.g. hemangioblastoma), spinal AVM'S and tumours, aneurysms and super-selective Wada tests. More detailed perspective on the role of CVE is given in reviews such as that by Halbach, Higashida and Hieshima(5).

Studies such as that reported by Halbach and others(6) indicate that embolisation in combination with surgical intervention is an effective treatment for patients with dural fistulas involving the cerebral venous system. They used balloons, coils and liquid adhesives as embolic agents. Balloons were the least attractive, requiring large diameter catheters and venous pathways to facilitate placement. Coils, silk sutures or liquid adhesive were preferred for most cavernous dural fistulas. They suggest coils are an attractive embolic agent with their thrombogenicity and opacity aiding accurate deposition within the vessel. Also coils will not migrate to undesired sites, unlike liquid adhesives. They mention that silk sutures can be delivered through small catheters and are highly thrombogenic, but

difficult to opacify making accurate localisation difficult. Liquid adhesives are said to have an advantage over balloons, silk sutures and coils in their ability to permeate small intestices, but there can be unwanted flow into venous pathways.

Thomson (personal communication) has suggested that the same radiologic equipment, neuroradiological and neurosurgical expertise required for treatment of vascular malformations of the brain and spinal cord is also required for a large number of other conditions which are of much higher frequency than intracranial vascular malformations. The use of interventional techniques for these more common diseases will increase significantly. These techniques are balloon dilatation of intracranial arteries in spasm following subarachnoid hemorrhage, super-selective chemotherapy or adjuvant therapy for brain tumours, and balloon embolisation of intracranial aneurysms.

TABLE 2
INDICATIONS FOR AVOAs

A. **Control of Hemorrhage**
Hemoptysis - Tumour - Inflammatory erosion - Cystic fibrosis
Trauma - Injury - Diagnostic Biopsy - Surgery
Gastrointestinal - ulceration - varices

B. **Malformations**
Arteriovenous malformation - Extracerebral - Cerebral
Arteriovenous fistulae - Congenital - Acquired

C. **Palliation of malignancy**
Preoperative blood flow reduction
Chemoembolisation
Total devascularization of tumour

D. **Aneurysm Therapy**
Intracranial-Extracranial

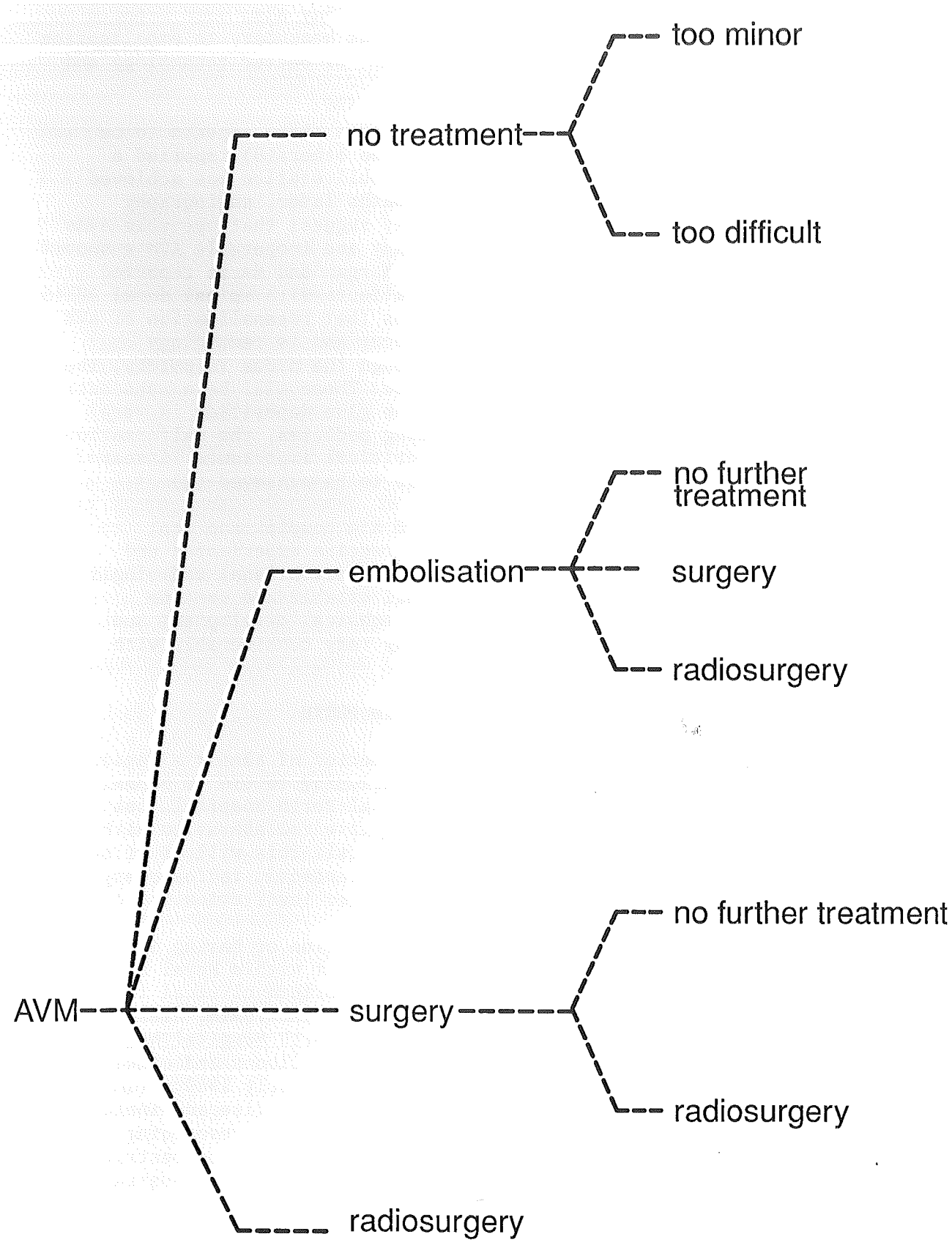
E. **Redistribution of flow**
Fully vascularized plastic surgery grafts

Source: K. Thomson, reference 2

Integration with other techniques

With whatever method of CVE is used, in the majority of cases the intention will be to use embolisation as a precursor to some other intervention(Figure 1). Usually this will be microsurgery to remove the occluded malformation. Where surgery is considered unduly hazardous or impossible, radiosurgery may provide an appropriate alternative. As noted in the submission from Western Australia the preferred approach is an integrated use of surgical excision, embolisation and radiosurgery(1). Heros and Korosue(7) have noted that not treating is always an option, particularly in older patients.

Figure 1: AVMs—possible treatment scenarios



Embolisation alone is a less promising form of therapy and in most cases there will be eventual recanalisation if surgery or radiosurgery is not possible. Halbach, Higashida and Hieshima cite cure rates of between 8% and 16% for AVM's treated by embolisation alone with a permanent complication rate of 13.5-22%(5). They also note reports that the prevalence of serious complications secondary to embolisation is declining, presumably due to development of better technology and advances in operator experience.

In embolisations that have used cyanoacrylate there appears to be dissolution on long term follow up. Rao and others(8) reported a series of 8 patients where 50-75 percent obliteration was achieved after embolisation, but six to twenty months later, angiography revealed almost the original status. They suggest that operable AVMs should be excised soon after embolotherapy and inoperable AVM's should be embolised as completely as possible. Morgan and Marsh reported recanalisation in most of a series of patients with spinal dural AVM's treated by embolisation(9). ApSimon notes that recanalisation of AVM's occluded with cyanoacrylate glue does occur and is technology dependant. When the glue deposition through the nidus is patchy, then the occlusion is predominently thrombotic. There will be a substantial potential for revascularisation. When the glue deposition is very uniform through the nidus and the feeding pedicles, the malformation will remain occluded. Technique is of critical importance if near uniform casting of malformation nidus is to be achieved (2).

The Panel notes that cases requiring CVE are complex and that decisions on management of the patients require experienced and skilled input from the neurosurgeons and interventional radiologists concerned. This is not an area where well established routine procedures abound - there is continual technical development and decisions on the approach to be taken may vary considerably with the nature of individual cases.

CEREBROVASCULAR EMBOLISATION PROCEDURES IN PERTH

CVE has been carried out at Perth over a period of almost a decade, beginning with work with animals and progressing to use on humans. Embolisation procedures are centred at Royal Perth Hospital, but the Panel notes that there is active and effective collaboration with specialists from Sir Charles Gairdner Hospital. This will be of some significance in regard to use of future stereotactic radiosurgery services which are to be centred at the latter institution.

The Perth unit has established a strong tradition of basing its clinical CVE procedures on research carried out within Royal Perth Hospital. The unit is participating in the American clinical trial of n-butyl cyanoacrylate in CVE. In addition to establishing links with centres in North America, the group at Royal Perth Hospital has been able to develop its own designs of catheters, balloons and other materials commencing with animal studies in the early 1980's (10,11). The Panel is impressed with the high level of expertise and innovation within the Perth unit while noting that with present resourcing and output the catheters and other materials are likely to be restricted to use in Western Australia and that any other centres in Australia would probably rely on commercial products.

Details of CVE procedures undertaken in Perth from 1987 to 1990 are shown in Table 3. The caseload remains small but appears to be increasing. The indication of increasing numbers of referrals from Eastern States noted in the Western Australian paper has been confirmed in the workload data for the first eight months of 1990.

TABLE 3
SUMMARY OF CEREBROVASCULAR MALFORMATIONS TREATED IN PERTH

	1987		1988		1989		1990	
Source of cases	**Total**	**CVE**	**Total**	**CVE**	**Total**	**CVE**	**Total**	**CVE**
W.A.	13	5	19	8	27	5		5
	(3)	(3)			(5)	(5)		(7)
Other States	2	2	4	4	5	4		15
Overseas	2	2	2	2	2	2		2
Total AVM's	17	9	25	14	34	11		
Total malformations	20	12	25	14	39	16		29

a) Figures in brackets refer to lesions other than AVM's (e.g. fistulas).
b) 1990 data pro rata on first 8 months
Source: References 1,2.

ApSimon has suggested that in view of the CVE activity in New South Wales referrals from that State may level off, but that referrals from other States could increase. He notes that the more complicated and difficult malformations continue to be referred from Sydney to Perth.

The Panel understands that the standard practice in Perth is to keep patients in hospital for four days following embolisation in case any serious complications develop.

CEREBROVASCULAR EMBOLISATION OUTSIDE WESTERN AUSTRALIA

The Panel notes that although the submission from Western Australia suggests that Perth is the major centre for CVE in Australia, there is also significant activity elsewhere. In Sydney, a collaborative group from the Royal Prince Alfred Hospital, Royal Alexandra Hospital for Children and Royal North Shore Hospital have treated about 75 cases of AVMs over the last two to three years (I. Johnston - personal communication). Neuroradiologists in the Sydney group have gained experience in CVE through working in Hieshima's group in the USA. The Panel understands that proposals for a CVE centre are also being developed in Melbourne.

TABLE 4
DETAILS OF AVM'S TREATED IN SYDNEY

Approach taken	**Number**	**Per cent**
Surgery	32	42.7
Embolisation	7	9.3
Embolisation plus other	21	28.0
Radiotherapy	3	4.0
No treatment	12	16.0
	75	100.0

Source: I. Johnston (personal communication)

The Panel understands that the Sydney group is now undertaking two CVE sessions a week. The approach taken is to aim for an early return home for the patient. With procedures undertaken at Royal Prince Alfred Hospital, patients are typically not anesthetised or kept overnight. In some cases, it is necessary to undertake staged embolisation so that the patient may return for more than one session. The practice of avoiding anesthesia and returning patients to their homes rapidly has obvious implications for overall costs of the procedure to health care budgets. It may not be feasible with more complex cases.

The Royal Melbourne Hospital also has experience in the application of embolisation techniques, at this stage mostly for extracranial applications. The hospital considers it has the patient numbers, the equipment, the research facilities, the staff and the determination to maintain a high level of activity in CVE procedures. (K. Thomson, personal communication).

COMPLICATIONS OF CEREBROVASCULAR EMBOLISATION

Details of deaths and complications in 49 patients treated at Royal Perth Hospital are shown in Table 5. These data have to be viewed in the context of the complicated cases that were treated and the probability of death or serious morbidity should CVE not be attempted.

ApSimon has noted the generalisations are difficult regarding the relative risks of treatment and non-treatment. Similarly, generalisation is difficult when discussing the probability of cure for those undergoing embolisation. This will depend on the severity of the case and the therapeutic approach that is used. He notes that apparently successful embolisation may not cure the patient because of delayed complications and that conversely incomplete embolisation may save the patient from future hemorrhage(2).

The Western Australian paper noted the findings on two studies of patients with untreated AVM's (12,13). The mean risk of hemorrhage found in both studies was about 2% a year, with cumulative risk of hemorrhage after 20 years of over 40%.

Crawford et al(12) estimated a 29% risk of death from all causes, including 25% as a result of a bleed. There was an 18% risk of epilepsy and a 27% risk of having a neurological handicap by 20 years after diagnosis in unoperated patients. Brown et al (13) reported that 29% of patients died as a result of a bleed and that 23% of survivors of hemorrhage had significant long-term morbidity. Risk of permanent morbidity in patients with AVMs who did not experience hemorrhage was estimated to 7%.

Of the 49 patients referred to in Table 5, 26 underwent femoral embolisation only, with radiosurgery in 14, 20 had embolisation followed by surgical excision and in three trans-femoral embolisation was followed by operative embolisation.

TABLE 5
DEATHS AND COMPLICATIONS IN 49 PATIENTS TREATED WITH CVE
AT ROYAL PERTH HOSPITAL

DEATHS (all due to hemorrhage)	
Vessel rupture during embolisation	3
ICH 48 hours post embolisation	1
9/12 after embolisation and radiosurgery	1
	5
NON FATAL HEMORRHAGE	
During embolisation	2
Post embolisation (1 deficit *)	2
Post surgical excision	1
	5
PERMANENT NEUROLOGICAL DEFICITS	
New sensory deficits post embolisation	2
Worsening of field defect post embolisation	1
Hemiparesis *	2
Hemianopia post surgical excision	3
Hemiparesis post surgical excision	1
	9

* = same patient
Source: ApSimon, Reference 2

Australian experience in treating intracranial venous malformations.

Morgan and Johnston have summarised eleven years' experience in Australia on surgical management of intracranial AVM's with a consecutive series of 107 patients(14). In 71 patients, complete obliteration was attempted, and achieved in 69. In some cases, the surgery was combined with pre-or peroperative embolisation. Five patients were treated by embolisation alone, three by radiotherapy and twenty eight managed conservatively for various reasons. Mortality in the surgically treated series was 9.9 percent with significant morbidity on 22.3 percent of patients largely related directly to the initial hemorrhage. One year mortality in the group which did not undergo operation was significantly higher than in those patients treated surgically.

These authors propose practical guidelines for management of AVM's, suggesting that unless they occur at a difficult site, small lesions should be treated surgically at presentation, but that larger and more complex lesions present the need for a particularly individual decision. They suggest combined embolisation surgery and surgery in a staged manner should be used in these lesions, if they present with hemorrhage or intractable epilepsy and if this is considered feasible. Morgan and Johnston also point to the need for close collaboration of a neurosurgeon and neuroradiologist in treatment of such cases. The Perth unit has stressed the importance of the neurosurgeon retaining overall responsibility for the management of the patient.

In commenting on this paper Atkinson(15) has noted that the mortality and morbidity rates reported by Morgan and Johnston are a significant improvement on the natural history of such cases and that such rates suggest that a positive interventional approach is required if possible.

Of 20 patients from Royal Perth Hospital, total occlusion was achieved in one case, more than 90% in seven, 60-85% in eight and less than 60 percent in the remaining four. The Perth group considers that useful benefit is produced or can be produced at greater than 60% occlusion.

POTENTIAL CASE LOAD FOR AUSTRALIA

The national case load suggested in the Western Australian paper uses an estimate based on Swedish data and suggests that there might be 280 AVM cases per year for Australia of which 84 would require CVE. A further 84 patients would require stereotactic radiosurgery, some of whom would receive such treatment subsequent to embolisation. (The Western Australian submission does not consider cases which would be treated surgically without embolisation).

The Western Australian estimate of cases that might require treatment through embolisation is consistent with that in an AIH paper which suggested 83 to 100 cases per year might be appropriately treated by radiosurgery(16). Data given in papers cited by Alexander(15) suggest a case load of perhaps 69 per year.

However, in addition to AVM's it appears that there is likely to be a significant use of embolisation in other situations (Table 2). Thus while the national case load for AVM's needing CVE might between 80 and 100 per year, significantly numbers of other types of case in which CVE would be appropriate could emerge. Possible numbers for Perth suggested by ApSimon include: intracranial aneurysm 10-20 cases per year (50% interstate); fistulas 10-18 per year; arterial spasm/complicating subarachnoid hemorrhage 5-10 per year(2).

It is difficult to predict what the eventual national case load might be. Conceivably the increased numbers of cases detected or considered suitable for intervention could be offset by further advances in surgical technique which could reduce the need for CVE. For example, Yamada, Brauer and Knierim(17) have reported a microsurgical approach to treatment of AVM's with multi-staged resections of larger malformations to permit obliteration compartment by compartment. Halback, Higashida and Hieshima note that surgical management of cerebral aneurysms is preferred to CVE, despite impressive initial results with detachable balloon embolisation(4). On the other hand the range of indications for CVE, often in combination with other approaches, seems likely to widen.

The number of Western Australian cases treated (Table 3) is close to the expected number, while numbers from other States treated in Perth are substantially less than the estimate given above, despite recent growth. An important question is whether cases referred from other States could realistically be expected to rise to a level suggested in

the proposal, that is to permit a case load at Royal Perth Hospital of perhaps 80 AVM's per year.

There would appear to be some doubt on this point. A substantial number of embolisations are already being undertaken in Sydney and it seems possible that case loads will increase with establishment of more formal links between the hospitals concerned. It also appears possible that other centres in the Eastern States would eventually introduce CVE procedures. Given these additional facilities, the Panel considers it unlikely that neurosurgeons in the Eastern States would necessarily wish a high proportion of their patients to be referred to Perth, given the additional cost involved and the potential availability of adequate resources in their more immediate area.

The Western Australian paper draws attention to the need to concentrate expertise, because of the high level of skill required with CVE and the need for a realistic minimum case load to maintain this. The Panel agrees with this perspective and believes that given the limited caseload and the demanding nature of the procedure, that there is a good case for concentrating expertise in this area. However, it does not appear to be appropriate to limit support for the procedure to a single national centre. A more realistic approach would at this stage appear to be support for a second unit in an Eastern State whose work would be complementary to that undertaken at Perth. The situation would need to be kept under review as newer techniques evolved and case load changed.

The Panel understands that in New Zealand CVE procedures are undertaken in both Auckland and Wellington. A few cases have been referred to Perth, but it would appear that there will continue to be only a small contribution from New Zealand to the CVE caseload at Australian centres.

COST FACTORS

The Western Australian submission has proposed establishment costs to cover equipment of between $450,000 and $500,000. These include a number of small items some of which would already be available at Royal Perth Hospital. Some items of equipment would be used for other procedures, and the Panel notes that the hospital has already acquired necessary angiographic equipment. The Sydney group has advised that little would be required there in terms of capital equipment.

Staffing costs suggested for the proposed Perth Unit totalled $227,000 a year based on the listing shown in Table 6. The Panel notes that embolisation is a demanding procedure which will require two interventional radiologists to be present during each session; and considers the estimate to be reasonable, although this has not been considered in detail.

TABLE 6

STAFFING PROPOSED BY WESTERN AUSTRALIA TO TREAT 80 AVM'S PER YEAR

	Sessions per week	$
Senior Radiologists	5	50,000
Radiologist	3	25,500
Radiologist	3	25,500
Anesthetist	4	34,000
Radiographer - Supervisor	10	40,000
Radiographer, Interventional Neuro Level 2	4	14,000
Anesthetic Technician	4	10,000
Enrolled Nurse - permanent appointment to unit	4	10,000
Enrolled Nurse on Department establishment	4	10,000
Medical typist/clerk	4	8,400
Total		**$227,400**

Source: Reference 1

The Western Australian paper refers to average hospital stay for embolisation of AVM's as 14 days, with a number of longer stays for patients who have developed complications. However, the expected stay might be shorter than that, based on the current practice of keeping patients in hospital for four days.

A further cost factor that would be associated with a single national CVE centre would be that for transportation of patients. The Panel understands that air transport of patients requiring CVE would not present a significant acute risk. Notional comparative transportation costs for units in Perth and Sydney are shown in Table 7. They refer to unaccompanied patients who would stay in motel accommodation at $80 per day. Some patients would be accompanied (I Johnston personal communication) with consequent increase in transport and accommodation costs. If these costs were to be borne by the patients and those accompanying them there would clearly be a substantial additional burden. If such transport costs were to be met or offset by health authorities, there would be a need to establish appropriate mechanisms to ensure that patients at some distance from an appropriate CVE centre were ensured reasonable access.

TABLE 7

NOTIONAL TRANSPORT AND ACCOMMODATION COSTS

FOR PATIENTS FROM EASTERN STATES

1) One centre in Perth

	Population (millions)	Number of AVM's	Transport costs, $	Accommodation costs, $
NSW	5.77	46	48,745	3,693
VIC	4.32	35	32,625	2,765
QLD	2.83	23	26,898	1,811
SA	1.42	11	4,760	911
WA	1.59	13	-	-
TAS	0.45	4	3,832	289
NT	0.16	1	1,316	100
ACT	0.28	2	2,303	17
AUST	16.81	135	120,479	9,746

Total accommodation and transport costs = $130,225

2) One centre in Sydney and one in Perth

	Transport costs, $	Accommodation costs, $
NSW	-	-
VIC	14,085	2,765
QLD	9,555	1,811
SA	4,761	911
WA	-	-
TAS	2,201	289
NT	1,344	100
ACT	502	178

Accommodation and transport costs to Sydney = $32,830

Accommodation and transport costs to Perth = $ 5,672

Total = $38,502

Assumptions

- Patients not accompanied
- Incidence of AVMs needing CVE = 8.0 per million
- Only Adelaide patients go to Perth

Cost effectiveness considerations

The Western Australian submission(1) includes a section on the cost-effectiveness of embolisation to illustrate the cost per life saved or free from neurological handicap. Comparison is made with the cost of therapy per quality adjusted life year for various procedures used in the treatment of heart disease.

Using the expected costs of equipment included in the submission and staff costs, and including ward costs, the cost of embolisation per patient is estimated at $10,741. On the assumption that there is an 80% cure rate and 29% risk of death within 20 years after diagnosis with a risk evenly spread across the 20 year period, the cost of embolisation per year of life saved is estimated at $4,670 with an average of 2.3 years of life saved per patient. Costs per year free from neurological handicap or death is estimated at $2,397. The submission makes the point that such levels of cost compare favourably with those for procedures commonly used in treatment of heart disease.

The Panel notes that the model used in the W.A. submission is subject to some qualifications.

- It is assumed that embolisation alone gives an 80% cure; more realistically it would be embolisation followed by surgery or radiosurgery, given the poor success rate of embolisation when used on its own. Costs of surgery should therefore be added.

- The model may over-estimate ward costs for embolisation as such. Ward costs would of course have to be added for surgery.

- Given the complexities of treatment, there will in fact be a number of scenarios and a possibly significant range of costs per patient. The costs in the submission are based on an 80 per year caseload which would not be in place for some time. The current costs of embolisation and surgery might be significantly higher.

- Costs of catheters are not included.

- No account is taken of transport and accommodation costs, or other costs to the patients.

- The calculation is made on the basis of deaths averted over a 20 year period, on the assumption that deaths from causes other than the AVM would be negligible considering the relatively young age of diagnosis for most cases. This argument could underestimate the cost effectiveness of embolisation and it might be argued that the years of life saved would be higher than estimated.

- The submission may also underestimate the effectiveness of embolisation in reducing neurological deficit - on the assumption that all cured patients would have had some neurological deficit at the time of diagnosis. The costs per year of handicap removed might be as low as $600 to $700.

. Cost implications of mortality and morbidity associated with CVE are not considered.

However, the Panel accepts the general point made in the submission that CVE appears to be an effective method of treatment in a group of patients with life threatening conditions and that the costs are not unreasonable when compared with other widely used therapeutic procedures.

The eventual yearly national cost of CVE and related procedures might be between $1 and 2 million depending on the rate of which indications for use of CVE emerge for conditions other than AVM's. These costs would be offset by reduction in the morbidity and associated procedures associated with less demanding surgery following embolisation, and with reduction in the number of other medical consultations and treatments for people with malformations who would otherwise not have been treated.

AVAILABILITY OF AVOAS

At present some AVOAs commonly used in the USA are not readily available within Australia and this presents a problem to those centres already undertaking CVE. A number of agents are available on an individual patient basis where permission has to be obtained for each case from the Commonwealth Department of Community Services and Health. The Royal Australasian College of Radiologists (RACR) has pointed out that the present system of individual patient approvals presents difficulties as the need to use an AVOA is not always pre-determined or made during normal working hours(3). It has also been noted that high levels of expertise are required in the use of AVOAs and that their general availablity would not be desirable.

The Panel understands that, to some extent, the differing approaches taken at the Perth and Sydney units have been dictated by the availability of AVOA's to them. The Panel supports the suggestion by the Sydney group (Hallinan, Grinnell and Sorby, personal communication) that both centres need access to all proven techniques.

The Panel understands that the RACR and the Commonwealth Department are currently discussing options for appropriate approaches to approval for use of AVOAs one of which might include accreditation of users. The Panel suggests that assured access to these materials would be essential for any national centres undertaking CVEs. One option would be to link approval to importation to specific centres, this approval being on the basis of assurance of use by appropriate specialists (as is contemplated by the RACR) and suitable recording of CVE details. For example, the RACR has suggested that it would not be unreasonable to expect each registered site to maintain a register of patient name, record number, indications for use of AVOA, types of AVOA used and the outcomes including complications(3).

DISCUSSION AND CONCLUSIONS

The Panel accepts that cerebrovascular embolisation is a useful and evolving technique for a small number of persons who would be at

substantial risk without intervention. The Panel notes the need to integrate CVE appropriately with other methods of therapy and that the technique is demanding. Because of the limited caseload and the substantial evolving technical demands, the Panel considers that concentration of expertise with this technique is essential. CVE centres should have an appropriate research component so that the staff can acquire and develop new techniques.

The Panel has been impressed with the high level of expertise and commitment at Royal Perth Hospital and notes that the Western Australian group is widely recognised in Australia as having taken a lead in the use of CVE. The Panel considers that formal recognition of the Royal Perth Hospital unit as a national centre would be justified.

However, in view of the increasing caseload throughout Australia, the development of expertise with CVE in other States and the cost and inconvenience associated with transport of patients to Perth, the Panel does not consider that Royal Perth Hospital should be nominated as a single national unit. Taking account of the points mentioned above, the Panel suggests that support and recognition is given to two cerebrovascular embolisation units, one in Perth and one on the Eastern seaboard. From the information currently available to the Panel, the latter could be based on the arrangements developed between the Royal Prince Alfred and the Royal North Shore Hospitals in Sydney, or at the Royal Melbourne Hospital.

The Panel notes that there will be some costs associated with establishment of the two national centres. It is suggested that capital costs would probably be quite modest and centred on the need to ensure that adequate angiographic and video facilities were available. Personnel demands would centre on the need for an adequate pool of interventional radiologists with appropriate skills and training in CVE.

The proposal put forward by Western Australia envisaged a caseload of 80 per year, but it would probably take several years for referrals to reach the numbers estimated. In the first year of operation perhaps 30 patients would be referred for embolisation.

The Panel notes the sustained and impressive research record of the Perth group and that the availability of catheter and other materials developed at Royal Perth Hospital has reduced consumable costs while placing further demands on staff. However, given the resource demands in preparing these materials, it is unlikely that they will be readily available to other centres on the basis of the present arrangements. The Panel also notes that there has been significant recent development of commercially available materials. At some stage a judgement will need to be made as to whether the continued production and further research into catheters at Perth can be justified in view of the availability of improved commercial products, particularly if the build up in caseload at Royal Perth Hospital continues.

The Panel suggests that both units should continue to develop their expertise in the various approaches to CVE and in selecting appropriate associated therapies and patients. The Panel recommends

that close contact is maintained between the two centres which ideally should operate in close liaison. It would also be highly desirable for data on the CVE cases to be routinely collected and published. Such data should include long term follow up of the patients and details of complications.

Both units should continue to work in close cooperation with neurosurgical staff and neurosurgeons should have overall responsibility for patients.

The Panel notes that availability of Amorphous Vascular Occluding Agents (AVOAs) has presented a problem to those undertaking CVE in Australia largely due to restrictions on the importation of these materials. The Panel recommends that action is taken by the Commonwealth Department of Community Services and Health in association with the Royal Australasian College of Radiologists to develop a mechanism whereby AVOA's can be made available promptly and without unreasonable conditions of use to both the national centres. Details of the use of these materials should be recorded by both centres and made available for ongoing evaluation.

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ACKNOWLEDGEMENTS

The Panel is grateful to the following for information and comment.

Dr HT ApSimon Dr IMM Chakera Dr J White Dr FJ Ives Mr DE Hartley	Royal Perth Hospital
Dr M Khangure Mr BAR Stokes Mr C Henderson	Sir Charles Gairdner Hospital, Perth
Dr C Martin	Western Australian Department of Health
Dr J Hallinan	Royal Prince Alfred Hospital, Sydney
Dr I Johnston	The Royal Alexandra Hospital for Children, Sydney
Dr K Thomson	Royal Melbourne Hospital
Dr J Stewart	NSW Department of Health
Dr B Doust	Royal Australasian College of Radiologists
Dr V Grinnell Dr W Sorby	Royal North Shore Hospital, Sydney
Dr GAJ McCulloch	The Neurosurgical Society of Australasia Inc.