

# The Management of Thoracic Aortic Aneurysms

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## INTRODUCTION:

The Operative Management of Thoracic Aortic Aneurysms remains a major surgical challenge. Problems with maintenance of cerebral and vital organ perfusion, the avoidance of particulate and air embolus during manipulation and excessive postoperative haemorrhage, previously resulted in mortality rates of greater than 40%. With the introduction of safer methods of vital organ support, allied to improved materials, anaesthetic and haemostatic techniques, the mortality in these otherwise uniformly fatal conditions is now 10%.

While the surgical techniques appropriate for aortic reconstruction were first described by Carrell in 1910 and later by Caraford and Nylin in 1945, it has only been with the introduction of safe techniques of vital organ perfusion, developed from experience with cardiopulmonary bypass in the last 10 years, that successful major aortic reconstruction has become feasible. Currently these methods are available and will be described:

1. Cardiopulmonary Bypass with Moderate Hypothermia and Selective Perfusion.
2. Cardiopulmonary Bypass with Deep Hypothermic Arrest.
3. Extra-Anatomical Shunts. (Gott Shunt.)

Each method has advantages and disadvantages, the decision as to which method to use can only be made after a careful appraisal of the location and extent of the aneurysm, which is based on thorough angiographic studies.

An Aneurysm is an abnormal dilatation in

a blood vessel in continuity with its lumen.

An aneurysm may be

Saccular.
Fusiform.
Dissecting.

The form of the aneurysm is important surgically as it has a direct bearing on management. If the aneurysm is saccular it may be directly excised with or without a patch, whereas if it is fusiform or dissecting a more major procedure is required with excision of the aneurysm and replacement with a prosthetic graft.

## AETIOLOGY

In Western society the majority of aneurysms are degenerative in origin, resulting mostly from longstanding atherosclerosis with consequent degeneration of the media and elastic layers of the aorta. In other countries the most common pathology are chronic inflammatory conditions such as Syphilis and Mycotic infection, which again result in chronic weakening of the arterial wall and aneurysm formation.

Other conditions resulting in aneurysm formation are listed below:

CONGENITAL Post-stenotic (coarctation)  
Marfan's Syndrome.  
Ehlos-Danlos Syndrome.

ACQUIRED Degenerate-Atherosclerosis.  
Cystic Medial Necrosis. Inflammatory-Syphilis, Mycotic. Traumatic. Iatrogenic. Catheterisation.

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**SYMPTOMS**

Often patients with thoracic aneurysms may be asymptomatic, the diagnosis only being made following the incidental finding of a widened mediastinum on the chest X-ray. With enlargement of the aneurysm the predominant feature is one of pain as described by Kampmeier in 1938. This symptom is usually a late one and indicates erosion of the sternum or neighbouring neurovascular structures. Occasionally the aneurysm may directly erode the adjacent lung parenchyma or oesophagus in which case the patient presents with haemoptysis or dysphagia, such symptoms are only seen at a late stage and presage imminent rupture. In the case of dissecting aneurysms the classic symptom of sudden tearing pain is noted and on examination pulse inequalities are found. With involvement of the great arch vessels, neurological signs are to be expected.

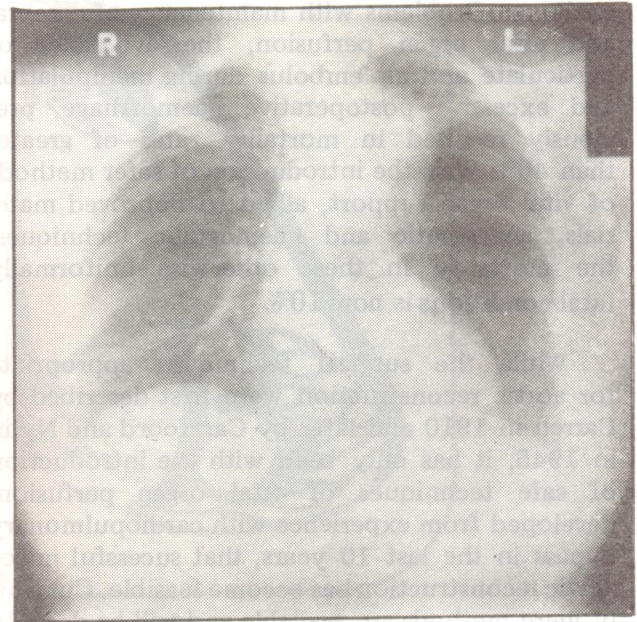
**SYMPTOMS AND SIGNS WITH THORACIC ANEURYSMS**

SYMPTOM	CAUSE
Pain	Sternal erosion
Cough, Dyspnoea, Haemoptysis.	Pressure on Recurrent
Hoarseness.	Pressure on Reaurrent Laryngeal Nerve.
Horner's Syndrome.	Pressure on Sympathetic Chain.
Caval Obstruction.	Pressure on Vena Cava.

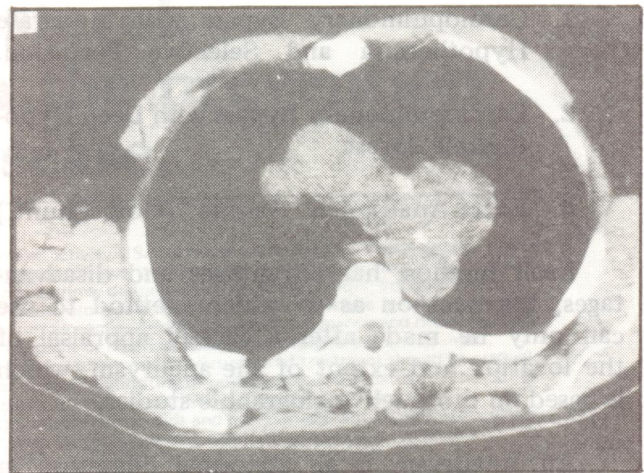
**DIAGNOSIS**

Diagnosis is made having taken a careful history and full physical examination. With a small aneurysm it is unlikely that any abnormal physical signs will be apparent, but occasionally a pulsatile mass may be felt retrosternally or in the root of the neck. Vocal cord paresis due to pressure on the recurrent laryngeal nerve as it passes around the ligamentum arteriosum is sometimes seen.

The diagnosis is usually suggested following routine chest X-ray which demonstrates widening of the mediastinum. (See Illustrations). Computerised Axial Tomography will accurately delineate the extent of the aneurysm, but the definitive investigation remains Contrast Aortography. Full contrast studies of the aorta are readily obtained via the femoral or brachial artery. The recent introduction of Digital Subtraction Angiography enables good quality arterial studies to be obtained from venous injections thus obviating the need for arterial puncture and the hazards associated with this procedure.



Chest X-ray demonstrating Widened Mediastinum with thoracic aortic aneurysm.



C.T. SCAN demonstrating thoracic aortic aneurysm.



With suspected dissecting aneurysm of the aorta it is mandatory to perform full angiographic studies as this is the only method which can identify the tear in the arterial intima, causing the dissection, with any accuracy.

### LOCATION OF ANEURYSM

The thoracic aorta is classified in three parts:

ASCENDING AORTA.

TRANSVERSE ARCH.

DESCENDING AORTA.

The location and extent of the aneurysm dictates the surgical management and also the method of protection used.

	AT RISK	METHOD
ASCENDING	Heart. CNS. Cord. Kidneys.	Deep Hypothermia. Moderate Hypotherm.
ARCH	Heart. CNS. Cord. Kidneys.	Deep Hypothermia. Moderate Hypotherm.
DESCENDING	Cord. Kidneys.	Moderate Hypothermia. Gott Shunt.

### METHODS OF CIRCULATORY SUPPORT AND PROTECTION

Possibly the most important determinant in achieving a good operative result is the method of circulatory support used during the operation. The methods are designed to enable cross-clamping of the aorta to be safely applied, to provide a dry surgical field while perfusion of the central nervous system and other vital organs proceeds. To prevent ischaemic damage to the brain, spinal cord and kidneys, it is necessary to cool the patient to between 18 and 24 degrees centigrade using the heat exchanger in the bypass circuit. At this temperature cellular metabolism is much reduced resulting in a safe period of up



Angiogram demonstrating aneurysm arising from aortic arch.

to 50 minutes during which the circulation may be stopped if required. (deep hypothermic arrest.). For aneurysms which involve the ascending and transverse arch, it is mandatory to adopt a cooling method.

In the descending aorta it is possible to use a heparin bonded shunt to perfuse the distal aorta and thereby protect the spinal cord and kidneys. In this situation the central nervous system is perfused by the heart and systemic heparinisation used in the other methods is not required.

### CARDIOPULMONARY BYPASS WITH MODERATE HYPOTHERMIA AND SELECTIVE PERFUSION. (Diagram 1.)

In this method described by Cooley and De Bakey, following full heparinisation Cardiopulmonary Bypass is established with venous cannulation of the right atrium and arterial return to the femoral artery. A Y piece is inserted into the arterial line and this is used to perfuse the head and neck vessels by way of the innominate artery or carotid artery (See diagram). Having established full bypass the patient is cooled to 24 degrees Centigrade. At this temperature the heart normally fibrillates and further protection may be afforded by infusing 800-



Diagram 1

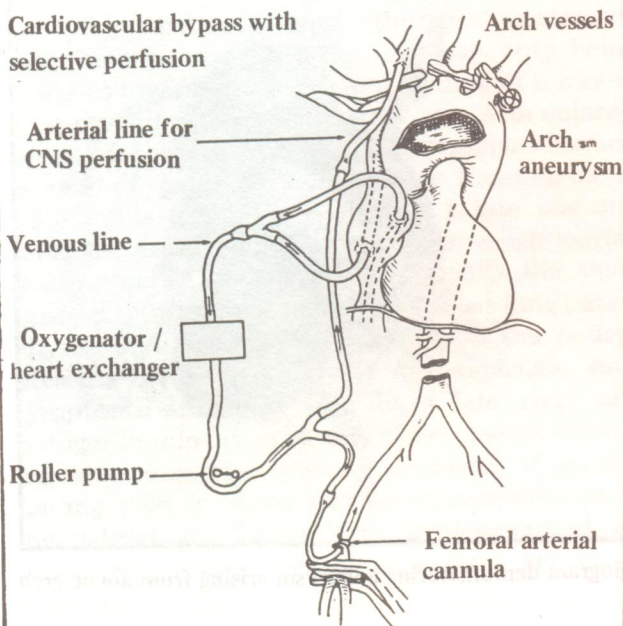
Cardiovascular bypass with selective perfusion

Arterial line for CNS perfusion

Venous line

Oxygenator / heart exchanger

Roller pump



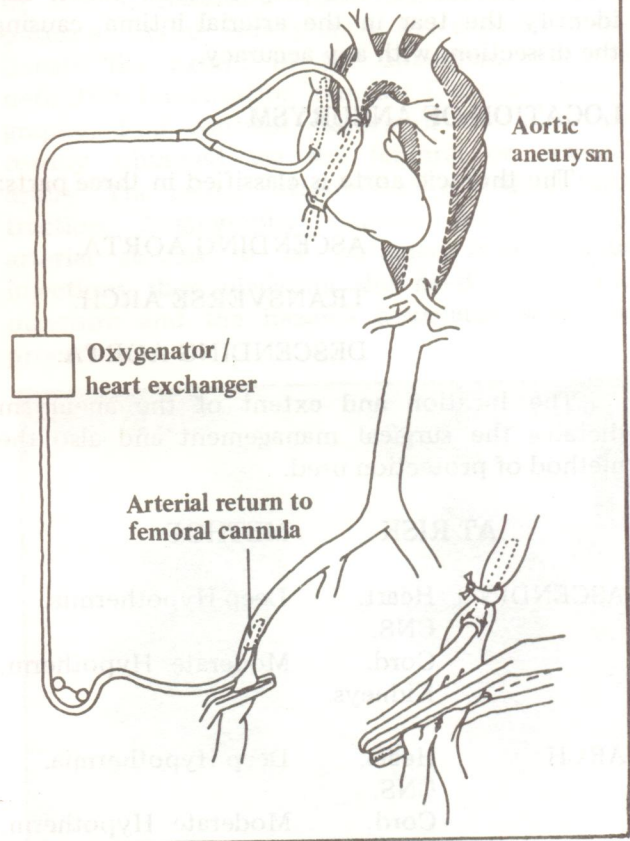
1000ccs. of cold cardioplegia solution either to the coronary ostia directly or via an aortic root needle. Following this the segment of the aorta bearing the aneurysm can be excised and replaced with an appropriate preclotted woven Dacron graft. During the period of repair the flow to the brain is maintained at approximately 1 Litre per minute.

This method has the advantage that the cerebral circulation is maintained throughout, but has the disadvantage that monitoring of cerebral perfusion may be problematical. Under conditions of non-pulsatile flow which exist during conventional cardiopulmonary bypass, the cerebral circulation is not self-regulatory and this can result in difficulties maintaining appropriate cerebral perfusion. Commonly neurological complications are seen postoperatively due to either under or overperfusion, linked with the hazards of microemboli of air and particulate matter from the aneurysm.

**DEEP HYPOTHERMIA WITH CIRCULATORY ARREST. (Diagram 2.)**

In the second method described by Barnard and Schrire and Borst, following cannulation in a similar manner to that described before, the

Diagram 2 Deep hypothermia with circulatory arrest.



patient is slowly cooled to 18 degrees Centigrade. During the cooling period, haemodilution is produced by removing autologous blood (for transfusion following repair) and replacing it with crystalloid solution ml. for ml. When the target temperature is reached the arterial line is clamped and the venous line allowed to drain into the cardiotomy reservoir. Cardioplegia solution is also used to further protect the myocardium during the arrest period. Having produced circulatory arrest the great vessels are clamped to prevent air embolus and then the aneurysm is excised and a graft inserted.

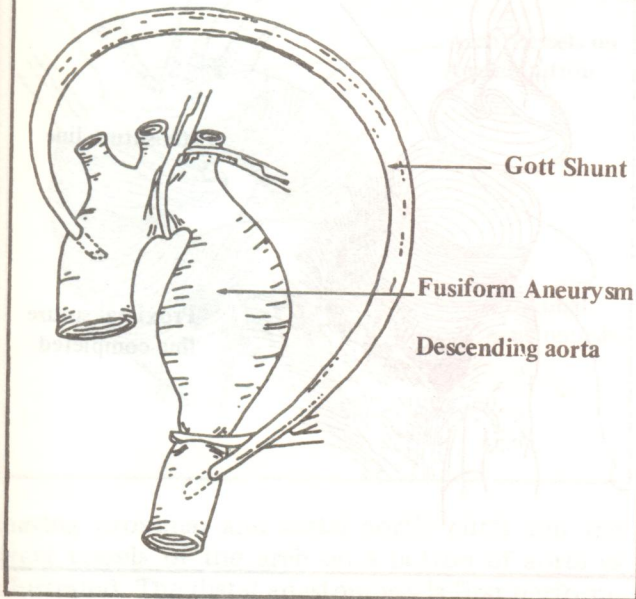
**EXTRA ANATOMICAL SHUNT. GOTT SHUNT. (Diagram 3.)**

In the third method a polyethylene tube with a heparin bonded internal surface is used to bypass the aneurysm. This method has the advantage of simplicity and avoids the need for systemic heparinisation with the consequent haemor-



Diagram 3

## Heparin bonded Gott Shunt



rhagic complications. A 9mm. diameter shunt is used and can be inserted via purse string sutures from the ascending aorta to the distal aorta or the left ventricle to the distal aorta thus bypassing the aneurysm. In this way perfusion is maintained to the head and also the distal aorta, providing protection for the spinal cord, kidneys and abdominal viscera (see diagram). When using a Gott shunt a flow meter can be incorporated, and this demonstrates flows of up to 4 litres per minute.

Purse string sutures in aorta &amp; ventricle for insertion of shunt

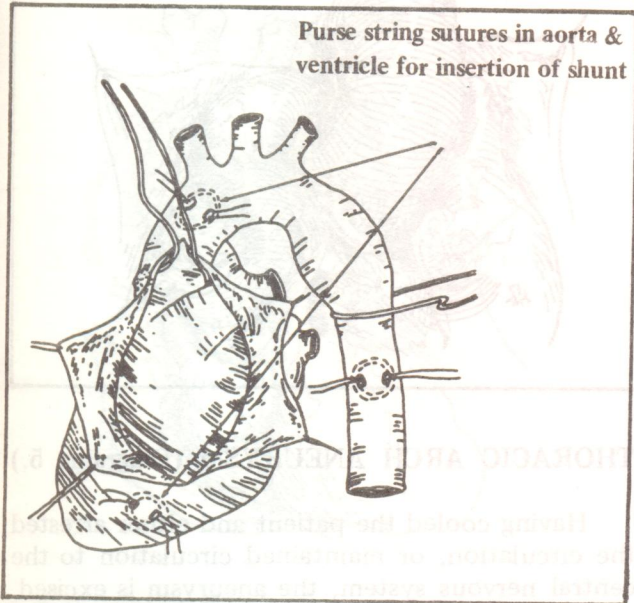
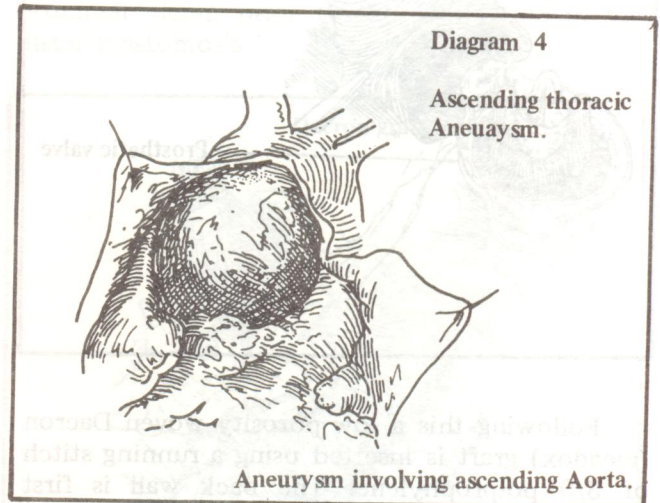


Diagram 4

## Ascending thoracic Aneurysm.



Using the methods described above an aneurysm that occurs in any part of the thoracic aorta may be excised safely and replaced with a woven Dacron graft.

## SURGICAL TECHNIQUE WITH THORACIC AORTIC ANEURYSMS

## Exposure:

Median Sternotomy offers good access for ascending and aortic arch aneurysms, the incision may be extended to the neck or laterally to extend exposure.

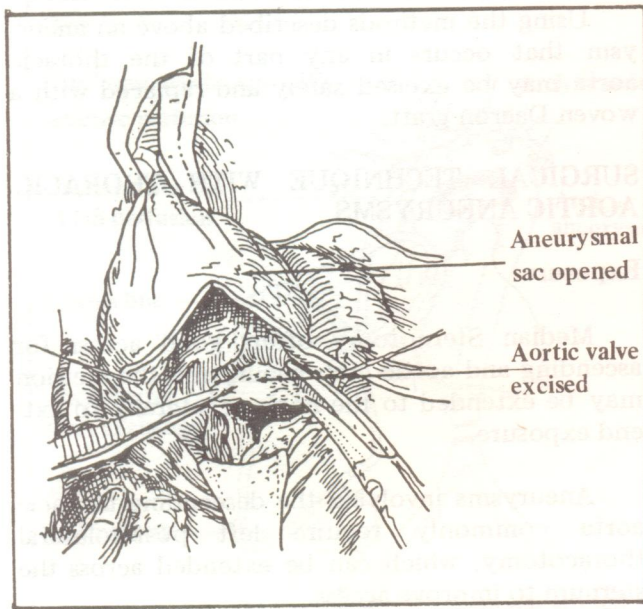
Aneurysms involving the descending thoracic aorta commonly require left posterolateral thoracotomy, which can be extended across the sternum to improve access.

ASCENDING THORACIC ANEURYSMS:  
(Diagrams 4.)

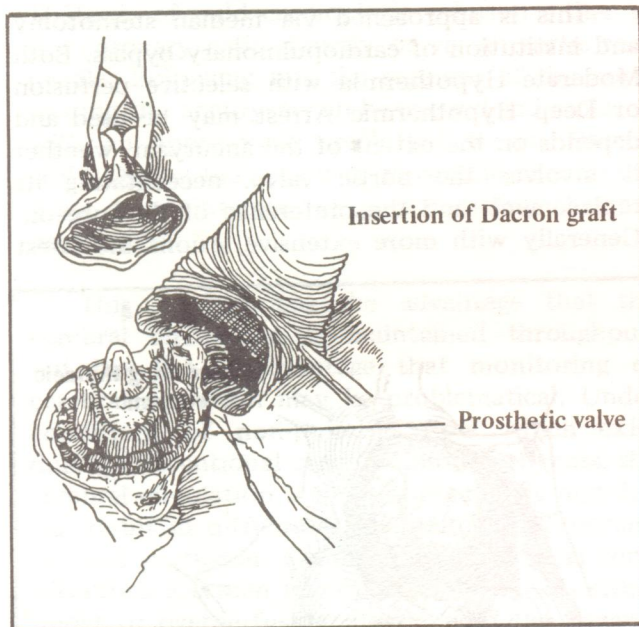
This is approached via median sternotomy and institution of cardiopulmonary bypass. Both Moderate Hypothermia with selective perfusion or Deep Hypothermic Arrest may be used and depends on the extent of the aneurysm, whether it involves the aortic valve, necessitating its replacement, and the preference of the surgeon. Generally with more extensive lesions the safest

method is currently thought to be deep hypothermic arrest with the addition of cardioplegia for further myocardial protection. Having arrested the heart, a cross clamp is applied to the aorta

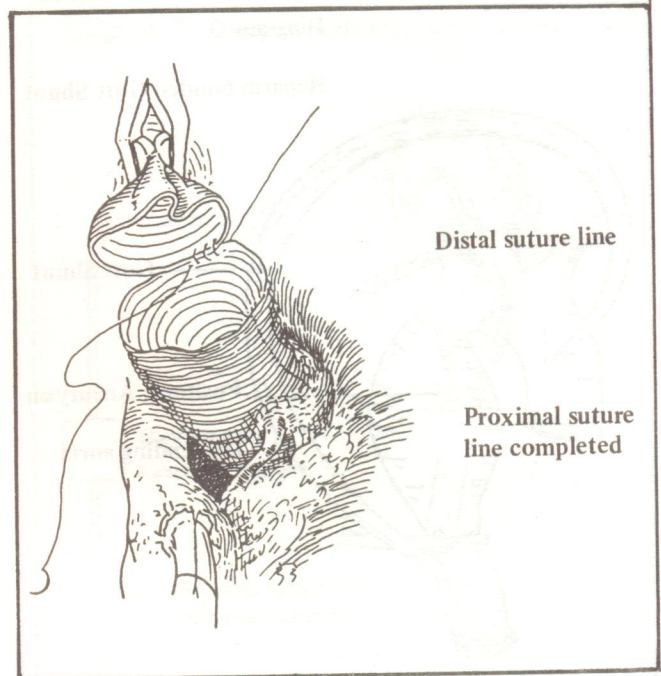




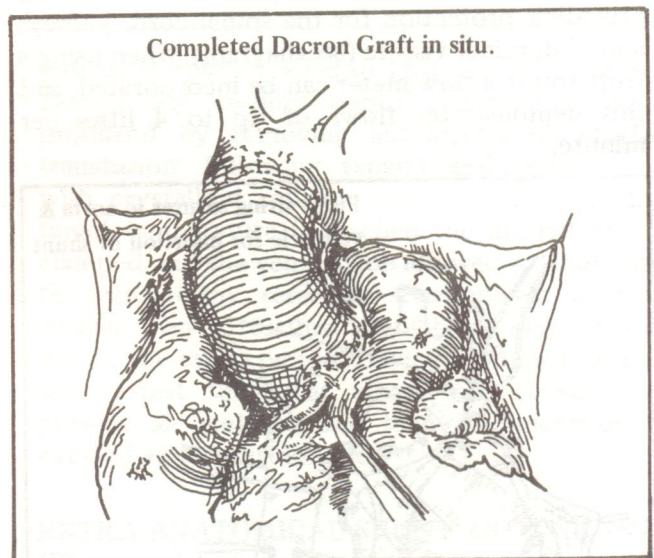
proximal to the great vessels and an aortotomy made. If the valve is involved, a prosthetic valve is inserted with interrupted sutures.



Following this a low porosity woven Dacron (meadox) graft is inserted using a running stitch of 3/0 polypropylene. The back wall is first sutured from within out, with particular attention being paid to conserving the adventitial layer which both subserves mechanical strength and haemostatic properties. The anterior portion of the anastomosis is likewise fashioned and then



the proximal suture line is made. Prior to completion of the proximal anastomosis through de-airing procedures are undertaken both by the anaesthetist and surgeon. Following de-airing the patient is rewarmed and the operation completed after securing haemostasis.

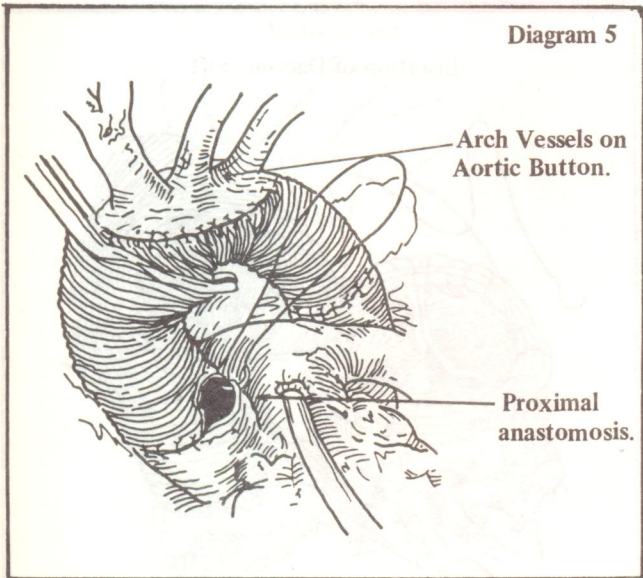


### THORACIC ARCH ANEURYSM (Diagrams 5.)

Having cooled the patient and either arrested the circulation, or maintained circulation to the central nervous system, the aneurysm is excised,

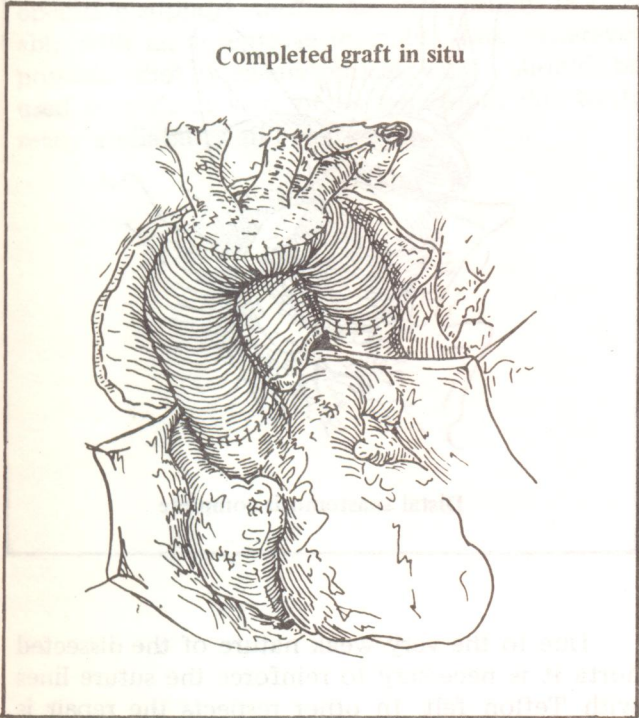


Diagram 5



leaving proximal and distal aortic cuffs and the great vessels of the arch on a button of aorta as illustrated. The distal anastomosis is first performed, following which an oval incision is made in the Dacron graft to which the great vessels on their aortic button are anastomosed, using a single running suture of 3/0 prolene. The proximal anastomosis is next made, and following thorough de-airing and rewarming, the patient is weaned from cardiopulmonary bypass.

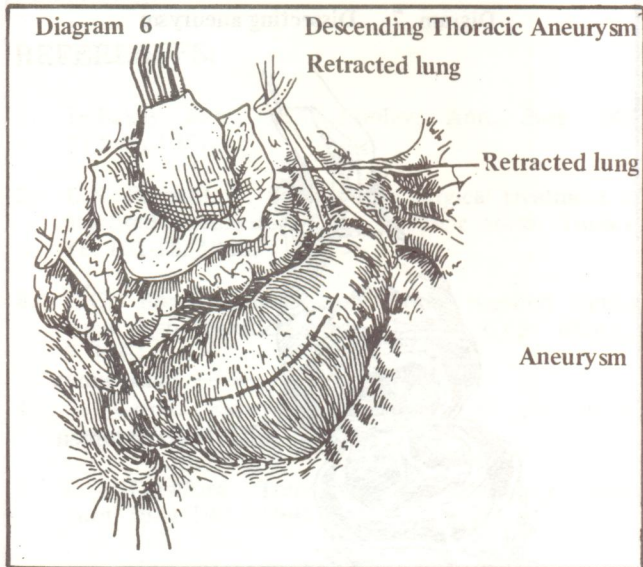
Completed graft in situ



**DESCENDING THORACIC AORTA.**  
(Diagrams 6.)

These are usually approached through a left posterolateral thoracotomy, at the level of the

Diagram 6



fourth rib. Having provided protection by inserting a Gott shunt as previously illustrated, the aorta is cross clamped and the aneurysm is excised. A Dacron graft is then inserted, with the proximal anastomosis being constructed first. The distal anastomosis is next made, air being excluded from the graft by opening the proximal clamp prior to the completion of the distal anastomosis.

Dacron graft in situ

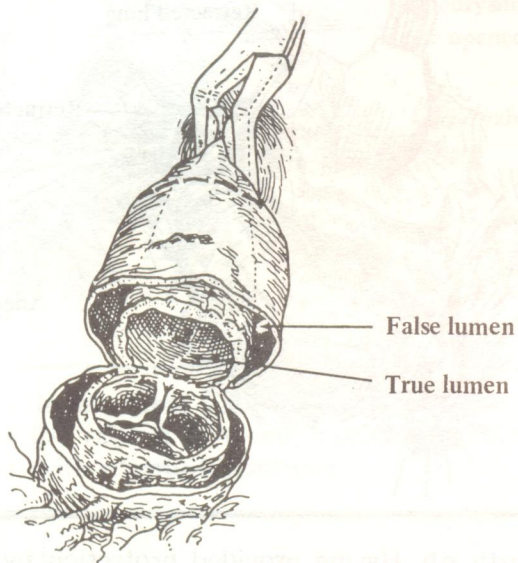




**DISSECTING ANEURYSM. (Diagrams 7.)**

With dissecting aneurysms, a small tear in the arterial intima leads to arterial blood forcing

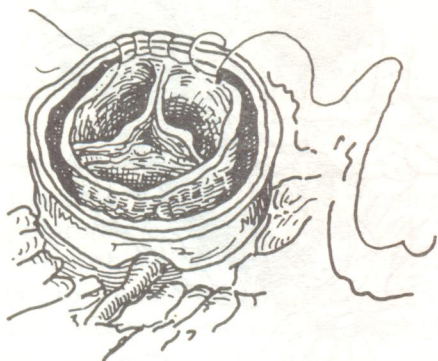
**Diagram 7 Dissecting aneurysm**



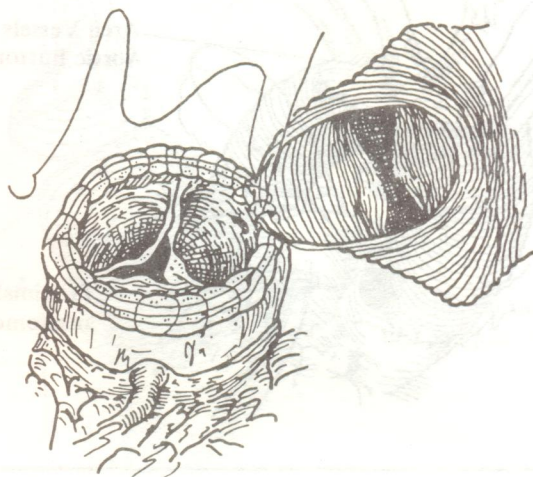
through the media of the arterial wall causing a false lumen which may extend for any length along the aorta. When seen in cross section the double lumen is apparent as seen in the diagram.

**Obliteration of false lumen**

**Suture line reinforced with Ieflon felt**

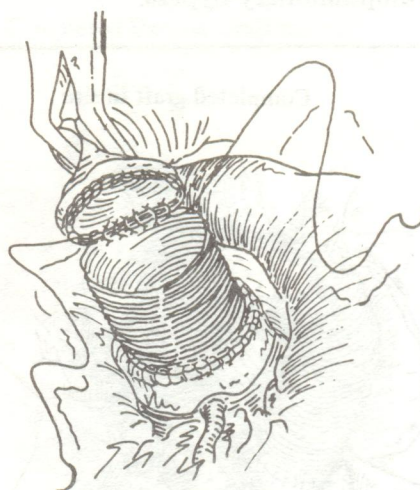


**Insertion of Dacron graft**



When performing surgical repair of such cases it is necessary to oversee the intimal tear and then exclude the false lumen from the real lumen, usually with the inclusion of a graft.

**Proximal anastomosis**

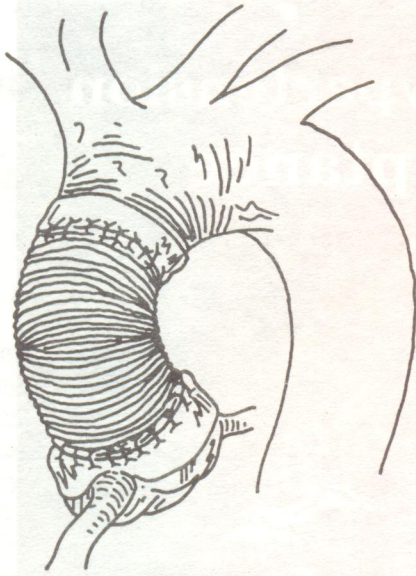


**Distal anastomosis complete**

Due to the very weak nature of the dissected aorta it is necessary to reinforce the suture lines with Teflon felt. In other respects the repair is



Graft in situ



similar to that described for ascending aortic aneurysms.

### CONCLUSION

Although the surgical management of thoracic aortic aneurysms remains a major challenge, with proper investigation, preparation and intra-operative support, results are increasingly favourable with an acceptable mortality rate. Wherever possible the extra-anatomical shunt should be used to protect vital organ perfusion, due to its ready availability and ease of application.

In situations requiring formal support with cardiopulmonary bypass, it is difficult to advise on the superiority of either method, and the choice of method used is dependent on a careful appraisal of the individual case and the preference of the surgeon.

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