

# Results of surgery for atrial septal defect in patients of 40 years and over

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Surgical closure of an atrial septal defect was performed on 104 patients over the age of 40 at the Brompton Hospital. The hospital mortality was 9.6%, reducing to 2.7% in the last six years. There were five late deaths.

A moderate increase in preoperative pulmonary artery systolic pressure did not influence mortality. Twenty-five per cent of patients in preoperative atrial fibrillation have been maintained in sinus rhythm an average of five years following operation. Seven per cent of patients in sinus rhythm preoperatively left hospital in atrial fibrillation. Another 7% developed atrial fibrillation an average of seven years after operation.

At late follow-up 75 patients were symptom-free and leading normal lives. It is concluded that patients in this age group with atrial septal defect benefit from surgical closure of the defect.

Atrial septal defect is the commonest congenital heart lesion found in adults. Although the condition normally follows a benign course in early life, progressive disability in the fourth and fifth decades is the general rule, resulting in significant shortening of the lifespan (Campbell, Neill and Suzman, 1957; Burrett and White, 1945).

Surgical correction of this anomaly has become an established procedure, and in the younger age groups is associated with little morbidity and a

low mortality (Cohn, Morrow, and Braunwold, 1967; Barratt-Boyes, 1963). However, there has been some reservation regarding the advisability of operation in the older age group, particularly in those patients with established severe pulmonary hypertension (Markman, Howitt, and Wade, 1965; Wolf, Vogel, Pryor, and Blount, 1968).

This study was undertaken to assess the experience at the Brompton Hospital in the surgical management of patients in this older age group with particular regard to postoperative morbidity and mortality.

### PATIENTS UNDER REVIEW

Between 1953 and December 1970, 567 patients with atrial septal defect as their predominant lesion were treated surgically at this hospital (Figure). Of these, 104 patients were aged over 40 years at the time of operation. There were 64 in their fifth decade, 33 in their sixth decade, and seven in

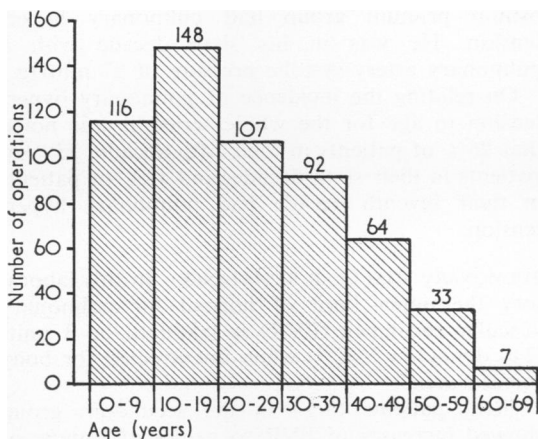


FIGURE. Atrial septal defect 1953-70. Number of operations related to age.

TABLE I  
AGE AT OPERATION

Age (yr)	No. of Patients			Total
	Secundum	Primum	Sinus Venosus	
40-49	55	3	6	64
50-59	27	2	4	33
60-69	7	-	-	7

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their seventh decade, the eldest patient being 66 years old (Table I). The commonest lesion was the secundum type and this occurred in 89 patients. Another 10 had a sinus venosus defect and the remaining five were of the ostium primum type.

#### CLINICAL FEATURES

Sixty-five per cent of the patients were female.

The majority of patients were symptomatic. Only 9.7% denied symptoms and these were referred following routine medical examination or routine chest radiography.

The commoner presentations were breathlessness on exertion (86%), palpitations (42%), and chest pain (22%). A high incidence of symptoms occurred in those patients with ostium primum defects (Table II) and it was also noted that this group developed these symptoms a decade earlier than the secundum and sinus venosus groups (Table III).

On clinical examination 28% of all patients were in established dysrhythmias (atrial fibrillation 22%, atrial flutter 3%, supraventricular tachycardia 2%, nodal rhythm 1%, and complete heart block 1%).

TABLE II  
SYMPTOMATOLOGY

Symptom	Percentage of Defects			Total
	Secundum	Primum	Sinus Venosus	
Breathlessness	85	100	90	86
Palpitations	40	60	50	42
Chest pain	20	40	33	22

TABLE III  
DURATION OF SYMPTOMS

	Defect		
	Secundum	Primum	Sinus Venosus
Average age at onset of symptoms	43.4	33.4	44.5
Average age at operation	48.5	47.8	48.8
Average duration of symptoms (years)	5.1	14.4	4.3

TABLE IV  
INCIDENCE OF DYSRHYTHMIA AND CONGESTIVE HEART FAILURE

	Percentage of Defects			Total
	Secundum	Primum	Sinus Venosus	
Dysrhythmia	28	20	33	28
CHF	26	—	10	20

Twenty per cent of all patients were in congestive heart failure, as evidenced by a high central venous pressure and peripheral oedema (Table IV).

#### INVESTIGATION

Ninety-nine patients underwent cardiac catheterization preoperatively to confirm the diagnosis, exclude or confirm co-existing defects, measure the pulmonary artery pressure and pulmonary vascular resistance, and assess the degree of shunt. Five patients in the secundum group did not undergo cardiac catheterization.

**PULMONARY ARTERY PRESSURE** In this laboratory the upper limit of pulmonary artery systolic pressure is taken as 35 mmHg referable to the sternal angle.

**Ostium secundum group** Twenty-seven patients (33%) with secundum defects had pulmonary hypertension. Of these patients 14 were in their fifth decade, nine in their sixth decade, and four in their seventh decade. Four patients (4.5%) showed elevations of pulmonary artery systolic pressure above 60 mmHg, the highest pressure recorded being 85/32 mmHg.

**Sinus venosus group** Three patients (30%) with sinus venosus defects had pulmonary hypertension. All were in their early forties. One patient (10%) showed a pulmonary artery systolic pressure of 60 mmHg.

**Ostium primum group** One patient (20%) in the ostium primum group had pulmonary hypertension. He was in his sixth decade with a pulmonary artery systolic pressure of 37 mmHg.

On relating the incidence of pulmonary hypertension to age for the whole series, it was noted that 26% of patients in their fifth decade, 33% of patients in their sixth decade, and 43% of patients in their seventh decade had pulmonary hypertension.

**PULMONARY VASCULAR RESISTANCE** In this laboratory the upper limit of normal for pulmonary vascular resistance (PVR) is taken to be 3 units (240 dynes/sec/cm<sup>-5</sup>) when uncorrected for body surface area.

Eight patients (9%) in the secundum group showed increases of PVR to values of 3 units or over. Six of these patients were in their fifth decade and two in their sixth decade. Only one patient (10%) with a sinus venosus defect had an increased PVR. He was aged 40 with a PVR value

of 4.6 units. No patient in the primum group showed an increased PVR.

**SHUNT** All but six patients had pulmonary/systolic flow ratios of 2 to 1 or higher. In 23 patients the shunt was more than 4 to 1, including 19 in the secundum group, three in the sinus venosus group, and one patient in the primum group.

#### SURGICAL TECHNIQUE

Surgical technique has changed over the years.

The earliest case was corrected by atrioseptomy. Subsequently moderate hypothermia by veno-venous or surface cooling was employed. During 1963 and 1964 seven cases were operated upon under profound hypothermia by the Drew technique. Since 1965 only cardiopulmonary bypass has been used. In all, 45 patients underwent moderate hypothermia, seven profound hypothermia, and 51 cardiopulmonary bypass.

The method employed to close the defect depended on its size and anatomical type. Thus, in the secundum group closure by direct suture was possible in 86 patients. In only three was the defect considered large enough to require a patch. In the sinus venosus group the defect and associated partial anomalous pulmonary venous drainage were corrected in the seven earlier cases by direct suture. More recently it has been the practice to insert a patch of Teflon or pericardium with the patient on cardiopulmonary bypass.

Although the five patients with primum defects all had cleft mitral valves at operation, only two patients were considered to have significant mitral regurgitation on preoperative clinical assessment. In both of these cases the cleft was repaired by direct suture. All primum defects were closed with a pericardial patch.

Of the four patients with co-existing mitral stenosis, three underwent mitral valvotomy through the atrial septal defect with the use of Tubbs' dilator on two occasions and digital dilatation on the third. Mitral stenosis in the fourth patient was unsuspected, the diagnosis being made at necropsy.

#### RESULTS

**HOSPITAL MORTALITY** There were 10 deaths in the series within one month of operation, all in the secundum group. Six of these patients had their defects repaired under moderate hypothermia, three under cardiopulmonary bypass, and one under profound hypothermia.

Only one death has occurred in 37 defects repaired in the last six years under review, a hospital mortality of 2.7%.

Of the six deaths following moderate hypothermia, three occurred during operation from irreversible ventricular fibrillation. One died 30 hours postoperatively in persistent ventricular fibrillation, while another died suddenly 10 days after operation from cardiac tamponade following the administration of prophylactic anticoagulants. The remaining death was also sudden eight hours following operation and was attributed to adrenal failure. This patient had been receiving preoperative prednisone for polyarteritis nodosa.

The one death following profound hypothermia occurred during operation from irreversible ventricular fibrillation. There were three deaths in the 51 patients operated upon under cardiopulmonary bypass. One died 24 hours postoperatively in persistent ventricular fibrillation. Another failed to regain consciousness after operation, developed a left hemiplegia, and died on the sixth postoperative day. The third death occurred in the fourth week during quinidine therapy for atrial fibrillation.

The relationship of various adverse preoperative factors to hospital mortality for the whole series is shown in Table V. It may be noted that a moderate elevation in pulmonary artery pressure (up to 60 mmHg systolic) did not significantly increase the overall hospital mortality. In the seven patients with pulmonary artery pressures above 60 mmHg there were two deaths, both following hypothermia in 1958. Since that time there has been no hospital mortality in five patients in this group (average pulmonary artery systolic pressure of 72 mmHg).

Analysis of the eight patients from all groups with increased pulmonary vascular resistance shows that the two deaths in this group also occurred in 1958 and both were associated with severe pulmonary hypertension. Since then there

TABLE V  
PREOPERATIVE FACTORS

	1953-1964		1965-1970	
	No. of Patients	% Mortality	No. of Patients	% Mortality
Age 50+	23	17	17	6
Dysrhythmias	22	18	7	0
Heart failure	15	33	6	0
Pulmonary artery pressure				
Up to 35 mmHg systolic	45	8.8	36	3
36 to 59 mmHg systolic	20	15	8	0
60+ mmHg systolic	7	28	2	0
PVR > 3 units	7	28	1	0

has been no hospital mortality in six patients with increased PVR (average PVR 4.5 units, range 3–5.8 units).

**LATE DEATHS** The period of follow-up ranged from four months to 13 years. Apart from seven cases lost to follow-up and those patients undergoing surgery in the last year, all patients were followed up for at least one year. The average length of follow-up for the moderate hypothermia group was 7.2 years, for the profound hypothermia group 4.6 years, and for the cardiopulmonary bypass group 3.4 years.

There were five late deaths. All five patients were over the age of 60 years at the time of their death (average 63 years) and four of the five were in atrial fibrillation and congestive cardiac failure preoperatively. The earliest death occurred in a 61-year-old woman in whom a quadriplegia was noted following operation under moderate hypothermia. She died four months later from neurological deficit. The second death occurred in a 65-year-old man nine months postoperatively from myocardial infarction. He had been symptom-free until his death. Another 61-year-old man died from congestive cardiac failure five years after operation. Postoperatively his exercise tolerance had considerably improved compared with his preoperative state. The fourth death occurred in a 60-year-old man 10 years postoperatively from myocardial infarction. Up to his death he had led a normal life. The remaining late death occurred in a 66-year-old man from cor pulmonale 11 years following operation. It is not known whether his cor pulmonale resulted from lung disease or pulmonary vascular disease.

**COMPLICATIONS** Postoperative complications occurred in 75 patients (72%) leading to 10 early deaths and one late death. Twenty-nine patients (28%) had an uneventful postoperative course.

**Rhythm disturbances:** (a) *preoperative sinus rhythm group* Of 70 patients from all groups surviving operations who were in sinus rhythm preoperatively, 35 (50%) developed arrhythmias postoperatively, including atrial fibrillation (29 patients), atrial flutter (4 patients), and nodal rhythm (2 patients). Sixteen of these reverted to sinus rhythm spontaneously, 13 required DC defibrillation, and one converted after quinidine therapy, leaving five patients still in a dysrhythmia at follow-up. Five others who had been successfully converted postoperatively developed atrial fibrillation 2 to 12 (average 7) years later.

(b) *Preoperative dysrhythmic group* Of 24 patients surviving operation who were in established dysrhythmias preoperatively, six were in sinus rhythm at late follow-up 1 to 8 years (average 5 years) later, four having converted with quinidine therapy and two spontaneously.

**Neurological disturbances** Eleven patients (10.6%) developed neurological abnormalities postoperatively. Seven of these were minor episodes consisting of transient hallucinations, delusions, and inco-ordination of movement. Four of these were operated upon under moderate hypothermia and two under cardiopulmonary bypass. The average age of this group was 45 years. None had systemic hypertension and all recovered fully before leaving hospital.

In four patients a major cerebral incident occurred. All four patients were over the age of 55 and one had systemic hypertension. One failed to regain consciousness following cardiopulmonary bypass and died on the sixth postoperative day. The other three occurred following moderate hypothermia. One of these died four months postoperatively from cerebral damage while the remaining two survived, although with residual neurological deficit.

**Thromboembolic episodes** Clinical thromboembolic phenomena were recorded in 15 patients. Seven patients developed clinical deep vein thrombosis, leading to venous gangrene of the toes in one. Clinical pulmonary infarction occurred in six patients, all of whom survived. A further patient developed an axillary vein thrombosis. Peripheral arterial emboli occurred in two cases, including an aortic saddle embolus and a mesenteric artery, both requiring surgical intervention. The patient developing the saddle embolus was in sinus rhythm while the other occurred in a patient with atrial fibrillation.

**Haemorrhage** Four patients were returned to the theatre for further haemostasis and all survived. Three of these had been operated upon using cardiopulmonary bypass and the fourth using moderate hypothermia. A retroperitoneal haemorrhage in one patient and cardiac tamponade in another were directly attributable to postoperative anticoagulant therapy.

**Reopening of defect** Three patients in the secundum group were noted to have a recurrence of their defect six days, four months, and one year, following operation. Two of these

patients had their defects successfully closed at a second operation without mortality. The third has refused a further operation.

#### RESULTS AT LATE FOLLOW-UP

Seventy-five patients were symptom-free and leading normal lives at late follow-up. This group includes 63 patients in the secundum group, three in the ostium primum group, and nine in the sinus venosus group.

Fourteen patients were symptomatic including nine with exertional dyspnoea. Four of these patients had improved, four were the same, and one was worse compared with their preoperative level of exercise tolerance. The patient who is worse still has his atrial septal defect open as well as a malabsorption syndrome resulting from bowel resection necessitated by a mesenteric artery embolus. He refuses a further operation.

Two have had recurrent chest pains since operation but otherwise normal exercise tolerance. Two have residual hemiplegias and one is under treatment for psychosis.

#### DISCUSSION

Although the majority of children with atrial septal defect are symptom-free there is an increasing incidence of symptoms with advancing age (Markman *et al.*, 1965).

Campbell *et al.* (1957) found that of those patients attending hospital who had not had their atrial septal defects closed only half were still well at 40 and less than a quarter at 50 years of age. This deterioration most frequently occurs in association with a dysrhythmia, usually atrial fibrillation, following which the heart rapidly enlarges. Tricuspid regurgitation and heart failure soon become evident (Wood, 1962).

Pulmonary hypertension has been noted with a greater frequency in older patients with atrial septal defect than in those under the age of 40 (Markman, *et al.*, 1965), and Gault, Morrow, Gay, and Ross (1968) demonstrated a clear relationship between pulmonary hypertension and degree of disability.

The reported average age of death in patients with atrial septal defect ranges from 36 years (Roesler, 1934) to 49 years (Cosby and Griffith, 1949).

To prevent the development of these late sequelae, surgical closure of the defect in childhood has become established practice. The mortality rate associated with operation in this younger age group is sufficiently low to recom-

mend closure of medium and larger defects, even in the absence of symptoms (Cleland, Goodwin, McDonald, and Ross, 1969).

However, Wolf and his colleagues (1968), while agreeing that operation in the younger patient with atrial septal defect is advisable, suggest that the role of surgery in the middle-aged patient is uncertain. Reviewing 34 patients over the age of 45, of whom 15 underwent surgery, they concluded that surgery offers the greatest benefit to the progressively symptomatic adult with normal or mild to moderate increases in pulmonary artery pressures, and that operation in those with severe pulmonary hypertension is too hazardous. In a study of 48 surgically treated patients with atrial septal defect in this age group, Gault and his co-workers (1968) concluded that, despite the presence of pulmonary hypertension and congestive failure, operative closure could be undertaken with low operative mortality, with sustained clinical and haemodynamic benefit in the survivors.

In this series the overall hospital mortality rate was 9.6%, reducing to 2.7% in the last six years studied. This reduction in mortality rate is comparable with that observed in other centres (Gault *et al.*, 1968; Daicoff, Brandenburg, and Kirklin, 1967) and appears to be a reflection of improved operative technique and postoperative care with experience, rather than to patient selection. It is interesting to note that the mortality following hypothermia was double that following cardiopulmonary bypass and that of the three deaths following the latter technique the one due to quinidine therapy was potentially avoidable. Analysis of the five late deaths shows that the average age of the patients was 63 years and that four of the five had derived considerable benefit from the operation. With regard to the effect of preoperative pulmonary hypertension, it may be noted that a moderate increase in pulmonary artery pressure (up to 60 mmHg systolic) did not significantly increase the overall hospital mortality. In the seven patients with pulmonary artery pressures above 60 mmHg systolic, there were two deaths which would tend to support the contention of Wolf and his colleagues (1968) that operation in patients with severe pulmonary hypertension is too hazardous. However, both of these deaths occurred following hypothermia in 1958 and since that time there has been no mortality in five patients in this group (average systolic pulmonary artery pressure of 72 mmHg).

Dysrhythmias are common in elderly patients with atrial septal defects. In this series, although these dysrhythmias were frequent in the postopera-

tive period, of those patients in sinus rhythm before operation only 7% left hospital in atrial fibrillation. Another 7% have since developed atrial fibrillation an average of seven years after operation.

However, 25% of patients who were in atrial fibrillation before operation have been maintained in sinus rhythm an average of five years following operation. It would appear that closure of the defect has a beneficial effect in preventing dysrhythmias.

At their last attendance 75 patients were symptom-free and, of those who were symptomatic, only five had obtained no subjective benefit from the operation.

It is concluded from this study that recent advances in surgical and cardiopulmonary bypass techniques and improved postoperative care have decreased the mortality and morbidity of operation to the extent that surgical closure of atrial septal defects at any age is now justified, even in the presence of pulmonary hypertension.

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