ATRIAL ARRHYTHMIAS POST CORONARY BYPASS GRAFTING

J T H Chew, K K Ong

ABSTRACT

Atrial arrhythmia is a relatively common complication post coronary bypass grafting. A retrospective study of 400 patients who had undergone coronary arterial bypass grafting over a period from June 1989 to December 1990 were studied to determine the incidence of atrial arrhythmias in an Asian population. The incidence of atrial arrhythmias post coronary artery bypass grafting was 14.25% (57 out of 400 patients). The commonest type of atrial arrhythmia was atrial fibrillation (82.5%), followed by supraventricular tachyarrhythmia (14.0%) and atrial flutter (3.5%). The preoperative state of the myocardium, intra-operative ischaemia to the myocardium and hypokalemia were found to be the possible contributory factors to the development of atrial arrhythmias.

Keywords : *atrial arrhythmias, coronary artery bypass grafting, myocardium pre-operative state, myocardial ischaemia, hypokalemia.*

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INTRODUCTION

Atrial arrhythmias are a relatively common complication in post coronary bypass grafting (CABG). The reported incidence varies between 11-46%[1-4]. Previous investigators have tried to elucidate the possible aetiologies with conflicting results[5-8]. The aim of this study is to document the incidence of atrial arrhythmias in our local population and to try to postulate possible aetiology in this Asian population.

METHODS

Four hundred consecutive patients undergoing elective Coronary Artery Bypass Grafting (CABG) at the Cardio-thoracic Unit, Singapore General Hospital between June 1989 to December 1990 were analysed. All patients who had emergency operations, requiring intra-aortic balloon support and concomitant additional procedures (eg left ventricular aneurysmectomy or valvular surgery) were omitted. Variables studied were divided into 3 groups : (a) pre-operative variables, (b) intra-operative variables, and (c) post-operative variables.

a. The pre-operative variables studied were : age, sex, diabetes, hypertension, smoking, New York Heart Association class, previous myocardial infarction, number of diseased coronary vessels and coronary dominance, anti-arrhythmic agents, serum electrolytes and arterial blood gases.
b. The intra-operative variables studied were : coronary bypass time, aortic cross clamp time, serum potassium and arterial blood gases on coming off bypass, lowest termperature recorded, number of vessels grafted, use of electro-cardioversion or spontaneous reversion of sinus rhythm.
c. The post-operative variables were : type of atrial arrhythmias, serum potassium and arterial blood gas, anti-arrhythmic therapy.

Operative methods

The operations were performed with standard cardio-pulmonary bypass at 2.4L/m^2/min under moderate hypothermia varying between 23^0-28^{0}C. The distal anastomoses were performed during a single period of aortic-cross clamping with intermittent infusion of cold blood cardioplegic hyperkalemic St. Thomas' solution at 20 mins intervals. Topical hypothermia was maintained by irrigation of the pericardial cavity with iced slush at 4^{0}C. A single two-stage Sarn's cannula was inserted through the right atrial appendage for venous return. The ascending aortic cannulation is metal tipped. The left ventricle is vented using a Sarn's left ventricle cannula inserted via the right superior pulmonary vein. The proximal anastomoses of saphenous vein grafts to ascending aorta were performed with the aid of aortic side clamp during rewarming with the heart beating. All patients had a pacing wire inserted on the right ventricular surface. All patients had normalisation of potassium levels to 4.0-5.0 mEq/L range on coming off cardio-pulmonary bypass. In the intensive care unit, all patients had continuous ECG monitoring for at least 48 hours. The arterial blood gases, electrolytes and clinical and haemodynamic parameters are monitored at 4 hourly intervals. Patients who developed atrial fibrillation had immediate analysis of calcium, potassium, sodium and blood gases. Only those with sustained atrial fibrillation for more than 3 minutes were considered to have clinically significant atrial fibrillation.

All patients had 12 lead ECG monitored daily till the day of discharge. Any patient with complaints of palpitations or had any irregular pulse was investigated with serum electrolytes and arterial blood gases and a full 12 lead ECG.

Atrial fibrillation was defined as an irregularly irregular pulse with absence of 'p' waves on ECG. Supraventicular tachyarrhythmia was defined as >120 beats/min with normal QRS complexes in the absence of bundle branch blocks. Atrial flutter was defined as a 'saw tooth' pattern appearing on the ECG. All these arrhythmias were collectively entered into the study as atrial arrhythmias.

All patients with atrial arrhythmias had serum electrolytes, arterial blood gases and calcium levels investigated. Serum potassium was first corrected to 4.0-5.0 mEq/L, and if the arrhythmia still persisted, a loading dose of digoxin was used, followed by a maintenance dose. Patients with atrial fibrillation persisting more than 24 hours duration were treated with propranolol. Patients who developed haemodynamic instability were given direct synchronised cardioversion.

Statistical analysis

The variables are tabulated in Tables I, II and III. Univariate analysis on all variables on the post operative occurrence of

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Table I - Pre-operative clinical values of patient characteristics

	total (n=400)		sinus rhythmn (n=343)		atrial arrhythmia (n=57)		p value
age	60±10		61±10		61±10		NS
sex							
a.male	316	79%	274	80%	45	79%	NS
b.female	84	21%	69	20%	12	21%	
diabetes							
a. yes	208	52%	175	51%	30	53%	NS
b. no	192	48%	168	49%	27	47%	
hypertension							
a. yes	284	71%	247	72%	40	70%	NS
b. no	116	29%	96	28%	17	30%	
smoking							
a. yes	160	40%	137	40%	23	40%	NS
b. no	240	60%	206	60%	34	60%	
NYHA class							
a. I, II	276	69%	240	70%	23	40%	$p < 0.01$
b. III, IV	124	31%	103	30%	34	60%	
previous MI							
a. yes	176	44%	185	54%	26	46%	NS
b. no	224	56%	158	46%	31	54%	
severity of vessel involved							
a. left main	40	10%	34	10%	6	11%	NS
b. double vessel	52	13%	38	11%	7	12%	
c. triple vessel	308	77%	271	79%	44	77%	
coronary dominance							
a. right	282	71%	247	72%	40	70%	NS
b. left	68	17%	55	16%	10	18%	
c. equal	48	12%	41	12%	7	12%	
serum potassium at pre-op (<4.0)							
a. yes	16	4%	7	2%	2	3%	NS
b. no	384	96%	336	98%	55	97%	
mean ejection fraction	0.51±0.04		0.52±0.03		0.32±0.02		p<0.01
use of anti-arrhythmics							
a. yes	387	97%	326	95%	55	96%	NS
b. no	13	3%	17	5%	2	4%	

NYHA : New York Heart Association
MI : myocardial infraction
NS : not significant

SVT were performed using the chi squared test. T-tests were performed for those continuous variables.

RESULTS

A total of 400 cases were analysed. The overall incidence of all types of atrial arrhythmia is 14.25% (57 out of 400 patients). Of the 57 patients with atrial arrhythmia, 47 patients (82.5%) had atrial fibrillation, 8 patients (14.0%) had supraventricular tachycardia and 2 patients (3.5%) had atrial flutter. All these were collectively grouped into atrial arrhythmias. The mean time of onset of the atrial arrhythmia after CABG was 2.5±1.2 days. Most of the arrhythmias lasted on the average a duration of 1.1± 1.2 days.

Data Analysis

A. Pre-operative data

Table I summarises the pre-operative patient characteristics comparing those who developed atrial arrhythmias with those who remained in sinus rhythm. The risk of developing an atrial arrhythmia was increased in those who were in pre-operative New York Heart Association class III or IV ($p < 0.01$) and those with poorer ejection fractions ($p < 0.01$) .

There was no significant difference demonstrated between age, sex, diabetes, smoking, hypertension, previous myocardial infarction, severity of vessel involvement, coronary dominance or serum electrolytes pre-operatively.

Table II - Intra-operative variables of patient characteristics

	total (n=400)		normal rhythmn (n=343)		atrial arrhythmia (n=57)		p value
CPB time mean range	105±22 0-210		105±22 0-210		95±23 33-192		NS
cross-clamp time mean range	35±11 0-92		35±11 0-108		58±11 22-92		p<0.01
serum potassium on coming off bypass mean range	4.1±0.4 3.9-5.2		4.1±0.4 3.9-5.2		4.0±0.3 3.8-4.7		NS
lowest temp cooled to mean range	25±4 20-27		25±4 20-27		24±4 21-27		NS
no. of grafts mean	3.7		3.8		3.7		NS
requiring DC shock yes no	160 240	40% 60%	130 213	38% 62%	25 32	43% 57%	NS

CPB : cardio-pulmonary bypass

B. Intra-operative data

Table II summarises the intra-operative data collected. Those who developed a higher chance of atrial arrhythmia were noted to have a prolonged cross clamp time ($p < 0.001$). There was no significant difference between cardio-pulmonary bypass time, serum potassium on coming off bypass, lowest temperature cooled to, number of grafts or those requiring direct current (DC) conversion to revert to normal sinus rhythm.

C. Post-operative data

Table III summarises the incidence of those post cardio-pulmonary bypass developing atrial arrhythmias. Those developing atrial arrhythmias were noted to have lower potassium values. This was statistically significant at $p < 0.001$.

Treatment of AF

A total of 57 patients had atrial arrhythmias. Eight patients (14%) had spontaneous reversion to sinus rhythm. The remaining 49 patients (86%) required treatment. Prior to treatment, electrolyte levels were checked and normalised where required. The commonest electrolyte abnormality was hypokalemia. Most of the patients with atrial arrhythmias reverted to normal sinus rhythm following correction of their potassium deficits. Drug therapy was used only after electrolyte correction failed to induce normal sinus rhythm. Digoxin was the most commonly used drug. A loading dose of 0.5 mg was first administered followed by another two intravenous doses of 0.25 mg over the next 12-24 hours. All potassium levels were corrected to 4.0-5.0 mEq/L before initiation of digoxin therapy. A total of 6 patients were treated with DC cardioversion. This was because these patients were noted to be hypotensive. Following DC cardioversion, digitalisation was started. There were no deaths related to those patients with atrial arrhythmias. None of these patients required re-opening or any external pacing. Four patients were discharged with persistent atrial arrhythmias requiring daily digoxin doses.

DISCUSSION

The exact cause of atrial arrhythmias in patients who have undergone CABG is not entirely known, but the data seem to suggest that the pre-operative state of vascularisation and ischaemia to the myocardium intra-operatively are strong factors contributing to the development of atrial arrhythmias[4]. Serum potassium levels appear to have a strong correlation between the development of atrial arrhythmia in post coronary bypass grafting.

Ischaemia to myocardium

Rousou and colleagues demonstrated the use of various cardioplegic solutions in comparison to the development of atrial arrhythmias, showing that blood cardioplegia had the least incidence compared to crystalloid cardioplegia probably because of their less perioperative injury[8]. Similar findings have been demonstrated by other researchers[9].

Consequently, prolonged ischaemia to the myocardium which could have resulted from inadequate delivery of cardioplegic solution, early rewarming during cardioplegic arrest or by virtue of intricacies of the operation requiring a longer cross clamp time could have resulted in ischaemia. The longer cross clamp time noted in those who developed the arrhythmias is a possible contributing factor to the generation of atrial arrhythmias.

Smith and colleagues have demonstrated differential atrial and ventricular activity both during cardioplegic arrest as well as during rewarming. There is thus a possibility of inadequacy of protection of both the atrial as well as the supra-ventricular conduction system. It has also been demonstrated that the atria and atrio-ventricular node receive significantly less blood supply during the period of cardioplegic arrest than they do during normal coronary perfusion, also resulting in the marked reactive hyperemic response after removal of the cross clamp[10].

The degree of tissue ischaemia in the atria has been demonstrated to be greater in the ventricles[10]. This together with

Table III - Post-operative variables of patient characteristics

	total (n=400)	sinus rhythmn (n=343)	atrial arrhythmia (n=57)	p value
serum potassium mean	4.2±0.3	4.2±0.3	3.6±0.2	p<0.001
ABG at outset pH mean pCo_2 mean pO_2 mean	 7.35±0.02 40 97	 7.4±0.02 41 97	 7.37±0.02 41 97	 NS
serum calcium mean	1.0±0.1	1.0±0.1	0.9±0.1	NS

ABG : Arterial blood gas.

the sensitivity of the supraventricular conduction system to ischaemia as well as ischaemic injury of the atrio-ventricular node may be a strong contributory factor to the development of post operative conduction abnormalities. It has been demonstrated that those patients with a prolonged cross clamp time have a higher incidence of atrial conduction defects.

Brazier[11] has shown that the atria receive 30% of their blood supply from "non coronary collateral flow" and consequently receive less hypothermic cardioplegic solution volume/unit weight than did the ventricular myocardium and consequently are subjected to greater chance of ischaemic injury as compared to the ventricles per unit weight.

Persistent atrial activity has also been noted to occur with some frequency during cardioplegic arrest and such atrial activity has been correlated with increased incidence of supraventricular arrhythmias[10].

Hypokalemia

The causative influence of extra-cellular hyperkalemia and hypokalemia on the development of atrial arrhythmias has been well documented[12,13]. The extra-cellular hyperkalemia caused by the administration of high potassium concentrations in the cardioplegic solutions have been implicated by Ellis[13] who postulated that hyperkalemia cause both conductive disturbance and atrial arrhythmias. These findings are, however, not consistent amongst the researchers. One postulate is that high potassium cardioplegia is of importance in the preservation of high energy phosphate bonds, especially during periods of hypothermia and infusions of high potassium appear to block the atrio-ventricular node from depolarising[13].

However, Smith and his colleagues demonstrated that the influence of high levels of potassium in cardioplegic solutions on subsequent arrhythmias were negligible[10]. In our study, we demonstrated a higher incidence of patients with lower potassium levels developing atrial arrhythmias ($p < 0.001$).

Hypokalemia has been known to induce ectopic rhythms in a wide variety of clinical settings eg atrial, junctional and ventricular arrhythmias. The ectopics may be due to enhanced automaticity of latent pacemaker fibres thought to be due to decreased potassium conductance. Potassium itself is known to depress spontaneous phase 4 depolarisation by increasing potassium conductance. The resultant decrease in potassium conductance and efflux of potassium in the face of influx of sodium allows for a more rapid loss of intracellular negativity. The duration of recovery of the action potential may exceed the duration of the refractory period. Consequently, a propagated impulse may be elicited before complete recovery of the action potential can take place. Should this occur at a time when the trans-membrane resting potential is abnormally closer to the threshold potential of the membrane, a weak stimulus may trigger another action potential[12]. The myocardium in post cardiac surgery patients is probably more sensitive to subtle electrolyte changes. Thus smaller changes in potassium may result in the triggering of atrial arrhythmias.

Use of pre-operative antiarrhythmic agents

There has been much controversy as to the use of propranolol as well as other anti-arrhythmics prior to surgery and its ability to decrease the incidence of atrial arrhythmias[14-17]. There was no significant difference between the use of anti-arrhythmics pre-operatively in the prevention of post-operative atrial arrhythmias. Previous investigators have produced conflicting data with respect to the use of such drugs as a form of prophylaxis. Our study being a non randomised retrospective study, it was difficult to ascertain whether the use of anti-arrhythmics had any influence on the incidence of atrial arrhythmias post-operatively. Further investigations will have to be carried out to determine the use of such drugs in further prevention.

CONCLUSION

The incidence of atrial arrhythmias in our local context was demonstrated to be 14.25%, not unlike previously reported series.

The appearance of atrial arrhythmias following post coronary arterial bypass grafting appears to be related to pre-operative state of the myocardium, degree of ischaemic injury to the myocardium and hypokalemia.

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