

# Stroke and Atrial Fibrillation Following Cardiac Surgery

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## ABSTRACT

**Objective:** Stroke is an occasional devastating complication of cardiac surgery. Transient atrial fibrillation (AF) is a frequent complication of cardiac surgery. Emboli originating from the fibrillating left atrium are a known cause of stroke in the non-surgical setting. The purpose of this quality improvement initiative, conducted by the Wausau Heart Institute, was to characterize strokes after cardiac surgery and to investigate the relationship between AF and the occurrence of postoperative strokes.

**Methods:** We conducted a retrospective record review of all patients undergoing cardiac surgery utilizing cardiopulmonary bypass without associated carotid surgery at our institution between January 1, 1993 and June 30, 1999. The occurrence of strokes and AF was noted. The timing of the AF (duration and relationship to surgery) was recorded.

**Results:** Of the 2104 eligible patients, strokes occurred in 68 (3.2%). In 18 patients (27%), stroke was immediately apparent as the patient recovered from anesthesia (intra-operative stroke). Fifty of the 68 strokes (74%) were acquired following the immediate operative period after the patient awoke from anesthesia neurologically intact (postoperative stroke). Postoperative stroke occurred in 2.1% of patients undergoing coronary bypass surgery only, in 2.2% if valve surgery only was performed, and 4.6% if both valve and bypass surgery were performed. AF occurred in 700 patients (33%). The incidence of postoperative stroke was 5.4% in patients with AF and 0.89% in those without AF ( $P < 0.001$ ). Of those patients suffering a postoperative stroke, 76% had AF following cardiac surgery, com-

pared to 32% if a postoperative stroke did not occur ( $P < 0.001$ ). Carotid bruits were present in 7 (14%) of the patients with postoperative stroke. Carotid ultrasound studies were performed in 32 patients (63%) and a lesion of  $>70\%$  was found in 8 patients (25%). Cerebral lesions contralateral to the stenotic carotid artery occurred in 3 of these 8 patients.

**Conclusion:** Most strokes complicating cardiac surgery occur in patients without significant carotid disease, and are acquired after the patient awakens neurologically intact. The high incidence of postoperative AF in these patients suggests a possible embolic cause for some of the strokes. As such, some postoperative strokes may be preventable.

## INTRODUCTION

Strokes are a well-recognized complication of cardiac surgery.<sup>1-3</sup> Some strokes occur as a complication of the surgical procedure (intra-operative stroke) and are evident as the patient recovers from anesthesia. These strokes may result from air or atheromatous emboli during aortic cannulation or manipulation of the heart during surgery.<sup>1,2</sup> Other strokes are acquired later in the postoperative period after the patient has recovered from anesthesia neurologically intact.<sup>1-3</sup> The mechanisms responsible for postoperative strokes are not well delineated.

Atrial fibrillation (AF) is a frequent complication of cardiac surgery.<sup>4-12</sup> In this setting, AF is usually a transient arrhythmia without lasting sequelae.<sup>4-6</sup> Cerebral embolism is a known complication of sustained AF in the non-surgical setting.<sup>13</sup> Thus AF could play a role in strokes following cardiac surgery.

In January 1999, the Wausau Heart Institute initiated a quality improvement project to characterize strokes following cardiac surgery and determine whether AF could be playing a role in postoperative strokes. This report details the results of that investigation and the influence it has had on our management of postoperative AF.

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## METHODS

All patients undergoing cardiac surgery without associated carotid surgery at Wausau Hospital January 1, 1993-June 30, 1999 were included in the study. Each patient undergoing cardiac surgery was abstracted in the SUMMIT database submitted to the Society of Thoracic Surgeons.<sup>14</sup> All patients who had a stroke following cardiac surgery were identified. The medical record of each patient was reviewed and the strokes were characterized as intra-operative or postoperative. Intra-operative strokes were defined as a new fixed neurological defect that was immediately apparent upon recovery from anesthesia or within 12 hours of surgery.<sup>1</sup> Postoperative strokes were defined as those strokes occurring greater than 12 hours after surgery in a patient who recovered from anesthesia neurologically intact.<sup>1</sup> Each postoperative stroke was confirmed by a computerized tomographic scan of the head. The stroke was characterized as to when it occurred (days post-op), whether it was unilateral or bilateral, and the morbidity and mortality associated with the stroke.

The clinical characteristics of each patient who developed a postoperative stroke were noted, including age, sex, recent myocardial infarction (within 7 days of surgery), and the usual risk factors associated with stroke (history of prior stroke or transient ischemic attack, tobacco use, hypertension, evidence of carotid vascular disease—bruits on exam or results of carotid doppler analysis if obtained [significant abnormality defined >70% stenosis]). We also noted the types of surgery performed and grouped them as follows: coronary bypass only, valve surgery only, coronary bypass surgery and valve surgery, or miscellaneous (resection of atrial myxoma, repair of ventricular, or atrial septal defect). Finally we noted whether the patient experienced AF during the postoperative period.

All patients underwent continuous electrocardiographic monitoring for the duration of their hospital stay. The monitoring system is alarm-triggered and capable of automatic recall. A central monitor technician observed the monitors continuously. Strips were recorded routinely whenever an arrhythmia was noted and the time of any event was recorded simultaneously on the strip. Postoperative AF was defined as an irregularly irregular rhythm with typical characteristic fibrillatory atrial activity that persisted for at least 30 seconds.<sup>4</sup> Since the AF we observed was usually intermittent, we recorded the total duration of the AF arrhythmic period by noting the time of onset of the initial episode and the ending time of the final episode. The duration of the AF arrhythmic period was then characterized as lasting less

than 6 hours, 6 to 48 hours or greater than 48 hours. We also determined whether the AF preceded or followed the stroke.

The SUMMIT database was used also to identify all patients who had AF noted during their hospitalization. This data was used to calculate the incidence of AF and the incidence of postoperative stroke. The incidence of postoperative stroke in patients with AF was compared to the incidence of such stroke in those who did not have AF.

## DATA ANALYSIS

Continuous variable data is presented as mean  $\pm$  SD. Categorical data is reported as the frequency of occurrence of the variable. A chi-square test was used to compare categorical data. A *P* value of  $\leq .05$  was considered significant.

## RESULTS

During the time span of the study, 2104 patients had cardiac surgery without associated carotid surgery. All but 38 of these patients had their surgery performed utilizing cardiac arrest with cardiopulmonary bypass. Stroke occurred in 68 (3.2%) patients. Intra-operative stroke occurred in 18 patients (26%). Fifty of the 68 strokes (74%) were postoperative. Computerized tomographic scans revealed that all strokes were due to ischemia rather than hemorrhage. Table 1 includes the clinical characteristics of the 50 patients with postoperative stroke, the association with pre-existing carotid vascular disease, and the effect of the stroke on outcome. Only a small number of these patients had AF before surgery. Carotid bruits were noted in 14% of patients. Although a carotid doppler was performed in the majority of patients (62%), including all patients with carotid bruits, only 8 patients (26%) undergoing doppler analysis had an obstructive lesion. In the 8 patients in which an obstructive lesion was present, 3 had contralateral cerebral lesions, either isolated or as part of a stroke affecting both hemispheres. Finally, note the devastating outcome of the strokes as only 20% of the patients were discharged to home.

AF occurred in 700 of the 2104 patients (33%). Table 2 demonstrates the relationship between AF and postoperative stroke as an aggregate group as well as a function of the type of surgery performed. There was a greater than 2-fold increase in the rate of AF found in patients sustaining a postoperative stroke compared to those not experiencing a stroke. The occurrence of AF in the postoperative period was associated with a greater than 6-fold increase in the incidence of postop-

**Table 1.** Clinical Characteristics of Postoperative Stroke Patients

	Number	Percentage
<b>Patient characteristics</b>		
Total patients	50	100
Male/Female	25/25	(50/50)
Mean Age (range)	60 (41-83)	NA
Indication for surgery		
CAD	37	(74)
Valve replacement or repair	3	(6)
CAD + valve	7	(14)
Miscellaneous	3	(6)
Prior cardiac surgery	5	(10)
LVEF (%) 50±15	NA	
Prior stroke	11	(22)
History of CHF	11	(22)
Peripheral vascular disease	15	(30)
Recent myocardial infarction	15	(30)
Prior myocardial infarction	9	(18)
Peri-operative myocardial infarction	5	(10)
Diabetes	23	(46)
Hypertension	36	(72)
Hyperlipidemia	20	(40)
Tobacco use	15	(30)
Chronic atrial fibrillation	3	(6)
<b>Carotid vascular disease</b>		
Carotid bruits	7	(14)
Prior endarterectomy	2	(4)
Carotid Doppler performed	31	(62)
>70% stenosis	8	(26)
Ipsilateral to stenosis	5	(63)
Contralateral to stenosis	1	(12)
Bilateral stroke	2	(25)
<b>Stroke characteristics</b>		
Postoperative stroke occurrence	50	2.3
Postoperative occurrence day	2.78 ± 2.5	
Hemisphere		
Right	21	(42)
Left	20	(40)
Bilateral	9	(18)
<b>Outcome</b>		
Hospital length of stay (days)	28 ± 23	
Discharge to nursing home	13	(26)
Discharge to rehab unit	17	(34)
Death	11	(22)
Discharge to home	10	(20)

CAD=coronary artery disease; LVEF=left ventricular ejection fraction; CHF=congestive heart failure; NA=not applicable.

erative stroke (5.4% vs. 0.89%,  $P < 0.001$ ). In 27 of the 38 patients (71%) who developed both AF and a postoperative stroke, the AF preceded the stroke. Thus, overall, AF preceded 54% of all postoperative strokes.

In the 27 patients in whom the AF preceded the stroke, only 1 patient had continuous AF lasting greater than 48 hours. Nineteen others had intermittent

AF with the arrhythmic period lasting greater than 48 hours. Three patients had intermittent AF producing an AF arrhythmic period of 6 to 48 hours. The remaining 4 stroke patients had an AF arrhythmic period of less than 6 hours.

## DISCUSSION

Improvements in surgical and anesthesia techniques as well as postoperative care have produced a significant decrease in the morbidity and mortality associated with cardiac surgery.<sup>3</sup> Despite this improvement, very little progress has been made in decreasing the incidence of strokes.<sup>3</sup> The overall 3.2% stroke rate we observed was similar to that reported by others.<sup>1-3</sup> Our results confirm the findings of others<sup>1-3</sup> that strokes complicating cardiac surgery are associated with high morbidity and mortality (Table 1).

Our study further characterizes strokes in the setting of cardiac surgery by demonstrating that the majority of the strokes are acquired after the patient awakens neurologically intact from anesthesia, a finding previously recognized by others.<sup>1-3</sup> Our results also confirm that most of these patients do not have evidence of significant carotid vascular disease.<sup>1-2</sup> Thus, the mechanism of most postoperative strokes would appear to be related to factors present in the postoperative period rather than emboli during the operation or due to severe carotid vascular disease.

AF is the most common complication after cardiac surgery.<sup>6-8</sup> The 33% incidence in our study is consistent with that reported by others.<sup>4-12</sup> Since emboli originating from the fibrillating left atrium in AF are a known cause of strokes in the non-surgical setting,<sup>15</sup> we investigated the relationship between postoperative stroke and the occurrence of AF in the postoperative period. We found a striking relationship between postoperative strokes and postoperative AF. Postoperative strokes were over 6 times more likely to occur if the patient had AF, and AF preceded more than 50% of all post-operative strokes (Table 2). We also found that the majority of AF patients experiencing a stroke had an AF arrhythmic period (continuous or intermittent) exceeding 48 hours.

The concept that even brief periods of AF can lead to left atrial thrombus formation and strokes is now well established in the non-surgical patient. Stoddard et al<sup>18</sup> performed transesophageal echocardiograms on patients with acute AF and a recent embolic event. They discovered a 14% incidence of left atrial thrombus in patients whose AF duration was less than 48 hours. Since the cardiac surgical patient is in a hypercoagulable state,<sup>19</sup> it is likely the AF duration commonly ob-

**Table 2.** The Relationship Between Atrial Fibrillation and Postoperative Stroke

Patient Group	Total n (%)	n (%) Experiencing Postoperative Stroke	n (%) Experiencing Postoperative AF
All patients	2104 (100)	50 (2.4)	700 (33)
CAD surgery only*	1798 (85.5)	38 (2.1)	570 (32)
Valve surgery only	135 (6.3)	3 (2.2)	55 (41)
CAD and valve surgery	151 (7.1)	7 (4.6)	61 (40)
Miscellaneous†	20 (1.0)	2 (10)	14 (70)
Postoperative stroke pts	50	NA	38 (76) <i>P</i> <0.001
Non-postoperative stroke pts	2054	NA	662 (32)
Postoperative AF pts	700	38 (5.4) <i>P</i> <0.001	NA
Non-postoperative AF pts	1354	12 (0.89)	NA

\*Includes 38 mid CAB patients.

†See methods text for details.

AF=atrial fibrillation, CAD=coronary artery disease, NA=non applicable.

served in the postoperative setting is more than sufficient to predispose to atrial thrombus and subsequent emboli.

Other investigators have also suggested a relationship between AF and stroke following cardiac surgery. In a study of 3855 patients, Almassi et al<sup>8</sup> showed that AF was associated with a significantly higher incidence of most postoperative morbid events including a nearly 2-fold increase in the incidence of stroke. Others have also noted a higher incidence of stroke in patients with postoperative AF.<sup>9-11</sup> Unlike our study, these investigations did not include the temporal relationship of the AF and the stroke, or the duration of the arrhythmic period. This makes it more difficult to determine if there was a possible cause-and-effect relationship between the AF and the strokes.

Our study does not prove a cause-and-effect relationship between the AF and postoperative stroke. Since AF and postoperative stroke share important risk factors, such as age and hypertension,<sup>5,16,17</sup> it is possible that the AF is simply a marker for the stroke-prone patient. Indeed, in 46% of our postoperative stroke patients, AF could not have been the cause as they either did not have AF (12 patients) or the AF did not precede the stroke (11 patients). It seems likely that multiple mechanisms may be involved in the genesis of postoperative stroke. We believe our data supports the notion that AF may be one of the most important causes.

In our study, all but 38 patients had their cardiac surgery utilizing cardiopulmonary bypass. This remains the predominant way cardiac surgery is performed in the United States.<sup>20</sup> However, there is a rapidly growing trend to perform cardiac surgery without cardiopulmonary bypass. Whether this will affect the incidence of

AF and postoperative stroke remains to be determined and is currently under investigation at our institution.

If AF is an important cause of postoperative stroke, many patients might be spared the morbidity or mortality of the stroke by aggressively being treated for AF. As a result of our observations, we instituted a protocol to decrease the incidence of postoperative AF as well as to treat any occurrence of AF promptly so as to minimize its duration. This protocol includes the routine postoperative use of beta blockers.<sup>21</sup> Oral Amiodarone given several days prior to surgery is utilized when time allows or started immediately before surgery and continued 2-3 weeks postoperatively.<sup>22</sup> When AF does not promptly abate within 24 hours, anticoagulants and electrical cardioversion is considered.

## SUMMARY

Our study shows that postoperative AF significantly increases the likelihood of developing a stroke after cardiac surgery. Although a cause-and-effect relationship is not proven, the association is so striking that it seems prudent to recognize AF as a possible cause for some of these strokes and to devise methods to treat the arrhythmia aggressively.

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