Atrial Fibrillation After Minimally Invasive Direct Coronary Artery Bypass Surgery

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OBJECTIVES	The study compared the adjusted risk for developing atrial fibrillation (AF) after minimally invasive direct coronary artery bypass surgery (MIDCAB) and coronary artery bypass graft surgery (CABG).
BACKGROUND	Atrial fibrillation results in increased morbidity and delays hospital discharge after CABG. Recently, MIDCAB has been explored as an alternative to CABG. Because of differences in surgical approach between the two procedures, the incidence of AF may differ.
METHODS	Randomly selected patients undergoing CABG and MIDCAB were examined. Baseline variables and postoperative course were recorded through review of medical record data.
RESULTS	The MIDCAB patients were younger than CABG patients (64 ± 12 vs. 67 ± 10, p < 0.04) and had less extensive coronary artery disease (53% of MIDCAB vs. 3% of CABG had single-vessel disease, while 15% of MIDCAB vs. 69% of CABG had triple-vessel disease, p < 0.001 for overall group comparisons). No other differences in clinical or treatment data were noted. Postoperative AF occurred less often after MIDCAB (23% vs 39%, p = 0.02). Other significant factors associated with postoperative AF included age (p = 0.0024), prior AF (p = 0.0007), left main disease (p = 0.01), number of vessels bypassed (p = 0.009), absence of postoperative beta-blocker therapy (p = 0.0001), and a serious postoperative complication (p = 0.0018). Because of differences between CABG and MIDCAB patients, multivariate logistic analysis was performed to determine independent predictors of postoperative AF. The type of surgery (CABG vs. MIDCAB) was no longer a significant predictor of postoperative AF (estimated relative risk for AF in CABG vs. MIDCAB patients: 1.57, 95% confidence interval (0.82–2.52).
CONCLUSIONS	Although AF appears to be less common after MIDCAB than after CABG, the lower incidence is due to different clinical characteristics of patients undergoing these procedures. (J Am Coll Cardiol 2000;36:1884–8) © 2000 by the American College of Cardiology

Atrial fibrillation (AF) is the most common arrhythmia occurring after coronary artery bypass graft surgery (CABG), and results in increased morbidity and prolonged postoperative hospital stay (1–7). Proposed hypotheses to explain the high incidence of AF after cardiac surgery include the increased adrenergic drive in the postoperative period (8–10), atrial ischemia/necrosis associated with atriotomy and incomplete or prolonged atrial cardioplegia (4,11–13), electrolyte abnormalities during and following cardiopulmonary bypass (14–16), or pericarditis (17,18).

Minimally invasive direct coronary artery bypass (MIDCAB) surgery on a beating heart through a left thoracotomy or limited median sternotomy incision has recently been explored as an alternative to CABG (19–24). The advantages of MIDCAB include the absence of cardiopulmonary bypass and the smaller incisions, presumably contributing to a more rapid postoperative recovery with shorter hospital stays and decreased costs.

It can be hypothesized that the incidence of AF after MIDCAB would be lower than that reported following CABG due to the less invasive surgical technique. In fact, earlier reports on the MIDCAB procedure have demonstrated a low incidence of postoperative AF (24–27). It is unclear, however, whether the lower incidence of AF in these groups relates to the healthier population of patients typically referred for MIDCAB. The two purposes of this study were to compare the incidence of AF in patients undergoing MIDCAB to the incidence seen in patients referred for traditional CABG, and to determine whether the mode of coronary artery bypass is an independent predictor of postoperative AF.

METHODS

Patient eligibility. Consecutive patients undergoing coronary artery bypass at The Valley Hospital during the period January 1996 through May 1999 were identified through a department log. Approximately eight times as many CABG procedures were performed over this period compared with MIDCAB. Because selection of consecutive patients might bias the results of our analysis in favor of the MIDCAB group who were more recently operated and received more contemporary postoperative care, we randomly selected

Abbreviations and Acronyms

AF = atrial fibrillation
CABG = coronary artery bypass graft surgery
MIDCAB = minimally invasive direct coronary artery
bypass surgery

patients over a similar time period. The hospital charts for these selected groups of patients were then examined in detail. Patients undergoing concomitant valvular or septal repair surgery were excluded. Only patients who were in normal sinus rhythm on preoperative electrocardiogram (ECG) were eligible for the study.

Data collection. Baseline clinical variables, method of bypass (CABG vs. MIDCAB), and postoperative course, including the development of postoperative AF or the occurrence of other serious postoperative events, were recorded through careful chart review. A postoperative event included any one or more of the following events: significant postoperative infection (pneumonia, wound infection, bacteremia), a significant neurologic event (cerebral vascular accidents or seizures), respiratory failure requiring mechanical ventilation over 48 h, peripheral or pulmonary emboli, acute renal failure, clinically significant ventricular arrhythmias or high-grade atrioventricular (AV) block, repeat surgery, or wound disruption. The development of AF was defined as any episode of AF noted by ECG or telemetry monitoring, or documented in the chart by a member of the healthcare staff, lasting for 1 h or more. The postoperative day that AF was first detected, the development of recurrent AF, and the longest duration of AF were also recorded.

Statistical analysis. Statistical analyses were performed using SPSS (Statistical Package for the Social Sciences). Baseline characteristics and postoperative course for the two surgical techniques were compared by chi-square tests for discrete outcomes and the Student *t*-tests for continuous outcomes. Logistic regression was employed to obtain unadjusted and adjusted odds ratios (ORs) for all predictors of postoperative AF. Because ORs overestimate the relative risk (RR) when the rate of the event is greater than 10%, we evaluated the univariate OR for developing AF in CABG patients compared with MIDCAB patients. Logistic regression analysis was then used to test whether the difference in rates of AF between the MIDCAB and CABG groups was still significant after adjusting for possible AF risk factors. All ORs were corrected to obtain a closer estimation of the RR, as proposed by Zhang and Yu (28).

RESULTS

Baseline clinical variables and hospital course. Two hundred and nine patients (101 MIDCAB patients and 108 CABG patients) were examined. The baseline clinical characteristics of these patients are depicted in Table 1. The MIDCAB patients were younger (64 ± 12 vs. 67 ± 10 years, p = 0.04), were less likely to have had a history of

Table 1. Baseline Clinical Variables

Clinical Variable	MIDCAB	CABG	p Value
Age (yrs)	64 ± 12	67 ± 10	0.04
Male gender	75%	71%	0.54
Diabetes	23%	32%	0.13
Hypertension	66%	67%	1.0
Prior AF	6%	11%	0.40
Prior MI	34%	38%	0.57
Prior CABG	2%	12%	0.006
Lung disease	10%	11%	0.82
LVH on ECG	15%	8%	0.19
Preoperative BB	71%	70%	1.00
LVEF	54 ± 11	51 ± 12	0.10
Single-vessel disease	53%	3%	< 0.001*
Triple-vessel disease	15%	69%	

*The p value for overall test of difference in number of diseased vessels.
AF = atrial fibrillation; BB = beta-blockers; CABG = coronary artery bypass graft surgery; ECG = electrocardiogram; LVEF = left ventricular ejection fraction; LVH = left ventricular hypertrophy; MI = myocardial infarction; MIDCAB = minimally invasive direct coronary artery bypass surgery.

prior cardiac surgery (2% vs. 12%, p = 0.006) and had less extensive coronary artery disease (53% of MIDCAB patients vs. 3.0% of CABG patients had single-vessel disease, whereas 15% of MIDCAB patients vs. 69% of CABG patients had triple-vessel disease, p < 0.001 for overall group comparisons). There was a trend toward higher left ventricular ejection fractions (LVEF) in the MIDCAB group (54 ± 11 vs. 51 ± 12, p = 0.10). No significant differences existed in gender, or the incidence of diabetes, hypertension, prior myocardial infarction, prior AF, preoperative use of beta-blockers, or left ventricular hypertrophy between the two groups.

Table 2 depicts the intra-operative and postoperative course for the two surgical techniques. As a result of the less extensive coronary artery disease, MIDCAB patients received significantly fewer bypass grafts (1.4 ± 0.8 vs. 3.3 ± 1.0, p < 0.001). There was a trend toward a lower incidence of postoperative events for MIDCAB patients (19% vs. 30%, p = 0.08). The postoperative length of stay was significantly shorter in MIDCAB patients (6.6 ± 3.6 vs. 8.8 ± 5.8, p = 0.001). The percentage of patients treated with beta-blocking agents after surgery was similar for the two groups.

Postoperative atrial fibrillation. Twenty-three (23%) of MIDCAB patients and 42 (39%) of CABG patients developed AF after surgery (p = 0.02). The AF occurred 2.4 ± 1.2 days after MIDCAB versus 3.1 ± 1.9 days after CABG

Table 2. Intraoperative and Postoperative Course for CABG Versus MIDCAB

Clinical Variable	MIDCAB	CABG	p Value
Number of vessels bypassed	1.4 ± 0.8	3.3 ± 1.0	< 0.001
Postoperative BB	65%	70%	0.46
Postoperative event*	19%	30%	0.08
Postoperative hospital stay (days)	6.6 ± 3.6	8.8 ± 5.8	0.001

*See Methods for details.
BB = beta-blockers; CABG = coronary artery bypass graft surgery.

Table 3. Results of Univariate Logistic Regression for Postoperative AF

Clinical Variable	OR (95% CI)	p Value
Age*	1.05 (1.02, 1.08)	0.0024
Male gender	1.66 (0.87, 3.14)	0.12
Prior AF	9.87 (2.62, 37.27)	0.0007
LVEF*	0.99 (0.96, 1.01)	0.26
Left main disease	2.46 (1.23, 4.94)	0.01
CABG	2.16 (1.18, 3.95)	0.01
Number of vessels bypassed	1.34 (1.08, 1.68)	0.009
No postoperative BB	4.08 (2.18, 7.64)	0.0001
Postoperative event	2.84 (1.47, 5.46)	0.0018

*Odds ratios for continuous variables increase exponentially with each additional unit increment.

AF = atrial fibrillation; BB = beta-blockers; CABG = coronary artery bypass graft surgery; LVEF = left ventricular ejection fraction.

(p = 0.15). The percentage of patients with recurrent episodes of postoperative AF was similar in the MIDCAB and CABG groups (52% for MIDCAB and 60% for CABG, p = 0.60). The duration of AF ranged between 1 and 300 h (median = 9 h) for the MIDCAB group and between 1 and 432 h (median = 8 h) for the CABG group (p = 0.52). Eighty-seven percent of MIDCAB patients and 83% of CABG patients had AF for over 24 h (p = 0.73).

Table 3 depicts the univariate predictors of postoperative AF for the entire set of patients studied. Among nine variables examined, seven were associated with postoperative AF. Patients undergoing CABG were significantly more likely to develop AF compared with MIDCAB patients, OR = 2.16, 95% (CI [confidence interval] 1.18–3.95). The corrected OR using the approximation by Zhang and Yu (28) was 1.71, 95% CI (1.17–2.59).

To control for possible confounding attributable to baseline differences between CABG and MIDCAB patients, a multivariate logistic regression analysis was performed on all potentially significant variables to determine which variables constituted independent predictors of postoperative AF (Table 4). After adjustment for baseline clinical variables and operative data, the method of revascularization was no longer a significant predictor for the development of AF. The uncorrected OR for developing AF in CABG versus MIDCAB was 2.10, 95% CI (0.57–7.71). With correction, the approximation to the RR was found to be 1.68, 95% CI (0.63–3.03). An even lower estimate of the RR for AF in the two patient groups was obtained when only four other covariates are included in the logistic regression (left main disease, absence of postoperative beta-blocker use, prior AF, and postoperative event). The uncorrected OR for method of revascularization was 1.9, 95% CI (0.78–4.62), whereas

Table 4. Results of Multivariate Logistic Regression of Postoperative AF

Clinical Variable	OR (95% CI)	p Value
Prior AF	14.50 (2.88, 73.06)	0.0012
No postoperative BB	5.61 (2.17, 14.50)	0.0004
Significant event	2.73 (1.04, 7.22)	0.04

AF = atrial fibrillation; BB = beta-blockers.

correcting this to obtain the approximation to the RR yielded 1.57, 95% CI (0.82–2.52).

Because patients with a prior history of AF are known to be at higher risk for developing postoperative AF, we performed a separate analysis, excluding patients with a history of AF. When the data was re-analyzed by excluding patients with a prior history of AF, the results were similar: uncorrected OR (by multivariate analysis) for developing AF in CABG versus MIDCAB: 2.06, 95% CI (0.52 to 7.94). A closer approximation to the RR for developing AF in CABG versus MIDCAB (as explained in the previous paragraph) gives an OR of 1.72, 95% CI (0.59 to 3.42).

DISCUSSION

Atrial fibrillation is a common and clinically important postoperative arrhythmia and is associated with increased morbidity (3,4,6) and prolonged postoperative hospital stay (1–7), with a resultant increase in healthcare costs (1,7). In fact, AF prolongs hospitalization independent of other variables and is the most important remediable factor responsible for excess hospitalization (7). The current study demonstrates that although there is a significantly lower rate of AF in MIDCAB patients, after adjusting for differences in baseline and perioperative variables, postoperative AF appears to occur at similar frequencies irrespective of the method of revascularization. To our knowledge, this is the first study to examine the rates of AF among MIDCAB and CABG patients after accounting for differences in baseline variables and perioperative course.

In the current study, rates of AF in MIDCAB patients were high, with nearly one-fourth of patients developing postoperative AF. In addition, the patterns of AF after MIDCAB, including the rates of recurrent AF and the longest duration of AF, paralleled CABG patients. This information is important to healthcare professionals caring for patients referred for MIDCAB procedures; it implies that AF following MIDCAB is analogous to AF after CABG, with an equal possibility for associated co-morbidity and increases in healthcare costs. By recognizing the potential for AF after MIDCAB, physicians will be more likely to institute aggressive measures to prevent AF, in an effort to decrease postoperative costs, and to avoid associated complications.

Atrial fibrillation in MIDCAB patients: Earlier reports. Prior investigators have reported that AF is uncommon following MIDCAB, occurring in 0% to 24% of patients (24–27). However, few studies have actually compared the rates of postoperative AF in MIDCAB patients with that of CABG patients (25–27). In one small report (25) in which 23 patients undergoing reoperation using the MIDCAB approach were compared with a historical control of 12 patients undergoing conventional reoperative bypass surgery, none of the MIDCAB patients developed postoperative AF, compared with 7 (58%) of the CABG patients (p < 0.001). In another report that retrospectively examined

a group of 34 MIDCAB patients and 747 CABG patients (26), there was a trend toward a lower rate of AF in the MIDCAB group compared with the CABG group (12% vs. 26%, p = 0.06). Neither of these studies controlled for potential differences in baseline variables between the two surgical groups. Because we know that age (1,3–5,29,30) and LVEF (31) can impact on risk for developing postoperative AF, it is important that these clinical characteristics be considered when comparing rates of AF.

In a study by Cohn et al. (27) the investigators compared 55 MIDCAB patients with an age-matched group of 55 patients referred for conventional CABG. As a result of the study design, the mean ages for both groups were similar; however, important differences existed in other preoperative variables and in the postoperative course between the two groups. The incidence of postoperative AF was similar in the MIDCAB and CABG groups (24% vs. 20%, p = 0.64), implying that age may be a significant factor to explain the seemingly low rate of AF in MIDCAB patients.

Mechanisms of postoperative atrial fibrillation. Certain patient subsets are at known higher risk for developing postoperative AF. Although age is probably the most important risk factor for developing postoperative AF (1,3–5,29,30) compromised left ventricular function has been shown to independently predict the development of AF after cardiac surgery (31). In the current study, important differences were seen in the mean age and in LVEF of CABG and MIDCAB patients, indicating that the CABG group may have been at higher risk for developing postoperative AF.

Among patients with an underlying predisposition to develop postoperative AF, this arrhythmia is likely triggered by factors related to cardiac surgery and the postoperative recovery. Clinical observations have demonstrated the importance of adrenergic tone as a determinant of postoperative AF (32–36): patients experiencing AF after cardiac surgery have higher levels of norepinephrine than do those who remain in sinus rhythm (30), and studies of heart rate variability have indicated that sympathetic activity precedes AF after CABG (33).

In the current study, the absence of postoperative beta-blockers was independently associated with higher rates of postoperative AF, demonstrating the importance of controlling adrenergic tone after surgery. The similar adjusted rates of AF for MIDCAB and CABG patients implies that increased adrenergic tone is an important inciting factor for developing AF in both surgical groups. It is possible that adrenergic tone may be heightened in MIDCAB patients, despite the less invasive surgery, owing to a relatively higher degree of postoperative discomfort/pain related to thoracotomy, and earlier reversal of deep anesthesia.

Atrial necrosis or ischemia (4,11–13), electrolyte abnormalities occurring as a result of cardiopulmonary bypass (14–16), and pericarditis (17,18) have all been proposed as potential triggers for postoperative AF. However, excessive myocardial manipulation (which may predispose to pericarditis), atriotomy (which can contribute to atrial necrosis) and cardiopulmonary bypass (which can result in atrial ischemia or electrolyte abnormalities) are absent in MIDCAB procedures. Despite their absence, the rates of AF after MIDCAB are similar to that of CABG patients. Although these stimuli for developing postoperative AF may be important among CABG patients, the equal frequency of AF in MIDCAB and CABG patients implies that other triggers for AF likely predominate.

Conclusions. We conclude that the adjusted rates of AF are similar after MIDCAB and CABG. The fact of similar frequencies of AF for the two surgical techniques raises the possibility that similar inciting factors are at work.

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