Patient care problems in patients undergoing reoperation for coronary artery grafting surgery

Chester Brummett MD, J.G. Reves MD,
William A. Lell MD, Lloyd R. Smith MA

Over the past six years there has been a 15-fold increase in the number of patients requiring reoperation coronary artery bypass grafting (RCABG) surgery at the University of Alabama in Birmingham. To determine the perioperative risk, a retrospective chart survey of one calendar year's (1981) experience was made comparing the 58 RCABG patients with 59 cohorts undergoing primary operation. All patients were anaesthetized with diazepam, fentanyl and halothane or enflurane anaesthesia. Preoperative evaluation revealed by history that the incidence of unstable angina and digoxin use were greater ($p = 0.05$) in the RCABG patients. Cardiac catheterization revealed a higher incidence (26 vs 89 percent) of left main coronary disease in controls and similar indices of left ventricular function (wall abnormalities, ejection fraction and LVEDP). Operating and bypass times were longer ($p < 0.01$) for RCABG patients and there was a trend for greater ($p = 0.08$) use of dopamine in the RCABG patients. CK-MB release was significantly ($p < 0.05$) greater in RCABG patients. Serious postoperative complications (CK-MB ≥ 15 IU/L, low cardiac output, and death) were significantly ($p = 0.02$) greater in the RCABG group. It is concluded that RCABG patients represent a greater risk of complications and that new strategies for improving myocardial protection need to be developed to reduce the risk.

Key words
SURGERY, CARDIAC: coronary artery bypass grafting, reoperation; ANAESTHESIA, CARDIOVASCULAR: myocardial protection.

Over the six-year-period from 1976 through 1981, the percentage of reoperations for coronary bypass grafting (RCABG) increased fifteen-fold at the University of Alabama Medical Center. Although complete data are not available, this probably represents a world-wide trend. Despite the increasing frequency of this operation there is little published information regarding the course of these patients during anaesthesia and in the perioperative period. This study compares the intraoperative and early postoperative interventions and clinical course of RCABG patients with cohorts undergoing primary revascularization. RCABG patients have more perioperative complications than their cohorts, and therefore, present a greater anaesthetic risk.

Methods

From January to December 1981, 1,289 patients underwent isolated myocardial revascularization at UAB. Fifty-eight (4.5 per cent) were reoperations. These 58 patients were compared with 59 cohorts of the same age, undergoing primary operation during the same time period. All patients underwent elective operation scheduled for treatment of

From the Department of Anesthesiology, The University of Alabama Medical Center, Birmingham, Alabama.

Address correspondence to: J.G. Reves MD, Department of Anesthesiology, The University of Alabama Medical Center, 619 19th St. S, Birmingham, Alabama 35294.

TABLE I Variables compared between RCABG and CABG patients

Preoperative	*Intraoperative*	*Postoperative*
Age, weight, BSA	Anaesthetic agents	Cardiovascular adjuvant agents
Systemic disease	Cardiovascular adjuvant agents	Arrhythmias
Hypertension, CHF	Duration of CPB	Hypertension
Arrhythmias	Duration of myocardial ischaemia	Hypotension
Myocardial infarction	Time in OR	Low cardiac output
Unstable angina	Number of grafts	Myocardial damage (EKG and CKMB isoenzyme)
Angina class	IABP use	IABP use
Medications		Hemoglobin at 12 hrs
Catheterization data		Cumulative chest tube drainage
		Cumulative blood administration
		Duration of intubation
		Duration of ICU stay
		Mortality

angina, myocardial infarction, or positive stress test which lead to angiographic determination of coronary artery disease. The majority of patients had symptoms of unstable angina which was defined as an increased severity of angina and/or an increased frequency of anginal attacks during the past three months. The cohorts were chosen by matching patients of the same age and surgeon done in the same week of the year. Anaesthetic management was conducted according to previously published techniques.[1] Briefly, patients were premedicated with diazepam (0.1–0.15 $mg \cdot kg^{-1}$, p.o.), morphine (0.1 $mg \cdot kg^{-1}$, i.m.), and scopolamine (0.2–0.5 mg, i.m.) given about 90 minutes prior to surgery. Induction was accomplished with diazepam (0.3–0.5 $mg \cdot kg^{-1}$, i.v.), pancuronium (0.08–0.1 $mg \cdot kg^{-1}$, i.v.) and lidocaine (160 mg) four per cent applied topically to the larynx, followed by orotracheal intubation. Anaesthesia maintenance consisted of 50 per cent N_2O in O_2, fentanyl (10–30 $\mu g \cdot kg^{-1}$) and halothane or enflurane sufficient to keep haemodynamic variables ±20 per cent of baseline. Before and after orotracheal intubation, the following interventions were made when necessary to control the determinants of myocardial oxygen supply and demand:

1. Crystalloid fluid administration to insure adequate circulatory blood volume, cardiac output and coronary perfusion.

2. Adjustment of the inspired concentration of halothane or enflurane to minimize increases in heart rate and blood pressure.

3. Administration of additional agents (diazepam, fentanyl, droperidol, propranolol) in part to control blood pressure and heart rate.

4. Administration of vasodilators (nitroprusside, nitroglycerin) to minimize elevation in left and right atrial pressures.

5. Administration of vasoconstrictors (methoxamine or phenylephrine) to increase aortic pressure and thus coronary blood flow.

After establishment of cardiopulmonary bypass and aortic cross-clamping, 4° C cardioplegic solution containing 30 mEq/l potassium was infused at a flow of 150 $ml \cdot min^{-1} \cdot m^2$ for 2 to 3 minutes. The cardioplegic infusion was repeated every 20 to 30 minutes, when septal myocardial temperature exceeded 18° to 20° C, or upon return of electromechanical activity.

RCABG patients were compared with primary CABG patients with regard to the pre, intra, and immediate postoperative variables listed in Table I. The post-operation period was defined as the entire stay in the intensive care unit. Mean data between groups were compared for statistical differences with a Student's t test or by Chi square analysis where appropriate.

Results

Preoperative

The incidence of preoperative arrhythmias and congestive heart failure was almost twice as great in RCABG patients (Table II). Unstable angina was significantly greater in the RCABG group as was the use of digoxin. Cardiac catheterization data (Table III) revealed a significantly higher incidence

TABLE II Preoperative variables and medications

	RCABG			*CABG*			
Variables	*Positive*	*Total Cases*	*%*	*Positive*	*Total Cases*	*%*	*P*
Hypertension	22	53	42	20	56	36	NS
Congestive heart failure	10	53	19	5	58	9	NS
Arrhythmias	15	51	29	8	56	14	0.096
Myocardial infarction	34	51	67	35	59	59	NS
Unstable angina	38	48	79	30	51	59	0.05
Angina class	0 I II III IV		0	I II III IV			
	5 0 8 17 12		6	1 9 21 8			

	RCABG			*CABG*			
Medications	*Positive*	*Total Cases*	*%*	*Positive*	*Total Cases*	*%*	*P*
Aldomet	0	52	0	5	59	8	0.09
Apresoline	3	52	6	3	59	5	NS
Digoxin	24	54	44	7	59	12	0.0002
Hydrochlorthiazide	9	53	17	9	59	15	NS
Isordil	37	52	71	34	59	58	NS
Nitroglycerin	39	54	72	37	59	63	NS
Propranolol	37	54	69	39	59	66	NS
Quinidine	3	53	6	2	59	3	NS

	RCABG	*CABG*	*P*
Since last MI (months)*	56.84 ± 10 (0–204)	41.21 ± 9.7 (1–204)	NS
Age (yrs)	58 ± 0.89 (42–68)	58.1 ± 0.89 (42–74)	NS
Weight (kg)	79.3 ± 1.68 (52–109)	79.3 ± 1.43 (53–108)	NS
BSA (m^2)	1.97 ± 0.025 (1.51–2.38)	1.97 ± 0.021 (1.55–2.35)	NS

*Mean ± SEM (range).
The number of total cases does not equal the number of patients in each group (n = 58 RCABG, n = 59 CABG) when the variable under study could not be ascertained from the record. For example, presence or absence of a history of hypertension could be documented in 53 RCABG and 56 CABG.

of left main disease in the primary group but a similarity in indices of left ventricular function (ejection fraction, LVEDP, and wall motion abnormalities). Ejection fractions were available in 22 CABG patients and 19 RCABG patients; there were seven patients in both groups with ejection fraction <0.40.

Intraoperative

The anaesthetic agents used in the two groups were the same. Though not statistically different, there were some different trends in the use of cardiovascular adjuvant drugs (Table IV). Post-bypass inotropic support with dopamine was more frequent in the RCABG (11 pts.) group compared to controls (4 pts.). Nitroprusside was used more often in CABG patients and nitroglycerin more frequently in the RCABG group. The total anaesthesia time and duration of cardiopulmonary bypass were significantly ($p < 0.01$) longer in the RCABG group. However, the aortic cross-clamp times were similar despite the fact that significantly ($p < 0.02$) more anastamoses were performed in the CABG group. The intra-aortic balloon assist device was used in 3 RCABG patients and no CABG patients.

Postoperative

Postoperative uses of dopamine, sodium nitroprusside and nitroglycerin were similar to the intraoperative period (Table V). The incidences of arrhythmias and postoperative hypertension (mean blood pressure > 100 mmHg) were similar for both

TABLE III Cardiac catheterization data

	RCABG			*CABG*			
	Present	*Total Cases*	*%*	*Present*	*Total Cases*	*%*	*P*
Akinesia	10	42	24	14	48	29	NS
Dyskinesia	3	41	7	4	48	8	NS
Hypokinesia	29	42	69	27	48	56	NS
Involvement of left main	4	49	8	14	54	26	0.035
LAD disease	52	53	98	52	57	91	NS
LCX disease	48	55	87	49	58	84	NS
RCA disease	48	51	94	52	56	93	NS

	RCABG	*CABG*	*P*
Ejection fraction*	0.46 ± 0.041 (0.15–0.75)	0.50 ± 0.038 (0.21–8.5)	NS
Pre-injection LVEDP	14.04 ± 1.55 (4–32)	14.35 ± 1.91 (1–52)	NS
Post-injection LVEDP	22.67 ± 2.25 (8–40)	19.67 ± 1.38 (10–34)	NS

*Mean ± SEM (range) – ejection fractions were available in only 22 CABG patients and 19 CABG patients.

TABLE IV Intra-operative data

	RCABG (n = 58)				*CABG (n = 59)*				
CV adjuvant agents	*Prebypass*	*%*	*Postbypass*	*%*	*Prebypass*	*%*	*Postbypass*	*%*	*P*
Atropine	1	2	0	0	0	0	0	0	NS
Calcium	0	0	1	2	0	0	4	7	NS
Dopamine	0	0	11	19	0	0	4	7	0.08
Ephedrine	1	2	0	0	0	0	0	0	NS
Epinephrine	0	0	1	2	0	0	0	0	NS
Lidocaine	0	0	3	5	1	2	5	8	NS
Nitroglycerin	6	10	11	19	3	5	6	10	NS
Nitroprusside	4	7	12	21	9	15	18	31	NS
Norepinephrine	0	0	1	2	0	0	0	0	NS
Phenylephrine	1	2	0	0	0	0	2	3	NS
Procainamide	0	0	0	0	0	0	1	2	NS
Propanolol	1	2	0	0	0	0	0	0	NS

	RCABG	*CABG*	*P*
OR time (min)*	309 ± 13.6 (150–720)	266 ± 9 (165–575)	0.009
Bypass time (min)	97.6 ± 5.1 (31–209)	80.8 ± 3.3 (33–139)	0.007
X-clamp time (min)	49.5 ± 3.1 (12–105)	50.9 ± 3 (13–106)	NS
No. of grafts	3.45 ± 0.19 (1–6)	4.2 ± 0.24 (1–9)	0.02

*Mean ± SEM (range).

groups (Table VI). Although the incidence was not significantly different, hypotension (mean blood pressure requiring support) and low cardiac output (CI ≤ 1.8) occurred more frequently in the RCABG group. EKG evidence of infarction (appearance of a new Q wave of 0.04 second duration) was two per cent in both groups; however, CK-MB isoenzyme release was significantly greater in RCABG patients (Figure 1). There were three deaths in the RCABG group and none in the CABG patients.

Despite similar postoperative chest tube drainage volumes and greater blood administration to the

RCABG patients, the 12-hour postoperative haemoglobin was significantly lower in the reoperation group (Table VI). The duration of endotracheal intubation was similar, but the ICU stay was longer for RCABG patients.

Discussion

There are increasing numbers of patients with ischaemic heart disease who require anaesthesia for reoperation coronary artery bypass grafting. The incidence of RCABG surgery is 4.5 per cent of all CABG operations at our hospital and the Cleveland Clinic.[2] Indications for reoperation include progression of disease and/or graft occlusion. There are a number of reports of the results of RCABG operations,[2–12] most of which address only the operative risks and surgical complications. Some suggest an increase[2,9,12] while others report similar risks to the first operation.[3,5,6,8] None of these reports have compared a RCABG group of patients with a cohort group undergoing operations during a contemporaneous period. Studies which compare morbidity and risk of RCABG patients to their initial operative course[4–8] introduce biases by assuring zero mortality and probably some reduction of high risk complications in the control group. Only one previous study addresses considerations of anaesthetic management.[2] Estafanous found a potential for development of left ventricular dysfunction, myocardial damage, high blood utilization and respiratory insufficiency in RCABG patients.[2] With the exception of prolonged ventilatory requirements, our findings are in agreement; however, we examined many more variables and have a contemporaneous control group for comparison.

We found an important history of congestive heart failure, unstable angina and arrhythmias in RCABG patients collectively; a need for intra- and postoperative use of dopamine, nitroglycerin, and IABP to treat low cardiac output; and an increased mortality among RCABG patients. If the incidence of CK-MB > 15, low cardiac output, IABP use, and death are combined, there is a significantly ($p = 0.02$) greater risk of these serious cardiac complications in the RCABG group compared to controls. This increased risk is associated with an increased release of CK-MB isoenzyme (Figure 1), a sensitive and specific index of myocardial damage. Myocardial damage can occur at any time during the perioperative period secondary to inadequate anaesthetic or surgical management or inadequate myocardial preservation during cardiopulmonary bypass. With regard to anaesthetic and surgical management, we have previously reported low levels of myocardial damage using the anaesthetic techniques described.[1,13] The finding that fewer grafts were performed in RCABG patients compared to CABG patients during similar aortic cross-clamp times suggests that revascularization was technically more difficult and/or incomplete in the RCABG group. However, we hypothesize that the primary cause of increased CK-MB isoenzyme

TABLE V Postoperative support medications

Cardiovascular adjuvant agents	*RCABG* ($n = 58$)	%	*CABG* ($n = 59$)	%	*P*
Alphamethyldopa	11	19	13	22	NS
Calcium	2	3	0	0	NS
Digoxin	22	38	24	41	NS
Dopamine	11	19	5	8	NS
Furosemide	15	26	14	24	NS
Isordil	23	40	17	29	NS
Lidocaine	15	26	10	17	NS
Nitroglycerin	13	22	6	10	NS
Nitroprusside	39	67	47	80	NS
Procainamide	13	22	13	22	NS
Propranolol	8	14	6	10	NS
Quinidine	10	17	15	25	NS

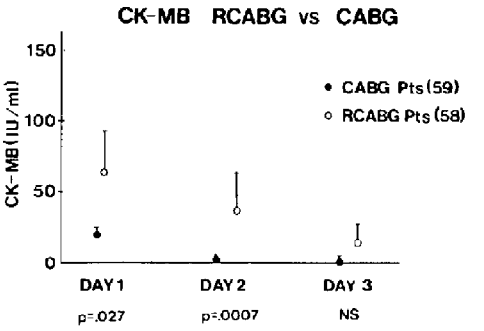

FIGURE 1 Mean ± SEM of values of the myocardial specific isoenzyme, CK-MB, in patients following coronary grafting surgery. Note that on the first and second postoperative days the CK-MB is significantly higher in reoperation (RCABG) than in primary coronary artery bypass grafted (CABG) patients.

TABLE VI Postoperative variables

	RCABG			*CABG*			
	Positive	*Cases*	*%*	*Positive*	*Cases*	*%*	*P*
Arrhythmias:							
PVC	36	58	62	35	59	59	NS
Ventricular tachycardia	2	58	3	1	59	2	NS
Ventricular fibrillation	1	58	2	0	59	0	NS
PAC	8	58	14	8	59	14	NS
Atrial tachycardia	11	58	19	11	59	19	NS
Atrial fibrillation	9	58	16	15	59	25	NS
Junctional	2	58	3	0	59	0	NS
Hypertension	6	57	11	5	59	8	NS
Hypotension	8	58	14	2	59	3	0.09
Low cardiac output	3	58	5	0	59	0	NS
Infarct EKG-postop day 3	1	47	2	1	54	19	NS
Mortality	3	58	5	0	59	0	NS
IABP Use	3	58	5	0	59	0	NS
Re-entry for bleeding	1	58	2	5	59	8	NS

	RCABG (n = 58)	*CABG (n = 59)*	*P*
CKMB – day 1*	65.5 ± 27.3 (0–1386)	19.3 ± 3.9 (0–172)	0.027
CKMB – day 2	37.6 ± 23.1 (0–1886)	1.1 ± 0.3 (0–8)	0.0007
CKMB – day 3	14.0 ± 11.5 (0–514)	0.3 ± 0.17 (0–7)	NS
Hb – 12 hrs	9.6 ± 0.16 (6.1–11.8)	10.4 ± 0.144 (8.4–12.9)	0.0003
Chest drainage ml – 12 hrs	615.3 ± 46 (156–1783)	597.3 ± 55.2 (191–2280)	NS
Blood used ml – 12 hrs	793.8 ± 90.5 (0–2863)	569.6 ± 59.7 (0–1845)	0.04
Intubation time – hrs	13.4 ± 0.566 (5–30)	13.3 ± 0.577 (5–24)	NS
ICU – hrs	31.2 ± 2.65 (4–122)	23.8 ± 0.727 (16–52)	0.009

*Mean ± SEM (range).

release in RCABG is inadequate myocardial preservation during cardiopulmonary bypass. We have no direct data to prove or disprove this hypothesis. It is likely that non-coronary collateral flow via mediastinal adhesions is enhanced in RCABG patients. Buckberg *et al.*[14] have emphasized that the presence of noncoronary collateral flow can modify the effect of cardioplegic solutions used for myocardial preservation during aortic cross-clamping. The effective concentration and temperature of cardioplegic solutions infused after aortic cross-clamping will diminish with time secondary to persistent non-coronary collateral flow washout.[15] Thus interventions to maintain homogeneous myocardial cooling and prevent the accelerated washout of cardioplegic solution are critically important in RCABG patients. Supplemental measures to improve myocardial protection include periodic reinfusions of cardioplegic solutions and reducing systemic perfusate temperature, flow and pressure. Cold saline irrigation of the pericardial cavity, or other topical hypothermic techniques which are usually effective in minimizing the rate of myocardial rewarming[16–17] may be technically difficult in RCABG patients.

The limitations of retrospective studies, including the incomplete availability of data, as illustrated in this study, must be recognized. The findings of this study suggest the need to undertake prospective studies examining the clinical course and outcome in patients undergoing reoperation for coronary artery graft in surgery in comparison with patients undergoing primary operations.

In summary, we found RCABG patients to be susceptible to myocardial damage and its sequelae, low cardiac output and death. Whether this problem resulted from suboptimal application of current knowledge or demonstrate a need for new ap-

proaches is a question for continued investigation. However, the implications of this report are clear, reoperation patients represent greater risks and anaesthesiologists in concert with surgeons need to develop strategies to minimize this risk.

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Résumé

A l'Université de l'Alabama à Birmingham, on a observé au cours des six dernières années une augmentation par un multiple de 15 du nombre de réopérations pour pontage aorto-coronarien (RCABG). Pour déterminer le risque péri-opératoire de la réopération, une étude rétrospective portant sur l'année 1981 a comparé l'évolution de 58 malades réopérés avec l'évolution de 59 malades subissant la même opération pour la première fois. Tous ces patients ont été anesthésiés avec une combinaison de diazépam, fentanyl et halothane ou enflurane.

L'évaluation pré-opératoire indique que l'incidence de l'angine instable et de la digitalisation était plus élevée ($p = 0.05$) dans les malades réopérés. Au cathétérisme cardiaque on découvre une incidence plus élevée (26 vs 8 pour cent) de sténose du tronc commun de la coronaire gauche dans le groupe contrôle. Par ailleurs les indices de fonction ventriculaire gauche (dyskinésie, fraction d'éjection et pression télédiastolique) étaient similaires.

Le temps opératoire et le temps de circulation extra-

corporelle étaient plus longs ($p < 0.01$) pour le groupe réopéré et dans ce même groupe une tendance à employer la dopamine de façon plus fréquente ($p = 0.08$).

La production d'iso-enzymes CK-MB était plus élevée au cours de réopération ($p < 0.05$). Les complications post-opératoires graves (CK-MB ≥ à 15 IU/l, bas débit cardiaque, décès) sont survenues plus fréquemment dans le groupe réopéré ($p = 0.2$). On en conclut que la réopération pour pontage aorto-coronarien constitute un risque plus élevé de complications et qu'il faudra inventer ou à tout le moins perfectionner les méthodes de protection du myocarde pour les malades de cette catégorie.