Early outcomes of coronary artery bypass with and without cardiopulmonary bypass in octogenarians

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BACKGROUND: Off-pump coronary artery bypass (OPCAB) surgery has been successfully used in diverse patient populations and has been postulated to be safer than conventional coronary artery bypass (CCAB) surgery in some high-risk patients, including the elderly.

OBJECTIVE: To compare the safety of OPCAB surgery versus CCAB surgery in the octogenarian population of two large southwestern Ontario cardiac surgical units.

RESULTS: Two hundred thirty-six consecutive octogenarians underwent primary isolated coronary artery bypass surgery from November 2000 to March 2005. Patients undergoing OPCAB surgery tended to have higher Parsonnet scores, while patients undergoing CCAB surgery had a greater number of emergent operations. The Canadian Cardiovascular Network predicted that mortality risk was similar in both groups. In-hospital mortality was similar between groups, as was postoperative myocardial infarction and new onset of renal dysfunction. However, in the OPCAB group, there was a decreased incidence of postoperative neurological dysfunction (2.3% in the OPCAB group versus 10.5% in the CCAB group, $P=0.01$), in particular cerebrovascular accidents (1.5% in the OPCAB group versus 7.6% in the CCAB group, $P=0.05$), and a decreased incidence of prolonged intubation (5.3% in the OPCAB group versus 13.3% in the CCAB group, $P=0.04$). Multivariable analysis found that cardiopulmonary bypass had no significant impact on mortality or length of stay.

CONCLUSIONS: In octogenarian patients, OPCAB surgery is as safe as CCAB surgery in terms of mortality and major morbidity. Furthermore, a significant reduction in neurological dysfunction and prolonged intubation was seen in the OPCAB group compared with the CCAB group.

Key Words: *Cardiopulmonary bypass; Cerebrovascular accident; Coronary artery bypass surgery; Octogenarian; Off-pump; Stroke*

Octogenarians are an expanding group of patients referred for cardiac surgery. Currently comprising 3.0% of the Canadian population, the over 80 segment has been projected to reach 5.0% by 2026, and 8.8% to 8.9% by 2051 (1). Patients in this age group (ie, persons 80 years of age or older) tend to have higher rates of comorbid risk factors, which may result in more frequent and severe complications, and higher mortality rates. The consequent reluctance to operate on these 'old old' people has created a self-fulfilling prophecy wherein these older patients are referred for surgery only when their disease is highly advanced, thereby increasing morbidity and mortality rates (2). Nevertheless, surgical outcomes in this age group have been encouraging (3-7).

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Les issues précoces du pontage aortocoronarien avec et sans circulation extracorporelle chez des octogénaires

HISTORIQUE : Le pontage aortocoronarien à cœur battant (PACCB) est utilisé avec succès auprès de diverses populations de patients et est considéré plus sûr que le pontage aortocoronarien classique (PACCC) chez certains patients très vulnérables, y compris les personnes âgées.

OBJECTIF : Comparer l'innocuité du PACCB par rapport au PACCC dans la population octogénaire de deux grandes unités de chirurgie cardiaque du sud-ouest de l'Ontario.

RÉSULTATS : Deux cent trente-six octogénaires consécutifs ont subi un pontage aortocoronarien isolé primaire entre novembre 2000 et mars 2005. Les patients qui ont subi le PACCB avaient tendance à afficher un indice de Parsonnet plus élevé, tandis que ceux qui subissaient un PACCC avaient tendance à subir plus d'opérations émergentes. Le *Canadian Cardiovascular Network* prévoyait un risque de mortalité similaire dans les deux groupes. La mortalité hospitalière était similaire entre les groupes, de même que les infarctus du myocarde postopératoires et la dysfonction rénale *de novo*. On remarquait une diminution de l'incidence de dysfonction neurologique postopératoire (2,3 % au sein du groupe de PACCB par rapport à 10,5 % au sein du groupe de PACCC, $P=0,01$), surtout des accidents cérébrovasculaires (1,5 % au sein du groupe de PACCB par rapport à 7,6 % au sein du groupe de PACCC, $P=0,05$), ainsi qu'une diminution de l'incidence d'intubation prolongée (5,3 % au sein du groupe de PACCB par rapport à 13,3 % au sein du groupe de PACCC, $P=0,04$) au sein du groupe de PACCB. L'analyse multivariable a déterminé que la circulation extracorporelle n'avait aucune répercussion significative sur la mortalité ou la durée d'hospitalisation.

CONCLUSIONS : Chez les patients octogénaires, le PACCB est aussi sécuritaire que le PACCC pour ce qui est de la mortalité et de la morbidité importante. De plus, on a rendu compte d'une diminution marquée de la dysfonction neurologique et de l'intubation prolongée au sein du groupe de PACCB par rapport au groupe de PACCC.

The merits and indications of off-pump coronary artery bypass (OPCAB) surgery continue to be debated as the body of evidence examining this technique grows. Recent meta-analyses have suggested that compared with conventional coronary artery bypass (CCAB) surgery, OPCAB surgery may significantly reduce stroke (OR of 0.38, 95% CI 0.22 to 0.65) (8), duration of ventilation (3.4 fewer hours, 95% CI 1.7 to 5.0) (9), atrial fibrillation (OR of 0.58 to 0.7, 95% CI 0.44 to 0.89) (9,10), transfusion requirements (OR of 0.43, 95% CI 0.29 to 0.65) (9) and postoperative length of stay (LOS) (one fewer day in hospital, 95% CI 0.5 to 1.5) (9). Conversely, some randomized controlled trials have been unable to show such benefits (11-13),

or have questioned the long-term benefit of OPCAB surgery in terms of graft patency (14).

As investigators continue to elucidate the appropriate role for OPCAB surgery, some authors have shown that higher-risk patients, including the elderly, stand to benefit most from avoiding the cardiopulmonary bypass (CPB) circuit (4,15-17). The elderly may be particularly at risk for higher morbidity after CPB due to decreased physiological reserves and greater incidences of comorbid illnesses, which may impair their response to the post-CPB inflammatory syndrome. Avoiding the aortic cannulation and cross-clamping associated with CPB may also benefit these patients because they may have a higher prevalence of aortic atheromatous disease. Published series examining the use of CPB in the elderly have reported significantly better outcomes in the OPCAB group, namely, decreased mortality (18,19), stroke (19,20), blood product transfusion (19,21), and postoperative intensive care unit (ICU) and hospital LOS (21). Here we present an analysis of our experience with this group of patients, in a combined series, from two busy cardiac surgery units in southwestern Ontario: the London Health Sciences Centre (London, Ontario) and the Trillium Health Centre (Mississauga, Ontario).

METHODS

From November 2000 to March 2005, 3379 patients at the Trillium Health Centre and 6919 patients at the London Health Sciences Centre underwent cardiac surgery. From these patients, those who were at least 80 years of age undergoing primary isolated coronary bypass were selected for study. To minimize extraneous factors, patients who underwent a salvage operation or had minimally invasive direct coronary artery bypass surgery were excluded from the study. An operation was defined as salvage if the patient was in hospital within 48 h preoperatively, in a state of cardiogenic shock requiring inotropes or an intra-aortic balloon pump, and/or being ventilated, and/or had a cardiac arrest. The two cardiac surgery databases yielded 236 consecutive octogenarians meeting our inclusion criteria. Fifty-six women and 75 men (n=131) who received an off-pump procedure formed the OPCAB group, while 28 women and 77 men (n=105) who received an on-pump procedure formed the CCAB group. These groups were concurrent and not sequential cohorts. It was the individual surgeon's decision to pursue either surgical strategy; this depended on factors such as the coronary anatomy, aortic calcification, the patient's ability to withstand an off-pump procedure and the surgeon's previous experience with OPCAB surgery.

Data were obtained by a retrospective review of prospectively recorded divisional databases and hospital records. Operational definitions of the study variables from the two databases were aligned. Recent myocardial infarction (MI) was defined as that occurring within one month of the operation. A preoperative serum creatinine level greater than 120 µmol/L, or the need for dialysis, was taken to indicate renal insufficiency. An emergent operation was one in which the patient was in either the coronary care unit or the ICU with intractable angina, and the operation began outside of the normal schedule. Operative mortality was defined as death from any cause within the same hospital admission. A neurological complication was defined as a focal deficit persisting for more than 24 h or a delirium persisting for more than 48 h; a cerebrovascular accident (CVA) was diagnosed with computed tomography of the head. Postoperative renal failure was defined as a new need for dialysis. A new arrhythmia was one that required defibrillation, a temporary or permanent pacemaker, or which persisted despite treatment; atrial

fibrillation successfully treated with antiarrhythmic medication was not counted.

Surgical technique

In all patients, a balanced general anesthetic technique was used. The specifics depended on the attending anesthesiologist's preference, but generally consisted of a moderate dose narcotic (usually fentanyl), a sedative (usually midazolam and/or propofol), an inhalational agent (usually sevoflurane or isoflurane) and a muscle relaxant. Spinal or epidural anesthesia was not used in either group. Continuous intra-operative monitoring allowed the anesthesiologist to optimize each patient's variables. Epiaortic scanning was carried out selectively and Doppler graft flow was measured routinely.

In the OPCAB group, heparin was administered to achieve an activated clotting time greater than 350 s. Deep pericardial retraction sutures were placed to facilitate exposure of the posterior and lateral borders of the heart. The Trillium Health Centre used suction-based stabilization, while the London Health Sciences Centre used mechanical stabilization. Operating table positioning was used to further improve exposure. When required, an intraluminal shunt was used. A clean surgical field was maintained by proximal and/or distal vessel occlusion with a silastic snare, and visibility was maintained using a CO₂ blower or blower/mister. In patients requiring proximal aortic anastomoses, a side-biting aortic clamp was used. Normothermia was maintained using a forced air blanket.

In the CCAB group, heparin was administered to achieve an activated clotting time greater than 480 s, and was reversed at the end of the procedure using protamine sulfate. CPB was instituted via standard cannulation. Depending on the surgeon's preference, myocardial protection was provided using intermittent antegrade and/or retrograde, tepid or cold, crystalloid or blood cardioplegia. CPB techniques, including pulsatile flow, were used to achieve and maintain a cardiac index of 2.4 L/min/m² and a mean arterial pressure greater than 60 mmHg. Blood gases were managed as per the alpha-stat protocol.

Statistical methods

Univariable statistical comparisons were made using Fisher's exact two-tailed test for nominal variables and the Wilcoxon two-sample test for continuous variables. A composite outcome comprising 10 prespecified major complications (death, stroke, MI, prolonged intubation, arrhythmia, intra-aortic balloon pumping, renal insufficiency, septicemia, mediastinitis and reoperation for bleeding) was analyzed to identify general trends in group outcomes. To evaluate the effect of OPCAB surgery versus CCAB surgery on LOS, death, and the composite of 10 major complications after adjustment for other significant characteristics, stepwise multivariable models were developed allowing for the entry of all potential characteristics except surgery type. To obtain an adjusted comparison, surgery type was forced into the stepwise model. The C-index and the Hosmer-Lemeshow goodness-of-fit test were calculated for the logistic regression models. Data were analyzed according to the intention-to-treat principle. Statistical significance was assumed when P<0.05. Statistical analyses were performed using SAS version 8.2 (SAS Institute Inc, USA).

RESULTS

Demographics

A summary of patient characteristics is presented in Table 1. The CCAB group had significantly fewer women, a higher incidence of left mainstem disease and more emergent operations. The OPCAB group had higher incidences of preoperative

TABLE 1
Demographic characteristics

Patient characteristics	CCAB group (n=105)	OPCAB group (n=131)	P
Age, mean years $\pm$ SD	82.3 $\pm$ 2.0	82.1 $\pm$ 2.3	0.20
Female, n (%)	28 (26.7)	56 (42.8)	0.01
Body mass index >30 kg/m ² , n (%)	25 (23.8)	27 (20.6)	0.64
Cerebrovascular disease, n (%)	8 (7.6)	14 (10.7)	0.50
Myocardial infarction, n (%)	40 (38.1)	62 (47.3)	0.19
Heart failure, n (%)	18 (17.3)	21 (16.0)	0.86
COPD, n (%)	13 (12.4)	16 (12.2)	>0.99
Diabetes, n (%)	16 (15.2)	26 (19.9)	0.40
Hypertension, n (%)	61 (58.1)	101 (77.1)	0.002
Hyperlipidemia, n (%)	54 (51.4)	85 (64.9)	0.05
Creatinine >120 μ mol/L, n (%)	25 (23.8)	41 (31.3)	0.24
Smoking history, n (%)	36 (34.3)	58 (44.3)	0.14
Peripheral vascular disease, n (%)	17 (16.2)	20 (15.3)	0.85
Left mainstem disease, n (%)	50 (47.6)	26 (19.9)	<0.001
Emergent, n (%)	18 (17.1)	11 (8.4)	0.05
Previous angioplasty, n (%)	5 (4.8)	10 (7.6)	0.43
Preoperative IABP, n (%)	5 (4.8)	4 (3.1)	0.52
Ventricular grades III/IV, n (%)	22 (21.0)	38 (29.0)	0.18
CCS grade IV, n (%)	83 (79.1)	103 (78.6)	>0.99
Parsonnet score $\pm$ SD	24.4 $\pm$ 3.4	25.1 $\pm$ 3.1	0.05
EuroSCORE $\pm$ SD	8.0 $\pm$ 2.4	8.4 $\pm$ 2.2	0.15
EuroSCORE mortality risk, % $\pm$ SD	12.7 $\pm$ 10.1	13.0 $\pm$ 8.6	0.28
CCN expected LOS, mean days $\pm$ SD	8.3 $\pm$ 1.3	8.6 $\pm$ 1.2	0.05
CCN mortality risk, %	4.9 $\pm$ 4.8	4.8 $\pm$ 5.8	0.41

CCAB Conventional coronary artery bypass; CCN Cardiac Care Network; CCS Canadian Cardiovascular Society; COPD Chronic obstructive pulmonary disease; EuroSCORE European system for cardiac operative risk evaluation; IABP Intra-aortic balloon pump; LOS Length of stay; OPCAB Off-pump coronary artery bypass

hypertension and hyperlipidemia. The Parsonnet score was found to be slightly higher in the OPCAB group (25.1 $\pm$ 3.1 versus 24.4 $\pm$ 3.4, $P=0.05$), with a consequent greater Cardiac Care Network (CCN) predicted LOS (8.6 $\pm$ 1.2 versus 8.3 $\pm$ 1.3 days, $P=0.05$). The predicted European system for cardiac operative risk evaluation (EuroSCORE), EuroSCORE mortality risk, and the CCN mortality risk were similar for both cohorts.

Outcomes

Two patients planned for CCAB surgery were switched to OPCAB surgery due to aortic atheromatous disease, and six patients planned for OPCAB surgery were switched to CCAB surgery due to hemodynamic instability or unsuitable coronary anatomy. As previously mentioned, these patients' data were analyzed with their intended treatment group. However, when analyzed according to actual treatment received, the results were similar. The average number of grafts placed in the OPCAB group was 2.76 $\pm$ 0.90, compared with an average of 3.16 $\pm$ 0.76 grafts placed in the CCAB group ($P<0.01$). In both groups, the median number of grafts was three.

A summary of the postoperative data is presented in Table 2. There were a total of seven deaths (6.7%) in the CCAB group and four deaths (3.1%) in the OPCAB group ($P=0.22$). Comparing the observed values with the expected values predicted by the CCN algorithm revealed an observed to expected mortality ratio of 0.56 in the OPCAB group and a ratio of 1.48 in the CCAB group ($P=0.28$). Postoperative

TABLE 2
Postoperative outcomes

Outcomes	CCAB group (n=105)	OPCAB group (n=131)	P
Death, n (%)	7 (6.7)	4 (3.1)	0.22
Neurological dysfunction, n (%)	11 (10.5)	3 (2.3)	0.01
Myocardial infarction, n (%)	7 (6.7)	3 (2.3)	0.11
Intubation >48 h, n (%)	14 (13.3)	7 (5.3)	0.04
Arrhythmia, n (%)	6 (5.7)	9 (6.9)	0.79
IABP, n (%)	3 (2.9)	7 (5.3)	0.52
Renal insufficiency, n (%)	5 (4.8)	6 (4.6)	>0.99
Septicemia, n (%)	2 (1.9)	0 (0.0)	0.20
Mediastinitis, n (%)	0 (0.0)	3 (2.3)	0.26
Reoperation for bleeding, n (%)	5 (4.8)	6 (4.6)	>0.99
Any of 10 major complications, n (%)	34 (32.4)	30 (22.9)	0.11
Mean days in ICU $\pm$ SD	1.0 $\pm$ 11.1	1.0 $\pm$ 2.6	0.44
Postoperative LOS, mean days $\pm$ SD	7.5 $\pm$ 16.9	7.0 $\pm$ 10.6	0.43
Observed/expected LOS $\pm$ SD	1.70 $\pm$ 2.13 (n=96)	1.27 $\pm$ 1.18 (n=124)	0.23
Observed/expected mortality ratio $\pm$ SD	1.48 $\pm$ 7.02 (n=102)	0.56 $\pm$ 4.26 (n=131)	0.28

CCAB Conventional coronary artery bypass; IABP Intra-aortic balloon pump; ICU Intensive care unit; LOS Length of stay; OPCAB Off-pump coronary artery bypass

TABLE 3
Logistic regression modelling – any of 10 major complications or death

Characteristics	Univariable		Multivariable	
	OR (95% CI)	P	OR (95% CI)	P
Off-pump	0.62 (0.35–1.11)	0.10	0.69 (0.36–1.30)	0.25
Heart failure	2.81 (1.38–5.73)	0.004	2.31 (1.07–5.00)	0.03
Ventricular grade III/IV	2.51 (1.34–4.69)	0.004	2.29 (1.16–4.53)	0.02
CCS grade IV	2.71 (1.15–6.40)	0.02	2.53 (1.05–6.11)	0.04
Left mainstem narrowing	2.20 (1.22–4.00)	0.009	2.09 (1.09–4.02)	0.03

C-index = 0.72, Hosmer-Lemeshow goodness-of-fit $\chi^2=5.404$ (five degrees of freedom), $P=0.611$. CCS Canadian Cardiovascular Society

neurological complications occurred in 11 patients (10.5%) in the CCAB group versus three patients (2.3%) in the OPCAB group ($P=0.01$); eight (7.6%) versus two patients (1.5%) of the respective groups experienced a radiologically confirmed CVA ($P=0.05$). Fourteen patients (13.3%) of the CCAB group required prolonged ventilatory support with intubation exceeding 48 h compared with seven (5.3%) of the OPCAB group ($P=0.04$). Other major postoperative events, including MI and new onset of renal failure, were not significantly different between groups. When analyzed collectively, the composite outcome of 10 major postoperative complications was not significantly different between groups.

Multivariable analysis demonstrated that use of CPB was not a significant risk factor for an adverse outcome (Table 3). When surgery type was added to the stepwise model, no difference between OPCAB and CCAB surgeries ($P=0.69$) was found. For the composite outcome, univariable and multivariable OR values and P values were presented for the final model in which surgery type was forced into the stepwise model. As depicted in Table 3, there was no difference between OPCAB and CCAB surgeries (unadjusted $P=0.105$, adjusted $P=0.25$). For LOS, which was log-transformed to improve normality, Canadian Cardiovascular Society grade IV, left mainstem narrowing and emergent

TABLE 4
Linear regression modelling – logarithmic length of stay

Characteristics	b (SD)	R ²	P
Off-pump surgery	-0.105 (0.091)	0.006	0.25
Emergent admission	0.275 (0.137)	0.018	0.05
Diabetes	0.042 (0.119)	0.001	0.72
Creatinine >120 µmol/L	0.191 (0.100)	0.016	0.06
COPD	0.187 (0.145)	0.008	0.20
Heart failure	0.238 (0.124)	0.016	0.06
Myocardial infarction	0.136 (0.091)	0.010	0.14
Ventricular grade III/IV	0.176 (0.105)	0.013	0.10
CCS grade IV	0.345 (0.106)	0.046	0.001
Left mainstem narrowing	0.257 (0.096)	0.032	0.008

Off-pump surgery (adjusted) $P=0.689$. CCS Canadian Cardiovascular Society; COPD Chronic obstructive pulmonary disease; R² Square of the correlation coefficient

admission were the only factors to enter the stepwise model (Table 4).

DISCUSSION

Surgical treatment of coronary artery disease in the elderly involves a significantly higher risk of morbidity and mortality than that of the general population (6,22). The surgeon must balance outcomes and risks with life expectancy and quality of life issues in day-to-day decisions regarding patient care, which is not a small feat. Currently, the published literature provides only rudimentary guidance in this respect.

In the present retrospective study, we compared the early outcomes of coronary artery bypass surgery with and without CPB in the octogenarian population. The most significant finding was a decreased incidence of postoperative neurological dysfunction in our off-pump cohort. This finding is in agreement with most recent reports of OPCAB versus CCAB surgery in this age group (8,19-21). Adverse neurological events, including CVAs, transient ischemic episodes and other neurobehavioural dysfunction have been associated with cerebral hypoperfusion, edema and emboli generation in both OPCAB and CCAB patients (23). In the CCAB patient, the mechanism is presumed to be related to the proinflammatory phenomenon of CPB and atheroembolism during cross-clamping of the aorta; in the OPCAB patient, the mechanism is presumed to be related to hypotension during the construction of distal anastomoses and atheroembolism during partial aortic clamping (24).

Despite an increased Parsonnet score in the OPCAB group, the incidence of mortality was not significantly different between groups. Four deaths (3.1%) occurred in the OPCAB group versus seven (6.7%) in the CCAB group ($P=0.22$). In comparison with the CCN predicted mortality ratio, the observed to expected mortality ratio was 0.56 in the OPCAB group compared with 1.48 in the CCAB group ($P=0.28$). Table 5 contains reported surgical coronary bypass mortality rates for patients comparable in terms of age and operative risk factors.

It is possible that the high-risk profile, documented with the Parsonnet score and the EUROscore calculations, contributed to the long postoperative LOS we observed in both the on- and off-pump groups. Reported postoperative hospital stay in the elderly population ranges from 4.4 to 14.9 days following OPCAB surgery and from 4.9 to 20.0 days following CCAB surgery (19,21,25-29). Our observed median postoperative LOS was seven days for OPCAB surgery and 7.5 days CCAB surgery ($P=0.43$). This is in keeping with shorter LOS following OPCAB

TABLE 5
Reported mortality rates of coronary artery bypass surgery in octogenarians

References	Mortality
Peterson et al (32)	11.5%*
Kirsch et al (33)	CCAB 12.8%
Schmitz et al (34)	15.5%*
Craver et al (35)	CCAB 8.1%†
Fruitman et al (7)	8.4%*
Sahar et al (36)	CCAB 4.0%
Alexander et al (6)	8.1%*
Ricci et al (20)	OPCAB 10.3%, CCAB 5.2% ($P=NS$)‡
Stamou et al (37)	OPCAB 6.0%
Yokoyama et al (38)	OPCAB 0.4%, CCAB 2.7% ($P=NS$)
Avery et al (22)	CCAB 9.3%
Sakamoto et al (39)	CCAB 3.1%
Smith et al (5)	4.2%*
Vermeulen et al (40)	5.4%*
Demaria et al (19)	OPCAB 4.8%, CCAB 15.9% ($P=0.04$)
Engoren et al (41)	8.2%*§
Hoff et al (42)	OPCAB 0%, CCAB 4.7% ($P=NS$)
Beauford et al (4)	OPCAB 0.9%
Wilson et al (43)	2.7%*

*Cardiopulmonary bypass strategy not reported; †Including emergent cases; ‡30-day mortality; §Off-pump coronary artery bypass (OPCAB) versus conventional coronary artery bypass (CCAB) mortality categorization not reported. NS Not significant

commonly reported in the literature for both general and elderly study populations (9,16,18,21,30). Intubation time and ICU stay were also within the reported range for elderly patients undergoing primary isolated coronary bypass surgery (5,21,31).

Limitations of the present study relate mainly to the retrospective and nonrandomized nature of the review. Although there were no specific selection criteria for using CPB in a particular patient, the potential selection bias could have affected the accuracy of our conclusion, and could have only been overcome with prospective randomization. Relatively small group sizes have always plagued investigators conducting research on the elderly and it may hence be argued that the present study was underpowered. These results will therefore need to be further investigated with larger group sizes capable of detecting smaller differences between groups.

CONCLUSIONS

The present study reviews our initial experience with the off-pump technique in patients who are at least 80 years of age. We report a lower incidence of neurological complications, in particular CVAs, in patients undergoing OPCAB compared with CCAB surgery. We also found a lower incidence of prolonged intubation in the OPCAB group. We did not observe significant differences in postoperative mortality, MI, renal insufficiency or the incidence of a composite of 10 major adverse events between groups. Similarly, postoperative ICU and hospital stay were not significantly different between groups.

OPCAB surgery appears at least as safe and effective as CCAB surgery in octogenarians, and perhaps significantly more so in some respects. We support the use of OPCAB surgery in octogenarians; however, it remains possible that CPB may still prove to be of greater benefit for a subset of this population. Further investigation is required to draw firm conclusions.

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