Quality improvement program decreases mortality after cardiac surgery

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Supplemental material is available online.

Objective: This study investigated the effects of a quality improvement program and goal-oriented, multidisciplinary protocols on mortality after cardiac surgery.

Methods: Patients were divided into two groups: those undergoing surgery (coronary artery bypass grafting, isolated valve surgery, or coronary artery bypass grafting and valve surgery) after establishment of the multidisciplinary quality improvement program (January 2005–December 2006, $n = 922$) and those undergoing surgery before institution of the program (January 2002–December 2003, $n = 1289$). Logistic regression and propensity score analysis were used to adjust for imbalances in patients' preoperative characteristics.

Results: Operative mortality was lower in the quality improvement group (2.6% vs 5.0%, $P < .01$). Unadjusted odds ratio was 0.5 (95% confidence interval 0.3–0.8, $P < .01$); propensity score–adjusted odds ratio was 0.6 (95% confidence interval 0.4–0.99, $P = .04$). In multivariable analysis, diabetes ($P < .01$), chronic renal insufficiency ($P = .05$), previous cardiovascular operation ($P = .04$), congestive heart failure ($P < .01$), unstable angina ($P < .01$), age older than 75 years ($P < .01$), prolonged pump time ($P < .01$), and prolonged operation ($P = .05$) emerged as independent predictors of higher mortality after cardiac surgery, whereas quality improvement program ($P < .01$) and male sex ($P = .03$) were associated with lower mortality. Mortality decline was less pronounced in patients with than without diabetes ($P = .04$).

Conclusion: Application of goal-directed, multidisciplinary protocols and a quality improvement program were associated with lower mortality after cardiac surgery. This decline was less prominent in patients with diabetes, and focused quality improvement protocols may be required for this subset of patients.

Cardiothoracic surgery has a long history of commitment to improving the quality of patient care. Data collection and critical analysis have established high standards that may effectively decrease the rate of less acceptable outcomes.^{1,2} Recently, The Society of Thoracic Surgeons' executive committee created the quality measurement task force, a comprehensive quality measurement program for cardiothoracic surgery.² Measurement of existing quality and identification of substantial deviations from best practice are the first steps in any continuous quality improvement program (QIP). Such an examination leads to focused interventions, after which improvements are documented with repeated measurements.³

In contrast to the integral role that publication plays in scientific discovery, publication in medical quality improvement has unfortunately had only a limited role to date. This lack of published reports has arguably deprived the health care system of rigorous scholarly evidence on improvement work and thus has slowed advancement of the improvement process.^{4,5} There is little evidence evaluating the effects on post-operative mortality after cardiac surgery of implementing QIPs and quality measurement.^{4,6-11}

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Abbreviations and Acronyms

AVR	= aortic valve replacement
CABG	= coronary artery bypass grafting
QIP	= quality improvement program

This study was conducted in a large clinical setting to evaluate systematically the effects on mortality after cardiac surgery of the institution of a QIP and multidisciplinary protocols.

Materials and Methods**Patients**

The computerized database of the Division of Cardiothoracic Surgery at the Carolinas Heart Institute was used to select all patients who underwent coronary artery bypass grafting (CABG), isolated valve surgery, or valve surgery with CABG, in our institution from January 2002 to December 2006. Patients were divided into two groups: those who had surgery (CABG, isolated valve, or both CABG and valve surgery) after the establishment of the multidisciplinary QIP (January 2005–December 2006, $n = 922$) and those undergoing surgery before the institution of the QIP (non-QIP, January 2002–December 2003, $n = 1289$). Patients who underwent surgery during the transitional year of 2004 were not included in the analysis. The same group of cardiac surgeons, anesthesiologists, and perfusionists performed all operations for both periods. Baseline demographic characteristics, procedural data, and perioperative outcomes were recorded and entered prospectively in a prespecified database by a dedicated data-coordinating center.

Medical Ethics Approval

Study approval was sought and obtained from the investigational review board at our institution. Confidentiality of personal patient information was maintained at all times, consistent with the Health Insurance Portability and Accountability Act of 1996 regulations.

Definitions

Previous cerebrovascular accident was defined as history of central neurologic deficit persisting longer than 24 hours. *Chronic renal insufficiency* was defined as a serum creatinine value of at least 2.0 mg/dL. *Diabetes* was defined as any history of diabetes mellitus, regardless of duration of disease or need for oral agents or insulin. *Recent myocardial infarction* was defined as myocardial infarction occurring within 7 days before the surgery. *Depressed ejection fraction* was defined as an ejection fraction less than 40%. *Prolonged ventilatory support* was defined as pulmonary insufficiency requiring ventilatory support for longer than 24 hours. *Postoperative stroke* was defined as any new major (type II) neurologic deficit arising during hospitalization and persisting longer than 72 hours.¹² Transient ischemic attacks were not included in this analysis. Strokes were confirmed by an independent neurologist, appropriate brain imaging, or both. *Acute renal failure* was defined as the increase of serum creatinine to both greater than 2.0 mg/dL and greater than twice the value of the most recent preoperative creatinine level. *Prolonged hospital stay* was defined as hospital stay longer than the 75th percentile (9 days). *Prolonged pump time* and *prolonged operative time* were defined as pump and operative times longer than the 75th percentile (>125 min and >293 min, respectively). *Operative*

mortality included both (1) all deaths occurring during the hospitalization in which the operation was performed, even after 30 days, and (2) those deaths occurring after discharge from the hospital but within 30 days of the procedure, unless the cause of death was clearly unrelated to the operation. The Society of Thoracic Surgeons National Cardiac Database definitions were used for the purposes of the study.

Quality Improvement Program

The QIP was begun in 2004 to improve cardiac surgical outcomes. National trends toward increased acuity, aging patient populations, and declining volumes, as well as goals of transparency, pay for quality, and value-based competition, contributed to the impetus for change. The Society of Thoracic Surgeons National Cardiac Database and National Quality Forum metrics and guidelines³ focused our QIP. Evidenced-based intensive care unit management protocols and guidelines included communication tools (standardized handoff and goal sheets), sedation monitoring, respiratory protocols for early extubation and best pulmonary practices bundles, computerized euglycemia management, blood management, and an infection control program, (for detailed description of QIP protocols, see online [Appendix E](#)). Multidisciplinary intensive care unit rounds were a part of the QIP and included a nurse, charge nurse, nurse practitioner, respiratory therapist, pharmacist, and cardiac intensivist, as well as the cardiothoracic surgeons and residents.

Data analysis

Univariate comparisons of preoperative, operative, and postoperative variables were performed between QIP and non-QIP groups. Dichotomous variables were compared with a χ^2 test of general association or a Fisher exact test for cell counts less than 5. All tests were 2-sided. Some continuous variables had highly skewed distributions. They were therefore converted to dichotomous variables, and the upper 25th percentile was chosen as the cutoff point.

A multivariable, stepwise, backward logistic regression analysis was conducted to determine independent predictors of operative mortality. The criterion for a variable entry into the logistic model was a univariate probability level of $P < .05$. The quality of the fit of the logistic model was tested with the Hosmer–Lemeshow goodness-of-fit test. All statistical analyses were conducted with SAS software (SAS Institute, Inc, Cary, NC).

Propensity score adjustment was used on the postoperative outcomes to correct for differences between QIP and non-QIP groups at baseline. A logistic regression model was fitted where QIP or non-QIP was the outcome and baseline characteristics ($P < .1$) from the bivariate analysis were the covariates. Propensity scores were generated and included as regression (covariance) adjustments in each of the logistic regression outcome models.¹³ The ability of the propensity score to balance effectively the compared groups at baseline was confirmed with separate logistic models that used QIP or non-QIP group type as the dependent variable and the covariate and propensity score as the independent variables (online [Appendix E](#)).

Results**Preoperative Characteristics**

Univariate comparisons between QIP ($n = 922$) and non-QIP groups ($n = 1289$) are presented in [Table 1](#). QIP patients were more likely to be male and to have hypertension,

chronic obstructive pulmonary disease (mild), and three-vessel coronary artery disease than were non-QIP patients. Non-QIP patients were more likely to be older; to be in New York Heart Association functional class III or IV; and to have lower ejection fraction, recent acute myocardial infarction, or unstable angina than were QIP patients; they were also less likely to be operated on electively.

Operative and Postoperative Characteristics

Operative and postoperative patient characteristics are presented in Table 2. QIP patients were more likely to undergo valve surgery or both CABG and valve surgery than were non-QIP patients. Pump, operative, and crossclamp times were more prolonged for QIP patients than for non-QIP patients. QIP patients had lower rates of operative mortality, postoperative sepsis, acute renal failure, and cardiac tamponade than were non-QIP patients, and they were more likely to be extubated within 6 hours after surgery. The reintubation

TABLE 1. Baseline patient demographic characteristics

	QIP (N = 922)	Non-QIP (N = 1289)	P value
Male	684 (74%)	907 (70%)	.05
Hypertension	724 (79%)	948 (74%)	.01
Diabetes	342 (37%)	491 (38%)	.63
Chronic renal insufficiency	50 (5%)	61 (5%)	.46
Previous cerebrovascular accident	95 (10%)	136 (11%)	.85
Chronic obstructive pulmonary disease			.01
Mild	70 (8%)	94 (7%)	
Moderate	21 (2%)	83 (6%)	
Severe	34 (4%)	28 (2%)	
None	797 (86%)	1084 (84%)	
Previous cardiovascular operation	319 (35%)	482 (37%)	.18
Congestive heart failure	153 (17%)	240 (19%)	.22
Unstable angina	130 (14%)	324 (25%)	.01
Recent myocardial infarction	154 (17%)	313 (24%)	.01
Age >75 y	112 (12%)	190 (15%)	.08
Ejection fraction <40%	202 (22%)	349 (27%)	.01
New York Heart Association functional class			.01
I	45 (5%)	30 (2%)	
II	390 (42%)	227 (18%)	
III	347 (38%)	637 (49%)	
IV	140 (15%)	395 (31%)	
No. of diseased vessels			.01
0	182 (20%)	133 (10%)	
1	76 (8%)	61 (5%)	
2	409 (44%)	887 (70%)	
3	254 (28%)	195 (15%)	
Case priority			.01
Elective	315 (34%)	363 (28%)	
Urgent	535 (58%)	789 (61%)	
Emergency	72 (8%)	137 (11%)	

All data represent numbers and percentages of patients. QIP, Quality improvement program.

TABLE 2. Intraoperative and postoperative patient characteristics

	QIP (N = 922)	Non-QIP (N = 1289)	P value
Operative characteristics			
Type of surgery			.01
CABG	646 (70%)	1060 (82%)	
Valve	195 (21%)	145 (11%)	
CABG plus valve	81 (9%)	84 (7%)	
Prolonged pump time (>125 min)	252 (27%)	286 (22%)	.01
Prolonged crossclamp time (>78 min)	258 (28%)	286 (22%)	.01
Prolonged operative time (>293 min)	244 (26%)	302 (23%)	.12
Postoperative outcomes			
Stroke	25 (3%)	21 (2%)	.08
Sepsis	21 (2%)	50 (4%)	.04
Renal failure	51 (6%)	105 (8%)	.02
Atrial fibrillation	303 (33%)	349 (27%)	.01
Hemodialysis	15 (2%)	27 (2%)	.43
Cardiac arrest	20 (2%)	44 (3%)	.09
Intra-aortic balloon pump	2 (0.2%)	2 (0.2%)	>.999
Hemorrhage-related reexploration	51 (6%)	85 (7%)	.31
Blood transfusion	365 (40%)	526 (41%)	.57
Cardiac tamponade	2 (0.2%)	20 (1.6%)	.01
Mediastinitis	10 (1.1%)	8 (0.6%)	.23
In-hospital mortality	20 (2%)	61 (5%)	.01
Operative mortality	24 (3%)	65 (5%)	.01
Cause of death			
Cardiac	10 (42%)	45 (69%)	.01
Infection	0 (0%)	2 (3%)	
Stroke	4 (17%)	7 (11%)	
Respiratory failure	5 (21%)	7 (11%)	
Acute renal failure	1 (5%)	3 (5%)	
Other	3 (13%)	1 (2%)	
Unknown	1 (5%)	0 (0%)	
Return to ICU	73 (8%)	108 (8%)	.70
ICU stay <24 h	295 (32%)	568 (44%)	.01
Prolonged stay (>9 d)	210 (23%)	269 (21%)	.28
Reintubation	65 (7%)	64 (5%)	.04
Ventilation <6 h	490 (53%)	490 (38%)	.01
Prolonged intubation (>24 h)	88 (10%)	151 (12%)	.11

All data represent numbers and percentages of patients. QIP, Quality improvement program; CABG, coronary artery bypass grafting; ICU, intensive care unit.

rate, however, was higher in the QIP group than in the non-QIP group. No significant differences were found in prolonged ventilation, prolonged stay, mediastinitis, or hemorrhage-related reexploration.

Operative Mortality

Univariate analysis. In univariate analysis, operative mortality was lower in the QIP group than in the non-QIP

TABLE 3. Multivariate logistic regression analysis model of operative mortality

	⊖ Coefficient	SE	Odds ratio	95% Confidence interval	P value
QIP	−0.29	0.14	0.6	0.3–1.0	.04
Male sex	−0.26	0.14	0.6	0.4–0.9	.03
Diabetes	0.34	0.13	1.2	1.2–3.2	.01
Chronic renal insufficiency	0.37	0.19	2.7	1.0–4.2	.05
Reoperation	0.24	0.12	1.6	1.0–2.5	.04
Congestive heart failure	0.51	0.12	2.8	1.8–4.5	.01
Unstable angina	0.40	0.14	2.2	1.3–3.8	.01
Age >75 y	0.41	0.13	2.3	1.3–3.6	.01
Prolonged pump time	0.46	0.14	2.5	1.4–4.2	.01
Prolonged operative time	0.27	0.14	1.7	1.0–3.0	.05
QIP and no diabetes	−0.26	0.13	0.6	0.4–0.9	.04

QIP, Quality improvement program.

group (2.6% vs 5.0%, $P < .01$). Causes of death for the two groups are presented in Table 2. It is apparent that the decrease in operative mortality for QIP was almost entirely attributable to a marked decrease in cardiac-related death.

Multivariate analysis. The results of the multivariable logistic regression analysis are summarized in Table 3. The C statistic for the model is 0.8, which indicates a good fit. Diabetes ($P < .01$), chronic renal insufficiency ($P = .05$), previous cardiovascular operation ($P = .04$), congestive heart failure ($P < .01$), unstable angina ($P < .01$), age older than 75 years ($P < .01$), prolonged pump time ($P < .01$), and prolonged operative time ($P = .05$) emerged as independent predictors of higher mortality after cardiac surgery.

QIP ($P = .04$), male sex ($P = .03$), and interaction of QIP and nondiabetic status ($P = .04$) were associated with lower mortality (Figure 1). There was a lower relative decline in mortality among patients with diabetes than among those without diabetes. For patients with diabetes, QIP and non-QIP mortalities were 5% and 6%, respectively, whereas for patients without diabetes, the respective values for QIP and non-QIP groups were 2% and 5%.

Propensity score analysis. The propensity score-adjusted odds ratio demonstrated a significant decrease in mortality for the QIP group (odds ratio 0.6, 95% confidence interval 0.4–0.99, $P = .04$). Figure 2 shows the general decline of operative mortality with time.

Discussion

Cardiac surgery remains at the forefront of risk model development and clinical quality monitoring. Recently, the Society of Thoracic Surgeons created the Quality Measurement Task Force to develop comprehensive summary quality measures encompassing multiple domains of quality.¹⁴ Implementa-

Figure 1. Independent predictors of operative mortality after cardiac surgery (multivariable logistic regression analysis). QIP, Quality improvement program.

tion of the guidelines included in the report of the Quality Measurement Task Force is expected to foster improvement of outcomes. This study sought to investigate in a risk-adjusted fashion whether a systematic and consistent implementation of a QIP would decrease mortality after cardiac surgery.

Principal Findings

We demonstrated that a QIP and multidisciplinary protocols are powerful tools associated with decreased mortality after cardiac surgery. In our institution, mortality dropped almost 50% (from 5.0% to 2.6%); this decrease in operative mortality for the QIP group was almost entirely attributable to a marked decrease in cardiac-related deaths (Table 2). Specifically, there was a decrease in the incidence of cardiac causes of death by 30% in the QIP group relative to the non-QIP group.

This decline in operative mortality was made feasible by the consistent application of multiple protocols, including standardized communication tools and goal sheets, sedation monitoring, respiratory protocols for early extubation and best pulmonary practices bundles, computerized euglycemia management, multidisciplinary intensive care unit rounds, blood management, and an infection control program.

Predictors of Operative Mortality

In the multivariable analysis, well-documented risk factors such as diabetes,¹⁵ female sex,¹⁶ renal insufficiency,¹⁷ reoperation,¹⁸ congestive heart failure, unstable angina,¹⁹ advanced age,²⁰ prolonged pump time, and increased operative time²¹ increased the risk of mortality in this study, as they have done in other studies. The interaction of QIP and non-diabetic status indicates that there were different modes of

Figure 2. Graph demonstrating steady decline in operative mortality with time after institution of quality improvement program (QIP). Gray line represents line of best fit.

mortality decline for patients with and without diabetes. More specifically, the mortality rate for patients with diabetes was less affected by the process improvement initiatives, as has been previously shown.²²

Clinical Implications

For common surgical procedures, processes of care vary widely among cardiac surgical programs. Important components of a QIP program include a systems-based approach, standardization, team building, consistent and accurate communication, and active management of change and quality. Use of composite indicators is useful to drive performance improvement after cardiac surgery. This study, which demonstrated a 48% decline in operative mortality after implementation of a QIP, is among the first to demonstrate such a finding by the use of a rigorous risk-adjusted methodology and a large sample size. The mortality decline with the QIP was less pronounced for patients with diabetes, and future improvement processes should focus on this particular subset of patients.

Study Limitations

Limitations of this study include all those inherent in any retrospective, single-institution analysis. This was a nonrandomized study in which unmeasured patient or procedure-related variables may have influenced the study results. Furthermore, this investigation was conducted at a large tertiary referral center, and the results may not be broadly representative of community practice. Among the strengths of this study are the large cohort of patients, the prospective entry of all data elements into a cardiac surgical research database with strict definitions, and analysis of data performed with appropriately risk-adjusted statistical models to adjust for differences in preoperative risk factors.

Conclusions

The systematic and consistent implementation of a QIP in conjunction with the application of multidisciplinary protocols and quality improvement strategies decreased mortality after cardiac surgery. This decrease in postoperative mortality was less pronounced in patients with diabetes, and future quality improvement programs should focus on this high-risk category.

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APPENDIX

CVRU Adult Admission Goal Sheet

Date _____

Surgery _____

Attending _____

Resident _____

Allergies _____

Admission Goals

Stat Labs ☐ TEG ☐ Coags ☐ EndoTool ☐ CXR ☐Blood consent obtained ☐ I&O**Sedation:** Decrease Diprivan to 30 mcg/kg/min(If admission BIS <60 and Temp >35): Yes ☐ No ☐If meet weaning parameters, Diprivan off at 1 hour Yes ☐ No ☐Respiratory Therapist notified ☐**Respiratory:** Wean to extubate per protocol: Yes ☐ No ☐ETT position checked ☐ Repositioned _____ cmWean O₂ for sat's > _____ Yes ☐ No ☐**HOB 30 degrees:** Yes ☐ No ☐PUD prophylaxis Yes ☐ No ☐SCD's: Initiate ☐ Hold ☐ Plexipulse ☐**Cardiovascular:** Cardiac profile completed within 30 minutes:Yes ☐ No ☐ N/A ☐ Line position checked ☐Cardiac Index > 2.2 on arrival: Yes ☐ No ☐If no, ACNP/M.D. notified: Yes ☐ No ☐

Volume per protocol/orders: OR fluids _____

Albumin _____ Other _____

CV Medications:

Dopamine: _____ mcg/kg/min Continue ☐ Wean ☐Neosynephrine: _____ mcg/min Continue ☐ Wean ☐Primacor: _____ mcg/kg/min Continue ☐ Wean ☐Levophed: _____ mcg/min Continue ☐ Wean ☐Epinephrine: _____ mcg/min Continue ☐ Wean ☐Nitroglycerine: _____ mcg/min Continue ☐ Wean ☐Nipride: _____ mcg/kg/min Continue ☐ Wean ☐Amiodarone: _____ mg/min Continue ☐ Wean ☐Continue ☐ Wean ☐**GI:** NG/OG to suction Yes ☐ No ☐D/C with extubation Yes ☐ No ☐Start clear liquids 6 hours after extubation: Yes ☐ No ☐Progress to ordered diet: Yes ☐ No ☐**GU:** Foley: Yes ☐ N/A ☐

Notify ANCP/M.D. of UOP < 0.5ml/kg/hour

Skin: Ace wraps: Continue ☐ Discontinue ☐**Antibiotics:** Ancef ☐ Vancomycin ☐ Aztreonam ☐

M.D./ACNP/R.N. signature: _____

Admission blood glucose: _____

Insulin drip begun in: OR ☐ CVRU ☐ Time _____Insulin bolus given in OR: Yes ☐ No ☐ Time _____

Date: _____

Admission Extubation Goals

Admission Time: _____ Expected Time of Extubation: _____ Actual Time of Extubation: _____

Admission BIS: _____ BIS at expected Time of Extubation: _____

Diprivan off at: _____

Last narcotic/sedative in CVRU _____

Reason _____

Reversal given: Yes ☐ Time: _____ No ☐ Why: _____ ☐ *recheck twitches in 1 hour if applicable

Anesthesiologist/CRNA: _____

Significant Information: _____

M.D. Order to keep intubated? ☐ M.D. name: _____ Reason: _____

Preop Creatine _____ Renal failure preop _____

	Admission	1 st Hour	2 nd Hour	3 rd Hour	4 th Hour	5 th Hour	6 th Hour
Chest tube output							
Urine Output							
Cardiac Index							
Temperature							
Significant Support (IABP/VAD/Drips)							
Diprivan mcg/kg/min			*OFF				
BIS							

Respiratory Parameters at Time of Extubation: Pass ☐ Fail ☐ Reason: _____

ABG: _____

1st attempt: Time _____ NIF _____ FVC _____ TV _____ Ve _____ RR _____ ETCO₂ _____2nd attempt: Time _____ NIF _____ FVC _____ TV _____ Ve _____ RR _____ ETCO₂ _____

Admission R.N.: _____

Admission Respiratory Therapist: _____

Expected Time of Extubation R.N.: _____

NOTIFY CVT SURGERY	GUIDELINE STANDARD	GUIDELINE CUSTOM	
CI (liters/minute/m2)	2.2-4.4	<	>
HR (beats/minute)	60-90	<	>
SBP (mmHg)	90-140	<	>
PADP (mmHg)	12-20	<	>
CVP (mmHg)	5-15	<	>
PVCs (per minute)	<6	>	
RR (per minute)	12-20	<	>
O ₂ SAT %	94-100	<	
PaO ₂ (mmHg)	70-100	<	
Temperature (C)	37.5	<	>
Urine Output (ml/kg/hour)	>0.5	<	>
Chest Tube Drainage Hour 1	300	>	
Chest Tube Drainage Hour 2	200	>	
Chest Tube Drainage Hour 3	100	>	
Chest Tube Drainage Hour 4	100	>	
Chest Tube Drainage/ Hour any Hour thereafter	100	>	
PT (seconds)	9.4-11.1	>	
aPTT (seconds)	25.9-34.3	>	
Fibrinogen (mg/dl)	200-400	<	
Platelet Count (Hgb in mg/dl)	150-450	<	
TEG	Normal	Abnormal	
Transfusion Threshold for PRBC (Hgb in ml/dl)	7.5	<	
Autotransfusion (circle one)		Yes	No
Other			

The above values are guidelines (**not orders**) and each patient/operation requires individual consideration.

M.D. Signature: _____

Expected Time of Extubation Respiratory Therapist: _____

Patient Sticker

CVRU Adult Report/Goal Sheet Date _____ POD # _____

Surgery _____ Attending _____ Resident _____

Allergies _____

(AM / PM)

Physical Assessment(report)	Goals (Assessment & Plan)
PreOp weight _____ kg Today _____ kg	Laboratory ☐ Imaging ☐ I&O _____
Temp Current _____ Temp Max _____	Sedation: Discontinue ☐ Wean ☐ Continue ☐ Vacation ☐ Comments _____
Neuro: Alert ☐ Oriented x _____ ☐ Confused ☐ PERRLA (yes/no) _____ BIS _____ Pain _____ /10 Recent analgesia _____ Diprivan _____ mcg/kg/min Morphine _____ mg/hour Nimbex _____ mcg/kg/min Precedex _____ mcg/kg/hour Versed _____ mg/hour Restrained (yes/no) Orders signed (yes/no)	Mechanical Ventilation: Discontinue ☐ Wean ☐ Continue ☐ Comments _____ CLRT _____ Yes ☐ No ☐ N/A ☐ HOB 30 degrees _____ Yes ☐ No ☐ N/A ☐ PUD Prophylaxis _____ Pepcid ☐ Protonix ☐ N/A ☐ SCDs _____ Initiate ☐ Continue ☐ Hold ☐ Heparin SQ _____ Initiate ☐ Continue ☐ Hold ☐ Lovenox SQ _____ Initiate ☐ Continue ☐ Hold ☐ Oral Care _____ Basic ☐ Chlorhexidine ☐
Respiratory: RR _____ O ₂ sat% _____ NC _____ l/min FM _____ l/min Lungs: Right: Clear ☐ Diminished ☐ Rhonchi ☐ Rales ☐ Wheezes ☐ Coarse ☐ Left: Clear ☐ Diminished ☐ Rhonchi ☐ Rales ☐ Wheezes ☐ Coarse ☐ Vent settings: Mode _____ Rate _____ TV _____ PIP _____ PS _____ PEEP _____ FiO ₂ _____ ETCO ₂ _____ BiPap/CPAP (yes/no) Order obtained (yes/no)	CV Medications (dosage): Dopamine: _____ mcg/kg/min Wean ☐ Continue ☐ Neosynephrine: _____ mcg/min Wean ☐ Continue ☐ Primacor: _____ mcg/kg/min Wean ☐ Continue ☐ Levophed: _____ mcg/min Wean ☐ Continue ☐ Epinephrine: _____ mcg/min Wean ☐ Continue ☐ Nitroglycerine: _____ mcg/min Wean ☐ Continue ☐ Nitroprusside: _____ mcg/kg/min Wean ☐ Continue ☐ Amiodarone: _____ mg/min Wean ☐ Continue ☐ Other: _____ Wean ☐ Continue ☐ _____ Wean ☐ Continue ☐ _____ Wean ☐ Continue ☐
Cardiovascular: HR _____ Rhythm _____ BP _____ / _____ CVP _____ PAP _____ / _____ CO _____ CI _____ SVR _____ PA Cath: VIP ☐ FICK ☐ SVO ₂ /CCO ☐ SVO ₂ _____ Pulses: RUE _____ LUE _____ RLE _____ LLE _____ Cap Refill: RUE _____ LUE _____ RLE _____ LLE _____ IABP _____ VAD _____ Other _____	Nutrition: Diet _____ kcal/kg/day Enteral Initiate ☐ Continue ☐ Hold ☐ Goal ☐ TF _____ Parenteral (TPN) Initiate ☐ Continue ☐ Hold ☐ Goal ☐ Rate _____
Gastrointestinal/Hepatic: Bowel Sounds x _____ quadrants Soft ☐ Firm ☐ Rigid ☐ Flat ☐ Distended ☐ Last BM _____ NG ☐ OG ☐ Enteric Feeding Tube ☐ Placement verified (yes/no) _____ Tube Feeds _____ Tube Feed Goal _____	Fluid/Diuretic: Name & Dosage _____ Initiate ☐ Continue ☐ Hold ☐ Last fluid bolus _____ Maintenance IV fluid _____ ml/hour
Genitourinary: Foley ☐ Void ☐ Anuric ☐ Dialysis ☐ Urine: Clear ☐ Cloudy ☐ Sediment ☐ Hematuria ☐ > 0.5 ml/kg/hour ☐ <0.5 ml/kg/hour ☐ MD notified ☐	Skin: Ace Wraps ☐ Continue ☐ Discontinue ☐ JP drains ☐ Continue ☐ Discontinue ☐
Skin: Pink ☐ Pale ☐ Cyanotic ☐ Warm ☐ Cool ☐ Dry ☐ Diaphoretic ☐ Sternotomy ☐ Thoracotomy (right / left) _____ Leg incisions (right/left) _____ Wounds _____ Skin _____	Lines & Wires: (M.D./ACNP to complete this section) Pacing Wires _____ Discontinue ☐ Continue ☐ PA Cath _____ Discontinue ☐ Continue ☐ Change site ☐ A-line _____ Discontinue ☐ Continue ☐ Change site ☐ Central Lines _____ Discontinue ☐ Continue ☐ Change site ☐
Lines & Wires: Pacing wires (circle): Atrial MA _____ Ventricular MA _____ Pacing (yes/no) Rate _____ A-line (location) _____ Peripherals _____ Central lines (type/location) _____	Chest Tubes: (M.D./ACNP to complete this section) Discontinue ☐ Continue ☐
Chest Tubes: Right x _____ Left x _____ Mediastinal x _____ Suction ☐ Negative Pressure noted ☐ Air Leak ☐	Anticoagulation: ASA _____ mg _____ Initiate ☐ Continue ☐ Hold ☐ Heparin IV _____ Initiate ☐ Continue ☐ Hold ☐ Coumadin _____ Initiate ☐ Continue ☐ Hold ☐ Other _____
Additional Issues of Note: _____ _____ _____	Beta Blocker: _____ Initiate ☐ Continue ☐ Hold ☐ Name and dosage: _____
Signatures : _____ Reporting R.N. _____ _____ Receiving R.N. _____	Physical Therapy _____ Initiate ☐ Continue ☐ Hold ☐ Endocrine ☐ Drugs ☐ Transfer ☐ Pt/family ?/comments ☐ Pharmacist ☐ Respiratory Therapy ☐ Physical Therapy ☐ Nutritionist ☐ Consultants _____
	M.D./ACNP signature _____

Sticker

Patient Sticker

Carolinas Medical Center
Department of Anesthesia CHI/CVRU Transfer Record

PLEASE SEND 30 MIN BEFORE ARRIVAL TO CVRU

Admitting Diagnosis			
Surgery	CABG x Valve: Adult Other: Pediatric:	LIMA: Yes/ No Replacement/ Repair	IABP: Yes/No Type: Mech./ Porcine Chest: Open/Closed Skin: Open/Closed
Surgeon			
Resident			
Anesthesiologist			
CRNA/SRNA	CRNA:	SRNA:	
Difficult Airway	No/ Yes:		
ID Band	L/ R Wrist	L/ R Ankle	
Medical History <i>circle</i>	HTN, PHTN, GERD, CAD, Stent, Dyslipidemia, PVD, EF___%, DM, NIDM, Non-Q MI, CRI, CHF, COPD, Smoker, ETOH, CVA: residual + / - and Lt. / Rt.,		
Allergies	NKDA/ Allergies:		
Pump/ ACC/ Cerebra	Pump/min:	ACC/min:	Cerebral/min:
Systolic/Diastolic BP	Systolic:	Diastolic:	Art/NBP: L/ R
CO/ CI/ SVR	CO:	CI:	SVR:
PA Catheter	Measurement/cm: CCO/VIP		
CVP/ PAD/ LAP	CVP:	PAD:	LAP:
Heart Rate/ Rhythm	Rate: Rhythm:		
Hgb/Coags/TEGS	Hgb:	Coags: Yes/ No, Time:	TEGS: Yes/No
K+	Last:	Treatment:	meq Time:
Calcium	Last:	Treatment:	mg Time:
Creatinine	Last:		
Lasix/ Digoxin	Time:	Amount:	/ Time: Amount:
Insulin/Endo Program	Last BG:	Time:	Drip: units/hr
Antibiotics	Ancef (1st dose)/Time: Vancomycin/Time:	Ancef (2nd dose)/Time: Aztreonam/Time:	
Other Meds Given	Solumedrol		
Drips <i>Circle if running</i> <i>Doses verified at bedside</i>	Neo: _____ Dopamine: _____ mcg/kg/min NTG: _____ Primacor: _____ mcg/kg/min Levophed: _____ Diprivan: _____ mcg/kg/min Other: _____ NaBicarb: _____ ml/hr Other: _____ Amiodarone _____ mg/min Aprotinin: _____ ml/hr		
Muscle Relaxant	Yes/ No	Reversal in CVRU: Yes/ No	
Extubated/Intubated	Extubated:Yes/ No	Extended Intubation:Yes/No	
Blood Products: Given/Available	PRBC: / FFP: / Cryo: / Plts: / Bringing Blood w/ Pt.: Yes/No		
Comments			

NOTE: See anesthesia record for fluid totals (IV fluids, EBL, Urine output) / Blanks completed on arrival

Signatures of Report Given/ Received: CRNA _____ CVRU RN _____

Transfer of Care at: _____

Carolinas Medical Center (CMC)

Post Cardio-Pulmonary Bypass Adult Orders

CMC – CVRU

Initiate: CMC Post Cardio-Pulmonary Bypass Adult Orders

Verify Allergies

Admit to CVRU

Status Post: _____

List surgeon as Attending

Initiate: CABG pathway (for all CABG and valve patients)

Labs

On Arrival to CVRU:

ABG, Hgb, Potassium, Ionized Calcium, Magnesium, Coags and Glucose

If a TEG has not been performed in the OR obtain one upon admission.

ABGs PRN

Basic Metabolic Panel PRN

Ionized calcium PRN

Magnesium PRN

Glucose PRN

Potassium PRN

CBC PRN

Coags PRN

Hemoglobin PRN

Diagnostics:

PA portable CXR within 30 minutes of arrival to CVRU (CVRU to call request)

CXR when chest tubes removed

* May obtain CXR if patient in respiratory distress

* Daily CXR if patient remains intubated

* EKG PRN

Dressings:

* Remove ACE bandage on POD #1 (or if detrimental to leg)

* Redress all incision sites and chest tube sites for drainage PRN (remove ACE if saturated and redress)

* Change sternal dressing daily and PRN, paint lightly with povidone/iodine (Betadine) on each side of incision

and re-dress with gauze and secure with silk tape.

Equipment:

* Foley Catheter to straight drainage

* Chest tubes 20 cm suction

* NG/OG tube to 30-50 cm intermittent wall suction

VS and Hemodynamic Parameters

BP Q15 minutes while on vasodilators (excluding nitroglycerin), inotropes or vasoconstrictors

BP Q1H when off all vasoactive drips and condition stable

BP Q4H when invasive lines are discontinued

Q1H: RR, SVO₂, CCO, Pulse Oximetry, PAP, CVP, LAP, RV

Q1H: IABP systolic, augmented, diastolic, and mean pressures

Q1H: IABP distal pedal pulse and left arm pulses

Q1H: RVAD, LVAD or BiVAD settings

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1-5180-0003 CMC Post Cardio-pulmonary Bypass Adult Orders

1-5180-0003-a-8-06

Q1H: Pulses in limbs with invasive lines

Q1H: Input and Output

Q2H: Temp, pulses, and capillary refill

Wean hemoactive drips if cardiac index greater than or equal to 2

Document hemodynamic profile Q4H and PRN while on vasoconstrictors, Inotropic drugs

Respiratory

Initiate: CMC Cardiovascular Respiratory Post Op Orders

Emergency Treatment Parameters

Pulseless V tach or V fib

Initiate Pulseless Arrest Algorithm*

Asystole and PEA

Initiate Pulseless Arrest Algorithm*

Symptomatic Bradycardia (Per ACLS Protocol)

Initiate Bradycardia Algorithm*

*ACLS Protocol per American Heart Association (AHA) guidelines

STAT EKG for onset of chest pain and/or sudden tachydysrhythmia

Treatment of Hypertension (for first 24 hours post-op): Systolic greater than 160

Nitroprusside (Nipride) 50 mg/250 ml D5W to maintain systolic BP as designated by MD

May initiate the following to reduce or eliminate Nipride use after systolic BP controlled

Labetalol 5-10 mg IV Q15 minutes (not to exceed 60 mg total), if HR 80 or greater, normal SVR and no COPD or asthma

Enalapril (Vasotec) 1.25 mg IV Q15minute (not to exceed 2.5 mg total), if HR less than 80, and elevated SVR

Treatment of sustained/persistent Hypotension

Adjust/discontinue vasodilator, as able to maintain systolic BP at patient's preoperative baseline

For low filling pressures with associated hypotension (PCWP less than 18 and PAD less than 20) AND Hgb

greater than 7, give up to 4 bottles (1000 ml) 5% Albumin

If filling pressures are adequate with low systolic BP, begin Dopamine 400 mg/250 ml D5W and titrate up to

10 mcg/kg/minutes to maintain systolic BP

Treatment for Low Cardiac Index(CI)

Give 5% albumin (up to 500 ml) PRN for CI less than 2 **and** PCWP less than 18 **or** PAD less than 20

Pacemaker orders:

* Check Pacemaker Q Shift to override rhythm and threshold

* Keep Pacemaker on demand at rate of 50 unless pacer misfiring

* If pacer is misfiring, keep Pacemaker connected and in off position, until patient transfer

If HR drops below patient baseline or patient develops JR: Pacemaker may be utilized for support.

On transfer, if POD #2 and in SR, remove Pacemaker, ground and insulate wires, label and tape wires to chest

General Care:

Weight patient daily prior to 0600

May complete OR fluids

Keep HOB elevated at least 20-30 degrees while patient on ventilator

Chlorhexidine (Hibiclens) bath daily x 3 post op

* Continue Nitroglycerin (NTG) overnight if patient has had recent MI or Emergency surgery, IMA or radial artery harvest

Insert NG/OG tube if patient's abdomen distended or with persistent vomiting

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1-5180-0003 CMC Post Cardio-pulmonary Bypass Adult Orders

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Autotransfusion:

* Call for order to initiate if output greater than 200 ml in first 4 hours

Discontinue Autotransfusion after 12 hours (contact physician for orders if patient bleeding persists)

Pharmacy

Discontinue all pre operative medications.

____ Sodium Bicarbonate as started in OR: 150 mEq/1000 ml D5W IV at ____ ml/hour (1 ml/kg/hr) x 4 hours,

then ____ ml/hour (0.3 ml/kg/hour) x 20 hours

D5 ¼ NS with 30 mEq KCl/L IV at 50 ml/hour. If patient is receiving a sodium bicarbonate infusion, adjust this

fluid so that the total rate is 50 ml/hour. Convert to PRN adaptor when po intake is adequate.

Discontinue KCl from above fluid if potassium is greater than 4.7 and/or urine output is less than 0.5 ml/kg/hour

Concentrate IV drips as needed to reduce fluid intake

Flush PRN adaptor Q12H and PRN after use with NS

Famotidine (Pepcid) 20 mg IV Q12H, change to po x 48 hours when patient is extubated. Notify

Pharmacy.

Cefazolin (Ancef) 1 gm IV Q8H x 3 doses post op **Next dose due** _____

If patient received vancomycin in the OR, give vancomycin 1gm IV 12 hours from last dose in the OR.

If serum creatinine is above 2mg/dl, do not give another dose of vancomycin. **Next dose due** _____.

____ If patient received Aztreonam in the OR, give 1gm Q8H x 3 doses. **Next dose due** _____.

____ Enteric Coated Aspirin 325 mg po daily when patient able to take po's (CABG patients only).

Mupirocin (Bactroban) ointment to both nares BID x 9 doses. Apply with swab. Pharmacy to send one tube.

Sodium Bicarbonate 50 mEq IV for every base excess of negative 6 on ABG result (ex. for BE negative 12, give 100 mEq)

Heparin 1000 units/500 ml NS to maintain pressure lines

Morphine 2 -10 mg IV Q1H for tube tolerance and/or severe pain while on ventilator

Morphine 2-4 mg IV Q1H PRN for severe pain when extubated

Midazolam (Versed) 2-10mg IV Q1 H PRN for extreme agitation/ tube tolerance while on ventilator.

Ondansetron (Zofran) 4 mg IV Q6H PRN Nausea/Vomiting

Promethazine (Phenergan) 12.5mg IV Q4H PRN N/V if Zofran is not effective.

Zolpidem (Ambien) 5 mg QHS PRN sleep. May repeat x 1 dose in one hour

Lorazepam (Ativan) 0.5-1 mg IV/po Q8H PRN agitation when patient is extubated

Acetaminophen (Tylenol) 650 mg PR/po Q4H for temp greater than 38.5 degrees C*

Acetaminophen/Oxycodone 325/5 (Percocet) 1-2 tabs po Q4H PRN pain when extubated and tolerating po*

***Adult: Do not exceed 4 gm Acetaminophen (Tylenol) from all sources in a 24 hour period.**

Milk of Magnesia 30 ml po PRN constipation

All drips received from OR to be activated on admission

- ___ Amiodarone 900 mg/500 ml D5W
- ___ Aprotinin until current bottle is empty
- ___ Dobutamine 500 mg/250 ml D5W
- ___ Dopamine 400 mg/250 ml D5W
- ___ Epinephrine 1 mg/250 ml NS
- ___ Insulin regular 250 units/250 ml NS per "ENDO" program with goal blood glucose range of 71-119.

Discontinue drip and initiate SubQ scale when: patient resumes po intake and diabetic medicines are restarted, upon MD order, or when patient transfers out of CVRU.

- ___ Lidocaine 2 gm/250 ml D5W at ___ mg/min
- ___ Milrinone (Primacor) 40 mg/200 ml D5W
- ___ Nitroglycerin (NTG) 50 mg/250 ml D5W
- ___ Nitroprusside (Nipride) 50 mg/250 ml NS
- ___ Norepinephrine (Levophed) 16 mg/250 ml NS

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___ Phenylephrine (Neosynephrine) 40 mg/250 ml NS (note: concentration may be different than bag started in OR)

___ Propofol 1000 mg/100 ml lipid base

Electrolyte replacement orders:

Calcium Chloride 1 gm IV over 10-20 minutes PRN ionized Calcium 0.94 or less

Magnesium Sulfate 2 gm IV x 1 dose, then 1 gm IV Q8H x 3 doses PRN serum magnesium less than 1.9

Maintain Potassium level 4 - 4.5:

Central Line: KCl 10 mEq/50 ml sterile water over 30 minutes. May repeat up to 3 doses (30 mEq total)

Recheck serum potassium, redose as needed

Peripheral Line: KCl 10 mEq/50 ml sterile water over 60 minutes. May repeat up to 3 doses (30 mEq total)

Recheck serum potassium, redose as needed.

Oral: KCl 20 mEq x 1 dose for serum potassium 3.6 - 4

Give KCl 40 mEq x 1 dose for serum potassium less than or equal to 3.5

Recheck serum potassium 4 hours after dose, redose as needed.

Propofol Weaning (Fast Track)

1. Chest drainage less than 100 ml/hour. Must be less than 50 ml/hour to extubate
2. Hemodynamically stable with CI greater than 2
3. Temperature greater than 35° C
4. PaO₂ greater than 80 on no more than 45% FIO₂ and 5 cm peep
5. For Epinephrine or Norepinephrine (Levophed) drips, check with MD prior to weaning propofol. All other drips are acceptable
6. Propofol infusion begun at approximately 50 mcg/kg/minute in OR. After ventilator weaning criteria met, decrease infusion by half to 25 mcg/kg/minute. After 15 minutes, discontinue Propofol infusion.

Post Extubation Orders / Prior to transfer orders;

TCDB Q2H x 48 hours

* Discontinue NG/OG tube upon extubation

Discontinue pressure lines per established guidelines or for transfer to 6T

Dietary

NPO until extubated

NPO with ice chips for 4-6 hours post extubation

___ 2000 ml Fluid restriction

___ HDPD diet

___ HDPD, ADA diet, ___ Calories

Activity Level

Bedrest operative day until extubated

* Dangle 2 hours post extubation if patient hemodynamically stable, progress to OOB

DATE: _____ **TIME:** _____ **MD SIGNATURE:** _____

Carolinas Medical Center**Tight Blood Glucose Control Orders for****Adult Patient in MICU, SICU, TICU, DHU, CVRU, or Neuro ICU****(Target 80 – 120 gm/dL)****EndoTool™ Program****Do not use this order set to manage a patient with diabetic ketoacidosis (DKA)****unless approved by the Attending Physician.**

Initiate: CMC Tight Glucose Control for Adult Patient in MICU, SICU, TICU, DHU, CVRU, or Neuro ICU

Nursing1. Check blood glucose via finger stick **or** laboratory (BMP, CMP, or glucose) upon arrival to unit and PRN for symptoms

and/or changes in vital signs, neurological status, or nutrition status.

2. For known *Diabetic Patient*: a) If glucose greater than 130 gm/dL: initiate insulin infusion according to **Insulin Infusion Orders** below.b) If glucose 130 gm/dL or less: check glucose Q6H. Initiate **Insulin Infusion Orders** below if any blood glucose is greater than 130 gm/dL.For *Non-Diabetic Patient*: a) If glucose greater than 130 gm/dL: initiate insulin infusion according to **Insulin Infusion Orders** below.b) If glucose 130 gm/dL or less: check glucose every AM. Initiate **Insulin Infusion Orders** below if any blood glucose is greater than 130 gm/dL.

3. If an IV insulin infusion is started for tight glucose control: discontinue all current insulin orders, including PRN, sliding

scale, continuous infusion, and/or scheduled bolus doses.

4. Prior to starting the infusion, waste approximately 30 ml of the insulin mixture through the IV tubing prior to starting in

order to saturate the plastic tubing with insulin.

INSULIN INFUSION ORDERS

1. The patient must be on steady nutritional support to be eligible for EndoTool™ insulin dose calculations. This nutrition can be steady IVs with dextrose solutions, steady tube feedings, or TPN. Alternative blood glucose control measures must be used if patient is eating or receiving intermittent tube feedings. Titration of the TPN or titration of the tube feeding or titration of clear liquids is allowed with the EndoTool™ protocol.

2. Start the EndoTool™ Program by entering the necessary patient information into the computer.

i. If patient is currently on the EndoTool™ Program and is transferring from another intensive care unit: enter the "BR" and "F" factors if known.

ii. If patient is transferring from a non-intensive care unit: search for patient by medical record number in the inactive file by clicking on the View inactive patients link under the System Tasks heading.

3. Follow EndoTool™ Program instructions for insulin infusion rates, bolus doses, D₅₀W doses, and blood glucose

determination frequency. For glucose levels 80 mg/dL or less: the insulin infusion is zero (0.0) or OFF.

EndoTool™ will print MAR stickers and orders for all calculated doses. **Nurse must obtain a physician order to give any dose that is not the calculated dose.**

4. Use a micro-pump for insulin infusion and attach into a "Y" site as close to where the IV is inserted into the

patient as possible with compatible IV fluids that infuse at a constant rate of at least 30 ml/hour.

5. Insert Daily Summary Report and Order Sheet generated by EndoTool™ Program each morning into patient's chart for documentation of the glucose readings and insulin doses administered.

6. If patient is on TPN or tube feeding that is interrupted for more than 30 minutes while on the insulin infusion: run

D₁₀W IV at the same rate as the interrupted TPN or tube feeding rate (**Must have OK from Neurosurgery if Neurosurgery is attending or consulting**). **Check glucose Q1H after a change in nutrition status and PRN****STOPPING EndoTool™ PROGRAM**

1. Discontinue EndoTool™ Program once the patient is allowed to eat and contact the primary physician regarding

further orders for blood glucose management.

a. Stop insulin drip once alternative diabetic treatment is ordered and started.

b. "IV Insulin Drip Orders" option may be printed with a physician order and used if patient is ordered to remain on an insulin drip and is being transferred to another critical care unit.

2. Print the last MAR/Orders from the "Print Patient Reports/Orders" option and place in the patient's chart.

3. If patient is transferring out of current room: click on the Patient Information tab and change the patient's status to

"inactive" by changing the "Active" status from "Y" to "N". Click "Save & Continue" to save the information.

Pharmacy

1. Mix 250 units of Regular Insulin in 250 ml NS.

2. Mix all IV medications in NS **or** ½ NS when possible.**Date:**_____ **Time:**_____ **MD Signature:**_____

TABLE E1. P-values for significant predictors ($p < 0.1$) of QIP before and after propensity score adjustment

	Before Adjustment	After Adjustment
Gender	0.05	0.90
Hypertension	0.01	0.88
COPD	0.01	0.97
Unstable angina	0.01	0.98
Recent myocardial infarction	0.01	0.80
Age >75 years	0.08	0.89
Ejection fraction <40	0.01	0.97
NYHA class	0.01	0.98
Three-vessel disease	0.01	0.99
Case priority	0.01	0.96
Type of surgery	0.01	0.99