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.

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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 postoperative mortality after cardiac surgery of implementing QIPs and quality measurement.[4,6-11]

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 guidelines[3] 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 ($P < .l$) 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 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.

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.

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.

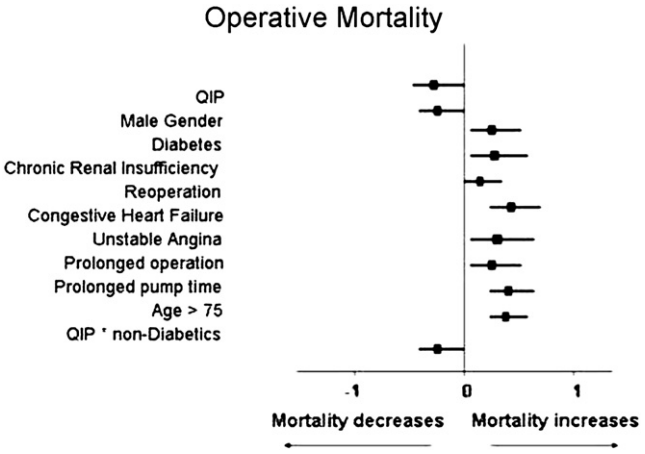

Figure 1. Independent predictors of operative mortality after cardiac surgery (multivariable logistic regression analysis). *QIP,* Quality improvement program.

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] Implementation 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 time[21] increased the risk of mortality in this study, as they have done in other studies. The interaction of QIP and nondiabetic status indicates that there were different modes of

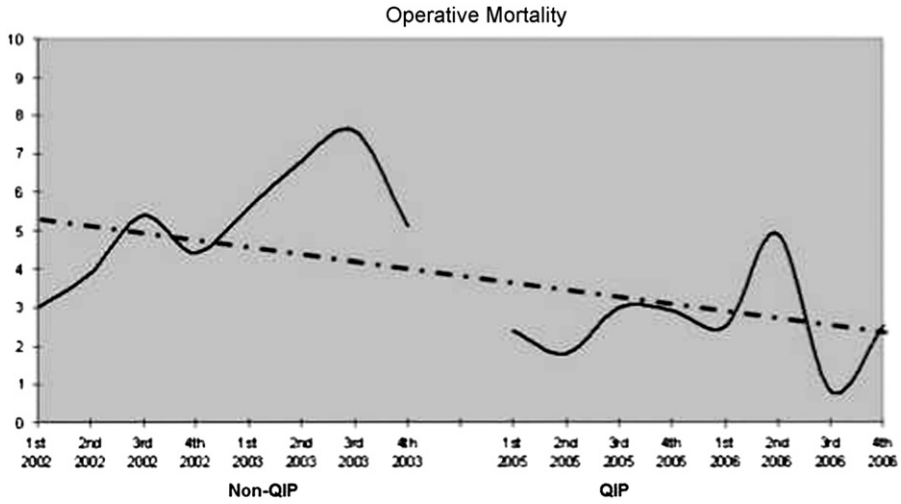

Figure 2. Graph demonstrating steady decline in operative mortality with time after institution of quality improvement program *(QIP). Gray line* represents line of best fit.

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_____cm
Wean O_2 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☐_____
_____ 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:

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_2SAT %	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:

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	1st Hour	2nd Hour	3rd Hour	4th Hour	5th Hour	6th 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 _____ $ETCO_2$ _____
2nd attempt: Time _____ NIF _____ FVC _____ TV _____ Ve _____ RR _____ $ETCO_2$ _____

Admission R.N.: _____

Admission Respiratory Therapist: _____

Expected Time of Extubation R.N.: _____

ACD

Expected Time of Extubation Respiratory Therapist: _____ Patient Sticker

CVRU Adult Report/Goal Sheet Date_____ POD # _____

Surgery _____ Attending _____ Resident _____

Allergies_____ **(AM / PM)**

Physical Assessment(report)

PreOp weight_____kg Today_____kg

Temp Current_____ Temp Max_____

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)

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)

Cardiovascular: HR ____ Rhythm_____
BP_____/_____ CVP _____ PAP _____/_____
CO_____CI_____SVR_____
PA Cath: VIP ☐ FICK ☐ SVO2/CCO ☐ SVO2 ____
Pulses: RUE _____ LUE_____ RLE _____ LLE _____
Cap Refill: RUE___ LUE___ RLE___ LLE___
IABP_____ VAD_____ Other_____

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____

Genitourinary: Foley ☐ Void ☐ Anuric ☐ Dialysis ☐
Urine: Clear☐ Cloudy☐ Sediment☐ Hematuria ☐
> 0.5 ml/kg/hour ☐ <0.5 ml/kg/hour ☐ MD notified ☐

Skin: Pink☐ Pale☐ Cyanotic☐ Warm☐ Cool☐ Dry☐
Diaphoretic☐ Sternotomy ☐ Thoracotomy (right / left)
Leg incisions (right/left) Wounds_____
Skin _____

Lines & Wires:
Pacing wires (circle): Atrial MA _____ Ventricular MA _____
Pacing (yes/no) Rate_____
A-line (location) _____ Peripherals _____
_____
Central lines (type/location) _____

Chest Tubes: Right x_____ Left x_____
Mediastinal x___
Suction ☐ Negative Pressure noted ☐ Air Leak ☐

Additional Issues of Note: _____

Signatures :_____Reporting R.N.
_____Receiving R.N.

Goals (Assessment & Plan)

Laboratory ☐ Imaging ☐ I&O ———

Sedation: Discontinue☐ Wean☐ Continue☐ Vacation☐
Comments _____

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 ☐

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☐

Nutrition: Diet _____ _____kcal/kg/day
Enteral Initiate ☐ Continue ☐ Hold ☐ Goal ☐ TF _____
Parenteral (TPN) Initiate ☐ Continue ☐ Hold ☐ Goal ☐ Rate_____

Fluid/Diuretic: Name & Dosage _____
Initiate ☐ Continue ☐ Hold ☐ Last fluid bolus _____
Maintenance IV fluid _____ ml/hour

Skin:
Ace Wraps ☐ Continue ☐ Discontinue
JP drains ☐ Continue ☐ Discontinue

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 ☐

Chest Tubes: (M.D./ACNP to complete this section)
Discontinue ☐ Continue ☐

Anticoagulation:
ASA _____mg Initiate ☐ Continue ☐ Hold ☐
Heparin IV Initiate ☐ Continue ☐ Hold ☐
Coumadin Initiate ☐ Continue ☐ Hold ☐
Other _____

Beta Blocker: Initiate ☐ Continue ☐ Hold ☐
Name and dosage:_____

Physical Therapy Initiate ☐ Continue ☐ Hold ☐

Endocrine ☐ Drugs ☐ Transfer ☐ Pt/family ?/comments ☐
Pharmacist ☐ Respiratory Therapy ☐ Physical Therapy ☐
Nutritionist ☐ Consultants_____

_____ M.D./ACNP signature

Sticker

ACD

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 LIMA: Yes/ No IABP: Yes/No Valve: Replacement/ Repair Type: Mech./ Porcine Adult Other: Chest: Open/Closed Pediatric: Skin: Open/Closed
Surgeon	
Resident	
Anesthesiologist	
CRNA/SRNA	CRNA: SRNA:
Difficult Airway	No/ Yes:
ID Band	L/ R Wrist L/ R Ankle
Medical History *circle*	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: Ancef (2nd dose)/Time: Vancomycin/Time: Aztreonam/Time:
Other Meds Given	Solumedrol
Drips *Circle if running* *Doses verified at bedside*	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: _____

ACD

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, SVO_2,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

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

1-5180-0003 CMC Post Cardio-pulmonary Bypass Adult Orders
1-5180-0003-a-8-06
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 adapter 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
Page 4 of 4
1-5180-0003 CMC Post Cardio-pulmonary Bypass Adult Orders
1-5180-0003-a-8-06
____ 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.
PropofolWeaning (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 35º C
4. PaO_2 greater than 80 on no more than 45% FIO_2 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: _____

ACD

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

Nursing

1. 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 than130 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, $D_{50}W$ 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 $D_{10}W$ 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:_____

ACD

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