Remote monitoring following adult cardiac surgery: A paradigm shift?

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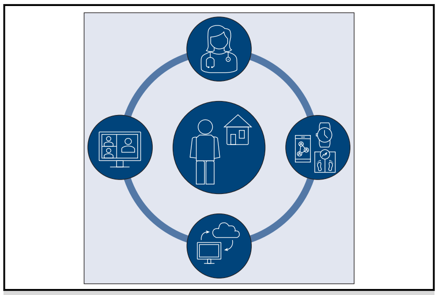
ABSTRACT

Background: The Perfect Care (PC) initiative engages, educates, and enrolls adult cardiac surgery patients into a transformational program that includes an app for appointment scheduling, tracking biometric data and patient-reported outcomes, audiovisual visits, and messaging, paired with a digital health kit (consisting of a fitness tracker, scale, and sphygmomanometer). PC aims to reduce postoperative length of stay (LOS) as well as 30-day readmission and mortality.

Methods: This was a retrospective review of patients who underwent coronary artery bypass (CAB), valve, or combined CAB and valve procedures at either of the 2 participating hospitals between April 2018 and March 2022. Patients who participated in the PC quality improvement initiative were compared to propensity-matched controls (1:1 matching). The evaluation focused on postoperative LOS and a novel composite measure comprising 30-day readmission and mortality.

Results: Remote monitoring (PC) was associated with a shorter postoperative LOS, lower combined rate of 30-day readmission and mortality, and less variation compared to matched non-PC controls.

Conclusions: Integrated improvements in postoperative remote monitoring of adult cardiac surgery patients may reduce time in the hospital and post-acute care facilities. Future prioritized efforts include the development of additional, personalized biometric monitoring devices, use of biometric data to augment risk assessment, and investigation of the value of remote monitoring on various patient risk profiles to address potential disparities in care. (JTCVS Open 2023;15:300-10)



Perfect Care includes an app and digital health kit for remote patient monitoring.

CENTRAL MESSAGE

The Perfect Care platform proposes a potentially transformational approach to engaging, remotely monitoring, and managing adult cardiac surgery patients after discharge to improve outcomes.

PERSPECTIVE

Cardiac surgery is common, costly, and risky. Despite continuous improvement efforts, considerable opportunities remain to reduce the time that patients are hospitalized and visit clinics and emergency departments, as well as to mitigate the risk of readmission and early mortality. Digital health technologies and novel care routines promise a paradigm shift in the delivery of high-quality cardiac care.

See Discussion on page 311.

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Abbreviations and Acronyms

CAB	= coronary artery bypass
DHK	= digital health kit
DSWI	= deep sternal wound infection
ICU	= intensive care unit
LOS	= length of stay
PC	= Perfect Care
PRO	= patient-reported outcomes
SMD	= standard mean difference
SPR	= standard-practice routine
STS ACSD	= Society of Thoracic Surgeons Adult Cardiac Surgery Database
STS PROM	= Society of Thoracic Surgeons predicted risk of mortality

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Adult cardiac surgery is common, risky, and costly. The Society of Thoracic Surgeons Adult Cardiac Database (STS-ACSD) recorded approximately 214,000 coronary artery bypass (CAB), valve, and combined procedures in 2021.[1] These procedures were associated with operative mortality ranging from 1.1% to 11%, major complication rates ranging from 0.2% to 27%, and 30-day readmission rates between 7.5% and 16%. The median postoperative length of stay (LOS) ranged from 5 to 9 days. Meanwhile, 2014 Medicare spending on CAB was approximately $2.3 billion, with 68% of these costs attributable to hospital inpatient care and 12% to post-acute care services.[2] Considerable variation also has been demonstrated between the lowest and highest quartiles of payments for post-acute care (29.6%) and readmission (35.1%).[3]

Driven by opportunities to improve care within the various Donabedian dimensions of quality care[4]—namely, safe, timely, effective, efficient, equitable, and patient-centered—and value, health care institutions and state collaboratives have demonstrated noteworthy success in mitigating risk and improving quality.[5-12] Since 2017, enhanced recovery associated with cardiac surgery initiatives, which popularized the notion of aggregation of marginal gains in cardiac surgery, have multiplied and extended these quality improvement efforts.[13-15] More specifically, and related to digital technologies, the 2019 Enhanced Recovery After Surgery cardiac guidelines suggest that e-health platforms should be used to engage patients.[13] Meanwhile, the opportunity to use so-called "exponential technologies" to simultaneously improve quality and value has led to burgeoning investments in health care information technologies and digital health—$6.4 and $29.1 billion, respectively, in 2021.[16-18]

Based on institutional experience and the identification of opportunities to foster institutional learning and improvement, the "Perfect Care: Personalized Cardiac Care and Collaborative" (PC) initiative was developed with the support of philanthropic funding through a generous grant from the Duke Endowment.[19,20] PC engages, educates, and enrolls adults undergoing cardiac surgical procedures into a transformational program that includes an application (app) for appointment scheduling, tracking biometric data and patient-reported outcomes, audiovisual visits, and messaging paired with a digital health kit (DHK) consisting of a fitness tracker, scale, and sphygmomanometer. PC is coordinated by nurse navigators and aims to reduce postoperative LOS as well as to improve the novel composite of 30-day readmission rates and mortality. In July 2019, the first PC was enrolled, and approximately 9 months later we entered the Coronavirus disease 2019 (COVID-19) era, but COVID-19 was not the impetus for this effort. The present study evaluated key clinical outcomes in patients undergoing CAB, valve, or combined (CAB + valve) procedures (Figure 1).

METHODS

Ethics

This study was initially approved on March 6, 2019, by the Carolinas HealthCare System's Institutional Review Board as a quality improvement initiative; following organizational changes it is now overseen by the Atrium Health-Wake Forest University School of Medicine's Institutional Review Board. Informed consent for publication of study data was obtained from all patients for their procedures and perioperative care. Data were de-identified and analyzed in aggregate in this quality improvement initiative.

Study Design and Patient Selection

The null hypothesis for this retrospective, case-cohort, quality improvement study was that remote patient monitoring does not improve postoperative LOS or the composite 30-day readmission and mortality. Patient records were eligible for evaluation if the patient underwent CAB, valve, or combined CAB + valve procedures at either of the 2 participating hospitals between April 2018 and March 2022. During this time frame, patients were selectively offered participation in PC subject to the availability of both DHKs and trained nurse navigators. Two mutually exclusive cohorts were analyzed: the PC cohort, comprising patients who participated in the PC program, and the propensity-matching pool, comprising patients who did not participate in PC.

Standard Practice Routines

As a part of continuous quality improvement efforts within our organization, a set of standard practice routines (SPRs) was implemented in 2018. These SPRs were applied universally to all patients in the study and preoperative, intraoperative, intensive care unit (ICU), and non-ICU SPRs are detailed in the online Appendix E1.

PC patients were offered the opportunity to participate in PC based on the availability of DHKs and nurse navigators. A DHK consisted of a fitness tracker, a weight scale, a sphygmomanometer, and a smartphone app was provided at each patient's preoperative clinic visit, delivered to their home, or provided at the time of hospitalization, based on procedural

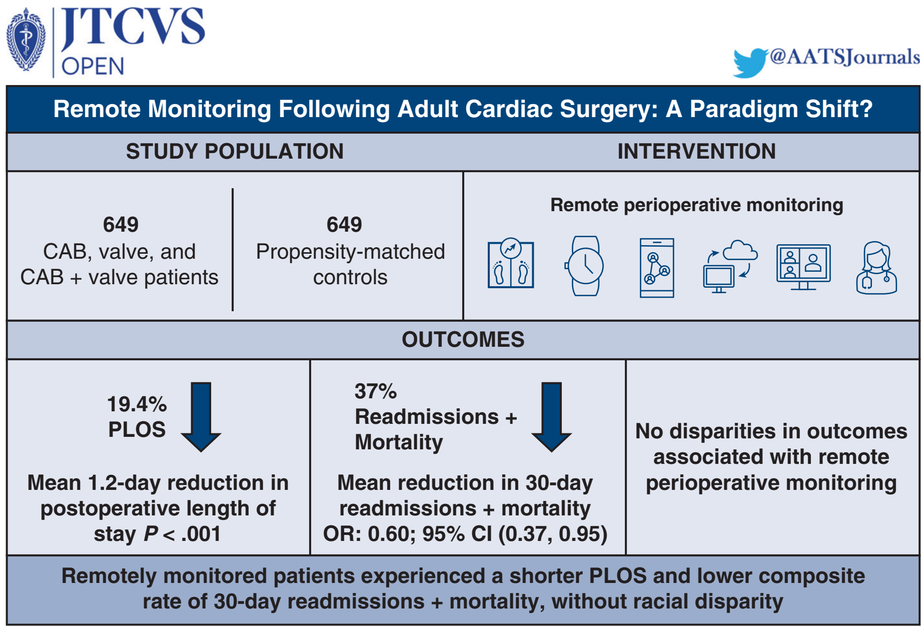

FIGURE 1. Study summary. Patients who participated in the Perfect Care initiative experienced favorable outcomes without racial disparity. *CAB*, Coronary artery bypass; *OR*, odds ratio; *CI*, confidence interval; *PLOS*, postoperative length of stay.

status and logistics. PC patients received preoperative training in the use of the app and DHK, as well as expectations regarding the PC pathway from their nurse navigator.

After discharge, the PC patient remote monitoring routine included a morning weight, twice-daily blood pressure measurements, and around-the-clock wearing of the activity tracker for recording data on sleep, steps, and heart rate data. Each patient was scheduled for a remote nurse navigator visit on the second day after discharge and then weekly for the first month, with additional visits as deemed necessary. The nurse navigators proactively monitored patient biometrics, identified trends, and intervened accordingly, and the data were monitored through 90 days postdischarge. Additionally, weekly nurse navigator huddles were held to review and improve PC process and individual patient care. PC patients were scheduled for an ambulatory clinic visit with a nurse navigator at 4 weeks postdischarge and also scheduled for visits with their primary care physician and/or cardiologist at 6 to 8 weeks postdischarge.

The non-PC patients were scheduled for a phone call with the nurse navigator at 2 days postdischarge and ambulatory clinic visits at 1 week and 4 weeks postdischarge. Additionally, the non-PC patients deemed "high risk" for readmission due to a mortality risk $\geq$3% and/or major morbidity $\geq$20% or postoperative LOS >14 days or "complex" due to hospital course or comorbidities were scheduled for additional visits with a nurse navigator, cardiologist, or their primary care physician as indicated.

Statistical Analysis

All outcomes were based on STS-ACSD definitions. The primary outcomes were postoperative LOS (defined as the time from the date of surgery through the date of discharge) and a composite measure comprising 30-day readmission and mortality. Mortality included all deaths occurring during the index hospitalization or acute care regardless of cause, as well as all deaths occurring within 30 days of discharge regardless of cause. Total LOS was defined as the span from the date of admission through the date of discharge.

SAS version 9.4 (SAS Institute) was used for all analyses. Descriptive statistics were presented as mean $\pm$ SD or median (interquartile range) for continuous variables and as proportion for categorical variables. Independent *t* tests (for continuous variables) and Fisher's exact test (for categorical variables) were used to evaluate the statistical significance of comparisons between groups. Median values were compared using the Wilcoxon signed-rank test. The α value was predefined as 0.05 for all comparisons.

To compare outcomes between groups, propensity scores were generated using PC as the outcome measure. The logistic model included the following baseline characteristics as potential confounders: sex, age, body mass index, left ventricular ejection fraction, cardiac arrhythmia, diabetes, renal failure, systemic hypertension, cerebrovascular disease, peripheral arterial disease, and Society of Thoracic Surgeons predicted risk of mortality (STS PROM) (Table 1). Using a nearest-neighbor ("greedy") matching algorithm, the scores from the model were used to create a 1:1 non-PC:PC match for analysis. Missing data for ejection fraction were imputed using the procedure- and gender-based criteria established by the STS database (Table 1). Standardized mean difference (SMD) was calculated to estimate the balance between groups. Conditional logistic regression was used to assess associations between categorical outcomes, and paired *t* tests were used for continuous measures, with a prespecified α value of 0.05.

RESULTS

Between April 2018 and March 2022, 2119 adult patients underwent CAB, valve, or combined CAB + valve procedures at the 2 institutions. Of these, 650 consecutive patients participated in PC programs, but 1 patient was excluded because they underwent multiple surgeries but did not participate in PC after both procedures. Propensity score matching analysis of baseline characteristics demonstrated no statistical

TABLE 1. Baseline Patient Demographics and Clinical Characteristics

Characteristic	Non-PC (N = 649)	PC (N = 649)	*P* value	Matched SMD*
Female sex, n (%)	166 (25.6)	166 (25.6)	>.99	0
Age, yr, mean ± SD	62.6 ± 10.7	62.6 ± 9.8	.92	0
Body mass index, mean ± SD	29.9 ± 5.5	29.7 ± 5.5	.58	0.04
Race, n (%)*			.005	NC
Caucasian	517 (79.7%)	559 (86.1%)		
African American	95 (14.6%)	68 (10.5%)		
Asian/Pacific Islander	16 (2.5%)	13 (2.0%)		
American Indian or Alaska Native	4 (0.62)	4 (0.62)		
Other	14 (2.2)	2 (0.31)		
Not reported	3 (0.46)	3 (0.46)		
Procedure type, n (%)				
CAB only	436 (67.2)	448 (69.0)	.51	
AV replacement	81 (12.5)	62 (9.6)	.11	
AV replacement + CAB	25 (3.9)	33 (5.1)	.35	
MV repair	42 (6.5)	34 (5.2)	.41	
MV repair + CAB	2 (0.3)	6 (0.9)	.29	
MV replacement + CAB	5 (0.8)	14 (2.2)	.06	
MV replacement only	58 (8.9)	52 (8.0)	.62	
LVEF, %, mean ± SD†	55.9 ± 9.5	55.4 ± 9.9	.37	0.05
Comorbidities, n (%)				
Cardiac arrhythmia	119 (18.3)	112 (17.2)	.66	0.04
Diabetes	243 (37.4)	249 (38.4)	.77	0.02
Renal failure	13 (2.0)	12 (1.8)	>.99	0.06
Hypertension	561 (86.4)	557 (85.8)	.81	0.03
Cerebrovascular disease	108 (16.6)	105 (16.2)	.88	0.02
Peripheral arterial disease	54 (8.3)	52 (8.0)	.92	0.03
STS predicted risk of mortality, %, mean ± SD	1.36 ± 1.61	1.31 ± 1.72	.66	0.03

PC, Perfect Care; *SMD*, standardized mean difference; *SD*, standard deviation; *NC*, not calculated; *CAB*, coronary artery bypass; *AV*, aortic valve; *MV*, mitral valve; *LVEF*, left ventricular ejection fraction; *STS*, Society of Thoracic Surgery. *SMDs were calculated for factors used in the propensity matching model. †Missing LVEF data for 1 PC patient and 2 non-PC patients were imputed using the STS algorithm,

differences in baseline characteristics between the PC and non-PC patients (N = 649 for each cohort; Tables 1 and E1). SMDs were all <0.1, suggesting a balanced distribution of covariates between the treatment groups. The predicted STS mortality rate was <1.5% for both treatment groups (Table E2).

Postoperative LOS was approximately 1 day shorter for remotely monitored PC patients compared to non-PC controls (mean 1.2-day reduction in LOS or 19.4% relative difference; median 1-day reduction in LOS or 16.7% relative difference; $P < .001$ for all comparisons) (Table 2). There was a 37.7% relative reduction in the composite measure of mean 30-day readmission and mortality rates between PC and non-PC patients ($P = .030$; odds ratio, 0.60; 95% confidence interval, 0.37-0.95) and less variation compared to matched controls (Tables 2, E2, and E3). There were no significant differences in the rate of major postoperative complications between the PC and non-PC patients. Small but statistically significant differences between the 2 groups were noted in mechanical ventilation time and ICU LOS (Table 3). Given the identical SPRs in the 2 groups, these differences are presented for a comprehensive perspective but are not attributable to the intervention of remote monitoring.

No significant differences in postoperative LOS or the composite of 30-day readmission and mortality were observed in the PC cohort when stratified by race (Table 4).

Analysis of discharge destinations demonstrated that a significantly greater proportion of PC patients than non-PC patients were discharged to home instead of to extended care or other types of health care facilities (Table 5).

DISCUSSION

In this analysis, patients enrolled in PC—a quality improvement initiative centered on remote patient engagement and monitoring—experienced a "paradigm shifting" combination of shorter postoperative LOS, lower rate of the composite 30-day readmission and mortality, and more frequent discharge directly to home instead of to inpatient transitional care or rehabilitation facilities compared to matched controls. This analysis parallels our earlier review of a smaller, homogeneous population of

TABLE 2. Outcomes after cardiac surgical procedures (STS definitions)

Outcome	Non-PC (n = 649)	PC (n = 649)	*P* value
Complications, n (%)			
Stroke	7 (1.1)	4 (0.6)	.37
Reoperation	27 (4.2)	20 (3.1)	.31
DSWI	1 (0.2)	0 (0.0)	>.99
ARF	9 (1.4)	6 (0.9)	.44
Prolonged ventilation	42 (6.5)	25 (3.9)	.027
Total LOS, d			
Mean ± SD	9.6 ± 8.8	8.1 ± 6.5	<.001
Median (IQR)	7 (5-11)	6 (5-10)	<.001
Postoperative LOS, d			
Mean ± SD	7.4 ± 7.7	6.2 ± 5.4	<.001
Median (IQR)	6 (5-10)	5 (4-6)	<.001
Readmissions and mortality, n (%)			
30-d combined readmissions and mortality	50 (7.7)	31 (4.8)	.029
30-d readmissions	43/642* (6.7)	31 (4.8)	.14
30-d mortality	8 (1.2)	0 (0.0)	.008†

PC, Perfect Care; *DSWI*, deep sternal wound infection; *ARF*, acute renal failure; *LOS*, length of stay; *SD*, standard deviation; *IQR*, interquartile range. *Seven patients died prior to discharge and are not included in the readmission analysis. †With no events in the PC group, conditional logistic regression could not be used. Fisher's exact test was used in this singular case.

isolated CAB patients.[21] Of note, our experience has recently included a third hospital and an unpublished analysis using the same methodology for nearly 1000 consecutive patients. That analysis demonstrated a statistically significant difference in the rate of 30-d readmission for those remotely monitored, with an odds ratio of 0.65 (95% confidence interval, 0.44-0.95). However, 30-day postdischarge mortality is rare, and an order of magnitude increase in experience likely will be needed to independently demonstrate a significant difference. Thus, future improvement efforts and analysis will emphasize 30-day readmission and 30-day postdischarge mortality, as opposed to the traditional 30-day mortality combining the more common in-hospital mortality and less common postdischarge mortality.

To our knowledge, PC is the largest and most comprehensive adult cardiac surgery digital health initiative developed to date. In a pilot study published in 2016, McElroy and colleagues studied how the addition of a DHK to a formal readmission reduction program affected outcomes after cardiac surgery.[22] The authors found no significant differences in readmission between study patients who received a DHK (n = 27) and those who did not (n = 416) and noted that although patients and providers were highly satisfied with the DHKs, the demand on resources required to address alerts was high. In 2022, Londral and colleagues published the results of another pilot study evaluating outcomes in 30 patients who were provided a DHK as part of follow-up after cardiac surgery[23]; again, although patient satisfaction with

TABLE 3. ICU outcomes

Outcomes	Non-PC (n = 649)	PC (n = 649)	*P* value
Initial ventilation time, h			
Mean ± SD	15.9 ± 63.3	11.1 ± 70.3	.20
Median (IQR)	5.2 (4.1-6.2)	4.9 (3.9-5.9)	.033
Early extubation, n (%)	475 (73.2)	503 (77.5)	.063
Reintubation, n (%)	17 (2.6)	12 (1.9)	.34
Initial ICU LOS, h			
Mean ± SD	80.1 ± 101.6	68.0 ± 74.8	.016
Median (IQR)	52.6 (47.0-80.8)	51.4 (46.7-73.7)	.019
Total ICU LOS			
Mean ± SD	80.2 ± 101.6	68.1 ± 74.8	.016
Median (IQR)	52.7 (47.0-80.8)	51.5 (46.8-73.7)	.019
ICU readmissions, n (%)	14 (2.2)	14 (2.2)	>.99

PC, Perfect Care; *SD*, standard deviation; *IQR*, interquartile range; *ICU*, intensive care unit; *LOS*, length of stay.

TABLE 4. Postoperative LOS and composite 30-d readmissions and mortality in PC patients, by race

Outcomes	Non-Caucasian* (n = 87)	Caucasian (n = 559)	*P* value
Postoperative LOS, d	6.4 ± 4.2	6.2 ± 5.5	.69
30-d combined readmissions and mortality, n (%)	4 (4.6)	27 (4.8)	>.99
30-d readmissions, n (%)	4 (4.6)	27 (4.8)	>.99
30-d mortality, n (%)	0 (0)	0 (0)	>.99

LOS, Length of stay. *Non-Caucasian includes all patients who self-reported as African American (n = 68), Asian (n = 13), American Indian or Alaska Native (n = 4), and other (n = 2).

the program was high, the study size was small, and no differences in clinical outcomes such as readmissions, mortality, or LOS were detected.

The results of the present study, with a much larger patient population and propensity score–matched controls, suggest that the technology and processes of PC may provide patients with more time at home, thereby allowing hospitals and health care systems the opportunity to reallocate ambulatory clinic and hospital resources to other priority patients and reducing the associated cost of procedures.

Limitations

This study has several limitations. Patient treatment assignment was made according to feasibility, and patient preference and was not randomized or blinded. Selection bias and/or the "Hawthorne effect" may have influenced the outcomes for both patients and their clinical teams,[24] but the large size of the 2 study populations, the use of propensity score matching, and the favorable results in both the PC and non-PC groups suggest significant impact and value. Furthermore, patients and clinicians may have confidence in earlier discharge for PC patients compared to non-PC patients. A similar phenomenon may have supported the decision to discharge to home, but we cannot measure the impact of these effects. Potentially confounding generalization is the low-risk mortality profiles of both study cohorts compared to STS benchmarks.

We examined a novel composite endpoint of 30-day readmission and mortality because both are intrinsically targeted by PC's remote monitoring efforts. It is noteworthy that our observed combined rates of 30-day readmission and mortality were low in both the PC and non-PC groups (Tables 2, E2, and E3). Furthermore, although the STS PROM is valuable and also a proxy for readmission risk, it lacks important variables from the various phases of care, such as ventilation time, complications and their timing, failure to rescue data,[25] ICU and postoperative LOS, and patient behavior and compliance with care. Additionally, readmission risk models for cardiac surgery lack consensus, acceptance, and use despite evaluation with large populations and various approaches to include phase of care considerations and advanced computing techniques.[26,27]

Future Efforts

The deliberate strategies for PC development and refinement include developing insight into patient compliance with DHK use, performing detailed analyses of biometric and PRO data, improving the quality and quantity of time at home through avoiding health care facility visits and stays,[28] and investigating variables associated with potential disparities in care, impact on various risk profiles and procedures, and the financial impact of PC implementation.[29-31] The favorable outcomes associated with PC accrued to patients regardless of racial background, and this initial—albeit rudimentary—analysis parallels the thoughtful efforts of the STS to elucidate social risk factor "concepts, variables, controversies, and risk model recommendations for further analysis, development, and use."[26]

The PC approach, combined with advanced computing, will accelerate learning and the development of more robust risk models and will catalyze continuous quality improvement.[32-34] We also envision the development of

TABLE 5. Discharge destination after mixed cardiac procedures

Discharge location	Non-PC (n = 642)*	PC (n = 649)	*P* value
Home	92.2	98.3	<.001
Extended care-transitional care unit	6.7	1.5	<.001
Other acute care hospital	0.3	0	.25
Nursing home	0.3	0.2	.57
Left against medical advice	0.5	0	.12

PC, Perfect Care. *7 patients died prior to discharge and were not included in this analysis "smart" clinical alarms, the advancement of computer-aided decision support with additional digital health tools, and models to optimize activity-based staffing.[35] Emergent strategies and tactics will inevitably develop and be addressed in a prioritized manner, based on the feasibility of technologies, processes, and people, as well as potential impacts.

CONCLUSIONS

Use of the PC platform to engage and manage patients correlated with earlier patient discharge and simultaneous decrease in the composite rate of 30-day readmission and death. A greater proportion of PC patients were discharged to home compared to non-PC patients. We conclude that the PC platform and processes are feasible, promising, and potentially paradigm-shifting. Further enrollment and analysis are warranted to refine and optimize remote monitoring following adult cardiac surgery.

Webcast

You can watch a Webcast of this AATS meeting presentation by going to: https://www.aats.org/resources/perioperative-remote-monitoring-improves-outcomes-without-disparity.

Conflict of Interest Statement

K.W.L.: Consulting relationships with Abiomed, Alexion, Medela, Medtronic, and Renibus. All other authors reported no conflicts of interest. No commercial entity was involved in any aspect of the Perfect Care initiative reported in this study.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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Key Words: digital health, remote monitoring, quality, safety, value, cardiac surgery

APPENDIX E1. STANDARD PRACTICE ROUTINES (SPRs)

Preoperative

All patients underwent an STS risk score assessment and a patient-centered, shared decision making process regarding the proposed procedure(s), risks, and alternatives. A specialized "heart team" evaluated patients with mortality risk >3% and/or combined mortality/major morbidity risk >20% to determine optimal therapeutic options and recommendations.

Intraoperative

SPRs for anesthesiology include use of a "balanced anesthetic" protocol (opioid, benzodiazepine, and low-dose inhalational agent); hemodynamic monitoring using a balloon-tipped, flow-directed pulmonary arterial catheter and a radial arterial catheter; intraoperative transesophageal echocardiography; peripheral oxygen saturation monitoring; and glucose monitoring with computerized glycemic control. For perfusion, SPRs included retrograde autologous priming and cardiopulmonary bypass with centrifugal pump, Del Nido antegrade cardioplegia with or without retrograde cardioplegia as indicated, and standard or modified ultrafiltration. Perfusion goals included a nadir hemoglobin of approximately 8 mg/dL, oxygen delivery of 275 to 300 mL/min/m^2, and a mean arterial pressure of 70 to 80 mm Hg. Heparin-induced anticoagulation was guided using activated clotting times, protamine was used for heparin reversal, and thromboelastography was used to monitor postbypass coagulation status and any requirements for transfusion of blood products. SPRs for surgical procedures included ascending aortic cannulation, single 2-stage venous cannulation for isolated coronary artery bypass, and bicaval cannulation when necessary for valvular procedures; normothermic bypass (34-35 °C); use of a single aortic cross-clamp; and, most commonly, a single dose of cardioplegia.

Postoperative

During the critical care phase, SPRs included intensivist-led twice-daily multidisciplinary rounds. Goals included extubation within 6 hours, goal-directed therapy (target cardiac index $\geq$2.2 L/min/m^2, systolic blood pressure approximately 100 mm Hg, systemic venous oxygen saturation $\geq$60%, and urine output of 0.5 mL/kg/h), and tight glycemic control. The thresholds for initiating continuous intravenous insulin infusion were >130 mg/dL for diabetics and >150 mg/dL for nondiabetics. Infusions were administered for approximately 48 hours, with a goal range of 90 to 120 mg/dL, before conversion to a computer-generated subcutaneous regimen.

The SPRs after the ICU transfer included surgeon-led multidisciplinary care coordinated by continuous APP coverage. Discharge timing and destination decisions were based on shared decision making among the multidisciplinary team, patient, and caregiver(s).

TABLE E1. Additional patient characteristics

Status, n (%)	Non-PC (N = 649)	PC (N = 649)
Status of procedure, n (%)*		
Elective	366 (54.6)	427 (65.8)
Urgent	270 (41.6)	213 (32.8)
Emergent	13 (2.0)	9 (1.4)
Salvage	0 (0)	0 (0)
Insurance status, primary payor, n (%)		
Commercial	243 (37.4)	289 (44.5)
Health maintenance organization	0 (0)	2 (0.3)
Medicaid	6 (0.92)	4 (0.62)
Medicaid, including commercially managed options	17 (2.6)	11 (1.7)
Medicare	125 (19.3)	34 (5.2)
Medicare, including commercially managed options	188 (29.0)	264 (41.0)
Military	6 (0.9)	15 (2.3)
Military health	9 (1.4)	1 (0.2)
None/self	47 (7.2)	14 (2.2)
Other	5 (0.8)	7 (1.1)
Other government insurance	0 (0)	1 (0.2)
State specific plan	3 (0.5)	7 (1.1)

PC, Perfect Care. *$P = .0023$, Fisher's exact test.

TABLE E2. Summary of mortality

Mortality	Non-PC (N = 649)	PC (N = 649)
30-d mortality, n (%)	7 (1.2)*	0 (0)
STS-PROM, %, mean ± SD	1.36 ± 1.61	1.31 ± 1.72

PC, Perfect Care; *STS-PROM*, Society of Thoracic Surgeons predicted risk of mortality; *SD*, standard deviation. *95% CI, 0.53%-2.41%; exact binomial test. Details: 7 in-hospital deaths prior to discharge on postoperative days 4, 4, 8, 8, 12, 15, and 18. One discharged patient was readmitted and died within 30 d of surgery.

TABLE E3. Reasons for readmission

Reason	Non-PC (N = 649), n (%)	PC (N = 649), n (%)
Any reason	43 (6.6)	31 (4.8)
Anticoagulation complication–pharmacologic	1 (2)	0 (0)
Arrhythmia/heart block	5 (12)	3 (10)
Blood pressure (hypertension or hypotension)	1 (2)	2 (6)
Congestive heart failure	5 (12)	2 (6)
Coronary artery/graft dysfunction	1 (2)	0 (0)
Gastrointestinal issue	1 (2)	4 (13)
Infection–conduit harvest	1 (2)	1 (3)
Myocardial infarction	0 (0)	1 (3)
Other-nonrelated readmission	2 (5)	3 (10)
Other-related readmission	8 (19)	7 (23)
Pulmonary embolism	2 (5)	0 (0)
Pericardial effusion and/or tamponade	6 (14)	2 (6)
Pericarditis/postcardiotomy syndrome	0 (0)	1 (3)
Pleural effusion requiring intervention	1 (2)	0 (0)
Pneumonia	2 (5)	1 (3)
Respiratory complications, other	1 (2)	1 (3)
Sepsis	2 (5)	0 (0)
Stroke	2 (5)	2 (6)
Vascular complication, acute	0 (0)	1 (3)
Wound, other (drainage, cellulitis)	2 (5)	0 (0)

PC, Perfect Care.