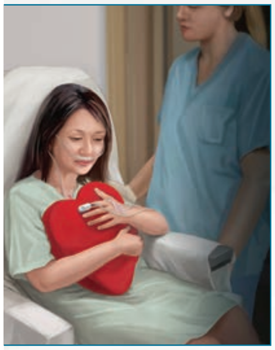

Reducing Intubation Time in Adult Cardiothoracic Surgery Patients With a Fast-track Extubation Protocol

Myra F. Ellis, MSN, RN, CCRN-CSC
Heather Pena, BSN, RN, CCRN
Allen Cadavero, PhD, RN, CCRN, CWON
Debra Farrell, RN, CCRN-CSC
Mollie Kettle, BSN, RN, CCRN-CSC
Alexandra R. Kaatz, BSN, RN, SRNA
Tonda Thomas, RN, CCRN-CSC
Bradi Granger, PhD, RN
Kamrouz Ghadimi, MD

BACKGROUND Prolonged intubation after cardiac surgery increases the risk of morbidity and mortality and lengthens hospital stays. Factors that influence the ability to extubate patients with speed and efficiency include the operation, the patient's baseline physiological condition, workflow processes, and provider practice patterns.

LOCAL PROBLEM Progression to extubation lacked consistency and coordination across the team. The purpose of the project was to engage interprofessional stakeholders to reduce intubation times after cardiac surgery by implementing fast-track extubation and redesigned care processes.

METHODS This staged implementation study used the Define, Measure, Analyze, Improve, and Control approach to quality improvement. Barriers to extubation were identified and reduced through care redesign. A protocol-driven approach to extubation was also developed for the cardiothoracic intensive care unit. The team was engaged with clear goals and given progress updates.

RESULTS In the preimplementation cohort, early extubation was achieved in 48 of 101 patients (47.5%) who were designated for early extubation on admission to the cardiothoracic intensive care unit. Following implementation of a fast-track extubation protocol and improved care processes, 153 of 211 patients (72.5%) were extubated within 6 hours after cardiac surgery. Reintubation rate, length of stay, and 30-day mortality did not differ between cohorts.

CONCLUSIONS The number of early extubations following cardiac surgery was successfully increased. Faster progression to extubation did not increase risk of reintubation or other adverse events. Using a framework that integrated personal, social, and environmental influences helped increase the impact of this project. (*Critical Care Nurse*. 2021;41[3]:14-24)

CE 1.0 hour, CERP A

This article has been designated for CE contact hour(s). The evaluation tests your knowledge of the following objectives:

1. Identify the importance of reducing intubation times in cardiac surgery patients.
2. Distinguish process, people, and patient barriers to extubation in postoperative cardiac surgery patients.
3. Explain the advantage of using a behavioral change framework to improve staff engagement in the improvement initiative.

To complete evaluation for CE contact hour(s) for activity C2131, visit www.ccnonline.org and click the "CE Articles" button. No CE fee for AACN members. This activity expires on June 1, 2023.

The American Association of Critical-Care Nurses is accredited as a provider of nursing continuing professional development by the American Nurses Credentialing Center's Commission on Accreditation, ANCC Provider Number 0012. AACN has been approved as a provider of continuing education in nursing by the California Board of Registered Nursing (CA BRN), CA Provider Number CEP1036, for 1 contact hour.

 doi:https://doi.org/10.4037/ccn2021189

For patients undergoing cardiac surgery, early extubation after surgery is associated with fewer adverse outcomes, shorter intensive care unit (ICU) stays, and lower costs.[1-4] The Society of Thoracic Surgeons (STS) defines early extubation as extubation within 6 hours after ICU admission following cardiac surgery.[3] Prolonged intubation of more than 24 hours is a key quality indicator following cardiac operations and is reported to STS-participating institutions as a morbidity metric for star quality ratings.[5] Prolonged intubation is associated with adverse outcomes and increased costs.[4,6] Examples of adverse outcomes reported in the literature are infectious complications, renal failure, stroke, ICU readmission, reintubation, and operative mortality.[4,7]

Local Problem

In our 32-bed dedicated cardiothoracic ICU embedded within a large academic medical center in the southeastern United States, patient extubation times were inconsistent. Specifically, our group lacked a uniform approach to advance patients toward extubation. Other challenges were a lack of staff awareness of the time-dependent extubation goal of the STS quality metric for early extubation and poor care coordination across disciplines (eg, among nurses, respiratory therapists, ICU clinicians, and physicians). For example, during handoff to the ICU team a surgeon would identify a patient as appropriate for early extubation, but no set criteria, workflow algorithm, or timeline for progression were in place. Therefore, progression to extubation lacked consistency and coordination across the team. Early extubation was dependent not only on patient readiness but also on communication and staff workflow (eg, delays during handoffs).

We sought to implement a fast-track extubation (FTE) program to improve patient outcomes and reduce costs associated with prolonged intubation times in adult patients after cardiac surgery. The purpose of this quality improvement initiative was to achieve early extubation in patients after cardiac surgery by using an extubation protocol and redesigned care processes. This study was approved by the Duke University Hospital institutional review board and met criteria for exemption as a quality improvement study. The framework used for this report of our quality improvement study was the Standards for Quality Improvement Reporting Excellence 2.0 publication guideline.[8,9]

Progression to extubation lacked consistency and coordination across the team.

Methods

We used the Define, Measure, Analyze, Improve, and Control quality improvement approach to design and conduct this implementation study.[10] In the definition phase, we recognized high rates of variability in extubation time among patients who had undergone cardiac

Authors

Myra F. Ellis is a clinical nurse IV in the cardiothoracic intensive care unit (CTICU) and chair of the CTICU nursing research committee at Duke University Hospital, Durham, North Carolina. She also serves as a director on the American Association of Critical-Care Nurses Certification Board.

Heather Pena is a strategic services associate in patient safety and quality improvement, Duke University Hospital.

Debra Farrell is a clinical nurse IV in the CTICU and a member of the CTICU nursing research committee, Duke University Hospital.

Mollie Kettle is a clinical team lead in the CTICU, Duke University Hospital.

Allen Cadavero is an assistant professor, Duke University School of Nursing, and a clinical nurse III in the cardiothoracic intensive care unit at Duke University Hospital, Durham, North Carolina.

Alexandra R. Kaatz is pursuing a doctor of nursing practice in nurse anesthesia, Duke University School of Nursing.

Bradi Granger is the director of the Duke Heart Center nursing research program and a professor, Duke University School of Nursing.

Tonda Thomas is a clinical nurse III in the CTICU and a member of the CTICU nursing research committee, Duke University Hospital.

Kamrouz Ghadimi is a cardiothoracic intensive care physician and cardiothoracic anesthesiologist in the Department of Anesthesiology and Critical Care, Duke University Hospital.

Corresponding author: Myra Ellis, MSN, RN, CCRN-CSC, 320 Moore Hill Way, Holly Springs, NC 27540 (email: myra.ellis@duke.edu).

To purchase electronic or print reprints, contact the American Association of Critical-Care Nurses, 27071 Aliso Creek Rd, Aliso Viejo, CA 92656. Phone, (800) 899-1712 or (949) 362-2050 (ext 532); fax, (949) 362-2049; email, reprints@aacn.org.

surgery and used the STS criteria for early extubation in patients in stable condition following surgery.

Sample

During the measurement phase, we collected data prospectively in a preintervention convenience sample of 101 cardiac surgery patients during 1 quarter in 2016 to determine the current state of practice and to define the scope of the problem in our local patient population. We evaluated intubation times and barriers to extubation in patients identified as eligible for progression to extubation. In this preintervention (baseline) cohort, 53 patients (52%) did not meet standard STS guidelines for early extubation. Of these, 21 (40%) had no identifiable barriers to extubation but still missed the goal.

Procedures

We used root cause analysis to identify extubation processes and patient and system barriers contributing to prolonged intubation times. Barriers to extubation were categorized into 3 groups: process-specific, people-specific, and patient-specific barriers.[11] Process issues included a lack of clarity about eligibility for early extubation by the surgical team, inappropriate use of sedation for hemodynamic control (eg, increasing the propofol infusion dose to lower blood pressure), inadequate pain management (possibly related to oversedation), and lack of a clear plan for initiating the weaning and extubation process. In the category of people-specific barriers, we found problems with interdisciplinary communication, poor patient progression during shift change, and an absence of cross-coverage when respiratory therapists were off the unit transporting patients. The most common patient-specific barrier was metabolic acidosis. Others included respiratory acidosis, hemodynamic instability, bleeding, and altered mental status.

Clinicians will change practice if they believe it is important and they are able to do what is needed.

Analysis

In the analysis phase, we used an interdisciplinary team to analyze preintervention data, consider the most common root causes, and posit solutions to minimize variability in extubation times. Stakeholders from all disciplines (nursing, anesthesiology, cardiac surgery, intensive care, respiratory therapy, pharmacy, and advanced practice) were invited and involved in eliminating barriers and improving time to extubation. Each discipline took ownership and collaborated to eliminate or minimize the impact of the barriers to extubation. These barriers and solutions are summarized in Table 1.

As part of the root cause analysis, we reviewed extubation protocols that successfully reduced duration of mechanical ventilation, weaning time, and ICU length of stay for adoption in our local setting.[11-13] Previous studies have demonstrated shortened intubation times without increased risk by using standard extubation protocols.[14] Using this information, our team developed an FTE algorithm and protocol rooted within our enhanced patient care processes (Figures 1 and 2).

Intervention

During the improvement phase we implemented a protocol-based approach focused on improving extubation variability. This quality improvement study was conducted in our high-volume, high-acuity, 32-bed cardiothoracic ICU. Postoperative ICU care is delivered for all types of cardiothoracic surgery, including coronary artery bypass graft and valvular surgeries; mechanical circulatory support (eg, ventricular assist devices and extracorporeal membrane oxygenation); and cardiac and pulmonary transplantation. The unit is staffed on each shift with dedicated intensivists, fellows, advanced practice providers, respiratory therapists, and registered nurses. The total number of staff members who required orientation to our newly developed processes included 170 nurses, 12 respiratory therapists, 14 intensivists, 40 advanced practice providers, 9 cardiothoracic surgery trainees, and 15 surgeons. Because of the large number of clinicians needed to fully staff the unit, approximately 70 nurses and more than 20 others typically receive orientation annually.

We chose the Influencer behavioral change framework created by Patterson and colleagues[15] to guide the improvement intervention. This framework is based on evidence suggesting that people will change behavior if they believe it is important and they are able to do what is needed. Historically, practice change in our unit has been difficult to sustain and new information has been disseminated primarily through written or verbal communication. To improve engagement with this initiative, the nursing research team used the model of change

Table 1 Barriers to extubation with barrier types and resolutions

Type	Barriers	Resolution
Process	Inconsistent weaning practice	Implement standardized weaning protocol for all patients identified as appropriate for the FTE protocol.
	Patients inappropriately labeled as ready to progress to extubation (eg, patients with hemodynamic instability, bleeding, acidosis)	Include considerations for exclusion in protocol; team will indicate clear yes or no for all patients during handoff in CTICU.
	NMB agents not reversed	Decrease NMB use after CPB; check TOF on admission (in protocol).
	RT unavailable for ventilator weaning or changes; no designated person to cover duties during lunch, travels off unit, etc	Designate a person for OR; each RT will let RN know who to call when RT travels off the unit with a patient; RTs will cover duties for each other.
	Workflow issues, handoffs (6 PM for APPs, 7 PM for RTs and RNs)	Try to discuss needs with APP before 6 PM if possible; hand-off can be interrupted for extubation order if ABG is WNL and patient is on extubatable settings ready for extubation; the only time patients will not be extubated is 7-7:30 PM during handoff for RNs and RTs.
	Hypertension management with pain and sedation medications	Discuss preferred agent for hypertension management with surgical team at handoff.
People	Nurses' desire for time to catch up before weaning and extubating (medical records, lunch, bath, etc); slow to decrease sedation	Start weaning as soon as ABG values are WNL; work together to cover each other's duties so patient progress is not delayed.
	Slow propofol weaning	Provide education to nurses for weaning; slow wean is not required (language in order not clear).
	Prolonged weaning using multiple ABG values	Provide education about using $ETCO_2$ and minute ventilation; ABG is not always needed to see patient improvement.
Patient	Metabolic acidosis	Implement modifications by OR team; decrease ultrafiltration.
	Hypothermia on admission	Protocol addresses rewarming.
	Pain control	Implement new pain control order set for FTE patients, allowing more frequent doses of pain medications on the basis of CPOT score or numeric scale.
	Anxiety and pain upon awakening, propofol wean not tolerated, dexmedetomidine started; transition delays extubation	Provide pain medications in OR for better pain control in first hours of admission to OR; in ICU, keep sedation lighter (RASS 0 to −2) to assess and treat pain.

Abbreviations: ABG, arterial blood gas; APP, advanced practice provider; CPB, cardiopulmonary bypass; CPOT, Critical Care Pain Observation Tool; CTICU, cardiothoracic intensive care unit; $ETCO_2$, end-tidal carbon dioxide; FTE, fast-track extubation; ICU, intensive care unit; NMB, neuromuscular blockade; OR, operating room; RASS, Richmond Agitation-Sedation Scale; RN, registered nurse; RT, respiratory therapist; TOF, train-of-four; WNL, within normal limits.

described by Patterson et al,[15] focusing on the conceptualization of behavior as motivated by 6 sources of influence. Using this evidence, we chose personal, social, and structural sources of influence to guide the interventions for FTE protocol implementation (Table 2). The stakeholder groups were educated by using an online module. This module included information about our internal performance data, the STS quality metrics, and the new FTE extubation protocol and redesigned care processes. We also posted flyers around the unit and provided information at staff meetings. We drew attention to the new protocol with a kickoff party that included snacks and unit decorations with a fast-track race car theme. We implemented the FTE protocol on September 1, 2017.

We created a monitoring and measurement plan to evaluate the success of the intervention. The primary end point for the quality improvement study was early extubation, as defined by the STS (< 6 hours following admission to the ICU from the operating room). In addition, patient demographics, type of surgery, operating room and ICU medications, arterial blood gas values, and barriers to extubation were recorded. We selected standard definitions for all data points, including categorical definitions for barriers to extubation. Environmental reminders such as copies of the FTE protocol and

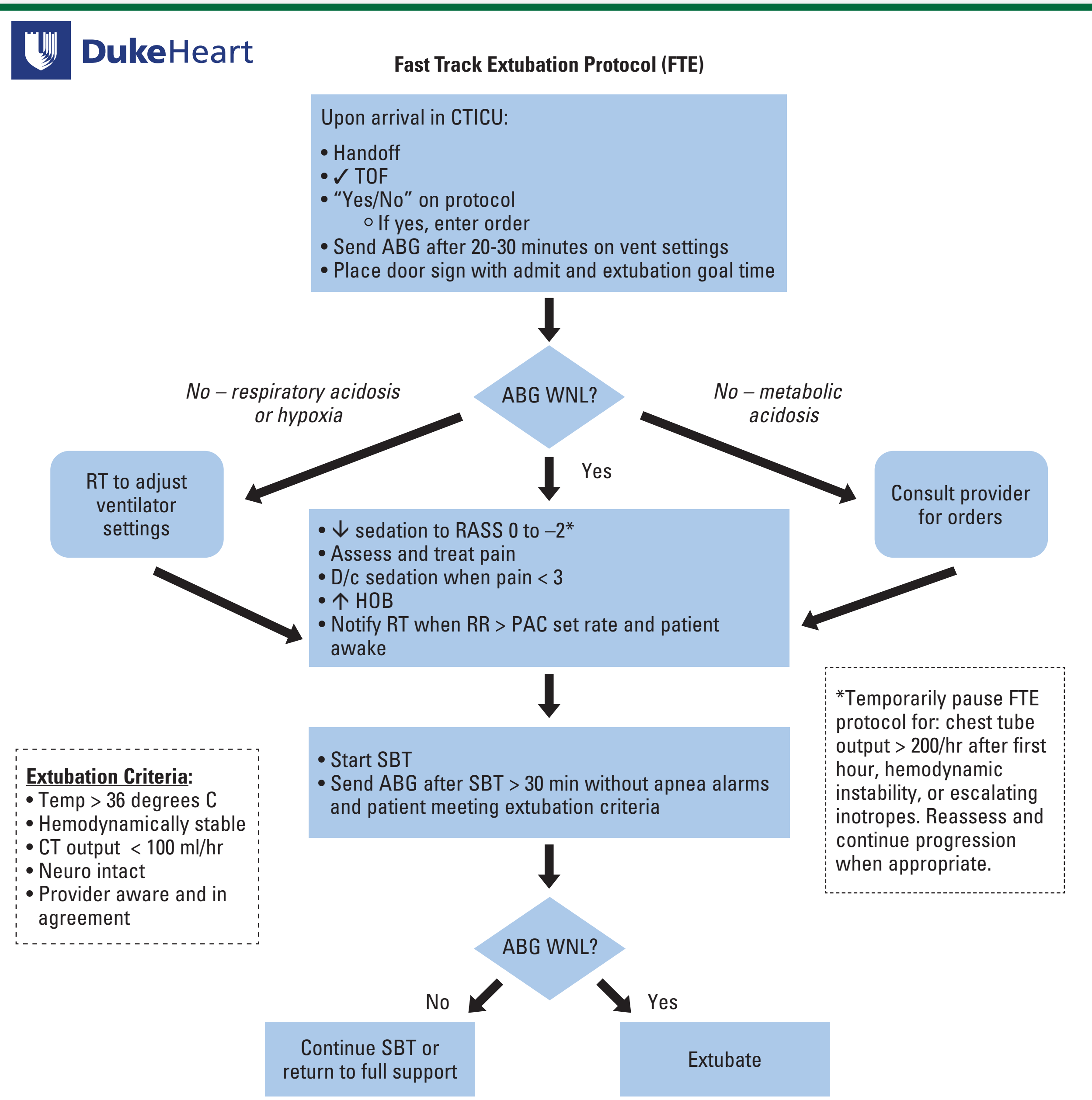

Figure 1 Fast-track extubation flowchart delineating patient progression and/or pauses in the extubation protocol.

Abbreviations: ABG, arterial blood gas; CT, chest tube; CTICU, cardiothoracic intensive care unit; D/C, discontinue; HOB, head of bed; PAC, pressure assist control; RASS, Richmond Agitation-Sedation Scale; RR, respiratory rate; RT, respiratory therapist; SBT, spontaneous breathing trial; TOF, train-of-four; WNL, within normal limits.

Reprinted with permission from Duke University Hospital.

signs with the extubation time goal (Figure 3) placed on the door of each patient room drew staff attention and defined expected practice.

Members of the unit nursing research team collected data for all FTE patients. We created a log of all FTE patients for daily tracking and follow-up with data collection. A standard data sheet was completed for every patient designated for FTE. Data were collected prospectively from the electronic health records. Barriers were identified through review of electronic health records for items meeting barrier definition criteria or with additional input from the care team. Team performance was reported as the percentage of eligible patients achieving early extubation each week. We used a racetrack that was updated weekly to include the names of the "pit crew" (nurse, respiratory therapist,

Fast-track Extubation Protocol

Inclusion criteria: Agreement of anesthesia and surgical team for appropriateness for FTE
Considerations for exclusion: Open sternum, chest tube output > 200/h after first hour, hemodynamic instability (ie, HR < 60 beats/min or > 120 beats/min, CVP > 20 mmHg, MAP < 60 mmHg, SvO_2 < 60 %, cardiac index < 2.0 L/min/m^2), escalating inotropes, or mechanical assist device (includes IABP, VAD, ECMO)

1. Upon arrival - handoff key components
   - Last paralytic (time, medication, dose)
   - Paralytics reversed
   - Last dose of analgesics (time, medication, dose)
   - Respiratory concerns (airway, ventilation, etc)
   - Last ABG value (including lactate, glucose)
   - Check TOF on all patients to assess if residual neuromuscular blockade is present. (RN brings TOF monitor to room on admission.)
   - Clear plan for extubation (yes/no "on protocol")
     - If yes, add Nursing miscellaneous order to "Implement Fast-track Extubation Protocol"

2. First ABG value drawn 20-30 minutes after arrival
   - RN checklist
     - Place door sign with admit time and extubation goal time (6 hours)
   - If ABG value within normal limits, begin patient progression to extubation (#3)
   - If ABG value abnormal:
     - Respiratory acidosis or hypoxia:
       - pH < 7.35 without contributory base deficit
       - RT adjusts ventilator parameters
       - Use $ETCO_2$ for monitoring – compare value with baseline $PaCO_2$ from ABG
     - Metabolic acidosis
       - pH < 7.35 with normal pCO_2 and base deficit $\geq$ –3
       - Consult provider for orders
     - Consult with provider to determine need for repeat ABG and/or ability to progress to extubation

3. Progression to extubation (begin as soon as patient is ready)
   - Wean sedation to RASS 0 to –2
     - Notify provider if unable to achieve RASS goal.
     - Treat hypertension with clevidipine or other antihypertensive as ordered
   - Assess and treat pain

4. Preparing for extubation
   - Once pain is under control, D/C propofol
   - Notify RCP when respiratory rate > PAC set rate
   - Discuss with RCP re: suitability for transition to SBT
   - Elevate HOB $\geq$ 30° or place bed in modified chair position with HOB $\geq$ 30°

5. Send ABG after patient on SBT $\geq$ 30 minutes without apnea alarms and meeting extubation criteria listed (refer to adult mechanical ventilation protocol for routine postoperative cardiothoracic surgery)
   - Temperature > 36°C
   - Hemodynamically stable
   - CT output < 100 mL/h
   - Neuro intact
   - Provider aware and in agreement

Figure 2 Fast-track extubation protocol with suggestions for exclusion and steps of patient progression to extubation.

Abbreviations: ABG, arterial blood gas; CT, chest tube; CVP, central venous pressure; D/C, discontinue; ECMO, extracorporeal membrane oxygenation; $ETCO_2$, end-tidal carbon dioxide; FTE, fast-track extubation; HOB, head of bed; HR, heart rate; IABP, intra-aortic balloon pump; MAP, mean arterial pressure; PAC, pressure assist control; RASS, Richmond Agitation-Sedation Scale; RCP, respiratory care practitioner; RN, registered nurse; RT, respiratory therapist; SBT, spontaneous breathing trial; Svo_2, venous oxygen saturation; TOF, train-of-four; VAD, ventricular assist device.

and advanced practice provider) who successfully extubated patients within the recommended period (Figure 4). Social influence can be a key factor in individuals' adoption of new innovations.[16] The racetrack generated enthusiasm and captured the power of peer influence. Having names on the racetrack created

Table 2 Sources of influence for implementing the fast-track extubation protocol[15]

	Motivation	Ability
Personal	Make it fun!	Provide education for the protocol.
Social	Have kickoff party with a racing theme.	Make using the fast-track extubation protocol the new norm.
Structural	Post a racetrack to recognize "pit crew."	Install door signs to remind team of the 6-hour time frame.

Fast-track Extubation

YES/NO

Intubation Time

Admit time: ___________

Extubate by: ___________

Figure 3 Example of the door sign created to notify team members of early extubation time frame.

Figure 4 Picture of the fast-track extubation racetrack in the unit break room, celebrating each successful "pit crew" that achieved early extubation. The racetrack was updated weekly on Monday mornings.

healthy competition between peers, making best practices socially desirable.

Members of the interdisciplinary team met monthly to review data and modify interventions if needed. Data were collected for 3 months following implementation. As the need for clarification or modifications arose, ongoing education was disseminated to the care team after discussion among stakeholders and protocol implementation.

In the final phase of the study (control), the research team agreed to continue to monitor every FTE patient for a full year with a modified data form to evaluate the 12-month sustained effect of the intervention. Staff member enthusiasm for seeing their car awarded on the racetrack was high, so the racetrack theme also continued for a year (September 1, 2017, to August 31, 2018).

Results

Our results demonstrated that an early extubation protocol can safely decrease ventilation time without increasing morbidity or mortality. All patients designated for progression to extubation were included in the analysis except 4 patients who received FTE but underwent unplanned reoperation following admission to the ICU. These 4 patients were excluded from the analysis according to STS database criteria for unplanned reoperations. The final analysis included 312 patients (101 in the preintervention cohort and 211 in the FTE cohort). Patients' procedures included coronary artery bypass graft surgery, valve repair or replacement, ascending aortic aneurysm repair, maze procedure, septal myectomy, and combinations of these procedures. Eighty-three patients (28 in the preintervention cohort, 55 in the FTE cohort) had combined procedures. Baseline demographic characteristics of the 2 cohorts were not significantly different (Table 3). The mean (SD) patient age for the combined cohorts was 62.0 (13.2) years. Most patients were male (n = 209 [67%]) and White (n = 253 [81%]). Patients' mean (SD) body mass index was 29.2 (6.3). The preoperative glomerular filtration rate was greater than 60 mL/min for most patients (n = 229 [73.4%]). Most patients had preoperative essential hypertension (n = 217 [69.6%]) and a diagnosis of heart failure (n = 183 [58.7%]). Current smokers made up a small proportion of the patient population (n = 32 [10.3%]), as did patients with chronic lung disease. Most patients underwent elective surgery (n = 270 [86.5%]).

The primary results of the study demonstrated significant, sustained improvement in the rate of extubation less than 6 hours after surgery (Figure 5). As shown in the control chart, the proportion of patients extubated within the recommended 6-hour window in the preintervention cohort was 47.5% (n = 48), demonstrating a large opportunity for improvement. Following the intervention, the proportion of patients extubated in less than 6 hours increased to 72.5% (n = 153; $P < .001$). In the FTE cohort, people- and process-related barriers decreased from 48% to 17%.

Factors associated with successful extubation in less than 6 hours were absence of heart failure within the previous 2 weeks (Wald $\chi^2 = 4.09$; $P = .04$) and being in the FTE cohort (Wald $\chi^2 = 15.48$; $P < .001$). We also found a tendency toward shorter ICU and hospital stays, but these differences were not significant ($P = .41$ and $P = .31$, respectively). The mean number of arterial blood gas samples obtained was 5.3 in patients extubated after more than 6 hours and 3.3 in patients extubated in less than 6 hours. This finding suggests a potential cost reduction, although cost data were not collected in this study. Reintubation rates during the hospital stay did not appreciably differ between the 2 cohorts (preintervention cohort, 2 of 101 patients [2%]; FTE cohort, 3 of 211 patients [1%]). At the end of 1 year, the monthly early extubation rate ranged from 62% to 85%, with an overall rate of 73.6% (559 of 760 patients).

The team selected surgical patients with similar medical conditions for the preintervention cohort but included some surgical patients with more complicated conditions in the early extubation quality initiative. We analyzed data for this group of patients separately because of lack of similarity with the preintervention cohort. This discovery cohort was defined as patients who were considered eligible for early extubation but met 1 or more of the prespecified considerations for exclusion (Figure 2). The study team chose to list exclusions as "considerations" rather than specifying limits for FTE protocol use. The apparent precision and safety of our FTE protocol ushered in the inclusion of high-risk patients in protocol-based care. Although these patients would not previously have qualified for inclusion in the quality improvement project according to the initial criteria, they were ultimately included and safely progressed to extubation. Of these 23 patients, 9 (39%) were successfully extubated within 6 hours. We likely achieved this result because safety is designed into the protocol: continuation or cessation of progression toward extubation depends on prespecified safety parameters (eg, patient free from acidosis, patient hemodynamically stable, chest tube output minimal) delineated in the FTE protocol.

Table 3 Baseline patient demographic characteristics

Characteristic	Preintervention cohort (n = 101), No. (%)[a]	FTE cohort (n = 211), No. (%)[a]
Age, mean (SD), y	60.8 (13.6)	62.91 (13.0)
Male sex	62 (61.4)	147 (69.7)
Race		
White	85 (84.2)	168 (79.6)
Black	13 (12.9)	35 (16.6)
Asian	3 (3.0)	6 (2.8)
Other	0 (0.0)	2 (0.9)
Body mass index,[b] mean (SD)	29.3 (6.9)	29.1 (6.0)
Preoperative GFR, mL/min		
> 60	80 (79.2)	149 (70.6)
30-59	15 (14.9)	55 (26.1)
15-29	1 (1.0)	2 (0.9)
< 15	5 (5)	5 (2.4)
Dialysis dependent	5 (5)	6 (2.8)
Diabetes	30 (29.7)	51 (24.2)
Type 1	2 (2.0)	2 (0.9)
Type 2	28 (27.7)	49 (23.2)
Hypertension	67 (66.3)	151 (71.6)
Essential	66 (65.3)	151 (71.6)
Secondary	1 (1.0)	0 (0.0)
Chronic lung disease		
Mild	2 (2.0)	5 (2.4)
Moderate	1 (1.0)	4 (1.9)
Severe	0 (0.0)	1 (0.5)
Severity unknown	6 (5.9)	7 (3.3)
Heart failure[c]	54 (53.5)	129 (61.1)
LVEF < 35%[d]	1 (1.0)	14 (6.6)
Cardiac reoperation	7 (6.9)	23 (10.9)
Operative status		
Elective	88 (87.1)	182 (86.3)
Urgent	13 (12.9)	29 (13.7)
Emergency	0 (0.0)	0 (0.0)
Current smoker	12 (11.9)	20 (9.5)
Cardiopulmonary bypass time, mean (SD), minutes	147.5 (65.7)	142.2 (65.2)

Abbreviations: FTE, fast-track extubation; GFR, glomerular filtration rate; LVEF, left ventricular ejection fraction.

[a] Unless otherwise indicated.
[b] Body mass index calculated as weight in kilograms divided by height in meters squared.
[c] Heart failure: systolic, within 2 weeks of surgery.
[d] *P* value nonsignificant for all factors except LVEF (*P* = .04).

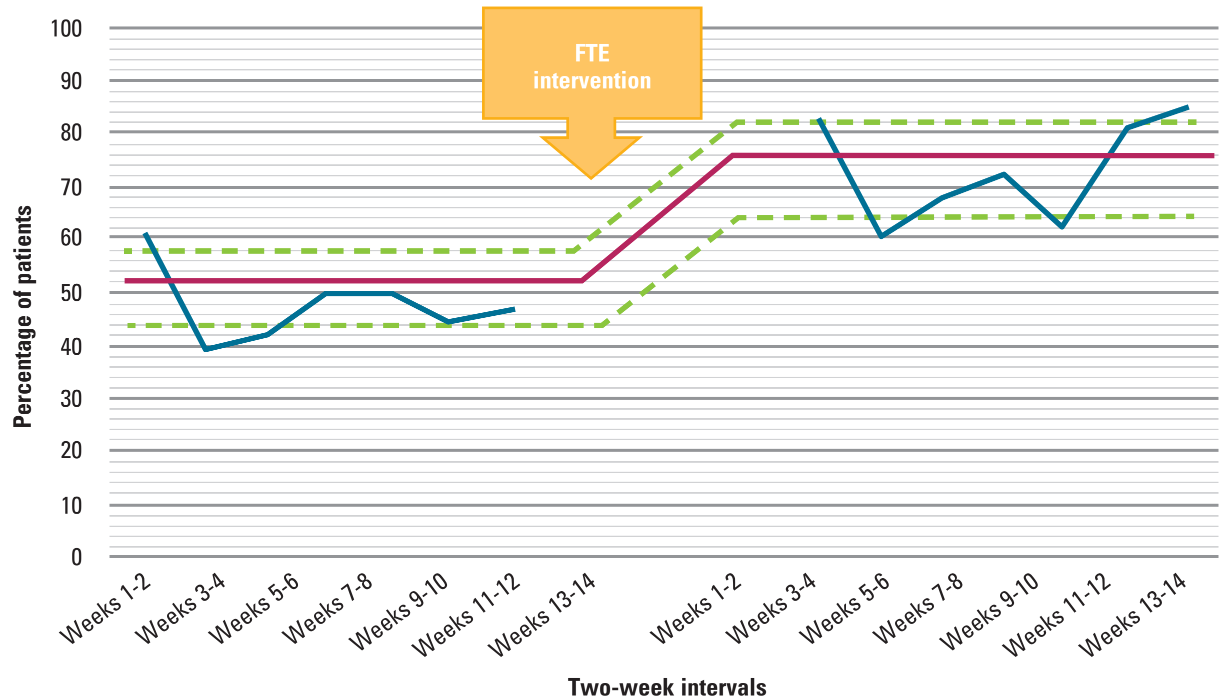

Figure 5 Primary results control chart showing the percentage of cardiac surgical patients extubated within 6 hours of intensive care unit arrival before and after implementation of a multidisciplinary fast-track extubation (FTE) protocol (blue line). The red line shows the median percentage of patients extubated within 6 hours. The green dashed lines show the SD.

Discussion

The results of this quality improvement study demonstrate that a multidisciplinary approach can successfully improve the proportion of patients extubated within a 6-hour window according to the STS quality recommendations. Similar to other published studies, our results demonstrated that an early extubation protocol can safely decrease ventilation time without increasing morbidity or mortality.[17]

Previous studies have successfully used quality improvement approaches to reduce variability in intubation times.[11-13] Extubating patients soon after cardiac surgery is based on a number of factors, including the patient's baseline physiological condition and comorbidities, workflow processes/culture, and provider practice patterns. Examination of all factors that influence the ability to decrease unnecessary intubation time is necessary to improve practice. In addition, the use of standardized extubation protocols has been shown to reduce intubation time without increasing patient risk.[14,17,18] Gutsche et al[11] identified workflow barriers, physical inconveniences, and interdisciplinary miscommunication as causes of increased intubation times. They used a coordinated approach to mitigate these factors, improving early extubation from 27% (53 of 195 patients) to 50% (85 of 171 patients).[11] Similarly, Fitch and colleagues[12] used a sequential approach to integrate a new process aimed at improving early extubation. Their approach consisted of monitoring current practice (phase 1); implementing an extubation protocol (phase 2); and continuing to use a protocol combined with reversal of paralytic agents, extubation at lower body temperature, and reminders in the patient room (phase 3). Early extubation improved from 11.8% in phase 1 (139 of 1174 patients) to 23.9% in phase 2 (151 of 631 patients) and 38.3% in phase 3 (98 of 256 patients).[12] In addition to implementing an extubation protocol and improving communication, Hefner et al[13] amended the postoperative order set to reduce intubation times and reported

Our findings support the use of multidisciplinary protocol-driven care in improving safety, timeliness, efficiency, and consistency of care delivery associated with patient extubation.

sustaining the reduction in intubation times for 4 years. Our study demonstrated an improvement in extubation time at 3 months, as was found in studies by Gutsche et al[11] and others,[12,13] but we were also able to show a sustained effect at 1 year.

By developing and implementing an extubation protocol with members of the interdisciplinary team as key stakeholders in the care redesign process, we were able to reduce barriers related to people (eg, individual-level variations in order writing or propofol weaning) and processes (eg, ventilator weaning, handoffs, and workflow issues). Our findings, consistent with those of Chan and colleagues,[18] support the use of multidisciplinary protocol-driven care in improving safety, timeliness, efficiency, and consistency of care delivery associated with patient extubation.[19]

We observed a decline in the number of patients achieving early extubation 6 to 7 months into the project. We attributed this observation to a high influx of new nurses, respiratory therapists, and residents with the new academic year. To improve compliance and reengage the team, we used the same strategies to raise awareness of the FTE protocol. These strategies included education for new team members and inclusion of the FTE content in the orientation curriculum.

Unique to our study as compared with others in the literature was the use of a change model to guide personal, social, and structural sources of influence to motivate change.[15] Implementation of the model resulted in universal and overwhelming enthusiasm for change, not only from members of the investigative team but also across all disciplines and staff, from the unit secretary to the chief of cardiothoracic surgery. The interventions and activities associated with improving quality of care for patients were adopted by all.

Limitations

We encountered several limitations, including initial barriers to buy-in by the full multidisciplinary team, resulting in implementation delays at the outset. Staff nurses in patient care roles also supported data entry needs, resulting in an occasional backlog of data and delays in internal feedback reporting. Unequal numbers of patients were included in the pre- and postintervention cohorts because of the use of convenience sampling. These limitations are considered part of the natural evolution of adoption of a change in practice and were not thought to detract from the overall improvements that resulted from the study.

Conclusions

Collaborative implementation of a standardized extubation protocol and redesigned patient care processes helped us successfully achieve the goal of reducing intubation time in patients in stable condition after cardiac surgery. We markedly improved the proportion of patients extubated in less than 6 hours following cardiac surgery. Use of the FTE protocol reduced intubation time without increasing reintubation rate or mortality. The use of a change model with multiple sources of influence was vital to the success of adoption of the FTE protocol. The fidelity of long-term implementation is driven by a team process that includes ongoing feedback and education to ensure success. CCN

Acknowledgments
The authors would like to thank and acknowledge the interprofessional leadership team for support of this project: Jill Engel, DNP, RN, Kelly Kester, MSN, RN, Lynn McGugan, DNP, ACNP, Jacob Schroder, MD, John Haney, MD, Raquel Bartz, MD, Shawn Kram, PharmD, Peter Henkel, PharmD, Brian Costa, RCP, Robert Slonac, RCP, and Yasmin Maisonave, MD.

Financial Disclosures
Dr Ghadimi is a remunerated consultant for UpToDate in the section for coagulation and blood management, receives grant support from the National Institutes of Health (T32GM008600) and Duke Health, and is a nonremunerated consultant and subject matter expert for ERAS Cardiac (Enhanced Recovery After Cardiac Surgery Society). He has received previous grant support from Octapharma. Dr Granger has received research support from Novartis, Janssen Pharmaceuticals, AstraZeneca, the American Heart Association, and the National Institutes of Health. She reports no relevant conflicts of interest related to this manuscript. Other authors have no conflicts of interest to report. Duke Heart Center departmental funding supported this project.

See also

To learn more about intubation of patients in the critical care setting, read “Intubation Setting, Aspiration, and Ventilator-Associated Conditions” by Talbert et al in the *American Journal of Critical Care,* 2020; 29(5):371-378. Available at **www.ajcconline.org**.

References

1. Wong WT, Lai VK, Chee YE, Lee A. Fast-track cardiac care for adult cardiac surgical patients. *Cochrane Database Syst Rev.* 2016;9(9):CD003587.
2. Reyes A, Vega G, Blancas R, et al. Early vs conventional extubation after cardiac surgery with cardiopulmonary bypass. *Chest.* 1997;112(1):193-201.
3. Crawford TC, Magruder JT, Grimm JC, et al. Early extubation: a proposed new metric. *Semin Thorac Cardiovasc Surg.* 2016;28(2):290-299.
4. Camp SL, Stamou SC, Stiegel RM, et al. Can timing of tracheal extubation predict improved outcomes after cardiac surgery? *HSR Proc Intensive Care Cardiovasc Anesth.* 2009;1(2):39-47.
5. STS public reporting: explanation of star ratings. Society of Thoracic Surgeons. Accessed January 16, 2018. http://publicreporting.sts.org/acsd-exp
6. Cheng DC. Pro: early extubation after cardiac surgery decreases intensive care unit stay and cost. *J Cardiothorac Vasc Anesth.* 1995;9(4):460-464.
7. van Mastrigt GA, Maessen JG, Heijmans J, Severens JL, Prins MH. Does fast-track treatment lead to a decrease of intensive care unit and hospital length of stay in coronary artery bypass patients? A meta-regression of randomized clinical trials. *Crit Care Med.* 2006;34(6):1624-1634.
8. Ogrinc G, Davies L, Goodman D, Batalden P, Davidoff F, Stevens D. SQUIRE 2.0 (Standards for Quality Improvement Reporting Excellence):

revised publication guidelines from a detailed consensus process. *Am J Crit Care.* 2015;24(6):466-473.
9. Stausmire JM, Ulrich C. Using SQUIRE 2.0 as a guide for planning your quality improvement project. *Crit Care Nurse.* 2017;37(6):72-80.
10. Meliones JN, Alton M, Mericle J, et al. 10-Year experience integrating strategic performance improvement initiatives: can the Balanced Scorecard, Six Sigma, and Team Training all thrive in a single hospital? In: Henriksen K, Battles JB, Keyes MA, Grady ML, eds. *Advances in Patient Safety: New Directions and Alternative Approaches.* Vol. 3: Performance and Tools. Agency for Healthcare Research and Quality; 2008.
11. Gutsche JT, Erickson L, Ghadimi K, et al. Advancing extubation time for cardiac surgery patients using lean work design. *J Cardiothorac Vasc Anesth.* 2014;28(6):1490-1496.
12. Fitch ZW, Debesa O, Ohkuma R, et al. A protocol-driven approach to early extubation after heart surgery. *J Thorac Cardiovasc Surg.* 2014;147(4):1344-1350.
13. Hefner JL, Tripathi RS, Abel EE, Farneman M, Galloway J, Moffatt-Bruce SD. Quality improvement intervention to decrease prolonged mechanical ventilation after coronary artery bypass surgery. *Am J Crit Care.* 2016;25(5):423-430.
14. Blackwood B, Burns KE, Cardwell CR, O'Halloran P. Protocolized versus non-protocolized weaning for reducing the duration of mechanical ventilation in critically ill adult patients. *Cochrane Database Syst Rev.* 2014(11):CD006904.
15. Patterson K, Grenny J, Maxfield D, McMillan R, Switzler A. *Influencer: The Power to Change Anything.* McGraw-Hill; 2008.
16. Yuan CT, Pronovost PJ, Marsteller JA. Harnessing the power of peer influence to improve quality. *Am J Med Qual.* 2018;33(5):549-551.
17. Jiricka MK. Ask the experts. The standard of care for cardiac surgery recovery in the area of weaning. *Crit Care Nurse.* 2006;26(3):70-72.
18. Chan JL, Miller JG, Murphy M, Greenberg A, Iraola M, Horvath KA. A multidisciplinary protocol-driven approach to improve extubation times after cardiac surgery. *Ann Thorac Surg.* 2018;105(6):1684-1690.
19. Institute of Medicine. Crossing the Quality Chasm: A New Health System for the 21st Century. National Academies Press; 2001. Accessed February 18, 2021. http://www.nap.edu/catalog/10027.html