

Quality improvement in cardiac critical care

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ABSTRACT

Our quality improvement program began in 2004 to improve cardiac surgery outcomes. Early tracheal extubation in the cardiovascular intensive unit was utilized as a multidisciplinary driver for the quality improvement program. Continuous improvement in the rate of early extubation to drive multidisciplinary quality improvement in cardiac critical care correlated with decreased mortality, morbidity, and improved operational efficiency. Supportive educational efforts included, but were not limited to, principles of change, trust, competing values, crew resource management, evidence based medicine, and quality improvement.

Keywords: *Cardiac surgery, Quality improvement, Mechanical ventilation, Fast track.*

INTRODUCTION

Quality improvement is a “pragmatic science” (1) with a detailed history in manufacturing and vital components of quality include efficiency, efficacy, effectiveness, optimality, acceptability, legitimacy, and equity (2).

A quality cycle (2) includes data acquisition, pattern analysis, interpretation, prioritization, change in action, and repetition with further data acquisition on subsequent performances.

Stimuli for change included increased acuity, aging patient populations, declining procedure volumes, as well as pay-for-quality and value-based competition. National Quality Forum and Society of Thoracic Surgeons-National Cardiac Database (STS-NCD) metrics and guidelines focused our QIP (3-5). Evidenced based management

protocols and guidelines included communication tools (standardized hand-off and goal sheets), sedation monitoring, respiratory protocols for early extubation and best pulmonary practices bundles, computerized euglycemia management, blood management and infection control programs. Multidisciplinary cardiac intensive care unit (ICU) rounds were a part of the quality improvement program (QIP) and included a nurse, charge nurse, nurse practitioner, respiratory therapist, pharmacist, cardiac intensivist, and the cardiothoracic surgeons and residents.

Our team believed that early extubation could unify the efforts of a complex system and serve as a key performance indicator, since factors contributing to successful early extubation span the preoperative, intraoperative, and postoperative periods as well as the disciplines (surgery, anesthesia, critical care, nursing, respiratory therapy, administration, etc.). We envisioned early extubation to be leading indicator, i.e. a predictor of future performance, of early and late outcomes.

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MATERIAL AND METHODS

Before data identification and analysis, study approval was sought and obtained from the Investigational Review Board at our institution. Confidentiality of patient personal information was maintained at all times, consistent with the Health Insurance Portability and Accountability Act of 1996 (HIPAA) regulations. The Society of Thoracic Surgeons' (STS) national cardiac database definitions were used for the purposes of the study. *Operative Mortality* is defined as operative death within 30 days of procedure or the same hospitalization as the primary operation. *Cerebrovascular accident* was defined as a central neurological deficit persisting for greater than 72 hours. *Early extubation* was defined as removal of endotracheal tube < 6 hours after arrival to the ICU. *Prolonged Ventilation* was defined as removal of endotracheal tube > 24 hours after arrival to the ICU. *Reintubation* was defined as reintubation for any reason during hospitalization. *Pneumonia* was defined as one of the following: positive cultures of sputum, blood, pleural fluid, empyema fluid, trans-tracheal fluid or transthoracic fluid; consistent with the diagnosis and clinical findings of pneumonia (may include chest x-ray diagnosis of pulmonary infiltrates). *Hemorrhage related re-exploration* was defined as operative re-intervention required for bleeding or tamponade. *Tamponade* was defined as fluid in the pericardial space compromising cardiac filling, and requiring intervention other than returning to the operating room, such as pericardiocentesis. *Renal failure* was defined as an increase in serum creatinine greater than 2.0 mg/dl, and a doubling of creatinine over baseline preoperative value, and/or a new requirement for dialysis/hemofiltration. *Septicemia* was defined as positive blood cultures post-operatively. *Prolonged intensive care*

unit length of stay was defined as greater than 24 hours. *Prolonged hospital length of stay* was defined as hospital stay more than the 75th percentile of hospital length of stay (> 9 days).

The Division of Cardiothoracic Surgery at Carolinas Heart and Vascular Institute computerized database was utilized to identify patients who had coronary artery bypass (CABG), isolated valve, and coronary artery bypass/valve combination at Carolinas Heart and Vascular Institute. All procedures were performed by the same group of cardiac surgeons, anesthesiologists, and perfusionists. Data including baseline demographics, procedural data, and perioperative outcomes were entered prospectively in a pre-specified database by a dedicated data-coordinating center.

Statistical analysis

Statistical methodology has been described in detail in each investigation (3-5). Briefly, each utilized univariate comparisons of pre-operative, operative, and postoperative variables between groups (QIP and non-QIP as well as early and conventional tracheal extubation), followed with multivariable, stepwise forward logistic regression analysis to determine independent predictors of death and complications (cerebrovascular accident, prolonged ventilation, reintubation, pneumonia, hemorrhage related re-exploration, cardiac tamponade, acute renal failure, septicemia, prolonged length of ICU and hospital stay).

Finally, propensity score adjustment was used on the postoperative outcomes between QIP and non-QIP groups, as well as early and conventional extubation, to correct for imbalances between groups at baseline. The ability of the propensity score to effectively balance the compared groups at baseline was confirmed using separate logistic models. All analyses were conducted using SAS (SAS Institute, Cary, NC).

RESULTS

QIP and Early Tracheal Extubation Predicts Improved Postoperative Outcomes

Our analysis (Figure 1, panel A and B) demonstrated QIP was associated with a statistically significant increase in the rate of early extubation and a 48% reduction in operative mortality (propensity score-adjusted odds ratio was 0.6 with 95% confidence interval 0.4-0.99, $P=0.04$). QIP was also associated with a statistically significant reduction in tamponade (propensity score-adjusted odds ratio was 0.2 with 95% confidence interval 0.04-0.8, $P=0.02$) and sepsis (propensity score-adjusted odds ratio was 0.5 with 95% confidence interval 0.3-0.9, $P=0.02$). Acute renal failure was markedly improved, but failed to reach statistical significance in our analysis.

Early tracheal extubation was associated with a statistically significant reduction in pneumonia (propensity score-adjusted odds ratio was 0.35 with 95% confidence interval 0.22-0.55, $P<0.001$), sepsis (propensity score-adjusted odds ratio was 0.38 with 95% confidence interval 0.20-0.74, $P<0.004$), and reintubation (propensity score-adjusted odds ratio was 0.53 with 95% confidence interval 0.34-0.81, $P<0.003$).

Early extubation improves late survival

Analysis of early extubation demonstrated a correlation with improved survival up to 16 months after cardiac surgery. Chronic renal failure, congestive heart failure, unstable angina, and advanced age predicted a decrease late survival.

Early extubation improves resource utilization

Early extubation was associated with a reduction in prolonged ICU (propensity score-adjusted odds ratio was 0.42

with 95% confidence interval 0.35-0.50, $P<0.001$) and hospital length of stay (propensity score-adjusted odds ratio was 0.37 with 95% confidence interval 0.29-0.47, $P<0.001$) as well as a decrease in readmission to the ICU (propensity score-adjusted odds ratio was 0.55 with 95% confidence interval 0.39-0.78, $P<0.001$).

DISCUSSION

Change is a fundamental component, and simultaneously a formidable challenge, in quality improvement. In fact, it is axiomatic that all improvement requires change, but not all change results in improvement. Niccolo Machiavelli, opined about change in *The Prince*: "It must be considered that there is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things." We incorporated eight recognizable components (6) to create major change:

- 1) establish a sense of urgency;
- 2) form a powerful guiding coalition of the right people who trust one another and have a common goal;
- 3) create a vision;
- 4) communicate the vision;
- 5) empower others to act on the vision;
- 6) plan for and create short-term wins;
- 7) consolidate improvements and produce more change;
- 8) institutionalize new approaches.

Furthermore, the importance of trust in the change process cannot be underestimated. Trust (7), emanating from reliability, openness, competence, and compassion, must be actively addressed and managed. Trust should be considered the foundation for a cohesive and effective team. Only with trust can a team deal with conflict, become committed, be held accountable, and focus on results.

Exercises in competing values were utilized to integrate our trust development, change management, and evaluation of the team. Early extubation as a multidisciplinary quality driver incorporated fundamental concepts such as Pareto's Principle (8),

where vital few percentages of factors are responsible for a significant percentage of effect, and Juran's (8) trilogy of planning, control, and improvement. Additionally, consistent with Juran's teachings, we established progressive annual

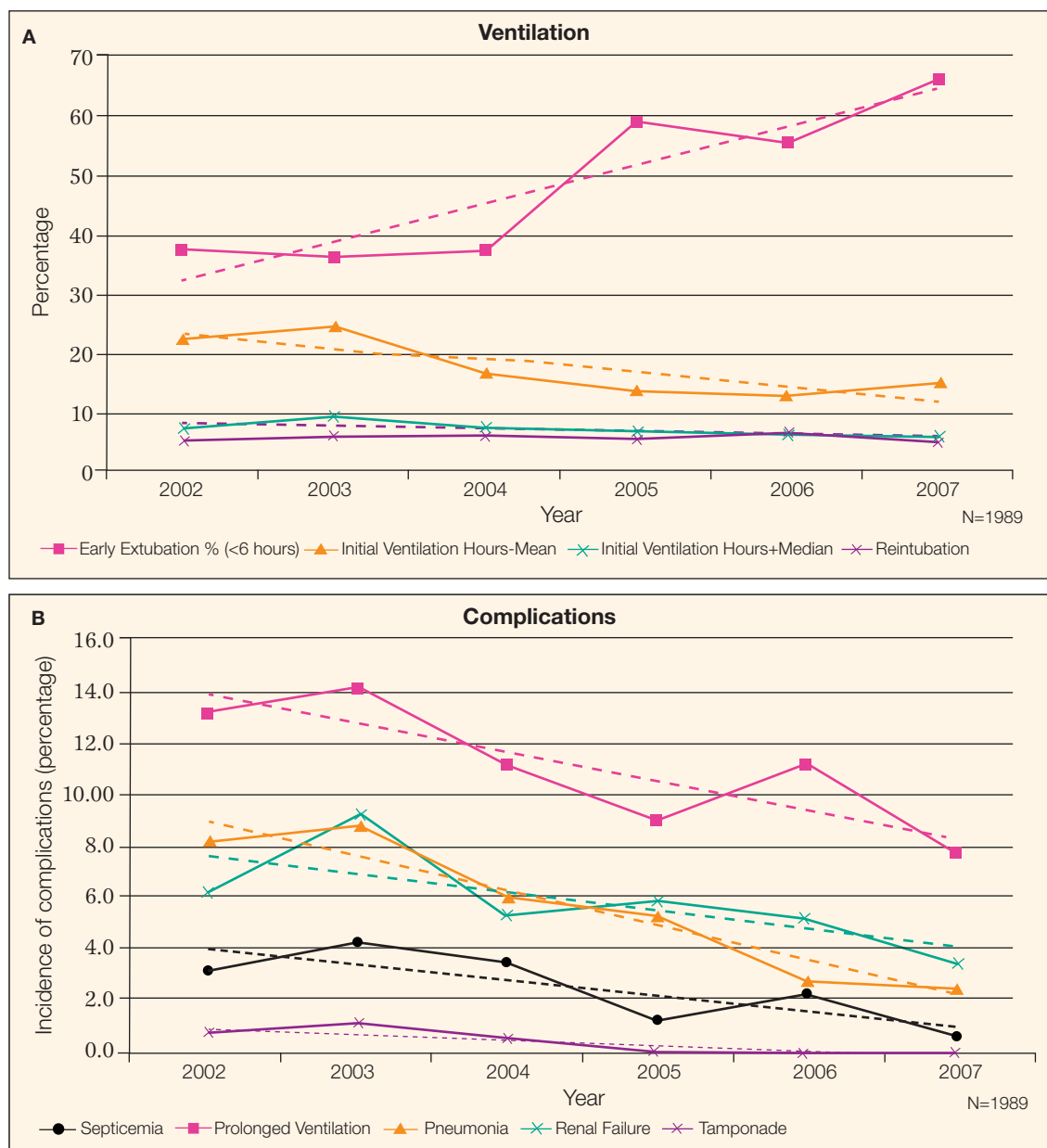


Figure 1 - Graphic depiction of improved early extubation and complications (CABG only). Panel A: Ventilation; Panel B: Complications.

goals, plans, clear responsibility, and rewards.

W. Edwards Deming (8) professed that elimination of variation is fundamental in quality improvement and forwarded 14 key concepts for management.

Our early extubation processes (as well as sedation monitoring, respiratory protocols for early extubation and best pulmonary practices bundles, computerized euglycemia management, blood management and infection control programs) were scrutinized and we consistently eliminated variation in our quest to combat death and complication.

Our goal sheets and other communication tools embodied the checklist concept (9), incorporating evidence based medicine and vital processes. The goal sheets evolved as we learned and altered our processes. We believe that it is axiomatic that a team can recognize patterns and learn more rapidly from simple, reproducible, recognizable processes.

Process and outcome improvement have positioned us to evaluate our system of care, which was our pragmatic variation of Donabedian's (5) concepts of structure, process and outcomes. Experts in system dynamics (Forrester (10) and Senge (11) have long recognized that systems (structure) determine outcomes, but our "grass roots" quality initiative didn't have the luxury of disassembling a system until improved results and credibility were demonstrated. We've now evolved to evaluate system design and resources, improved performance monitoring, and attempted to shorten our readjustment cycles.

Our efforts and investigations demonstrate the value of a quality improvement program as well as early extubation as a quality driver and leading indicator of improved

outcomes after cardiac surgery. Successful extubation within the first few hours after cardiac surgery correlates with lower operative mortality, morbidity, and operational efficiency.

Furthermore, early extubation is predictive of improved survival up to 16 months after cardiac surgery. Thus, it is possible to safely predict uncomplicated early and late recovery based on the timing of extubation.

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