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## Using Business Modeling to Streamline Cost of Anesthesia in a Cardiopulmonary Laboratory

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### Abstract

The Time Driven Activity Based Costing (TDABC) measurement system, a model used in the business arena, can capture clinical processes and costs that other costing models often overlook. Use of this system permitted tying costs to time and resources and identified areas of inefficiency such as depleted supplies and health care and emergency supplies placed inconveniently. A multidisciplinary team developed an anesthesia checklist for use in a remote cardiopulmonary laboratory. The compliance rate for checklist completion was approximately 85%. Checklist implementation translated to a decrease in case delays and time expenditure in patient care by 58% with a cost savings of 2.5% per patient.

### Keywords

TDABC, Anesthesia, Cost Efficiency, Nurse Anesthesia

### Cover Page Footnote

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## Introduction

Decreased reimbursements by payers coupled with increased costs of services have shifted the healthcare focus towards value-based care. Value-based care systems assign value to different patient care activities and require an accurate cost measuring system that has largely been ignored in the current healthcare delivery model to the extent that currently, providers associate expenses broadly to procedures, services, and departments without acknowledging the actual resources consumed during patient care (Kaplan and Porter, 2011). Because the bulk of healthcare costs involves resources such as clinical staff, supplies, and equipment, this approach to healthcare expense modeling is not sustainable without a veritable understanding of patient care costs. The Time Driven Activity Based Costing (TDABC) measurement system, a model used in the business arena, can capture clinical processes and costs that other costing models often overlook.

The manufacturing industry historically used TDABC to optimize operational processes and expenditures to enhance resource allocation, service, and product pricing. This traditional business model has been adapted for use in healthcare because it identifies patient care workflow, analyzes costs for a patient care cycle, and accounts for expended time and resources as well as capacity of usage (Kaplan & Anderson, 2007). The data derived from TDABC efforts illuminate disparities in practice and facilitate improvement measures that generate cost efficiency and improve patient outcomes.

### Applying the TDABC Model to Anesthesia Service

A large, tertiary oncology hospital applied the TDABC model as part of a system wide quality and cost improvement project. The methodology was applied in remote anesthesia locations, specifically the cardiopulmonary laboratory suite (CPL). The CPL is a remote location that provides anesthesia for pulmonary diagnostic and interventional procedures outside of the operating room environment. The TDABC improvement project was a collaborative effort of a clinical team that included anesthesia faculty, pulmonologists, bronchoscopy technicians, preoperative and post anesthesia care unit nurses, a graduate assistant, and the central administrative finance department.

### TDABC Methodology

The clinical team documented current patient care processes in the CPL and identified the expended time as well as personnel resources used for each activity. The data generated a process map depicting the workflow for an average patient encounter from patient check in to patient discharge (see Figure 1) (Kaplan & Anderson, 2007). An expended time and personnel resource was assigned to each clinical process, which in the map is color coded and shaped to identify the type of “patient transaction” (Kaplan and Anderson, 2007). The process map captured variances in patient care by displaying decision nodes with probabilities for patients that encounter or bypass a particular activity (French et al., 2013). Thus, TDABC methodology can illustrate patient workflow processes within a department and capture the time and cost for each patient transaction.

A cost analysis using the CPL process map data identified a cost capacity rate that could be measured in dollars per minute for each personnel and resource in a patient care process. The rate was calculated by dividing the annual salary by annual productive hours, and results were averaged if

multiple staff members were involved in a patient transaction (French et al., 2013). The cost capacity rate for each patient care process is multiplied by its expended time to calculate the cost for performing that specific process (Kaplan & Anderson, 2007). Finally, a summation of every patient care process cost determined the total cost for a patient encounter. The TDABC methodology accurately calculated the cost of a patient encounter by identifying utilized resources, its usage capacity, and time for each patient transaction. The clinical team analyzed these data to initiate improvements for specific patient care processes, especially those that are costly and inefficient.

### **Problem Identification and Process Improvement**

The CPL clinical team evaluated the initial process map and cost analysis to identify opportunities for improvement. The CPL routinely schedules between four to six patients per day, and depleted supplies are not routinely replenished by anesthesia technicians at the end of the clinical care day. This process increased time-consuming activities, such as paging anesthesia technicians who cover multiple remote locations and waiting for up to 20-30 minutes for supplies to be delivered. This delay often frustrated patients and their families. Furthermore, the lack of supplies produces variances in patient care, causing anesthesia personnel to not be able to sufficiently prepare for adverse events that sometimes occur in remote anesthesia locations. These events, such as mismanagement of hypoxia, loss of airway patency, pneumothorax, and major blood loss, lead to subsequent unanticipated intensive care unit (ICU) admissions.

In the CPL location, access to anesthesia supplies was limited due to the lack of space in the procedure room. Anesthesia supplies were primarily sequestered in a cabinet located several feet away from the main anesthesia workstation, and the bronchoscopy tower obstructed access to the cabinets during procedures, which complicated patient workflow during emergencies. In addition, emergency supplies were hard to locate and had no standard location. These issues also directly related to cost efficiency and potential patient safety concerns.

The complex bronchoscopy procedures performed in the CPL as well as the patients' critical health status together potentiate various complications, such as acute loss of airway patency and massive blood loss. According to Kirsner, Sarkiss, and Brydges (2010), anesthesia personnel need to understand emergency protocols and organize equipment and patient care supplies for any adverse occurrences that occur in a remote location in which equipment, surgical support, and resources are not readily available. A comprehensive plan of action and accessible equipment and supplies balance patient management while meeting health care needs.

### **CPL Team's Goal**

The CPL team's goal was to decrease case delays and unnecessary pages to support staff during patient care. In addition, the project aimed to streamline patient care workflow by organizing anesthesia supplies for immediate access. By doing so, the aim was to decrease unanticipated ICU admissions from the CPL.

### **Methodology**

To accomplish their goal, the CPL clinical team formulated an anesthesia supply checklist of commonly used patient care items. The anesthesia team completed this checklist at the end of the

day to alert anesthesia technicians of supplies needing to be replenished for the next day's cases. To increase accessibility, the CPL team organized and transferred commonly used supplies to a new anesthesia workstation cart. Each drawer was properly labeled for easy reference (Figure 2). The team also designated specific locations for emergency supplies, such as the cricothyrotomy kit, double lumen tubes, arterial line insertion kits, and blood tubing.

The process improvement checklist was disseminated via system electronic mail to the anesthesia department, including the anesthesia technician manager and anesthesia technicians. Formal meetings were also conducted with key anesthesia stakeholders to discuss current costly inefficiencies in the CPL that were related to the supply issue. The anesthesia checklist was presented as an improvement measure to increase the availability and accessibility of necessary supplies, while promoting cost savings without compromising patient outcomes. These meetings engaged key stakeholders in all stages of the process improvement, who in turn, promoted compliance and sustainability.

### **Evaluation**

The Kellogg Logic Model (Kellogg Foundation, 2004) was selected as the framework for evaluating the success of the process improvement project. The model was used to show the systematic relationships among the components of the improvement project and depict how the CPL team planned, evaluated and managed the project to achieve its short and long-term goals (see Appendix A).

The clinical team documented post-implementation patient care processes for several weeks. Electronic chart audits trended time expended for each patient process, turn over time, and unanticipated ICU admissions (Table 1). The anesthesia technician manager also collected each completed checklist and tracked compliance among anesthesia providers and technicians. The compliance rate was approximately 85%. Anesthesia technicians routinely reminded the CPL anesthesia providers to fill out the supply checklist at the end of the day, which further enhanced the team approach. Availability of necessary supplies for patient care was measured by the number of electronic pages to anesthesia technicians throughout the course of the day for supplies listed on the anesthesia checklist.

Personnel utilization among anesthesia staff members, pulmonologists, bronchoscopy technicians, and nurses were evaluated by a cost analysis before and after implementation of the CPL anesthesia checklist. A post CPL checklist email survey evaluated stakeholder's observed process and workflow changes after checklist implementation. Additionally, the nurse anesthetist conducted monthly meetings with the interdisciplinary CPL team and anesthesia division head to evaluate the implementation process and make appropriate modifications enhancing the improvement project's sustainability.

### **Quality Improvement Outcomes**

The process improvement project produced an increase of patient care supply availability in the CPL within two months after implementation. Furthermore, other rotating nurse anesthetists appreciated the ease of locating patient care supplies as well as emergency equipment during

patient care sessions. This seamless clinical workflow enabled anesthesia providers to fully dedicate their efforts on anesthetic management in the CPL.

After checklist implementation, the incidence of paging anesthesia technicians for supplies decreased by 50% (Figure 1). Checklist implementation translated to a decrease in case delays and time expenditure in patient care by 58% with a cost savings of 2.5% per patient (Table 1). The cost savings can be profound when calculated over the fiscal year as the CPL has approximately 1,200 patients requiring anesthesia annually. Although the quality metric of unanticipated intensive care unit admissions was unchanged during the project's time frame, efficiency in patient care allowed providers to dedicate more time for patient care and have adequate resources to address procedural complications.

Table 1: Outcome measures before and after checklist implementation

	Before	After
Probability of paging technician due to lack of supplies	60%	10%
Average time between cases	19.5 minutes	8.1 minutes
Clinical Process Time Savings	58%	
Cost Savings	2.5% per patient	
Unanticipated ICU admissions	No change	

### Conclusions and Application

The quality improvement process utilizing the TDABC methodology engages frontline patient care providers, such as nurse anesthetists, to evaluate current practices and spearhead sustainable changes to improve cost and optimize care. The result of adapting a business model to a healthcare setting was a gain in cost effective improvements without compromising patient outcomes. The CPL improvement project effectively validated advance practice nurses' value for redesigning clinical strategies in an evolving healthcare delivery system to improve cost efficiency and patient outcomes.

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Figure 1: Process map for the Cardiopulmonary Laboratory workflow before and after implementing anesthesia checklist

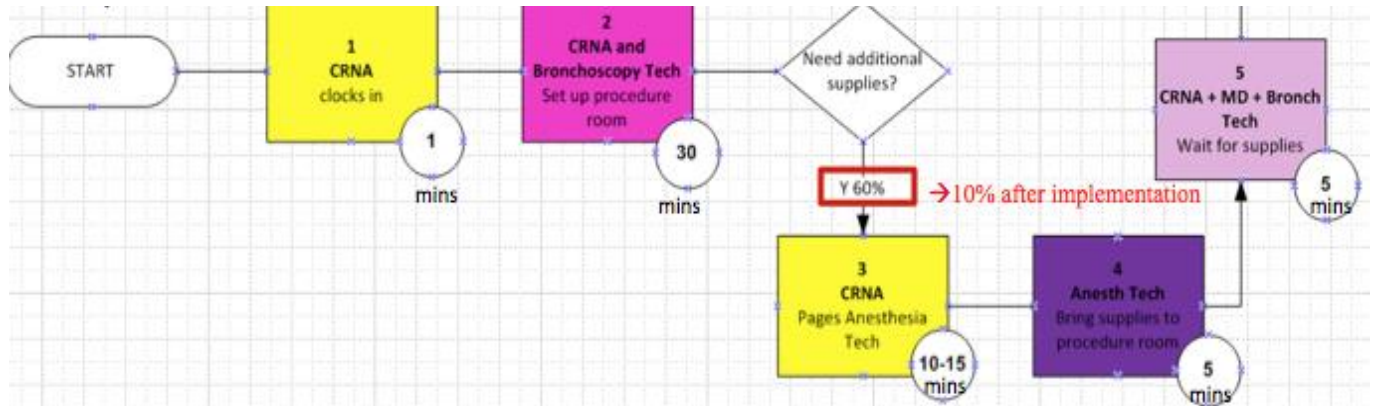


Figure Legend

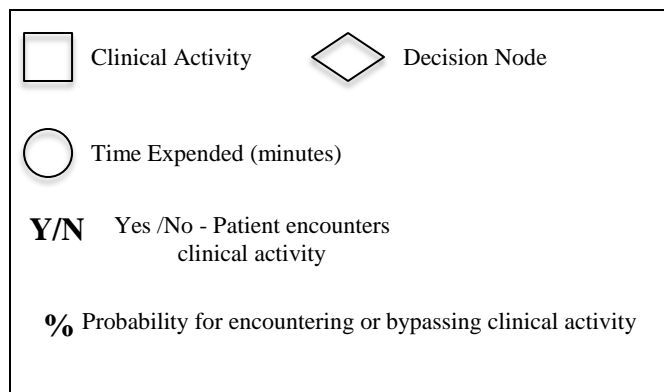


Figure 2: Organization of the cardiopulmonary laboratory suite

### Organizing supply cupboards



### Labeling drawers for quick reference and designating emergency supplies



Appendix A: W.K. Kellogg Model framework for planning, evaluating, and managing anesthesia checklist sustainability

INPUTS			OUTCOMES		
INPUTS (RESOURCES)	Activities	Outputs	Short Term	Long Term	Impact
STAFF EQUIPMENT MATERIALS ENVIRONMENT PROCEDURE ROOM	Evaluate CPL patient work-flow	Anesthesia CPL checklist	Increased availability of patient care supplies	Efficient use of space in the procedure room	Organization-wide use of TDABC
	Identify consistent inefficiencies	Increased compliance in completing the CPL checklist	Less paging to technicians for supply deliverance	Efficient CPL patient work-flow	Frontline patient care providers can improve clinical practices that optimize cost efficiency and patient care
	Disseminate checklist to Anesthesia department	Monthly meetings for feedback and subsequent improvement	Fewer delays in patient care associated with waiting for supplies	Decrease turn-over time to 15-20 minutes between patients	
	Educate providers in TDABC methodology			Increase personnel utilization for patient care	
	Meet with key stakeholder's monthly			Decrease in unanticipated ICU admissions	
				Cost efficiency	