Checklist Usage Decreases Critical Task Omissions When Training Residents to Separate From Simulated Cardiopulmonary Bypass

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Objective: **Separation from cardiopulmonary bypass (CPB) requires multiple preparatory steps, during which mistakes, omissions, and human errors may occur. Checklists have been used extensively in aviation to improve performance of complex, multistep tasks. The aim of this study was to (1) develop a checklist using a modified Delphi process to identify essential steps necessary to prepare for separation from CPB, and (2) compare the frequency of completed items with and without the use of a checklist in simulation. It was hypothesized that the use of a checklist would reduce the number of omissions.**

Design: **High-fidelity simulation study.**

Setting: **University-affiliated tertiary care facility.**

Participants: **Seven cardiac anesthesiologists created a checklist using a modified Delphi process. Ten residents participated in 4 scenarios separating from CPB in simulation.**

Interventions: **Each scenario was performed first without a checklist and then again with a checklist. An observer graded participants' performance.**

Measurements and Main Results: **A pre-separation checklist containing 9 tasks was created using the Delphi process. Without using this checklist, 4 tasks were completed in at least 75% of scenarios, and 8 tasks were completed at least 75% of the time when using the checklist. There was a significant improvement in completion of 5 of the 9 items ($p < 0.01$).**

Conclusions: **A modified Delphi process can be used to create a checklist of steps in preparing to separate from CPB. Using this checklist during simulation resulted in increased frequency of completing designated tasks in comparison to relying on memory alone. Checklists may reduce omission errors during complex periods of anesthesiologists' perioperative workflow.**

KEY WORDS: checklist, Delphi, omissions, simulated cardiopulmonary bypass

PROVIDING ANESTHESIA and separating from cardiopulmonary bypass (CPB) require a high level of vigilance while performing a specialized standard set of tasks in a fast-paced, stressful environment. A medical error or omission of a vital step during separation from CPB may lead to a critical incident, potentially resulting in patient harm.[1,2] In 1999, it was estimated that 98,000 patients die each year in the United States as a result of these human errors in healthcare, and numerous studies described frequent errors, specifically by operating room personnel.[3–5] More recent data suggest that the number of patient deaths per year is closer to 400,000.[6] Cardiac surgical team interactions, systems, and processes have been targeted recently for study because of their complexity, risk, and potential for improvement, all in an effort to minimize patient injury.[7–10]

The aviation industry, a high-reliability organization, boasts an impressive safety record and serves as a model for the specialty of anesthesiology in improving care delivery.[11] Aviation and anesthesiology have many similarities: Reliance on highly trained personnel to perform complex tasks, advanced instrumentation and monitors, periods of intense workload (take-off and landing; induction, emergence, and separation from CPB) interspersed with periods of decreased workload (cruising during mid-flight, maintenance of anesthesia).[12] One cornerstone of aviation safety is the extensive implementation of checklists for both routine tasks and emergency procedures, thereby reducing reliance on the fallible human memory.[13] Checklists, a form of cognitive aid, reduce errors by grouping related information and tasks and encouraging adherence to best practices, while maximizing task efficiency.[14–17] Checklists free mental capacity for the practitioner.[11] Taking this approach, errors are more likely to be identified and avoided, or their consequences mitigated.[18]

Checklists have been implemented in the intensive care unit and in the operating room, with resultant decreases in morbidity and mortality.[19,20] An aviation-style checklist implemented during simulated cesarean deliveries found that anesthesiologists failed to check nearly one-third of the items on their checklist when relying on memory alone.[13] Demaria et al found that anesthesiologists failed to complete proper room setup tasks before induction at a significant rate without the aid of a checklist.[21] Checklist creation and development require determining what items are essential for a given process. Individual physicians often have differing opinions regarding steps and processes of care. The Delphi process is an iterative technique that can facilitate merging multiple expert opinions into a single group consensus and has been used in healthcare and other industries to improve processes.[22,23]

Given the long track record of checklist usage in the aviation industry, this study attempted to apply a checklist to the process of preparation for separation from CPB. Specifically, the aims of this study were to (1) design an

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1053-0770/2601-0001$36.00/0

http://dx.doi.org/10.1053/j.jvca.2014.05.011

anesthesiologist's checklist to aid in preparation for separation from CPB, (2) test this checklist in a high-fidelity operating room simulation using experienced anesthesiology residents, and (3) provide a safe learning venue for residents to practice the separation process. It was hypothesized that the use of a checklist would reduce the number of errors and omissions when preparing to separate from CPB.

METHODS

This study was approved by the local internal review board, and written informed consent was waived. Each subject voluntarily participated after reviewing an information letter describing the study. Participating subjects were allowed to voluntarily withdraw from the study at any point during the simulated scenarios. The study was conducted in a tertiary care teaching hospital environment.

Checklist Development and Modified Delphi Process

Seven cardiac anesthesiologists, who performed an average of 80 CPB cases per annum, participated in the modified Delphi process (Fig 1).[24] Of those 7, 4 had completed cardiothoracic fellowships and 3 had completed critical care fellowships. The years of experience for these members were 2, 11, 18, 24, 27, 33, and 33 years. The average was 21 years. After consulting several references, an initial list of 27 steps commonly performed before separating from bypass was sent to all 7 faculty; they were asked to freely add, delete, or combine steps from the list during the initial iteration.[25–28] A modified list then was generated from this initial feedback. The second list contained 25 items,

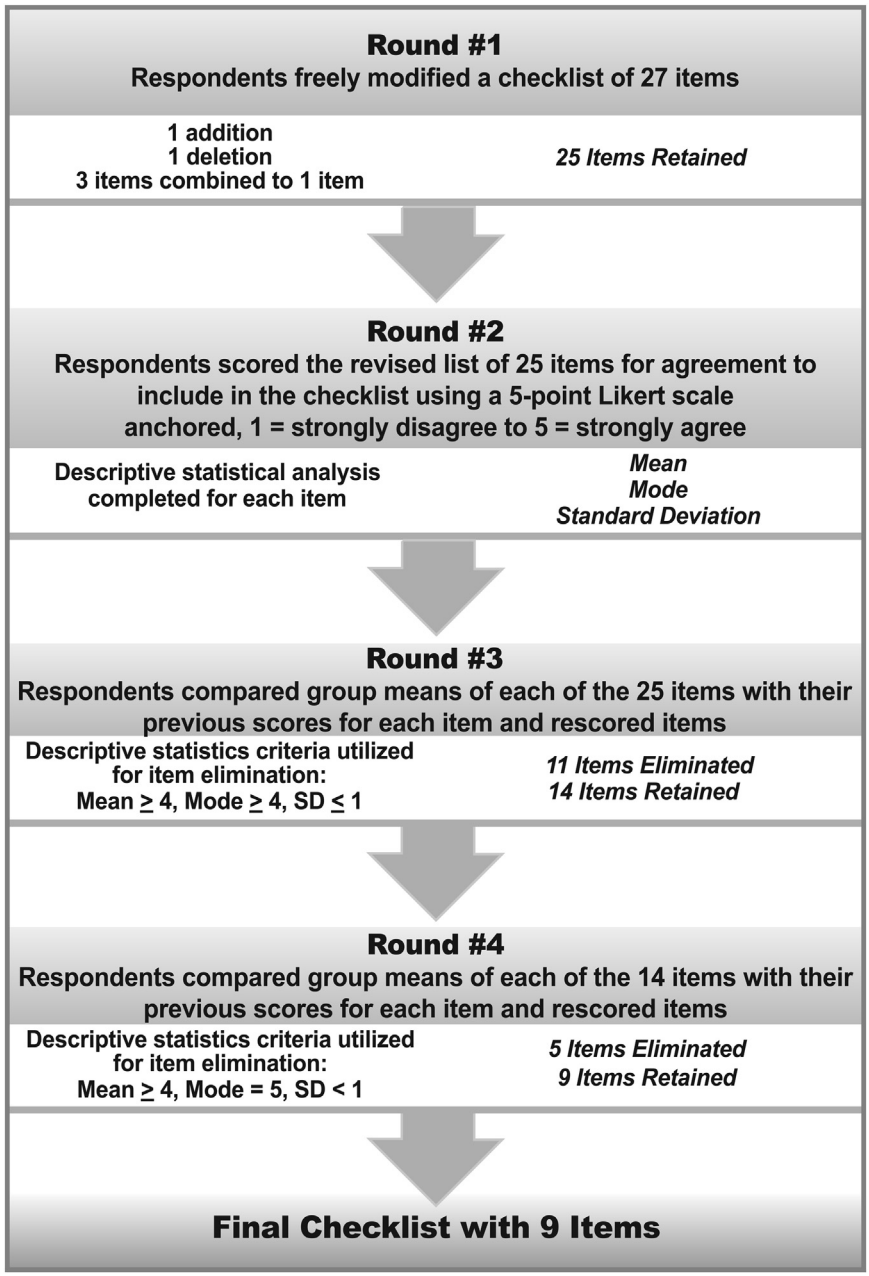

Fig 1. Graphic display of modified Delphi process for checklist development.