ORIGINAL CLINICAL RESEARCH

DESIGN AND IMPLEMENTATION OF A STRUCTURED APPLICATION-BASED INTRAOPERATIVE HANDOFF TOOL FOR ANESTHESIA CARE TEAMS: A QUALITY IMPROVEMENT APPROACH

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Abstract

Background: Incomplete or inadequate communication between anesthesia providers during intraoperative transitions of care increase the risk of medical errors and adverse patient outcomes. There is no universal, simple, accessible, standardized, and structured handoff tool in the intraoperative setting.

Methods: We conducted a prospective observational study to compare intraoperative transfer of patient, surgical, and anesthetic information between anesthesia care providers before and after the implementation of a checklist embedded in our electronic medical record (EMR) systems and on individual practitioner's mobile devices. The main outcome measure was the completeness critical information relayed.

Results: 123 intraoperative handoff events were observed (67 before the checklist and 56 after) and audio recordings were collected and transcribed. Most handoffs occurred between attending physicians. No significant difference was observed in completeness of information relayed, except for improvement in reporting of patient allergies. Although not statistically significant, there was a consistent trend toward less frequent reporting of ASA score, input/output, airway management, and plans for emergence and disposition.

Conclusion: An EMR and mobile device based electronic checklist tool was not associated with improvements in the quantity and quality of information relayed during intraoperative transitions of care between anesthesia care providers.

Keywords: Patient Handoffs; Patient Sign Outs; Clinical handover; Healthcare transition of care; Intraoperative care; Patient safety; Communication barriers; Information technology; Checklists.

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Introduction

During transitions of care from one clinician to another, insufficient or inadequate communication between providers is a significant source of medical errors and potential harm to patients.[1, 2] These transitions are also known as handover events or handoff moments. The Joint Commission defines a handoff as transfer and acceptance of patient care responsibility achieved through effective communication.[3] The Joint Commission, for example, made standardized handoffs a national patient safety goal in 2006.[4] Despite continuous campaigns and progress, no standardized or universally accepted protocols or tools exist for anesthesia care teams in the operating room (OR). In ORs where there are structured tools for handoff, little is known about their efficacy and impact on the transfer of vital information.

In other medical settings, high-quality handoff tools have been shown to improve communication, patient safety, and clinician satisfaction. A meta-analysis of 26 studies showed that a written safety checklist not only improves safety but also participants' perception of safety, teamwork, and communication.[5] A randomized controlled trial found that when a standardized handoff tool is implemented, there is consistent transfer of vital patient information. Furthermore, participants associated the structured handoff checklist with increased confidence.[6]

The perioperative period provides fertile ground for incomplete and inadequate communication between providers.[7] The operating room is characterized by complex transitions and coordination of critical care, fast-paced environment, frequent distractions, and overload of information. In 2011, the Agency for Healthcare Research reported 79,670 deaths of Medicare patients between 2007-2009 following patient safety events, with the highest incidence in surgical patients. Up to 80% of these events involved poor communication between providers, especially during handoffs.[8] In a large study, just one error increased adverse perioperative outcomes by 6.8%.[9] Each error increases risk, particularly in critically ill and high-risk patients.[10, 11]

Intraoperative handoffs have not been adequately studied, and this process is crippled by the lack of access to high-quality handoff tools along with the inherent culture of verbal handoffs among anesthesia providers. Alarmingly, up to 69% of clinical training environments do not have a standardized process for handoffs.[12] Fortunately, more recent research has investigated the role of electronic checklists in the relay and retention of information, improvement in patient care and outcomes, and clinician perceptions of the handoff process. In a large study of over 10,000 patients, the introduction of a handoff tool, along with intensive communication training and emphasis of its importance to anesthesia residents, reduced the rate of preventable adverse events by 23%.[13] Other studies echoed similar results and identified barriers to quality handoffs that include cumbersome and non-electronic based handoff tools that are not structured, standardized, or easily accessible. [14-15].

Our hypothesis is that there will be fewer information omissions measured during transitions of care between anesthesia care team members using an innovative and structured tool that is accessible through mobile phones. The primary goals of this manuscript are to report our experience in designing and implementing a novel handoff tool and to present our findings on the quality and quantity of critical information transferred in a major urban academic institution.

Materials And Methods

We obtained an institutional IRB waiver (IRB#2135398) for minimal-risk clinical investigations for this project. All efforts were made to de-identify any subject information throughout the study.

Through literature review, best-practice recommendations, and professional societal guidelines, the study investigators identified 17 crucial outcome variables for handoff in the OR (i.e., patient age, allergies, ASA score, etc.) [2, 16] The primary outcomes of our study were the measured delta changes in these 17 variables before and after the implementation of a standardized checklist.

Our study proceeded in 3 phases using the Plan-Study-Do-Act (PDSA) model. A task force was convened to design a structured checklist based on institutional practices and validated checklists available in the literature.[16] Our target audience was all anesthesia care team members: attending and resident anesthesiologists and certified registered nurse anesthetists (CRNAs). We conducted select focus groups to assess logistical issues and to refine elements of the checklist. Once the tool was finalized, we embedded it into our anesthesiology record interface within the EMR (EPIC and Haiku, Madison, Wisconsin). We subjected multiple versions of our work product to rigorous testing on the workstation, mobile, and app-based platforms. We sought feedback from various superusers before we implemented the final product and prepared educational materials for all users in the anesthesiology department. (See figure 1 for process map).

Through multiple venues of departmental communication (emails, grand rounds, coaching, etc…), we provided intensive education to all anesthesia providers. We informed all participants that any identifying information about providers or patients would be omitted from our analysis and all of our care teams were given the choice to opt out of data collection. Our 2 independent research assistants were not part of the care teams and were not involved in direct patient care. The assistants were responsible for collecting audio recordings in the operating room settings and transcribing the recordings into written transcripts. The total observational study timeline was 8 months with 3-month “run-in” periods before and after intervention. The pre- run-in period allowed time for providers to become facile with the novel electronic mobile app-based handoff platform while the post- run-in period identified any confounding variables.

In the final phase, each written transcript was reviewed by at least 2 investigators (JG, AA, DV) for accuracy and validity. Ten audio recordings and transcripts were randomly selected and audited by the study team for accuracy and quality control. Also, we logged a positive score if any information in that category was mentioned once at any time during the handoff. If there was disagreement between investigators during data analysis, the principal investigator (YL) provided the final arbitration for that element. (See Figure 2 for screenshot of sample handoff tool on mobile phone).

Statistical analysis

We analyzed differences in the provider types during the handoff moment and compared pre- and post-intervention handoff quality and completeness. For comparisons between checklist data from the pre- and post-intervention periods, chi-square or Fisher's exact tests were used for categorical variables; student t-tests, for normally distributed continuous variables; and Wilcoxon rank-sum tests, for skewed continuous variables, as appropriate. All analyses were performed using SAS University, version 9.4 (SAS Institute, USA). All tests were 2-sided, and statistical significance was defined as a p-value < 0.05.

Sample Size Calculation

Due to the observational design of the study, no sample size calculation was needed.

Results

Study participants

We recruited all 104 members of our academic anesthesiology department, including 45 faculty, 20 nurse anesthetists, and 39 resident trainees. During the 8 weeks recording process (4 weeks before and 4 weeks after), we evaluated 123 handoffs (67 pre- and 56 post-intervention). We presented demographic data on the gender and type (attending physician, resident physician, or nurse anesthetist) of the anesthesia provider pair (source vs. receiver) in addition to their handoff roles (source of providing handoff vs. receiver for the information) (Table 1). Notably, the post-intervention group included a statistically significant higher number of attending-to-attending handoffs (p=0.017).

Information transfer

We analyzed individual handoff transcript for 17 outcome variables (Table 2). Two additional variables reported were duration of handoffs on the audio recordings as well the number of receivers' questions raised during the handoffs. The random auditing of 10 audio recordings and transcripts showed an inter-rater reliability of 92%.

Our results showed that the rate of reporting certain case details was consistent before and after implementation of the checklist. Subgroup analyses of raw data prior to de-identification did not reveal any clinical significance between groups or any influence on the duration of handoff communication. These analyses included the type of surgery, surgeon, surgical duration, patient comorbidity, patient BMI, and other confounding variables. In the final analyses, over 90% of de-identified transcripts mentioned the surgical procedure, type of anesthesia, patient's age and gender, and patient's medical history. In contrast, 10% or less of the transcripts included ASA score, ease of mask ventilation, or airway management, including method of intubation. The average duration of audio recordings ranged from 81 to 83.5 seconds and did not differ after the introduction of the electronic handoff tool. On average, the number of questions raised by the receiver was 1 across 71-79% of transcripts, and this remained the same after the intervention.

Reporting of patient allergies increased significantly from 46% to 64% with the use of the checklist (p=0.0462). However, the overall transfer of patient and case specific information showed no significant improvement during handover using our electronic checklist tool. Results are shown in Figure 3.

Figure 1. Process map for design & implementation using PDSA model

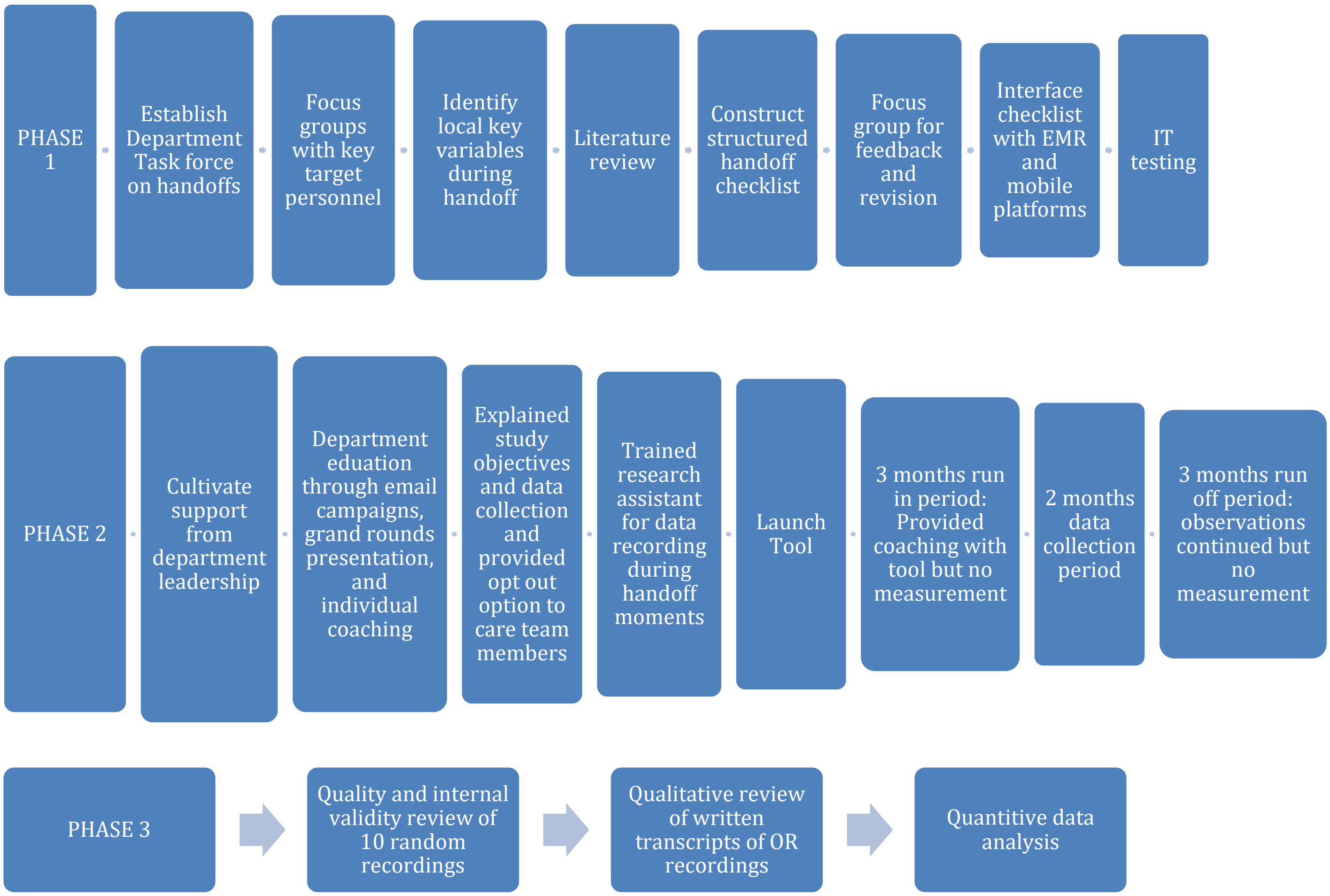


Figure 2. Screenshot of the phone or mobile app-based electronic handoff tool

Procedure Summary

Date: 12/21/18
Anesthesia Start: 1215
Procedure: TRAUMA PROCEDURE

Surgeon: Joanna Chikwe, MD
Anesthesia Type: general

Room / Location: MSW OR 02 / OR MSW
Anesthesia Stop:
Diagnosis:
Snake or lizard bite, venomous, assault, sequela
(Snake or lizard bite, venomous, assault, sequela [T63.193S])
Responsible Provider: Anesthesiologist Anesthesia
ASA Status: 3

Medical History

Bilateral headaches

Allergies as of 12/21/2018

	Reactions
Ibuprofen	Cough

Responsible Staff

12/21/18

Name	Role	Begin	End
Anesthesiologist Anesthesia	Starting Att	1215	

Events

Date	Time	Event
12/21/2018	1215	Anesthesia Start
	1220	Induction The patient was reevaluated immediately before moderate or deep sedation use and before anesthesia induction.
	1236	Intubation
	1246	Anesthesia Ready
	1252	Procedure Start

Hematology Labs

Today 1000
INR (POCT): 23
Today 0800
PLT CNT: 45

Chemistry Labs

Today 1130
PREGUR POCT: Negative

Blood Gas Labs

Today 0900
pH (arterial) P: 1
pCO2 (arterial): 2
pO2 (arterial): 3
HCO3 (arterial): 4
BE (arterial): 5
WB LACTATE-ART (POCT): 8

Ejection Fraction Results

(Last result in the past 365 days)

	EJECTION FRACTION
12/21/18	43

Lines, Drains, and Airways

Type	Details	Placement	Removal
Temporary Central Line	08/17/18; 1421 (created via procedure documentation)	08/17/18 1421 by Mleg Rosenblatt, MD	
Lumbar Drain	08/17/18; 1421 (created via procedure documentation)	08/17/18 1421 by Mleg Rosenblatt, MD	
Arterial Line	08/17/18; 1424 (created via procedure documentation)	08/17/18 1424 by Mleg Rosenblatt, MD	
Nerve Block Catheter	09/26/18; 1656 (created via procedure documentation)	09/26/18 1656 by Anesthesiologist Anesthesia	

Intraprocedure I/O Totals

Input	
Cell Saver	34 mL

Vitals (last 24 hours)

BP: 120/80
Resp: 15
Temp: 37 °C (98.6 °F)
Height: 1.676 m (5' 6") (12/21/18)
BMI: 29.87
Last edited 12/21/18 1610 by AA

Pulse: 110
SpO2: 95

Weight: 83.9 kg (185 lb) (12/21/18)
IBW: 59.3 kg (130 lb 10.4 oz)

Last Abx Admin

cefaZOLIN
Last given: 1316
Frequency: ONCE PRN

Last Narcotics Admin

remifentanil
Last given: 1323
Frequency: ONCE PRN

Last Paralytics Admin

rocuronium
Last given: 1225
Frequency: ONCE PRN

Last Vasopressors Admin

No vasopressor administrations found within the last 24 hours.

Last Heparin Admin

heparin
Last given: 1323
Frequency: ONCE PRN

Table 1. Demographics of handoffs in pre-intervention and post-intervention groups

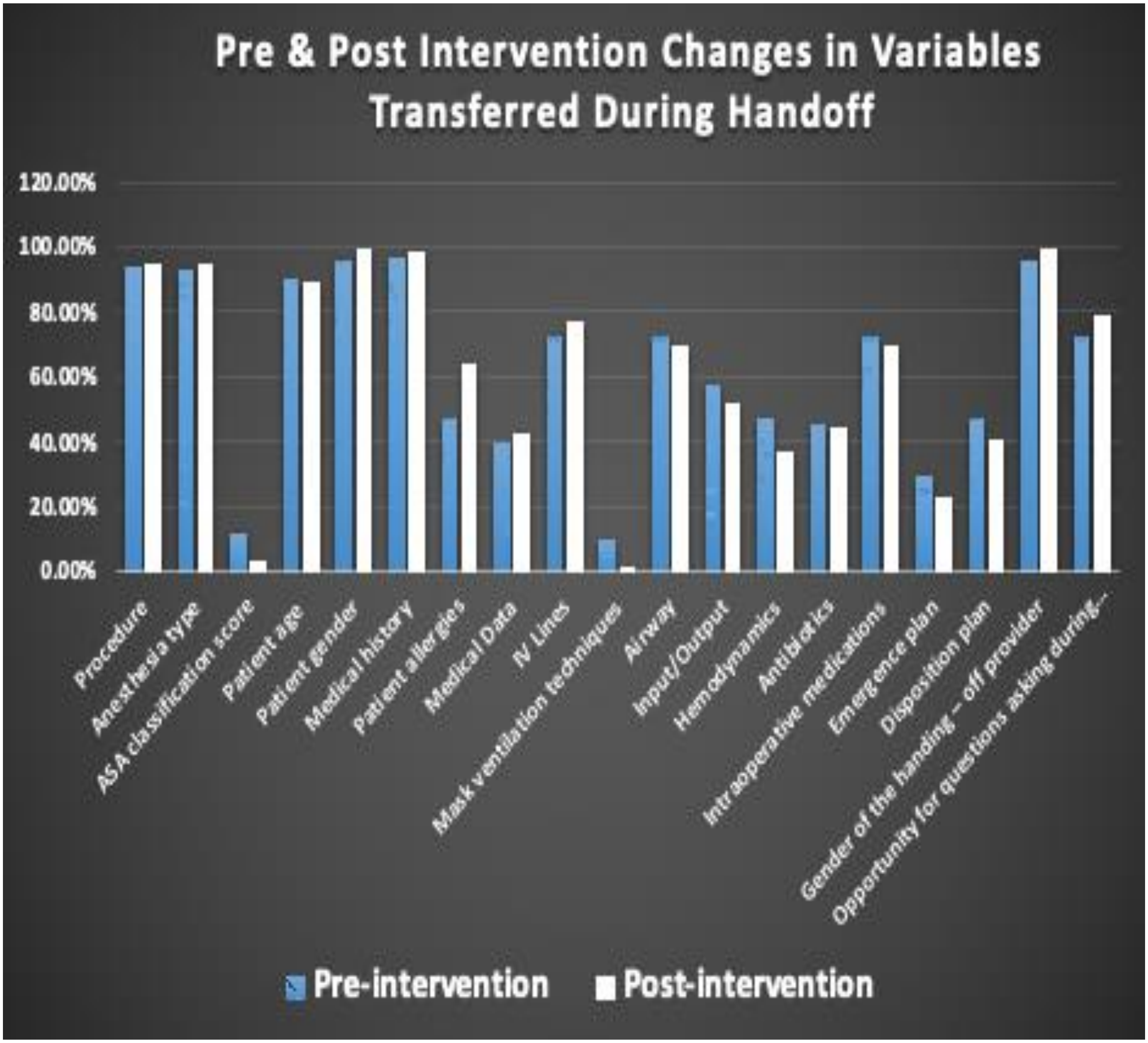
	Demographics	Pre-Intervention (N = 67)	Post-Intervention (N = 56)	Percentage change	P-value
Gender	Female, n (%)	35(52.2)	25 (44.7)	-7.6%	
	Male, n (%)	32 (47.8)	31 (55.4)	7.6%	
Introduction of roles		67(100)	56(100)	0	
Hand-off roles	Attending to attending, n (%)	35(52.2)	41(73.2)	21%	0.0172
	Resident to resident, n (%)	7(10.5)	1(1.8)	-8.7%	0.0701
	CRNA to CRNA	0(0)	1(1.8)	1.8%	0.4551
	Attending to resident, n (%)	3(4.5)	0(0)	-4.5%	0.2501
	Resident to attending, n (%)	1(1.5)	0(0)	-1.5%	1.0001
	Resident to CRNA, n (%)	6(9)	8(14.3)	5.3%	0.3542
	CRNA to attending, n (%)	3(4.5)	0(0)	-4.5%	0.2501

Table 2. Case information communicated before and after intervention

Case information	Pre-Intervention (N=67)	Post-Intervention (N=56)	% Change	P-value
Procedure	63(94.03)	53(94.64)	0.61%	1.000
Anesthesia type (general anesthesia [GA], regional anesthesia [RA], sedation [MAC])	62(92.54)	53(94.64)	2.10%	0.727
ASA physical status classification score	7(10.45)	2(3.57)	-6.88%	0.180
Patient age	60(89.55)	50(89.29)	-0.26%	0.962
Patient gender	64(95.52)	56(100)	4.48%	0.250
Medical history	65(97.01)	55(98.21)	1.20%	1.000
Patient allergies	31(46.27)	36(64.29)	18.02%	0.0462*
Medical data (pertinent labs, vital signs, CXR, EF, any other imaging or workup)	28(41.79)	24(42.86)	1.07%	0.905
IV lines (location, gauge)	50(74.63)	43(76.79)	2.16%	0.781
Mask ventilation techniques (oral airway used, ventilation difficulty)	7(10.45)	1(1.79)	-8.66%	0.070
Airway/device placement techniques (nasal cannula, mask, LMA, ETT)	49(72.86)	39(69.64)	-3.22%	0.669

Data presented as n (%)

Figure 3. Pre and post intervention changes in variables transferred during handoff



Discussion

Transitions of care between providers are vital components of excellent patient care. Thoroughness and quality of handoffs improves patient outcomes and clinical care, while poor handoffs can potentially contribute or exacerbate harm to patients.[1-3, 9-13] A checklist tool that is thorough, standardized, widely used, and easy to access can support patient safety by ensuring that key information is transmitted and received appropriately.

The perioperative handoff culture at our hospital shared many of the problems that were identified in national databases and publications. We lacked a standardized and accessible checklist, with frequent breakdown in provider handoff communications. As a result, we formed a task force to study and improve our handoff culture using best practice evidence. Our innovative approach was to structure a thorough and user-friendly electronic interface checklist that is easily accessible on our providers' workstation and mobile phone devices through an app-based platform. In this prospective, observational, pre- and post-intervention quality assurance study, we designed, implemented, and evaluated our electronically mobile application-based handoff tool. Qualitatively and quantitatively, we assessed the handoff for pertinent information between anesthesia providers through transcripts of audio recordings and found no significant improvement in the thoroughness of handoffs, except for reporting of patient allergies.

There are several limitations to our observational study design. During our initial focus workgroups with participants, it was apparent that de-identified recordings were essential to preserve the validity of handoff content, maximize provider confidence, and minimize biases. Therefore, due to anonymity, we could not match anesthesia provider pairs in our pre-intervention cohort to subsequent post-intervention groups. Another consequence to unlinking our handoff recordings from EMR information was that we could not account for the duration, type, or complexity of the surgery. Nevertheless, our initial subgroup analyses before we blinded our raw data did not suggest any major confounding influences. Longer or more complex cases presumably require greater transfer of information and potentially multiple transitions of care.[11]

Furthermore, even though we have incorporated known literature and existing checklists into our design, our tool is created from an institutional point of view and thus may lack external validity to other settings. This lack of generalizability also applies to providers at our institution who have been trained in our standards for intraoperative handoffs. Lastly, we could not measure non-verbal communication such as body language, cues, or gestures through audio recordings. Since handoffs were observed and audio recordings were transcribed by research assistants who are not trained in anesthesiology, it is possible, for instance, a receiver can observe the type of surgery or anesthetic technique without a verbal confirmation from the transmitter. However, even though non-verbal signals are a crucial part of human communication, these would not strengthen the perioperative culture of patient safety without the appropriate mutual acknowledgement and checkbacks from providers in this context.

It is important to note that the largest group providing handoffs in our study was attending physicians, and the most common interaction was attending to attending. We speculate that most of these handoff observations occurred toward the end of the workday when faculty were working in operating rooms alone and not in a supervisory role. Unfortunately, we did not obtain sufficient samples from providers in other roles (residents, CRNAs) to perform sub-analyses.

Our study was also limited by lack of awareness and familiarity of our electronic handoff tool within our department. In part this was caused by the turnover of anesthesia providers during the study period, especially residents. Despite multiple educational refreshers and updates, we cannot determine which providers use the tool, how frequently, or whether they use it as a replacement or as a cognitive supplement to traditional intraoperative handoffs. Although all participants had access to the tool as an app on their mobile devices, we could not monitor frequency of access during handoffs due to technological limitations.

In summary, our findings contradict our hypothesis as well as the conclusions of most published studies that show that standardized checklists do improve intraoperative handoffs. Our intention was to implement a novel app-based tool that is thorough, standardized, easy to use and accessible on a mobile device. We hoped that such a tool would be an improvement over cumbersome printed checklist. However, overall, completeness of information transfer did not improve after implementation of our checklist, raising questions about why our findings differed from others in similar studies. It is possible that our outcomes can be explained by the fact that our cohort of participants were skewed heavily towards faculty and attending physicians, while previous, similar studies have focused largely on trainees.[13, 17] Future studies are needed to address further the role of electronic checklist tools while accounting for provider type.

Conclusion

Implementation of a structured, electronically accessible application and mobile based intraoperative handoff tool for anesthesia care teams did not improve the quantity of critical information communicated during handover moments. While limited by factors inherent to an observational design, our prospective pre- and post-intervention quality assurance study reveals extensive variations in practice patterns on communication of relevant patient information among providers. Further studies that address barriers to provider communication, standardization of checklists and tools, and strategies for implementation and adherence in intraoperative settings can contribute to a culture of patient safety.

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Conflict of interest

None.

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