Building a novel pediatric intensive care iPad handover aid for residents

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Abstract. There is no consensus on how effective patient handover in the pediatric intensive care unit should occur. Complex patients with rapidly moving clinical trajectories are difficult to summarize and comprehend. We aimed to redesign our current handover instrument to encourage higher-level cognitive interactions, questioning and understanding for pediatric residents. Through an iterative process with five pediatric intensive care unit intensivists, the current hardcopy handover tool was reviewed and compared to other formats published in medical and non-medical domains. Several handover formats on the iPad were created and proposed, but continual feedback from intensive care unit physicians led to a selection, and further revisions were made. A mock handover with completed data fields allowed pediatric residents to provide the final feedback in both a semi-structured group review and a survey with responses on a 1–5 Likert scale (1 = strongly disagree; 2 = disagree; 3 = neither agree or disagree; 4 = agree; 5 = strongly agree). A novel two-axis data grid combining the ‘systems’ and ‘problem list’ approach was developed, with read back prompts, and off the shelf applications such as “burn notices”. Residents found ease with the organizational format (4.0 ± 0.67 Likert scale response) and the transition to the iPad device (4.3 ± 0.67). Improving physician handovers may be achieved efficiently and economically through physician led iterative processes. Pediatric residents were at ease when the novel handover was combined with newer iPad technologies and applications.

Keywords: Intensive care units, pediatric, patient handoff, computers, handheld

1. Introduction

Patient handovers are complex and “interactive engagements of knowledge synchronization” [1] intended for efficient continuity of care and safe care decisions [2]. We consider patient handovers as “the exchange between health professionals of information about a patient accompanying either a transfer of control over, or of responsibility for the patient” [3]. Ineffective handovers can result in communication

errors, omission of care tasks, misunderstandings, and inadequate clinical content, uncertainty of subsequent care decisions and ultimately patient harm [3–6]. They have also been associated with longer hospital stays and higher admission costs [4, 7, 8].

Currently, there is no consensus on the optimal manner to hand over patients. In the intensive care unit (ICU), handovers are particularly challenging. Multiple results and physiological variables must be interpreted concisely within the context of a complex patient [9]. Although the recent surge of handover instruments from electronic medical records are encouraging, they are typically summarized into a hard copy form, and struggle to amalgamate important

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and uncertain components of the patient's clinical trajectory [1].

Novel approaches that promote higher-level interactions, questioning and understanding in pediatric intensive care unit (PICU) handovers should be employed. We attempted to address these issues for pediatric residents, by documenting four stages of development for a novel hand held iPad handover platform.

2. Materials and methods

The following stages were guided by previously published targeted strategies of “enhancing awareness of handover problems, identifying solutions by adapting best practices in local contexts, and implementing locally adapted best practices supported by documentation” [10]. The University of Manitoba Research Ethics Board approved the project.

2.1. Stage 1: Identifying elements of an “ideal” critical care handover cognitive aid

Although there exists several different formats and philosophies of what constitutes an ideal resident ICU handover, a minimum data set and two-way verbal exchange are key elements of best practice. Minimum data sets (MDS) “contain standard sets of data fields and/or topics to guide handover communications” [10]. Through an iterative process, the MDS currently used by our residents (Table 1) and others recently published [11], together with known published formats (SBAR [12]; ISOBAR [13]; SHARED [14]; PEDIATRIC [15], and; SIGNOUT [16]) were interrogated by five attending pediatric intensivists. Omissions from our MDS were recognized and documented.

The value of a two-way verbal exchange is often neglected or under appreciated when using cognitive aids. It refers to “an intentional interaction in which both the transferring and receiving parties are actively engaged with opportunities to clarify information through questioning and repeating back information” [10]. Practices in non-medical and high consequence fields [17] National Aeronautics and Space Administration Centre, nuclear power generation plant, railroad/ambulance dispatch centers) were reviewed for potential ideas to augment this component.

2.2. Stage 2: Translation of an “ideal” cognitive aid to a working iPad format

Several workflow models were trialed, including those utilized in air traffic control at our international airport. ‘Off the shelf’ applications and data capture using Adobe Acrobat forms were utilized. To address clarity and face validity, four non-PICU intensivists reviewed the working hardcopy drafts. They were selected to add further insight from both the neonatal and adult domains of critical care. In a semi-structured interview, these interactions addressed potential redundancy and omission of crucial elements, ease of organization, and whether they may have the potential to facilitate an enhanced two-way verbal exchange.

2.3. Stage 3: Operational validity with patient scenario and data

A fabricated patient scenario involving an 18-month-old with a lower respiratory tract infection and myocardial dysfunction was created.

Table 1
Winnipeg children's hospital minimal data sheet

Bed number	Name	Age	Weight (kg)	Admission attending	Date
Problem list		Past medical history			
		History of presenting illness			
Central nervous system	Medications, investigations				
Respiratory system	Ventilatory support, oxygenation, medications, investigations				
Cardiovascular system	Medications, vitals, investigations				
Gastroenterology	Medications, feeds				
Genitourinary	Medications, urine output, continuous renal replacement therapy				
Infectious diseases	Medications, cultures				
Plan	1.				
	2.				

2.3.1. Patient scenario

A 18 month-old previously well boy from a Northern community with probable bronchiolitis and shock. He had a four-day history of wheeze, cough, rhinorrhea, and fever, and a one-day history of increased work of breathing. He was transported to a tertiary pediatric centre, intubated in the emergency department for hypercarbic respiratory failure, and promptly transferred to the PICU. Chest x-ray shows hyperinflation, patchy densities and an enlarged heart. His first day in the PICU can be summarized with difficulties to sedate, poor cardiac output despite dopamine at 10 mcg/kg/min, respiratory acidosis requiring high mean airway pressures, and high FiO₂ requirements. He was started on broad-spectrum antibiotics. His mother is present, but cannot speak English. Cardiology has been consulted.

To simulate a real handover, our tool was then formatted with completed data fields that were directly linked to the scenario. Again, four non-PICU intensivists trialed the application, and feedback was obtained in a semi-structured interview similar to stage 2.

2.4. Stage 4: Piloting iPad cognitive aid with pediatric residents

Over a 30 min period, ten consenting 2nd, 3rd and 4th yr pediatric residents were enrolled in the pilot project. The inclusion criteria reflected residents who had experience managing PICU patients.

Residents were randomly partnered. Once paired, they were randomly given one of two roles: presenters (PH) or receivers of the mock handover. A 5-min tutorial was then provided on how the handover aid was organized. The PH was provided with the fictitious patient scenario developed earlier in stage 3 (See patient scenario). A bell then rang to signal the onset of the timed four-minute handover encounter. With the handover aid as the central guide for the interaction, two PH utilized an iPad, while three utilized a hard copy of the same tool. The “drive by paper” pairs were allowed to write in the margins of the printout to reveal potential deficiencies of the cognitive aid. A second bell heralded the end of the interaction.

After the handover exercise, the residents gathered as a group for semi-structured feedback and a five-question survey with responses on a 1–5 Likert scale (1 = strongly disagree; 2 = disagree; 3 = neither agree or disagree; 4 = agree; 5 = strongly agree). The survey

inquired whether; (a) the given information was not redundant, (b) important data was not excluded, (c) the handover time was appropriate, (d) the organization of data was easy to follow and comprehend, and, (e) the transition from the original paper form to the iPad format was easy.

3. Results

3.1. Stage 1

It was determined that improvements to our MDS should focus on the hospital/PICU course, patient's illness trajectory, short and longer term management goals, required actions, and potential issues/contingency planning. By reviewing known MDS mnemonics, it was agreed that DNR (do not resuscitate) status, allergies and an indication of the patient's stability should also be considered. Finally, a two-way verbal exchange consisting of a face-to-face interaction and concluding with a read back were deemed necessary.

3.2. Stage 2

Four hardcopy drafts were prepared differing on macro organizational structure: mnemonics, problem list, systems based, and hybrid (problem list with systems based). It was agreed that the hybrid model may capture the strengths of the three other formats, but ease of organization was an issue. Redundancy or omission of data was not recognized. Several revisions of the hybrid model were reviewed for formatting, and workflow was improved within the finite page.

3.3. Stage 3

The hybrid model with completed data fields was well received. Adding color to convey critical information was suggested, which reduced visual clutter and provided immediate and important recognition.

3.4. Stage 4

Group feedback revealed that although each resident had a preferred approach (systems vs. problem list), the hybrid model added further visual links that may improve complex patient understanding. Furthermore, they reported that more active cognitive processes

would be necessary to complete the data fields, requiring an enhanced patient understanding for the PH. The “drive by paper” pairs did not add supplement notes in their margins. Residents found that patient data was not redundant (4.2 ± 0.63 Likert scale response) or excluded (4.1 ± 0.74), and that the handover time was appropriate (4.7 ± 0.48). The organization format was easy to comprehend (4.0 ± 0.67), as was the transition to the iPad device (4.3 ± 0.67).

4. Discussion

In the ICU, striking the right balance of having a sufficient level of recorded information while accurately presenting the patient should remain at the core of patient handovers. We have demonstrated an iterative process involving physicians that addressed these issues, and utilized iPads with off the shelf technologies. The product of our iterative process was a novel hybrid two-axis grid that our residents found to easy to comprehend and use.

Similar to previous reports, the iterative process proved to be as useful as the tool itself, “in that it may have helped force some standardization of process and content” [18]. This was accomplished by placing the tool into the hands of physicians for continuous iteration and improvement of processes, with minimal information technology involvement. Our inspiration came from healthcare systems [19] that successfully adopted the Toyota production system [20] and lessons from aviation [21]. In regards to handover, this equated to analyzing existing work processes, principles for opportunities to add value and removal of waste or error.

iPads are emerging as an attractive tablet platform in medicine, due to their high availability, a unified hardware, and a software ecosystem that doesn’t suffer from the marketplace fragmentation of Android-based tablets. In Canada, clinicians are embracing media tablets in greater numbers, as their workflows require a continual motion around the health enterprise [22]. Over 30% of physicians own an iPad, the majority utilizing them professionally, because stationary PCs, laptops or computers on wheels cannot meet their needs [22]. Equally important, iPad applications allowed us to test secure workflows that protect patient data. The thorny issue of the transitory nature of handover data was addressed by creating the ability to “burn notice”. This feature allowed us to destroy the

document after a time delay (after shift completion), thereby reducing the risks of unaccounted sensitive information in the chain of data custody.

While handover is currently a “driven by paper” process, our goal was to minimize the learning curve of moving to an electronic system. This included decisions to use off the shelf technologies, thereby precluding any software development that is application rather than process focused. Adobe Acrobat Professional was selected, as it was familiar, inexpensive, simple to acquire, and allowed for rapid workflow development. The templates that were created for review by physicians were converted to Adobe Acrobat forms that could be filled out and completed on the iPad. A low cost, best in class application from the Apple iStore (PDF Expert by Readdle) was purchased to work with the PDF Sign-Over document on the iPad itself.

Improving communication to enhance patient safety was the overarching goal. This resulted in controlled data fields, grid layouts and color (Fig. 1), to manage flow, prioritization, and communicates critical information. The identification bar (I) boldly highlights the patient’s trajectory in one of three colors, denoting whether the patient is unstable (red), a “watcher” (yellow) or stable (green). Allergies (A) and medications (M) are given heightened attention due to their frequent association with medical errors. The adjacent field contains pertinent patient history, with its size forcing residents to be succinct.

By focusing on a visual workflow versus a particular mnemonic, we were able to incorporate the novel utilization of a two-axis grid to map both a systems and problem list approach. This was accomplished by visually organizing the color-coded problems (red: severe, yellow: watcher, green: stable) to their corresponding systems data. While both approaches have their weaknesses, the overlap may diminish the “trajectory of accident opportunity” [23] as described in the Swiss cheese model of accident causation. We anticipated that the grid would diminish rote data entry and require higher thought processes to facilitate a greater patient understanding. Finally, and most importantly, only a correct read-back was considered a confirmation. This concept is at the core of best practices within air traffic control and other high consequence fields [17], to reduce incorrect or incomplete communications. Ultimately, we decided on a simple checkbox at the bottom of the document to signify from the presenter that a correct read-back was performed. This confirmed

BED 3 ADMIT DATE: 21 APRIL 2014 22 APRIL 2014 Attending Physician

I	Doe, John 18 mo M 11.5 kg Bronchiolitis? Full Code					
A	Ø					
M	Ø					

Previously well. 4 day Hx of fever, runny nose, cough and wheeze. 1 day hx of WOB. Intubated April 21 for hypercarbic failure. CXR shows hyperinflation, patchy densities and an enlarged heart.

Mother is present, but cannot speak English.

SYSTEMS	CNS	RESP	CVS	GI	GU	ID	OTHER
Respiratory Failure	morphine 0.04 mg/kg/hr, midaz 0.1 mg/kg/hr	ACVG, Vi60ml, PIP 30, PEEP 10, FiO2 0.6, pCO2 68					
Myocardial Dysfunction			Dopamine 10mcg/kg/min, lactate 4.5		Urine output 0.9 ml/kg/hr, BUN 7.5, Cr 37, Na 134, K 4.8		
Others			2 PIVs	NPO	D5NS @ 40cc/hr, Foley	Vancomycin Cefotaxime	HB 80, WBC 16.5, Plts 185

12 HRS Cardiology consult re: cardiomegaly, follow up cultures, monitor ins/outs, central/arterial line

CONTINGENCY Sedation -> increase midazolam slowly. Target pH 7.30 -> increase/decrease rate. Target MAP > 50 -> volume vs increase dopamine. Target u/o > 1.0 -> volume vs increase dopamine. Transfusion threshold ~ 70

☐ READBACK from Receiver to Giver Completed

Fig. 1. The iPad cognitive aid.

an exchange of information and responsibility for the patients.

We assume that enhanced patient knowledge should lead to superior handovers. Our pediatric residents suggested that a greater patient understanding would be required for the data fields to be completed by the PH. The aid does not automatically complete data fields from pre-existing electronic records, but requires contemplation of matching the data to the 'best fit'. We anticipate that this mental exercise would be within the scope of a second year pediatric resident's learning and experience, but this will require future evaluation. Implementing the new format, and making the transition from paper to iPad was also a concern. However, our residents reported a relative ease with both, confirming either a familiarity with handheld devices and/or the simplicity of the tool.

The major limitation of our study is that it is uncertain whether our cognitive aid will lead to higher-level

handover interactions, improved understanding of critically ill patients, and ultimately improved patient care and reduced medical errors. These questions however, are currently being addressed. Furthermore, as the verbal feedback was not anonymous, reporting biases from our residents cannot be excluded.

In conclusion, physician led iterative processes may economically and efficiently improve physician handovers. Pediatric residents were at ease when a novel handover format was combined with newer iPad technologies and applications. Whether the tool leads to improved patient handovers needs to be established.

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