Enhancing Patient Safety in the Trauma/Surgical Intensive Care Unit

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Background: Preventable deaths due to errors in trauma patients with otherwise survivable injuries account for up to 10% of fatalities in Level I trauma centers, 50% of these errors occur in the intensive care unit (ICU). The root cause of 67% of the Joint Commission sentinel events is communication errors. The objective is (1) to study how critical information degrades and how it is lost over 24 hours and (2) to determine whether a structured checklist for ICU handoffs prevents information loss.

Methods: Prospective cohort study of trauma and surgical ICU teams observed with and without use of the checklist. An observational period (control group) was followed by a didactic session on the science and use of a checklist (study group), which was used for patient management and handoffs. Information was tracked for a 24-hour period and all handoffs. Comparisons use $\chi^2$ or Fisher’s exact test and a $p$ value $<0.05$ was defined as significant.

Results: Three hundred and thirty-two patient ICU days were observed (119 control, 213 study) and 689 patient care items (303 control, 386 study) were followed. Seventy-five (10.9%) items were lost over 24 hours; 61 of 303 (20.1%) without checklist and 14 of 386 (3.6%) with checklist ($p < 0.0001$). Critical laboratory values and test results were the most frequent lost items (36.1% control vs. 4.5% study $p < 0.0001$). Six of 75 (8.1%) items were correctly ordered but not carried out by ICU nursing staff—all caught and corrected with checklist use.

Conclusion: Critical information is degraded over 24 hours in the ICU. A structured checklist significantly reduces patient errors due to lost information and communication lapses between trauma ICU team members at handoffs of care.

Key Words: Critical data, Communication, Checklist, Handoff of care, Patient safety, Prospective.

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In the United States and around the world, trauma is the leading cause of death in younger patient populations and one of the most common causes of death among the elderly.1 Traditionally, studies of fatal outcomes in trauma patients focus on the management of injuries from prehospital, surgical and intensive care perspectives. However, a review of adverse outcomes reveals that a significant percent of these deaths might have been avoided. Preventable deaths due to human and system errors account for up to 10%2–4 of fatalities in patients with otherwise survivable injuries cared for in Level I trauma centers. The number of unintended deaths equate to as many as 15,000 lost lives per year in the U.S. or two lives lost per hour.5 This rate of death due to error in trauma patients is 2 to 4 times higher than deaths due to errors reported in the general hospital patient population.6 The reasons for this rate of errors are multifactorial. The situations likely to produce errors are the exact circumstances in which trauma victims present and trauma surgeons work. Trauma surgeons are constantly operating in a complex environment of unstable patients, fatigued practitioners, incomplete and sometimes conflicting histories, time-critical decisions, concurrent tasks, involvement of many disciplines, complex teams, transportation of unstable patients, and multiple handoffs of patient management. These circumstances expose trauma patients to a “perfect storm” for medical errors.

Published data have established that 2.5% to 9.9% of deaths in the postinjury care of trauma patients are due to error in their management. Specifically, Davis et al.7 reported on 1,295 trauma deaths pooled from regional Level I trauma centers in which they documented 1,032 significant patient errors that were judged avoidable by two independent reviewers. These errors contributed to preventable or potentially preventable deaths in 5.6% of patients studied. Ivatury et al.2 studied 764 fatal outcomes in a Level I trauma center and judged 76 (9.9%) of deaths due to management errors. Gruen et al.3 studied avoidable deaths and identified 64 (2.5%) of 2,594 deaths due to error at their Level I trauma center.

The in-hospital postinjury care of patients can be divided into three phases: resuscitative phase, operative phase, and postoperative phase. Of the reported fatal errors studied by Gruen,3 36% occurred in the resuscitative phase, 14% to the operative phase, and 50% to the critical care phase. The nature of these errors is harder to elucidate but data published by The Joint Commission8 on root cause analysis of sentinel events have identified that 67% are the result of errors in communication between team members.

Just as we study the mechanism of injuries and how to repair them, trauma teams need to understand the mechanism of these errors, how they occur, and how they can be avoided. The purpose of our study was to trace communication of critical patient information in the Trauma/Surgical ICU to understand how patient data are communicated and if errors
occur or data are lost that might contribute to potential adverse outcomes in our patients. The hypothesis of our study was that a structured checklist used for handoffs of care in the ICU would reduce lost patient information that is critical to their safe management.

**MATERIALS AND METHODS**

A prospective cohort study of teams in the trauma and surgical ICU was conducted. Each ICU team was composed of interns, residents, and fellows led by an attending trauma surgeon. All participants were advised in advance that surgical rounds would be observed but were not told what observations were being carried out, and all team members were given an opportunity to refuse participation. During a pilot period, the nature and type of information that was discussed and exchanged during morning sign-out rounds was assessed by two observers, and a 10-item checklist was constructed based on Department of Transportation and FAA published protocols for information tracking and human factors. This checklist was then used in the study protocol as follows.

The 1-month ICU rotation for each team was divided into two 2-week periods. The first 2 weeks were used as the control period and the second 2 weeks as the study period so that each team served as its own control. During the control period, a trauma fellow or an attending observer was assigned to each ICU team to observe morning teaching and work rounds and evening sign-out rounds and record on the checklists all patient care data and clinical assignments that were discussed on rounds. Each observer worked for a 24-hour period so that the same observer was present at morning work rounds, evening sign-out rounds, and work rounds the following morning to assess information. During the control period, only the observer used the checklist to monitor assignments during morning work rounds and evening sign-out rounds. On evening rounds, the observer recorded which patient care items were addressed and which assignments had been completed. The same observations were made the following morning and items that had been appropriately acted upon were observed. Any items that were neglected during the 24-hour period were marked as “lost.” When an observer discovered a patient care item that had not been acted upon by evening rounds, the information was brought to the attention of the ICU team to ensure that no harm came to any patient during the study period. These items were scored as “lost” at that time and not carried forward to morning rounds observations.

After 2 weeks of observation during the control period, a basic didactic session with all team members on the theory and use of checklists was carried out with instructions on how to populate and complete the sign-out checklists. The second 2-week period of each rotation was used as the experimental period and each team member filled out the checklists on morning rounds. The checklists were used at handoff in the evening to present the patient history and follow up on patient assignments. The observers did not prompt team members to carry out items recorded on their checklists but did confirm that the items had been recorded on the checklists. All team checklists were collected after morning rounds the following day and comparisons to the observer checklists (filled out the previous day) were made after 24 hours to identify patient care items and their execution. Any item that had been on the team checklist and not carried out was scored as “lost” information. Items that had been assigned at morning report and not placed on the team checklists were assigned by the observers at evening sign-out rounds to the incoming team and scored as “lost” information.

Patient care items that were ordered directly in patient charts at the time of the assignment were not scored as complete items, because they did not involve communications between team members regarding patient handoffs of care over a 24-hour period. These items were followed up by the observer to ensure that the orders had been acknowledged and acted upon by the ICU nursing staff. Items that were correctly ordered but not carried out by the nursing staff were scored as complete by the ICU team but lost by the nursing staff.

The checklist was broken down into 10 categories that followed the natural care of complex ICU patients. Data were processed by combining similar items into categories (for example, antibiotic orders or changes in antibiotic medication were combined with microbiology culture reports) and comparisons were made using chi-squared or Fisher’s exact test where appropriate. A p value < 0.05 was defined as significant. The protocol was approved by The University of Miami Investigational Review Board.

**RESULTS**

A total of 332 patient ICU days were observed, 119 of those observation days were carried out during the control period and 213 during the study period (Table 1). A total of 689 patient care items were tracked for a 24-hour period, 303 during the control period and 386 during the study period. Over this time frame, 75 discrete patient care items were lost (10.9%), 61 of 303 (20.1%) of observation patient care items were lost during the control period and 14 of 386 (3.6%) of total patient care items were lost during the study period (p < 0.0001). The handoff checklist was divided into 10 categories of patient care items (Table A1). Among items in these categories, we found that critical laboratory values and test results were most frequently lost during the control period without the use of the checklist. Twenty-two of 61 (36.1%) patient care items related to critical laboratory test orders and were lost without the checklists. This was significantly reduced with the routine use of the handoff checklist where 4 of 89 (4.5%) were lost (p < 0.0001).

**TABLE 1. Data of Lost Patient Critical Items**

<table>
<thead>
<tr>
<th>Patient Care Item</th>
<th>n</th>
<th>No. of Lost Observation</th>
<th>No. of Lost Study</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical laboratory/meds</td>
<td>150</td>
<td>22/61 (36.1%)</td>
<td>4/89 (4.5%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Antibiotics/cultures/meds</td>
<td>193</td>
<td>11/94 (11.7%)</td>
<td>1/99 (1%)</td>
<td>0.010</td>
</tr>
<tr>
<td>Nutrition/vent/other</td>
<td>177</td>
<td>12/80 (15%)</td>
<td>4/97 (4.1%)</td>
<td>0.043</td>
</tr>
<tr>
<td>Tubes/CVP/IVs</td>
<td>117</td>
<td>12/47 (25.6%)</td>
<td>4/70 (5.7%)</td>
<td>0.018</td>
</tr>
<tr>
<td>Consults</td>
<td>52</td>
<td>4/21 (19.1%)</td>
<td>1/31 (3.2%)</td>
<td>NS</td>
</tr>
<tr>
<td>Total</td>
<td>689</td>
<td>61/303 (20.1%)</td>
<td>14/386 (3.6%)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

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The second most common category of patient care items found to be lost were items related to insertion or removal of tubes/drips and central venous lines (described on rounds as the “tubes/lines/drips” information) where 12 of 47 (25.6%) items were lost during the control period and 4 of 70 (5.7%) were lost during the study period (p = 0.018). There were 177 patient care items related to changes in ventilator settings and arterial blood gas review, of which 12 of 80 (15%) were lost during the control period and 4 of 97 (4.1%) were lost during the study period (p = 0.043). The most frequently assigned items were those relating to antibiotic medication and microbiology cultures. A total of 193 items were tracked in this category of which 11 of 94 (11.7%) were lost during the control period and only 1 of 99 (1%) were lost during the study period with checklists (p = 0.01). Another category of items related to communication with consult services or with the primary care team regarding patient management decisions. A total of 52 items were tracked, and during the control period, 4 of 21 (19.1%) were lost and with the use of the checklist only 1 of 31 (3.2%) were lost. This did not reach statistical significance likely because of the small sample number.

We found an unanticipated category of items that were functionally lost in the ICU even though correct communication and correct orders were entered into the patient charts. Six of 75 (8.1%) lost items were correctly ordered by the team but not carried out by ICU nursing staff that were discovered with use of checklists and corrected.

**DISCUSSION**

The surgical/trauma ICU is a complex environment of admissions and constantly changing patient conditions on a 24-hour schedule that does not respect time of day or night. There are, in addition, multiple teams of care givers who interact with differing schedules and responsibilities that include primary clinical trauma and surgical services, consultants, nursing teams, and ICU teams. Studies of adverse outcomes in trauma find that the ICU is the most common place for errors in the management of postinjury patients where 40% to 50% of these adverse events (AE) have been identified to occur.3

Data confirming the error risk during the ICU phase of management comes from an ICU observational study by Donchin.10 The authors documented 554 patient errors during the 4-month study with a rate of 1.7 errors per patient per day. Rothschild et al.10 carried out a similar study of 391 ICU patients. One hundred twenty AE occurred in 79 (20.2%) patients including 54 (45%) preventable AE as well as 223 potentially fatal errors. The rates per 1,000 patient-days for all adverse events, preventable adverse events, and serious errors were 80.5, 36.2, and 149.7, respectively. Among adverse events, 13% (16 of 120) were life threatening or fatal and among errors judged to be serious, 11% (24 of 223) were potentially life threatening. Data from our study support these findings in that the most serious errors occurred during the ordering or execution of treatments, especially medications (61%; 170 of 277). Further confirmatory results were reported by Orgeas et al.11 who studied 3,611 ICU patients. Their study documented that 39.2% of patients suffered at least one adverse event and 22.7% of patients two or more AEs (mean 2.8 AEs/patient) with median time to first AE = 4 ICU days. The presence of at least one AE increased the odds ratio of mortality as much as 17-fold over matched controls without AEs.

The source of these errors relates to a complex mix of human factors, team work, and system breakdowns that lead to communication mistakes and mishandling of critical patient information. Joint Commission statistics have identified that 67% of the root cause of sentinel events are the result of errors in communication between teams and among team members.12 Our study confirms this finding and specifically documents that 10.9% of critical patient care items were lost during a 24-hour observation period due to failures of communication between ICU team members. Poor teamwork and communication lapses among members of healthcare teams have emerged as key factors in the occurrence of errors.

In health care, understanding communication, team dynamics, and practicing functional team skills are important aspects of avoiding errors in the management of the trauma patient. Medical teams in general and surgical teams specifically have been studied in depth by many authors.13 Failure to communicate critical information occurs in ~30% of team exchanges.14 Such failures lead to inefficiency, rising tension, delay, workarounds, resource waste, patient inconvenience, and procedural error all of which can portend poor patient outcomes. The most common reason critical information is lost is that it is simply forgotten. This is described as errors of omission in human factors and error theory. A simple solution to failures of information handling and forgetting critical information in the complex environment of the ICU is to write it down and a template to do that is a checklist. Our data confirms that this is in fact a good solution to the problem in that use of a sign-out checklist reduced lost information from 20.1% to 3.6% (p < 0.001).

There are several flaws with this study. We made the assumption that lost patient data equates to adverse outcomes, but we used lost data as a marker for bad outcomes without proving that our method of enhancing data handling would improve outcomes. We did not follow the consequences of lost information with potential impact on fatalities, prolonged ICU stays, or prolonged ventilator days.

Another potential flaw with this investigation is that observational studies of human behavior are subject to the “Hawthorne Effect” whereby the simple process of the observation itself will have an impact on the behavior even if no other alterations are made in the system. We attempted to balance any bias that may have been introduced by having the same observations made during both the study and control periods.

**CONCLUSION**

Critical patient information is commonly degraded over a 24-hour time frame in the ICU due to poor communication between the team members. A structured checklist significantly reduces the incidence of lost information and communication lapses between trauma ICU team members at handoffs of care. We postulate that this reduces the incidence of patient errors in the ICU.
APPENDIX

TABLE A1. Patient Handoff of Care Checklist

<p>| PATIENT MANAGEMENT PLAN CHECKLIST for ______________<strong><strong><strong><strong>BED</strong></strong></strong></strong> |</p>
<table>
<thead>
<tr>
<th>Diagnosis/Operation</th>
<th>Primary Team</th>
<th>Date/Time</th>
<th>Action to be Taken</th>
<th>Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>Follow-Up Items</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical laboratory order/pending</td>
<td>Check</td>
<td>Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical tests order/pending</td>
<td>Treat</td>
<td>Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antibiotics/cultures/fever</td>
<td>Check</td>
<td>Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central/arterial lines</td>
<td>Treat</td>
<td>Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>Contact</td>
<td>Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consults/team</td>
<td>Check</td>
<td>Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medications/orders</td>
<td>Order</td>
<td>Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPN/nutrition</td>
<td>New</td>
<td>Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IVs/fluids/electrolytes</td>
<td>Change</td>
<td>Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGB/vent/respiratory Treatments</td>
<td>New</td>
<td>Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Change</td>
<td>Time</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DISCUSSION

Dr. Randall Friese (Tucson, Arizona): Good morning, EAST members and guests. I would like to thank the society for the opportunity to discuss this paper. First, I would like to congratulate the authors on a well presented and highly pertinent study regarding the human factor in perpetuating errors in medical care. In fact, it’s quite timely. One of my colleagues just brought to my attention that in today’s USA Today there is an article in the Lifetime Section regarding checklists in surgery and outcome improvements.

Next, I would like to use my remaining time at the podium not recapitulate a study that was so very eloquently presented, reviewed, and discussed just a few moments ago, but to highlight the importance of this type of research.

REFERENCES

addressing the potential for human error in the medical management of critically ill patients.

As healthcare providers, we must cease to downplay human error in medicine and we must make a concerted and focused effort to address the “error elephant” that has been lingering in our emergency rooms, our operating rooms, and our intensive care units for decades. Much has been written about the human factor in medical errors and experts have identified that it may be minimized with process simplification and standardization, specifically designing checklists and protocols that reduce the reliance on memory and improve information access.

Dr. Stahl and colleagues have taken the idea of utilizing a checklist, first introduced by Dr. Provonost to decrease central line infection rates, and have designed a process to aid in continuity of care for critically ill patients during ICU rounds and handoffs. They demonstrated that the process of ICU rounds unaided by checklists is likely to result in lost information. We all too frequently forget or omit addressing information that was identified as important at some earlier point in the day.

Although this is an important study, I have some concerns about the study design and analysis and would like to pose the following questions. First, the authors report a total of 323 ICU patient days observed in this study. Each study period, controlled on the checklist period, lasted two weeks. This works about to about eight to nine patients per day during the control period and fifteen to sixteen patients per day during the checklist period. Could the authors address why the enrollment during the checklist period was nearly twice as high then during the control period?

Second, were surgeons and other critical care providers active in the development of the checklist used?

Third, how intensive was the didactic session on checklists? Since we are all well aware that repetition plays a major role in learning, did each provider participate in multiple didactic sessions? Additionally, how many physicians participated in this study? How many refused to participate?

Lastly, were the errors clustered on specific days, possibly post-call days or weekends, or were more errors made specific to one team member or care provider, possibly a junior member who was maybe more likely to commit errors? Would the data be best represented as errors indexed by day or indexed by provider, rather than as total counts of errors that occurred during each time period?

Again, I would like to thank and congratulate the authors for completing this extremely important study. As Yogi Berra once so eloquently surmised: “None of us wants to make the wrong mistake.” Thank you.

**Dr. Kenneth Stahl** (Miami, Florida): Thank you very much for your generous comments. As I understand your questions, the first question related to enrollment and why there were more study days than observation days. We looked at that as we analyzed the study data. I think the reason the final numbers came out that way was not so much that there were more observation days or study days. There were close to an equal number of patient care items (303 vs. 386) and it was the communication data that was the subject of the investigation not the specific observed days. We did not capture as many useable days of data during the observation period and were forced to discard some of the observational data sheets which did not happen during the study period.

There was much better follow up of data using the written checklist, because we had a record of everything that was discussed and how it was understood by the residents. We collected enough data and days of observation to be sure that each arm of the study was statistically valid and the statistics were not slanted by the number of days in each arm.

As far as teaching, we devoted part of one morning to a didactic session on the checklist and then we had individual tutorials. Usually one of the trauma fellows would help the residents fill out the checklist on morning rounds and help them get adjusted to it and use it properly. It was a more one-on-one tutorial than multiple sessions for the entire group.

As far as participation in the group, this was IRB-approved protocol and all residents, interns, fellows, and trauma attendings were offered an opportunity not to participate by email and it was posted in the intensive care unit that we would be observing sign-out rounds and morning rounds. We didn’t tell them what we were observing, but they knew they were being observed and were offered the opportunity to decline participation. No one declined participation and a total of about sixty doctors participated in the data gathering.

Your fourth question had to do with the number of variables we analyzed and whether there were clusters of times when information was more likely than not to be lost. In this patient safety era, it’s difficult for the observer to see that something is not correctly acted upon and let it pass.

We discovered when we looked at our data and translated those into electronic data that a lot of these missing items were identified by the observer who sat in on handoff rounds in the evening. When something was clearly forgotten, he or she marked it on the checklist as “lost information” and then made sure that the patient received proper care. We really didn’t have the opportunity to understand whether post call days were more likely to portend the simple act of forgetting things as is a common human error.

It’s an excellent point and I think it emphasizes the fact that human factors, as, for example, the FAA has stressed so much in the cockpit, applies just as much to us. As trauma surgeons, we’re continually dealing with multiple changing variables and working all hours of the day and night and often fatigued, it’s even more important for us to be aware of the degradation in our cognition and skills when we’re fatigued and rushed.

It highlights one of the things we were trying to demonstrate, but we just simply couldn’t allow the process to play out in that manner and not address a critical patient care item just for the sake of the study.

**Dr. Faran Bokhari** (Chicago, Illinois): Thank you, Dr. Stahl. I have a question and then we’ll take a couple more questions from the audience. One of the concerns that I had about the study design was that your observation was at the beginning of the experiment. You had your checklist experiment in the last two weeks. Don’t you think that part of the improvement might be the team functioning well after two...
weeks of the control period and so it might not have as much to do with the checklist as we might want to believe?

**Dr. Kenneth Stahl** (Miami, Florida): I think that’s a very good point. We passed out opinion surveys to all the participants and found that they really liked the use of the checklist and so to have used the checklist for the two weeks and somehow undo it and take it away from them would have introduced the reciprocal contamination of these data.

It’s an excellent point and I think that team function improves handoffs and improves data management and improves information and care. That’s a great point and I don’t know how to factor that into the analysis.

**Dr. Jay Yelon** (Westchester, New York): I rise to congratulate you on looking at a vital component of surgical critical care and critical care in general. I am a little bit concerned about the methodology, similar to Dr. Bokhari, that not only is the teamwork getting better, but your nursing staff—Although the resident and fellow staff may change on a monthly basis, your nursing staff is fixed.

There’s going to be a bias over time, a biased attitude from the nursing staff over time. What we found in our ICU when we implemented checklists and daily goals is that initially there was a little bit of pushback, because it was a change of culture, but then the nurses really embraced it and they actually are the ones that drive our ability to have an effective daily goal sheet.

I think you looked at how the team functions, but I think you need to look at what’s happening on the other side, from the nursing end of things, and how that will change over time. Communication is a two-way street; even though you have a checklist, is it registering on the other side? Again, I enjoyed this and I congratulate you on your work.

**Dr. Kenneth Stahl** (Miami, Florida): Thank you for your kind comments and it’s an excellent point. In physics there is the “Heisenberg Uncertainly Principle,” which basically said that if you wanted to try and find where an electron was in space, you had to put energy into measuring it and putting energy into measuring it changed the position of the electrons; therefore, you could never really know where the targets were. I think that’s one factor that confounds all human factors research. Any time you observe systems of people, you likely change their behavior simply by observing it and that’s hard to account for. That’s an excellent point.

**Dr. Frank Davis** (Savannah, Georgia): One comment and a couple of questions and this really pertains to the progress note. Because of the increasing demands of regulatory requirements for documentation, progress notes have often evolved into more of a billing sheet. The question is, what’s the current role of your progress note in your ICU and maybe we should flip this around. If the check sheet is really so important in taking care of the patient and changing outcomes, should we replace a modified check sheet as a daily progress note?

The second question is, have you thought about leveraging the power of the computer to fill out your check sheet every day, so those structured components that don’t change, the computer can fill in and just you could use your time, or the residents or the attendings, to just fill in the change on a daily basis?

**Dr. Kenneth Stahl** (Miami, Florida): We have considered making this into an electronic record. Ideally, what I would envision is a screen above each ICU bed with red items that turn green when they’re addressed and we’ve begun to try and understand how we can turn this into an electronic reminder.

I couldn’t agree with you more that I think the progress note really is almost something we fill out thinking it’s a legal document more than a medical document sometimes. I think this is an important part of it, just as you said.