A Systematic Quantitative Assessment of Risks Associated With Poor Communication in Surgical Care

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Hypothesis: Health care failure mode and effect analysis identifies critical processes prone to information transfer and communication failures and suggests interventions to improve these failures.

Design: Failure mode and effect analysis.

Setting: Academic research.

Participants: A multidisciplinary team consisting of surgeons, anesthetists, nurses, and a psychologist involved in various phases of surgical care was assembled.

Main Outcome Measures: A flowchart of the whole process was developed. Potential failure modes were identified and evaluated using a hazard matrix score. Recommendations were determined for certain critical failure modes using a decision tree.

Results: The process of surgical care was divided into the following 4 main phases: preoperative assessment and optimization, preprocedural teamwork, postoperative handover, and daily ward care. Most failure modes were identified in the preoperative assessment and optimization phase. Forty-one of 132 failures were classified as critical, 26 of which were sufficiently covered by current protocols. Recommendations were made for the remaining 15 failure modes.

Conclusions: Modified health care failure mode and effect analysis proved to be a practical approach and has been well received by clinicians. Systematic analysis by a multidisciplinary team is a useful method for detecting failure modes.

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During the past 15 years, several systematic studies concerning medical errors have been published. Harvard Medical Practice Study investigators estimated that 3.7% of hospitalized patients experienced an adverse event during their 1984 hospital admission in New York State. Based on this and other studies, the US Institute of Medicine estimated in 1999 that 44 000 to 98 000 deaths occur annually in US hospitals at least partly due to preventable adverse events. Communication failures have been identified as a leading cause of these adverse events. One-half to two-thirds of these events are attributable to surgical care. Studies in the surgical domain also illustrate the prevalence of communication breakdowns in the perioperative period. In an operating room observational study, Lingard and colleagues identified 30% of communication events as failures. Another observational study of 10 patients undergoing general surgery found that patient safety was compromised by failures of communication and transfer of information in all cases. In a surgical malpractice claims study, serious communication breakdowns causing patient harm were distributed across the continuum of care, and they occurred at least as often in the preoperative and postoperative phases as during the intraoperative phase.

See Invited Critique at end of article

These findings suggest that any strategy aiming to improve the system of surgery and patient safety starts with information transfer and communication. Most importantly, the entire surgical process must be assessed to know where to target interventions. Although various investigations have looked at communication in surgery, most studies have focused on the operating theater, despite the fact that adverse events are distributed across all phases of surgical care (preoperative, intraoperative, and postoperative). To the best of our knowledge, no study has examined information transfer and communication for a patient’s entire surgical journey. This is a serious gap. If surgical processes that are vulnerable to...
communication failures can be systematically identified, interventions can be developed and applied to critical phases of care to reduce patient harm.

The present study sought to fill this void. We used a systematic quantitative validated method to assess risks in the process of information transfer across all phases of surgical care. The method is known as failure mode and effect analysis (FMEA) and was originally developed by engineers to accomplish proactive risk analyses.12 The National Center for Patient Safety of the US Department of Veterans Affairs adjusted FMEA for use in health care, resulting in health care FMEA (HFMEA).13 Health care FMEA is a multistep process (Figure 1) that uses a multidisciplinary team to proactively evaluate a health care process. The team uses process flow diagrams, hazard scoring, and decision trees to identify potential vulnerabilities and to assess their potential effect on patient care. The method captures the likelihood of risks, the severity of consequences, and the probability that they may be detected and intercepted before causing harm. Health care FMEA has so far been applied to medication administration,14–17 intravenous drug infusion,18–20 blood transfusions,21 and equipment problems.22–25 To date, HFMEA has not been applied to communication or to surgery.

The objective of this study was to apply HFMEA to the information transfer and communication process in the surgical journey of patients, using the knowledge and expertise of all health care professionals involved. The analysis aimed to map the surgical care process and to highlight specific areas prone to communication failures potentially resulting in patient harm.

**METHODS**

**DESIGN**

A modified HFMEA (as used by the Veterans Affairs National Center for Patient Safety13) was performed at an acute teaching hospital in the United Kingdom that is also a tertiary referral center for major gastrointestinal cancer surgery between July 1 and December 20, 2008. No approval from the hospital research ethics board was sought because the study was part of an ongoing safety program and no patients were involved in the study.

**HFMEA TEAM**

A multidisciplinary team was assembled consisting of 15 members (4 surgeons, 4 anesthetists, 6 nurses [ward, operating room, and recovery], and a psychologist with human factor expertise in health care [A.B.S.]). Inclusion of a wide spectrum of health care professionals ensured representation of every phase in the surgical care pathway (preoperative, intraoperative, and postoperative phases).

**HFMEA PROCEDURE**

Formal HFMEA guidelines were applied to the information transfer and communication processes throughout the surgical care pathway.13 An introductory session was held to explain the whole HFMEA process to participating experts. A team leader (K.N.) supervised the HFMEA procedure. The leader created a preliminary flow diagram after initial discussions with the HFMEA team and identified the main processes and subprocesses. Communication processes were examined across 3 phases, namely, preoperative, intraoperative, and postoperative. Initial analysis revealed 14 different steps across the 3 phases, which were subsequently grouped into 6 main steps in surgical care (Figure 2). Of these, preoperative assessment and optimization, preprocedural teamwork, postprocedural handover, and daily ward care were found to be most vulnerable to information transfer and communication errors through hazard analysis by the team. (The intraoperative phase was deemed equally vulnerable but was not the focus of this FMEA.) The final detailed analysis was conducted only on these 4 phases. The exploratory step of identifying failure modes was performed through chaired brainstorming focus group sessions of the HFMEA team. In addition, the modified HFMEA was reinforced through a review of the literature and from direct observations of the surgical care pathway for patients undergoing major general surgical operations. An independent observer (K.N.) followed up 10 patients undergoing major elective gastrointestinal surgery during preoperative, intraoperative, and postoperative care. The patient and procedural details are given in Table 1. This triangulated approach ensured that all potential failure modes were identified.

Hazard analysis uses a 4-point scale to rate severity (minor, moderate, major, or catastrophic) anchored to patient outcomes and a 4-point scale for probability (remote, uncommon, occasional, or frequent).13 The product of these 2 scores creates a hazard score. Although the focus group method13 is an excellent technique to explore various failure modes and their solutions because it evokes discussion among various members and empowers participants, it is not a reliable technique for determining an individual’s authentic point of view. Some people with leadership qualities may dominate the discussion, thereby silencing any individual voices of dissent. Therefore, the confirmatory formal analysis step of prioritizing the fail-

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**Figure 1. Main steps in surgical health care failure mode and effect analysis (HFMEA) (adapted from the Veterans Affairs National Center for Patient Safety13).**

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ure modes within this HFMEA involved individual hazard matrix scoring by 9 team members, as opposed to standard HFMEA that involves hazard matrix scoring by the team within a focus group session.

The failure modes that scored 8 or higher by more than 50% of team members were classified as critical. An interrater reliability analysis was performed using the mean measures intraclass coefficient to determine consistency among the assessors. We then used a decision tree for each critical failure mode to critically assess existing control measures and detectability, which measured whether the entire system would fail if this part of the process fails. Failure modes with high criticality that did not have effective control measures in place and are not easily detectable were prioritized for further action. Finally, we

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**Table 1. Patient and Procedural Details in Follow-up of 10 Patients**

<table>
<thead>
<tr>
<th>Patient No./Sex/Age, y</th>
<th>ASA Score</th>
<th>Surgical Procedure</th>
<th>LOS, d</th>
<th>LOS in HDU After Surgery, d</th>
<th>Readmission to HDU From Ward</th>
<th>Readmission to ITU From Ward</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/M/39</td>
<td>2</td>
<td>Hemicolecotomy</td>
<td>7</td>
<td>2</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>2/F/61</td>
<td>2</td>
<td>Total gastrectomy</td>
<td>13</td>
<td>7</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>3/F/45</td>
<td>2</td>
<td>Laparoscopic sigmoid colectomy and loop ileostomy</td>
<td>5</td>
<td>3</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>4/M/57</td>
<td>2</td>
<td>Total gastrectomy</td>
<td>28</td>
<td>7</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>5/F/56</td>
<td>2</td>
<td>Limited ileocolic resection</td>
<td>8</td>
<td>3</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>6/M/57</td>
<td>2</td>
<td>Subtotal gastrectomy</td>
<td>32</td>
<td>5</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>7/M/50</td>
<td>1</td>
<td>Anterior resection</td>
<td>7</td>
<td>2</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>8/F/42</td>
<td>2</td>
<td>Total gastrectomy</td>
<td>12</td>
<td>6</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>9/F/76</td>
<td>2</td>
<td>Subtotal gastrectomy</td>
<td>10</td>
<td>5</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>10/F/74</td>
<td>2</td>
<td>Subtotal gastrectomy</td>
<td>11</td>
<td>6</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Abbreviations: ASA, American Society of Anesthesiologists; HDU, high-dependency unit; ITU, intensive therapy unit; LOS, length of hospital stay.
determined actions to be taken to eliminate or control these failure modes. An anonymous satisfaction survey, including involvement in HFMEA, colleague participation, usefulness, and increasing awareness of patient safety, was subsequently conducted among all team members to evaluate the effect of HFMEA.

RESULTS

Figure 2 shows the distribution of failure modes in each process and subprocess. Across these care processes that were investigated, 132 failures were identified. Of those, 41 (31.1%) were classified as high risk by hazard scoring. There was substantial correlation among the assessors (mean measures intraclass correlation coefficient, 0.69; 95% confidence interval, 0.51-0.79; \( P < .001 \)). Of 41 high-risk failures, 26 were already sufficiently covered by protocols as determined by the decision tree. For the remaining 15 failures, 22 different causes were identified by the analysis, and 18 recommendations were made to address them (Table 2). Some failure modes identified with HFMEA were also observed during follow-up of 10 patients undergoing major gastrointestinal surgery. The failure modes noted by the independent observer are summarized in Table 3. Prescription errors and deep vein thrombosis prophylaxis omissions were common in all phases of care. Failure of communication among care providers was common in postoperative daily ward care.

FAILURE MODES AND RECOMMENDATIONS

Preoperative Assessment and Optimization

Memory lapses, lack of knowledge, blurring boundaries of responsibility, and hierarchical and power differences led to information transfer and communication problems. The HFMEA team recommended that junior staff be free to talk to senior staff and that vertical hierarchical differences be minimized. There should be increased continuity of care. Patient care tasks should be clarified and their responsibilities assigned to prevent ambiguity. The same team member should send and check investigations. Care pathway bundles should be introduced to improve record keeping.

A preoperative checklist should be designed to decrease memory lapses and to ensure that all tasks are completed and that patient care is adequately optimized. There should be automated alerts to clinical teams about abnormal test results. Anesthetic risk assessment should be standardized to improve preoperative assessment and optimization. Important information should be available in care pathway notes and on the intranet to ensure consistent access to key information when needed.

Preprocedural Teamwork

Poor communication within the operating room team before the start of a procedure can result in problems that range from medication errors to surgery at the wrong site. A preoperative standard briefing and checklist involving the whole operating room team should be implemented to develop a shared model of work and to minimize errors.

To reduce equipment problems, an electronic equipment checklist should be displayed in the operating room that informs the team about any equipment unavailability so that alternative plans or arrangements can be made before proceeding. To add redundancy to the system, the surgical team should also check the equipment 1 day before surgery.

Postoperative Handover

Postoperative handover occurs in a dynamic, rapidly changing environment where staff must care for patients in an at-risk state, often under considerable pressure. Anesthetists’ handovers are typically brief and take place amid a range of other activities that compete for the attention of receiving nurses. The information passed is often incomplete and inaccurate. The type of information written as notes and communicated at handover is left to the discretion of the operating surgeon, and standardization of items to include in the handover is lacking. There should be a pro forma postoperative handover to improve the information transfer from operating room to ward via the recovery area to exchange relevant clinical information and to enable continuity of care. Handover needs to be structured and organized to reduce omissions of information. Documenting and formalizing the handover may serve many functions such as aiding memory, providing support for and evidence of clinical decision making, and improving communication skills between the operating room team and the recovery team.

Daily Ward Care

Typical ward rounding is a dyadic interaction between patient and physician with minor contributions from nurses. This is a clear disadvantage in that, contrary to physicians, nurses see daily activities of patients. Therefore, crucial questions about patients’ overnight events, drain output, and so forth depend on the information that nurses possess. Multidisciplinary ward rounds need to be conducted so that the team can make an integrated assessment of the patient by having all necessary information from various professional groups, including nurses. Moreover, daily plans can be communicated and implemented better if nurses are present during the daily ward rounds.

PARTICIPANTS’ VIEWS ON HFMEA

After completion of HFMEA, a satisfaction survey was conducted among team members. Health care FMEA was considered useful in analyzing the surgical care process prospectively. Team members thought it highlighted problems in a systematic approach that would be impossible with any other method. Except for 1 participant, everybody agreed that the process would become safer after implementing recommendations. The participant who disagreed was unsure whether the recommendations made would improve the process. All participants except 1 believed that HFMEA had increased their awareness of patient safety. All participants said that if given a chance they would like to be included in other applications of HFMEA. One participant who was involved in several patient safety research projects did not think that HFMEA increased his awareness of patient safety. Because of the potential to en-
hance safety with HFMEA, all team members agreed that they would advise a colleague to participate.

Health care FMEA uncovered multiple system errors that had not been previously considered and acted on. Given the significant human resources needed to complete the hazard analysis, this investigation should be reserved for clinically significant problems. This study identified multiple correctable information transfer failures in the surgical process and served as the basis for development of interventions. In contrast to retrospective analyses, a prospective approach to a system permits complete evaluation of vulnerabilities (failure modes) before the occurrence of adverse events.

### Table 2. Failure Mode and Effect Analysis Recommendations and Suggestions

<table>
<thead>
<tr>
<th>Process Step</th>
<th>Failure Mode</th>
<th>Causes</th>
<th>Recommendations and Suggestions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preoperative Assessment and Optimization Phase</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check blood investigation results</td>
<td>Failure to check investigation results</td>
<td>Lack of knowledge, memory lapses, blurring of responsibility</td>
<td>Electronic communication system, increased continuity of care (same team should order and check blood test results)</td>
</tr>
<tr>
<td>Check special investigation results (eg, echocardiography or pulmonary function test)</td>
<td>Checked investigation results but action not taken</td>
<td>Hierarchy in system, lack of knowledge, failure to communicate with staff nurse</td>
<td>Standardize preoperative assessment, assign responsibility for ensuring results are checked in a specified time frame before date of surgery, using care pathway bundles to make record keeping systematic (with checklist of results to be checked and action taken), system with alerts or automated e-mails for incomplete tasks, clarity about responsibility for preoperative optimization</td>
</tr>
<tr>
<td>Make plan for medical comorbidities (eg, discontinue warfarin sodium and glucose-insulin regimen for patients with diabetes)</td>
<td>Failure to make plan for comorbidities</td>
<td>Lack of protocols, lack of interdisciplinary communication (surgeon-anesthetist), memory lapses, high workload</td>
<td>Preoperative checklist, clear guidelines for management of patients with diabetes and patients taking anticoagulant agents available on intranet and within care pathway bundles, alert or grading system to highlight patients who need specialist input, standardized communication protocols to improve information transfer between surgeons and anesthesiologists</td>
</tr>
<tr>
<td>Prescribe medications</td>
<td>Failure to prescribe routine medications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check special equipment in operating theater</td>
<td>Failure to check equipment</td>
<td>Assumption about equipment availability, competency issues among junior staff, high workload, lack of resources</td>
<td>Prepared equipment packs, electronic equipment checklist in operating theater, surgical team to confirm equipment availability the day before surgery</td>
</tr>
<tr>
<td>Anesthetic team and surgical team communicate with each other</td>
<td>Failure to communicate with each other</td>
<td>Assumption by teams that other team knows cultural factors, lack of formal briefing</td>
<td>Theater team briefing the evening before operation or before start of checklist, Web-based conference of operating theater team</td>
</tr>
<tr>
<td><strong>Preprocedural Teamwork Phase</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating theater team confirms patient identity and name and site of operation</td>
<td>Failure to confirm patient identity</td>
<td>Cultural factors, duplication of tasks, reduced time and operating theater efficiency, lack of hierarchy, power and social structure, multiple competing tasks</td>
<td>Briefing and checklist</td>
</tr>
<tr>
<td>Surgeon and anesthetist discuss anticipated problems, expected blood loss, duration of surgery</td>
<td>Failure to confirm name and site (if required) of operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating theater team checks that antibiotic has been given</td>
<td>Failure to discuss anticipated problems, duration of surgery, blood loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating theater team checks about pneumatic compression</td>
<td>Failure to check whether antibiotic has been given</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anesthetic team and surgical team communicate with each other</td>
<td>Failure to check pneumatic compression</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Postoperative Handover</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handover to recovery</td>
<td>Handover incomplete or inaccurate</td>
<td>Forgetfulness, high workload</td>
<td>Debriefing in operating theater with presence of recovery nurse, pro forma postoperative handover</td>
</tr>
<tr>
<td><strong>Daily Ward Care</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assess patient</td>
<td>Failure to take information from nurse</td>
<td>Unavailability of nurse owing to shortage of staff, high workload or multiple competing tasks</td>
<td>Multidisciplinary ward rounds, implementation of integrated care pathways or postoperative recovery protocols</td>
</tr>
<tr>
<td>Inform nurse about overall plan</td>
<td>Failure to inform nurse about overall plan</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In the preoperative assessment and optimization phase, critical failure modes were inadequate prescription of medications and failure to evaluate preoperative investigations. This can be addressed by delegating responsibility regarding various tasks among care providers. Other authors (eg, Patterson et al26) have demonstrated that increased clarity of responsibility among health care professionals is essential to prevent adverse events.

In the preprocedural teamwork phase, failure to conduct briefings was identified as a critical failure mode during information transfer. Preoperative checklist use and briefing are recommended as a solution. These interventions will identify knowledge gaps, reduce medical errors, and improve morbidity and mortality rates.27,28

In the postoperative handover phase, the most important failure mode identified was inadequate handover. This problem can be addressed by effective transfer of patient information, specifically the postoperative management plan, to the relevant team. Postoperative safety interventions such as checklists were recognized as key measures to improve information transfer. These interventions result in a structured and organized handover. Other authors showed a reduction in information omissions and technical errors after using a structured handover process based on the Formula 1 model in a pediatric intensive care unit.29

In daily ward care, unavailability of the ward nurse was the main problem noted that led to inadequate patient assessment and poor information transfer of the management plan. These failures can affect appropriate and timely decision making by the surgical team. Moreover, they may cause delays or omissions of care processes that compromise patient safety. Multidisciplinary ward rounds with equal representation from nurses in decision-making processes would help reduce errors in patient treatment. Weber et al30 highlighted the fact that verbal statements from nurses constituted only one-tenth of overall communication in ward rounds, emphasizing the need for increased involvement of nurses.

Based on HFMEA, we proposed several principles to guide reengineering of information transfer practices in the hospital environment (Figure 3). As suggested by the systems approach to surgical performance and outcomes,31 apart from patient and surgeon factors, a whole operation profile consisting of communication, work environment, equipment design, and decision making contributes to surgical outcome. Information standardization in the form of checklists, electronic communication systems, pro forma documents, protocols, and care pathways is needed at each phase to improve information flow and to reduce communication failures. Moreover, as in other industries, a degree of automation such as alerts may not be generalizable to other surgical environments. However, we believe that the findings can be extrapolated to other surgical procedures. A limitation of the outcome of our analysis is that we did not measure actual failure rates. Communication failures are common but underreported. To compare failure rates before and after HFMEA is difficult. However, our study uncovered previously unacknowledged failures. Every team member is expected to be biased by his or her personal position and experiences in the hospital. Nevertheless, bias in HFMEA is minimized by the multidisciplinary composition of the team.

Failure mode and effect analysis has the ability to formalize and integrate clinical experience and observations provided from the viewpoints of health care professionals. It provides a structured account of enacted errors and problems in the process, as well as their potential effect on the patient. The findings of HFMEA can be used to design an observational assessment instrument such as the Information Transfer and Communication Assessment Tool for Surgery, which is similar to that designed by our group for assessment of operating

**Table 3. Critical Failures Observed in Follow-up of 10 Patients**

<table>
<thead>
<tr>
<th>Type of Failure Observed</th>
<th>No. of Occasions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication failure between care providers (eg, delay in chest drain removal because surgical team did not inform nurses)</td>
<td>13</td>
</tr>
<tr>
<td>Medication and prescription errors (eg, nurse about to give medications twice because patient has 2 drug records with medications written on both of them)</td>
<td>11</td>
</tr>
<tr>
<td>Thromboprophylaxis administration errors</td>
<td>8</td>
</tr>
<tr>
<td>Failure to make plans for comorbidities (eg, patient was not returned to regular antihypertensive medication regimen)</td>
<td>2</td>
</tr>
<tr>
<td>Failure to assess patients (eg, patient had positive fluid balance of 4 L unnoticed by the team, was prescribed more fluids, and then developed crackles at the base of lung, resulting in delayed management of positive fluid balance)</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>39</td>
</tr>
</tbody>
</table>

![Figure 3. Suggestions based on health care failure mode and effect analysis to improve information transfer and communication among health care professionals in the surgical care pathway.](https://example.com/figure3)
theater teamwork, the Observational Teamwork Assessment for Surgery.11

Herein, we describe use of the HFMEA method to address information transfer and communication failures in surgical care through the surgical care pathway, the evaluation of which is not amenable to quantitative techniques. However, our investigation required a large amount of personnel resources. To our knowledge, this is the first published use of HFMEA in the information transfer process of surgical care. The flow diagram and hazard analysis will provide a blueprint for development of interventions and will assist health care organizations and surgical teams in improving this process. The results of our HFMEA have been put forward to the surgical department for initiation of local quality improvement programs such as a care pathway bundle for major gastrointestinal surgical procedures and a new protocol for handovers in surgical high-dependency units. Although it is difficult to verify the utility of these resource-intensive qualitative studies, the HFMEA method is complementary to quantitative investigations and can identify latent failures in complex surgical care. Further work is essential to evaluate the effectiveness of recommendations herein.

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