Hypothesis: Describe the incidence, type, and detection method of surgical listing errors and implement a system to reduce errors.

Design: All errors/discrepancies between the surgical listing and the performed procedure reported to an institutional event line during 2008 were analyzed.

Setting: Academic tertiary medical center.

Main Outcome Measures: Error characteristics and detection mode were documented. An error causal tree analysis was developed and used to modify the standard listing process to reduce errors.

Results: During 2008, 759 listing errors were reported of 55,197 surgical procedures for an error rate of 1.38%. No wrong-site surgeries occurred. The errors were missing laterality (501; 66%), incorrect side (108; 14%), incorrect listing besides laterality (86; 11%), and other (64; 9%). Identification/correction of the listing error occurred in the following areas: nursing review the evening prior to surgery (517; 68%), preoperative admission unit (132; 17%), operating room (98; 12%), recovery room (6; 0.8%), and other (6; 0.8%). Using a causal tree analysis, error-proofing strategies applied in an electronic standardized case listing system significantly reduced the error rate from 1.50% to 0.54% (P < .05) and 2.06% to 0.49% (P < .05) in gynecologic and colorectal surgery, respectively.

Conclusions: Surgical listings errors occur with a low constant rate across specialties. The majorities of errors were related to laterality and were detected prior to surgery. An electronic listing system using standardized case descriptions with required laterality significantly reduced the error frequency.

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Over the last decade, medical errors on both an individual and societal level have received increasing attention. The Institute of Medicine report “To Err Is Human: Building a Safer Health System” estimated that preventable medical errors could be responsible for up to 98,000 deaths per year in the United States.1 Following the Institute of Medicine report, the National Quality Forum published a list of 27 preventable adverse events that should never occur in US hospitals.2 These events were labeled as “never events.” Four of the original 27 never events relate to surgery: surgery on the wrong site, wrong procedure, wrong patient, and unintended retention of a foreign object after surgery.

In August 1998, the Joint Commission (TJC) issued a Sentinel Event Alert examining the problem of wrong-site surgery, including a review of 15 cases that had been voluntarily reported to the TJC Sentinel Event system since 1995.3 The review of the TJC database updated through June 30, 2009, reveals that of the 6244 events in the database, wrong-site, wrong-surgery, or wrong-patient events are the largest single category of adverse event with 837 cases (13.4%).4 Root cause analysis of these events identified a number of contributing factors. However, the most commonly cited reason was “a breakdown in communication between surgical team members and the patient and family.”5 In response to these findings, TJC issued a series of procedural requirements designed to minimize this category of errors.6 The revised Universal Protocol included documentation of detailed perioperative patient and procedure verification, preoperative site marking, and a preprocedural pause. Despite implementation of these safety checks, wrong-site, wrong-procedure, wrong-surgery, and wrong-patient events continue to occur. The Pennsylvania Patient Safety Authority, which mandates reporting of these events in all Pennsylvania health care centers, documented 76 such cases in 2008 and 12 in the first quarter of 2009.7

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Department of Surgery (Drs Cima, Cassivi, and Deschamps), Systems and Procedures (Mr Rogers), Quality Management Services (Mr Hale and Dr Kollengode), and Surgical Quality Assessment Committee (Drs Cima, Kollengode, and Cassivi and Messrs Hale and Rogers), Mayo Clinic, Rochester, Minnesota.
In 2003, Minnesota became the first state to require hospitals to publicly report the 27 never events. From 2003 to 2008, 303,029 operations were performed at the Mayo Clinic, Rochester (MCR). The MCR has reported 7 wrong-site, wrong-surgery, and wrong-patient surgeries since mandated reporting was instituted. To specifically address the surgical never events, a multidisciplinary Surgical Quality Assessment Committee was established to evaluate all aspects of the surgical practice to maximize patient safety. An area of concern is ensuring accurate communication during transitions in patient care.

A period of vulnerability occurs during the transition from the outpatient setting into the operating room. The surgical listing includes patient demographics, important medical concerns, surgeon information, procedure description, and essential instrumentation requirements. Errors in the surgical listing result in staff confusion, operating room inefficiency, and the potential for adverse patient events due to inaccurate or incomplete transfer of information. To the best of our knowledge, the nature and frequency of these errors have not been previously described. In this study, we analyze the incidence, type, and impact of incorrect surgical case listing. Furthermore, we developed a process to reduce listing errors.

**METHODS**

The MCR is a tertiary care academic hospital with 113 operating rooms distributed across 2 hospitals and 2 outpatient facilities all located on the MCR campus. All elective operations are scheduled through the Surgical Hospital Assignment computerized entry system. Some required information includes patient name and identification number, date of procedure, indication for surgery, and planned operation including side and site. Entries are performed by authorized patient care providers (surgeon, surgical resident, physician assistant, or nurse practitioner). Free-text entry is used for most of the procedure detail. On the day prior to surgery, the listing is reviewed and finalized by the primary surgical team. On the night prior to surgery, a nursing team reviews all listings to ensure accuracy and completion of the listings. Any deficiencies or discrepancies are resolved by contacting the appropriate service providers. Additionally, any discrepancy is reported to the Mayo Clinic event line. This telephone line is staffed at all times by trained nurses, who complete a detailed report describing the nature and seriousness of the event. Events are assigned a severity category based on the potential for patient harm. Most surgical listing errors are defined as error events that have capacity to cause harm but none occurred. If an error in the listing is discovered on the day of surgery either prior to or after the procedure, the event line is notified by the person who discovered the error.

Our study was divided into 2 phases. In phase 1, all surgical listing errors reported to the event line in 2008 were reviewed and categorized by Quality Management Services staff. The errors were categorized into 5 general types: incorrect laterality (right/left), no operative side or site provided, incorrect listing excluding laterality, incomplete listing, and “other” errors. Further procedure-specific data included operative specialty, surgeon, mode and time in the surgical process that the error was identified, and if any harm to the patient occurred. This study was approved by the Mayo Clinic institutional review board.

Once the causal tree analysis of the first 6 months of 2008 errors was completed, phase 2 of the study was initiated. Based on the phase 1 findings, design changes to the surgical listing computer entry system were developed to specifically address the types of errors identified. Further refinement was performed using listing error data reported during the last 6 months of 2008. These changes were tested in 2 specialties, obstetrics and gynecology in September 2008 and colon/rectal surgery in May 2009, to measure the effectiveness of the programming changes and to uncover any unanticipated problems or new error types. At no time during either phase 1 or phase 2 were the error analysis or rationale for the scheduling system change made public. Release of such information could have influenced the analysis of the system change effectiveness by altering staff performance due to increased vigilance.

The changes to the surgical listing computer entry and scheduling system were designed to eliminate the variation of the surgical description as a result of the manual free-text entry process. Free-text surgical procedure entry was replaced by implementing standardized procedure descriptions with required laterality and site, when applicable. To develop the specialty-specific standardized procedure list, an analysis of all the free-text procedural descriptions for the 2 specialties over the prior 12 months was performed. The list of all procedures was divided into the primary procedure and then the most common variations associated with the primary procedure. A surgeon representative from each specialty worked with a resident, physician’s assistant, and nursing representatives from the preoperative nursing unit and operating room to develop a common set of procedure descriptions. All procedures requiring laterality were identified; the appropriate laterality options were defined and assigned to each procedure description. From this list of procedures, an associated laterality table was constructed that would serve as the meta-database for the required laterality check. Finally, the surgical listing computer entry and scheduling system was redesigned to present the user with a drop-down pick list of the standardized procedure descriptions for each specialty and a required laterality selection if appropriate. An example of the listing entry input screen is displayed in Figure 1.

When scheduling a patient for surgery, the diagnosis and indication for surgery are free text. Next, the user selects the procedure description from the standardized procedure drop-down list. The system then looks up the procedure description table to determine if laterality is required and activates the laterality drop-down box if appropriate. This is a forced function and must be completed before the case can be saved into the scheduling system. When multiple procedures are to be performed during one surgery, each procedure is listed using this process.

In 2008, there were 759 surgical listing errors reported to the MCR event line of 55197 procedures performed, resulting in an overall listing error rate of 1.38%. No wrong-site, wrong-procedure, or wrong-patient surgeries were performed during 2008. The most frequent surgical listing errors were absence of laterality when required (501; 66%), incorrect side or site (108; 14%), incorrect procedural listing other than laterality (86; 11%), and other (64; 9%) (Figure 2). The 4 surgical specialties most commonly associated with listing errors were colorectal, plastic, thoracic, and general surgery (Figure 3). After the listing was finalized for surgery, listing errors were identified and corrected in the following areas: nursing personnel assigned to review the surgical list the evening prior to surgery (517; 68%), preoperative admission unit (132; 17%), the operating room (98; 12%), the recovery room (6; 0.8%), and other (6 [0.8%]) (Figure 4).
During phase 2 of the study, changes were made in the surgical listing system based on the error analysis performed on listing errors reported during the first 6 months of 2008 and refined from continued analysis of errors for the last 6 months of 2008. Also, an analysis of the listing errors reported after implementation of the modified scheduling system was performed. The modified scheduling system was first implemented in obstetrics and gynecology surgery in September 2008. After the introduction of the new scheduling system in obstetrics and gynecology surgery, there was a significant reduction in the listing error rate from 1.50% before to 0.54% after ($P < .05$) (Figure 5). This reduction was sustained for 11 months after implementation. The programming change was implemented in May 2009 for colon/rectal surgery and similarly there

Figure 1. Screen shot of new surgical entry and scheduling system screen. The diagnosis and indication for surgery are free text but the procedure and laterality are drop-down options that are required for completion of the listing. The laterality field is expanded to demonstrate the required drop-down option.

Figure 2. Mayo Clinic, Rochester, most common surgical listing errors by type in 2008. N=739.

Figure 3. Mayo Clinic, Rochester, average 2008 surgical listing error rates by surgical specialty. CCGS indicates critical care and general surgery; ENT, ears, nose, and throat; Gastro, gastrointestinal; MF, maxillofacial; Neuro, neurology; Ob-gyn, obstetrics and gynecology; and Ophthal, ophthalmology.
areas where surgical listing errors were identified and corrected in 2008. N=759.

Figure 5. Surgical listing error rates in obstetrics and gynecology by month for 2008 and 2009. The programming change was implemented in September 2008.

Figure 6. Surgical listing error rates in colon/rectal surgery by month for 2008 and 2009. The programming change was implemented in May 2009.

was a significant reduction in the listing error rate of 2.06% before to 0.49% after (P < .05). This performance was sustained for 5 months after implementation (Figure 6). The Table contains the comparative data. While listing errors were significantly reduced, they have not been eliminated. A comparison of the types of errors before and after the programming change demonstrates that side and site errors in both obstetrics and gynecology and colon/rectal surgery have been eliminated while incomplete and other miscellaneous errors continue.

In this article, we report for the first time in the surgical literature, to our knowledge, that errors in the surgical listing occur with regularity, even though at a low frequency, across all surgical specialties. In 2008, at an academic center with a high-volume surgical practice, the error rate associated with surgical listings was 1.38%. Errors associated with procedure laterality were the most common, with absence of laterality 66% of the time while incorrect laterality occurred in 14%. The majority (68%) of errors were identified the evening before surgery by a team of nurses reviewing all case listings. This indicates that relying solely on human intervention or installing “double checks” will not completely eliminate the problem of listing errors. Therefore, our approach has been to develop system-type solutions to facilitate standardization and error reduction. Using this framework, we redesigned our electronic surgical listing system to mitigate the potential for these errors, resulting in a significant reduction in the 2 pilot specialties. We are now implementing these system changes across our surgical practice.

Perrow8 noted in his classic analysis of failures in high-reliability organizations that as systems become more complex and interdependent the personnel working within those systems no longer possess all the required information about the system to safely monitor it. This can result in seemingly small errors or failures leading to catastrophic outcomes. As previously discussed, wrong-site, wrong-procedure, and wrong-patient errors are the most common errors reported in the TJC database. However, the TJC database is based on voluntary reporting so the actual numbers of these types of events are unknown and possibly underreported. In a study using multiple different databases including claims data, Seiden and Barach9 estimated that 1300 to 2700 such events occur annually in the United States. In an evaluation of claim records for the insurance company that covers nearly a third of Massachusetts physicians, the rate of nonspine-related, wrong-site, wrong-procedure, and wrong-patient surgery was 1 in 112 994 operations.10 The surgical listing is the 1 piece of information routinely used by operating room personnel that links the outpatient process to the different databases including claims data, Seiden and Barach9 estimated that 1300 to 2700 such events occur annually in the United States. In an evaluation of claim records for the insurance company that covers nearly a third of Massachusetts physicians, the rate of nonspine-related, wrong-site, wrong-procedure, and wrong-patient surgery was 1 in 112 994 operations.10 The surgical listing is the 1 piece of information routinely used by operating room personnel that links the outpatient process to the

Table. Listing Error Events for Obstetrics and Gynecology and Colon/Rectal Surgery Departments From January 2008 Through October 2009

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstetrics and gynecology</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>No. of procedures</td>
<td>2190</td>
<td>3336</td>
<td></td>
</tr>
<tr>
<td>No. of listing errors</td>
<td>33</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Error rate, %</td>
<td>1.50</td>
<td>0.54</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Colon/rectal surgery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of procedures</td>
<td>3299</td>
<td>1018</td>
<td></td>
</tr>
<tr>
<td>No. of listing errors</td>
<td>68</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Error rate, %</td>
<td>2.06</td>
<td>0.49</td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>

*Before and after the listing program changes completed in September 2008 for obstetrics and gynecology and May 2009 for colon/rectal surgery.*
operating room. In a review of these wrong-site, wrong-procedure, and wrong-patient types of events recorded in the Pennsylvania Patient Safety Authority database, the most common error was an incorrect surgical listing, which occurred in 111 of 427 reports. The frequency of incorrect surgical listings and a corrective intervention has never been described.

In 2006, it was estimated that there were nearly 50 million inpatient and 57 million outpatient surgical procedures performed in the United States. Extrapolating our experience to the rest of the country, the potential number of patients brought to the operating room with incorrect procedural descriptions could be quite large. The implications of our findings as they relate to wrong-site and wrong-procedure events are unclear. However, the surgical listing description provides key operational information to the personnel in the operating room environment and can influence their behavior. As Reason discussed in his work on human errors, an inaccurate mental model is a significant component to operator error in complex systems. An incorrect listing may establish an incorrect mental model for the operating room personnel that sends them forward on a trajectory toward an error unless there is credible conflicting information brought forward. This phenomenon may explain the persistence of these events despite other safeguards designed to mitigate them. Unfortunately, many of the measures introduced in the revised TJC Universal Protocol designed to avoid these errors, such as site marking and the preprocedural pause, may be compromised if the surgical listing is incorrect. If no other information or background data are brought forward to contradict the accuracy of the listing, then the listing serves as the foundation for the subsequent steps. Relying on the patient or family members to corroborate or contradict the listing accuracy is unreliable. The use of a preoperative team briefing as well as active preprocedural referencing of imaging data are steps that introduce additional information that might be helpful in mitigating the impact of an incorrect listing. In a study by Makary et al., they found that a team briefing significantly improved the team's perception of a reduction in the potential for a wrong-site, wrong-procedure, or wrong-patient event. However, they did not comment on if any errors were identified and corrected by using preoperative briefings. In the case of preoperative team briefing, while it serves as a critical check, from a patient safety/staff satisfaction point of view, it might be suboptimal compared with preventing the errors from happening in the first place.

Our approach to minimizing surgical listing errors was to reduce variability in procedure listing options and to use side and site required fields linked to the specific procedure. Our analysis revealed that for a single procedure there was wide variation in how that procedure was listed depending on the surgeon, the resident, or the midlevel provider who actually listed the operation. By developing standardized procedure lists and requiring “forced” site or side description in our scheduling system, we were able to significantly reduce the frequency of listing errors in our pilot specialties. More importantly, this was sustainable. We based our corrective approach on one that has been used successfully to reduce adverse drug events. Variability in prescribing practices of physicians and the required interpretation of information by other health care providers were recognized as major contributors in medication-prescribing errors. The implementation of computerized physician order entry reduced medication errors by limiting the range of prescribing options for a medication. Furthermore, computerized physician order entry “forced” correct prescribing by linking the medication with a limited number of dosing and scheduling options. This was further enhanced by integrating other relevant clinical information (ie, creatinine clearance, drug-drug interaction) into the process in the form of clinical decision support. Overall, this systematic approach to reducing prescribing variability and forcing linked options seems highly effective in reducing adverse medication errors, with reported risk reduction ranging from 13% to 99%. However, it is extremely important to continue to evaluate the impact of these system changes to ensure that no unintended consequences introduce new errors or limit clinical practice. Fortunately, in our experience we have not seen any new error types related to the surgical listing.

The primary limitation of this article is the retrospective review of the error database. This might result in a loss of specificity regarding the actual events. Furthermore, we cannot be absolutely sure that we have captured all of the listing errors and types. Some errors may not have been detected at any step along the process or errors that were identified on the day of surgery were not called into the event line, despite an institutional policy requiring notification. Despite these limitations, the impact of the Surgical Hospital Assignment changes were prospectively collected and evaluated, which ensures a highly accurate assessment of the impact of these changes. Finally, a major potential error element that is not addressed by our approach is the accuracy of the person inputting the surgical listing data into the system. An error at that level would not necessarily be addressed by such a system. However, our institutional approach is based on a multilayer defense, with an accurate listing being one component. Others are comparison with the procedure consent, the Universal Protocol, site marking, and, most importantly, the preoperative briefing of the entire team including the surgical consultant.

This study demonstrates that surgical listing errors in a high-volume tertiary care center occur across all surgical specialties with a low but relatively constant rate. While there were no adverse outcomes from these errors, this might be because the vast majority were detected the evening prior to surgery. However, this process is labor intensive and likely unique to our institution. The impact of this class of medical errors on wrong-site or wrong-side surgeries is unclear. However, current recommended safety practices, in isolation, can be ineffective if this type error goes undetected. A systems approach to reducing variability in how patients are listed for surgery, including standardized case descriptions and forced laterality functions, does reduce these errors and should be considered as an additional safety measure.

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Author Contributions: Study concept and design: Cima, Hale, Rogers, Cassivi, and Deschamps. Analysis and interpretation of data: Cima, Hale, Kollengode, and Cassivi. Drafting of the manuscript: Cima, Hale, and Rogers. Critical revision of the manuscript for important intellectual content: Cima, Hale, Kollengode, Cassivi, and Deschamps. Statistical analysis: Kollengode. Obtained funding: Deschamps. Administrative, technical, and material support: Cima, Hale, Rogers, Cassivi, and Deschamps.

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Previous Presentation: This paper was presented at the 117th Scientific Session of the Western Surgical Association; November 10, 2009; San Antonio, Texas; and is published after peer review and revision. The discussions that follow this article are based on the originally submitted manuscript and not the revised manuscript.

REFERENCES


DISCUSSION

Leigh Neumayer, MD, Salt Lake City, Utah: Dr Cima and his coauthors try to understand an aspect of the potential human and system errors behind wrong-site surgery. There are significant widespread implications of your data for any program relying on physician- or physician extender–entered data. It seems to me entering the planned procedure is a “high-stakes” event, and even for those with intense training and required input, there remain opportunities for system breakdown.

While it’s easy and in this case productive (in that you had a statistically significant finding) to use a simple t test to compare before and after, if one examines the graphs of the rates for colorectal and gynecology surgery presented in the manuscript, it is less clear that you have achieved real change with the required-entry computer program. This may well be a Hawthorne effect that is beginning to fade as the length of time from the implementation of the program increases. In fact, it looks like you might have had some contamination of the colorectal providers as their rates dropped as the program was implemented in gynecology. To account for these issues, you may want to consider a more rigorous statistical analysis of your data. I have 3 specific questions for Dr Cima:

• Do you have any idea of the number of wrongly listed procedures that were detected and corrected by the surgery team in their review on the day before surgery (prior to the nursing review that triggered the call to the reporting center)?

• What were the causes of your 7 wrong-site/side surgeries reported in the paper if they weren’t from wrong listing?

• In my mind, more disturbing than the listing errors caught before the operation are the 14% of the cases where the mistake was discovered in the operating room or later. Did you analyze and subsequently learn anything from these cases?

Dr Cima: In regards to the first question, as you can tell with most quality improvement projects, we are doing this on a fairly rapid cycle. This study represents all of 2008. When we look at the longer-term through the end of 2009, what we have seen is a complete flattening of the curve. I can’t explain why colorectal had a decline before they implemented the system other than to say that as a colorectal surgeon, I was directly involved in how we started doing things because I was seeing the number of errors that were associated with it.

As far as the surgical team identifying these errors the night before surgery, the answer to that was zero. Our surgical team is the only one that can complete the listing. If the listing is completed by the surgical team, it goes into the system as is. Unless they go back and physically reopen it and change it, which we would have the data to track, then any correction would either fall to the nurses the night before or other staff the morning of surgery. When we looked at how many times the surgical team actually made changes it was zero. We have people who preinput listings to hold a surgical position on the list, such as a surgeon’s secretary or nurse, knowing their patient is going to have some type of procedure. However, a licensed provider needs to check and finalize the listing before it becomes official.

Regarding the cases that were found in the operating room or later, we determined what was different about those cases. What we often found was some type of technical issue about how they were going to do the procedure. For example, an open or minimally invasive thoracotomy?

Finally, we reviewed 7 events that occurred prior to this study. However, in the calendar year 2008 we did not have any wrong-side procedures performed. The 7 cases that occurred in the preceding years were reported to the state as a requirement since 2003 when Minnesota became the first state to require mandatory reporting of the 27 never events. Those 7 cases included issues such as identifying a lesion on the right leg, yet the wrong lesion was removed. That raised the issue of site markings, which the Joint Commission added to the Universal Protocol.

Financial Disclosure: None reported.