Laboratory Tests and X-ray Imaging in a Surgical Intensive Care Unit: Checking the Checklist

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Context: Patients in the surgical intensive care unit (ICU) frequently undergo laboratory and imaging testing. These tests can lead to iatrogenic anemia and radiation exposure. Many of these tests may be unnecessary for the management of a patient’s illness in the surgical ICU, and their ordering may be a reflex rather than in response to a clinical question. Checklists have been used in critical care to identify and address patient care strategies.

Objective: To examine whether adding a “diagnostic testing” section to a daily checklist used for patient rounds in a surgical ICU would decrease the amount of laboratory tests and chest x-ray imaging ordered.

Methods: An additional section was added to an established ICU daily checklist, which included the following 2 questions: “Is a [chest x-ray] needed for clinical management tomorrow?” and “What laboratory tests are medically necessary for tomorrow?” Comparison was made between 3-month preintervention (control group) and intervention (intervention group) periods. Medical records of hospitalized patients during the preintervention and intervention periods were compared to determine differences in the number of tests ordered per day during each period.

Results: A total of 307 adult patients at a single institution were included in the analysis: 155 in the control group and 152 in the intervention group. The patients in each group were similar in terms of sex, age, Sequential Organ Failure scores, Charlson Comorbidity Index scores, elective admission status, surgical procedures, number of days of mechanical ventilation, ICU length of stay, and in-hospital death. No statistical reductions in laboratory tests or chest x-ray imaging ordered per day from the preintervention to intervention period were found.

Conclusion: The addition of the diagnostic testing section to the daily checklist did not result in a reduction of the amount of tests ordered per day. Further research on test appropriateness and the possible addition of a clinician decision-making tool could be studied in the future to assist with reduction of tests ordered in the surgical ICU.

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Patients admitted to the intensive care unit (ICU) often undergo many tests to assist in their evaluation and treatment. The overuse of testing is widely prevalent in hospitalized patients and can be caused by physician uncertainty, lack of
experience, hospital protocols, and failure to understand the economic and health costs associated with excessive testing. Many tests may be routinely ordered, rather than ordered to address a specific clinical question or guide therapy. Excessive tests place patients at risk for iatrogenic anemia, discomfort, false-positive or spurious results that may lead to further testing, and radiation exposure. Furthermore, unnecessary tests place an additional burden on the health care system through increased use of resources, increased costs, and extraneous biohazardous waste. Therefore, it should be a goal to minimize unnecessary testing.

Checklists are often used in the ICU as a tool to assist the care team in addressing the complex issues that critically ill patients face. Integrating checklist items that prompt ordering team-identified diagnostic tests that are necessary for a given patient’s care rather than protocol-driven test ordering may assist in reducing unnecessary testing. As part of a quality improvement initiative, a “diagnostic testing” section was added to an established daily checklist used for patient rounds in a surgical ICU. This addition to the checklist was intended to remind clinicians to thoughtfully assess test ordering for each patient. We hypothesized that the addition of the diagnostic testing section of the checklist would result in fewer tests being ordered per day.

Methods
This quality improvement project was approved by the Partners Healthcare Institutional Review Board. On October 16, 2015, an additional section was added to an established daily checklist in a multidiscipline surgical ICU at an academic, urban, level 1 trauma center. The surgical ICU was an 18-bed surgical/trauma/burn critical care unit primarily staffed by clinicians in anesthesia and emergency medicine, as well as surgical residents and anesthesia and surgical critical care fellows under the direction of a board-certified critical care physician. The new checklist section included the following questions: “Is a CXR [chest x-ray] needed for clinical management tomorrow?” and “What laboratory tests are medically necessary for tomorrow?”

A poster with information about the study was displayed in the critical care fellows’ office, because they are often charged with leading patient rounds. Two professional society recommendations were included on the poster: (1) “Don’t order diagnostic tests at regular intervals (such as every day), but rather in response to specific clinical questions,” from the American Board of Internal Medicine’s Choosing Wisely campaign and (2) the “usually not appropriate” recommendation for portable chest x-ray imaging of a “stable patient” with “no change in clinical status,” from the American College of Radiology’s appropriateness criteria for ICU patients.

The medical records of patients in the ICU during a 3-month preintervention period (control group, July 1, 2015, to October 15, 2015) were compared with the medical records of patients in the ICU during a 3-month intervention period (intervention group, October 16, 2015, to January 31, 2016) to gather information regarding the number of diagnostic and imaging tests ordered per day during each period. Basic demographic information and details regarding hospitalization were gathered from the medical records of the patients in each group. Patients were excluded from the analysis if they were younger than 18 years, if they were pregnant, or if they underwent a free-flap surgical reconstruction.

We estimated a test reduction of 15% and yielded 150 patients per arm with a 2-tailed \( \alpha \) level of .04 and \( \beta \) level of .2. For the comparison of demographic information and outcome data between the control and intervention groups, Fisher exact tests were used for categorical variables and \( t \) tests for continuous variables. Fisher exact tests and \( t \) tests were reported using the “fisher.test” function and “t.test” function, respectively, in R software version 3.1. Statistical significance was defined as \( P < .05 \).

Results
A total of 307 patients met the inclusion criteria: 155 patients in the control group and 152 in the intervention
group. The patients in each group were similar in terms of sex, age, Sequential Organ Failure scores, Charlson Comorbidity Index scores, elective admission status, number of surgical procedures, number of days of mechanical ventilation, ICU length of stay, and in-hospital death (Table 1). Table 2 shows the comparison between the mean (SD) number of diagnostic tests ordered per day during the preintervention and intervention periods. The mean (SD) number of chest x-ray imaging and coagulation tests (prothrombin time or activated partial thromboplastin time) ordered per day were lower during the intervention period than the preintervention period, but the differences were not statistically significant (0.56 [0.42] vs 0.52 [0.41] and 0.62 [0.62] vs 0.60 [0.61], respectively) (P=.39 and P=.75, respectively). The mean (SD) number of complete blood cell count, chemistry panel, and arterial blood gas tests ordered per day were higher during the intervention period than the preintervention period, but not significantly (1.36 [0.67] vs. 1.37 [0.69], 1.27 [0.62] vs. 1.31 [0.61], and 0.58 [0.76] vs 0.61 [0.77], respectively) (P=.86, P=.60, and P=.74, respectively). There was no statistically significant difference between the number of red blood cell transfusions ordered per day during the intervention and preintervention periods.

### Discussion

It has been estimated that at least $558 billion of health care spending in 2011 was on nonbeneficial care.\(^{10}\) The potential sources of waste included failures in care delivery, poor care coordination, and overtreatment.\(^{10}\) There has been a focus on providing high-value health care with improved outcomes at the lowest cost possible.\(^{11}\) One area of concern for patients, insurers, and clinicians is unnecessary testing, which is common in hospitalized patients.\(^{12}\) To address this problem, we designed a study to attempt to minimize unnecessary testing in a surgical ICU by prompting a discussion of test ordering through the questions on a daily care checklist. Checklists have been shown to improve the complex care that ICU patients require; thus, we selected it as the vehicle to address the issue.\(^{13}\) Although this intervention failed to produce a statistically significant reduction in test ordering, it may have prompted clinicians to think about test ordering that may affect practice patterns beyond the ICU.

In the current study, educational materials were not delivered to the staff, with the exception of the

### Table 1. Demographic Characteristics of ICU Patients for Whom the Number of Orders for Diagnostic Tests Were Studied

<table>
<thead>
<tr>
<th>Demographic Characteristic</th>
<th>Control Group (n=155)</th>
<th>Intervention Group (n=152)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, No. female</td>
<td>62</td>
<td>54</td>
<td>.48</td>
</tr>
<tr>
<td>Age, y, mean (SD)</td>
<td>63.14 (18.3)</td>
<td>63.14 (18.57)</td>
<td>&gt;.99</td>
</tr>
<tr>
<td>Sequential Organ Failure score, mean (SD)</td>
<td>4.06 (3.87)</td>
<td>3.66 (3.64)</td>
<td>.35</td>
</tr>
<tr>
<td>Charlson Comorbidity Index score, mean (SD)</td>
<td>2.3 (2.28)</td>
<td>1.89 (2.17)</td>
<td>.10</td>
</tr>
<tr>
<td>Elective admission, No.</td>
<td>45</td>
<td>43</td>
<td>.9</td>
</tr>
<tr>
<td>Surgical procedures, No.</td>
<td>106</td>
<td>117</td>
<td>.12</td>
</tr>
<tr>
<td>Days of mechanical ventilation, mean (SD)</td>
<td>2.69 (5.26)</td>
<td>2.2 (4.81)</td>
<td>.39</td>
</tr>
<tr>
<td>ICU length of stay, d, mean (SD)</td>
<td>5.60 (4.66)</td>
<td>5.64 (4.87)</td>
<td>.94</td>
</tr>
<tr>
<td>In-hospital death, No.</td>
<td>13</td>
<td>15</td>
<td>.65</td>
</tr>
</tbody>
</table>

**Abbreviation:** ICU, intensive care unit.

### Table 2. Mean (SD) Number of Diagnostic Tests Ordered Per Day Before and During an Intervention to Reduce Test Ordering

<table>
<thead>
<tr>
<th>Diagnostic Tests</th>
<th>Preintervention Period</th>
<th>Intervention Period</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest x-ray</td>
<td>0.56 (0.42)</td>
<td>0.52 (0.41)</td>
<td>.39</td>
</tr>
<tr>
<td>Coagulation</td>
<td>0.62 (0.62)</td>
<td>0.60 (0.61)</td>
<td>.75</td>
</tr>
<tr>
<td>Complete blood cell count</td>
<td>1.36 (0.67)</td>
<td>1.37 (0.69)</td>
<td>.86</td>
</tr>
<tr>
<td>Chemistry panel</td>
<td>1.27 (0.62)</td>
<td>1.31 (0.61)</td>
<td>.60</td>
</tr>
<tr>
<td>Arterial blood gas</td>
<td>0.58 (0.76)</td>
<td>0.61 (0.77)</td>
<td>.74</td>
</tr>
<tr>
<td>Red blood cell transfusion</td>
<td>0.10 (0.21)</td>
<td>0.15 (0.40)</td>
<td>.23</td>
</tr>
</tbody>
</table>
checklists may result in checklist fatigue, which could cause a decrease in attention to the checklist items. To minimize investigator influence, the authors did not participate in the patient rounds, which allowed the intervention to be performed without investigator bias. But, it also meant that we could not ensure that the checklist was reviewed daily. Additionally, clinicians caring for patients at different times may not have been present during the checklist review. Also, clinicians may have already been ordering tests at a minimal, necessary level, and further test ordering reduction was not possible.

Future studies could expand on the current study by requiring clinicians to identify their reasoning for ordering a particular test. This step could help to identify areas to direct education regarding the appropriateness of certain tests if the test ordered is outside of evidenced-based recommendations. Incorporating the clinical guidelines outlined by the American Board of Internal Medicine’s Choosing Wisely campaign on the checklist may provide clinicians a reminder of the recommendations at the time of discussion.

Conclusion
Reducing unnecessary laboratory and imaging tests in ICU patients may have positive clinical and financial implications. Because of consequence, reducing unnecessary tests is an important issue in intensive care medicine. The addition of questions to the daily patient rounds checklist, which were meant to remind clinicians to thoughtfully assess test ordering for each patient, did not reduce the amount of tests ordered. Further research on appropriate indications for laboratory tests and the possible addition of decision-making tools for clinicians could be studied in the future.

Author Contributions
All authors provided substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; all authors drafted the article or revised it critically for important intellectual content; all authors gave final approval of the version of the article to be published; and all authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References


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