The Feasibility and Impact of Midnight Routine Blood Draws on Laboratory Orders and Processing Time

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Key Words: Routine blood draws; Laboratory turnaround times; Stat laboratory test orders; Flow management

ABSTRACT

Objectives: To evaluate the feasibility of midnight routine blood draws and assess their impact on test result availability and stat laboratory orders.

Methods: We changed the timing of routine blood draws from early morning to midnight on five inpatient wards during the period November 16 to 30, 2011.

Results: For the entire institution, of all orders placed each day, laboratory test orders placed from 4:00 to 8:00 AM decreased from 55% to 39%, and those placed from 12:00 to 4:00 AM increased from 12% to 30%. Stat orders per day decreased during the intervention period (301 ± 53 vs 344 ± 55, P = .04). Morning specimens were more likely to be available by 9:00 AM (78.1% vs 58.9%, P < .001), and their turnaround time improved by 25.8 minutes (158 vs 184 minutes, P < .001). Patient survey revealed potential preference for midnight blood draws.

Conclusions: Midnight is a feasible alternative for the timing of routine blood draws. Redesigning inflow of laboratory orders improved efficiency of laboratory processing and reduced stat orders.

Routine blood tests are usually performed during the early morning hours at many hospitals as standard practice. Although timely review of those tests is critical for safe and efficient patient care, reporting of those results can be delayed and thus fail to meet providers’ expectations.1,2 Delayed reporting may lead to duplicate orders or inappropriate stat laboratory orders.3-5 In addition, the batched approach to routine morning blood draws creates an uneven workload distribution for laboratory services,6 leading to nonoptimal utilization of limited resources, namely, laboratory staff and equipment.7

Despite wide dissemination of routine morning blood draws, the clinical rationale for such practice is unclear. Normal circadian variations of electrolytes and blood count analytes are unlikely to have diagnostic importance.8-12 Lipid levels do not need to be checked fasting in the morning13 and fasting blood glucose measurement has largely been replaced by bedside fingersticks.14,15 Furthermore, early morning blood draws are not patient-centered. They interrupt critical sleeping times and contribute to poor quality of sleep for hospitalized patients.16,17

At our institution, both high volume and the batched approach of morning blood specimens resulted in a heavy workload for laboratory and nursing staff. This heavy workload was compounded by high demand for early test result availability, resulting in increased stat orders of morning blood tests. To explore possible solutions to this problem, we assessed the feasibility of routine midnight vs morning (6:00 AM) blood draws. We hypothesized that staggering the times of blood draws by obtaining routine blood specimens at midnight on selected floors would improve turnaround times for blood test results, increase availability of the
results early in the morning, and reduce the number of stat laboratory orders. We also examined if midnight blood draws were feasible from patient and staff perspectives.

Materials and Methods

Study Setting

The quality improvement intervention was conducted at Beth Israel Medical Center in New York, NY, an 856-bed urban teaching tertiary care hospital with a 504 medical and surgical bed capacity. Before the intervention, routine blood specimens were ordered to be drawn at 6:00 AM across the institution. The intervention was developed and implemented by an interdisciplinary team with members from the departments of medicine, surgery, nursing, laboratory medicine, transportation, and quality improvement and patient safety. The retrospective analysis of the intervention was exempt from the approval process by the institutional review board.

Laboratory Processing Workflow and Definition

Morning laboratory workflow at the hospital was analyzed through direct observation of laboratory-related tasks and procedures, as well as through staff interviews regarding timing of blood draws in relation to other job responsibilities.

At our institution, patient care associates (PCAs) are responsible for drawing and delivering all routine blood samples to the laboratory for processing in addition to other responsibilities, such as delivering meals and cleaning patients. After the orders for routine morning blood tests are placed, bar-coded labels are printed at the laboratory. PCAs pick up the labels and place them on the blood sample tubes to prepare for the blood draws. Bar-coded labels enable laboratory staff to scan the sample information into the laboratory information system (LIS), which posts the information to the electronic medical record (EMR). After completing the blood draw, PCAs print out the laboratory requisition form and deliver the samples to a dedicated box in the laboratory. Laboratory staff then scans the samples to record accession into the LIS and run the analyses.

The interdisciplinary team identified the printing of the laboratory requisition form, which is logged in the EMR, as a reasonable proxy for the actual blood draw time. Laboratory delivery time was defined as the time from printing the requisition form to when laboratory personnel record the specimen as received in the EMR. Laboratory processing time was defined as the time from the receipt in the laboratory to reporting of the result in the EMR. The total laboratory delivery time and processing time was defined as total turnaround time. PCAs, patient care associates.

Intervention

The intervention was to change the timing of routine blood draws from early morning (6:00 AM) to midnight.

We first conducted a pilot study on one medical teaching ward of the hospital during the period August 16 to 31, 2011. House staff was instructed to change ordering time for routine blood draws from 6:00 AM to midnight unless clinically contraindicated. Laboratory data for all complete blood counts, basic metabolic panels, and comprehensive metabolic panels were obtained from the EMR from August 1 to 31, 2011. An additional code was then manually obtained that indicated the provider’s request for the blood to be drawn at 6:00 AM or midnight. This allowed the identification of all orders to be obtained at 6:00 AM or midnight. The analysis showed that approximately 80% of morning orders were converted...
to midnight during the intervention. In addition, in-person feedback was solicited from day- and night-shift house staff, nursing staff, and laboratory staff, as well as from patients. The pilot intervention received positive feedback from all parties involved.

We then expanded the intervention to five medicine and surgery wards with a capacity of 160 beds, during November 16 to 30, 2011. In the first week of the expanded study, the interdisciplinary team identified that the bar-coded labels were not printed in time to be used for the midnight specimens. This resulted in a laboratory handling delay that required laboratory staff to manually input ordering data into the EMR upon specimen receipt. This was corrected for midnight specimens beginning on November 22 of the expanded intervention period.

**Data Collection and Handling**

Laboratory data were obtained from the EMR. All complete blood count, basic metabolic panel, and comprehensive metabolic panel laboratory data from the entire institution, including intensive care units, were collected from November 1 to 30, 2011. Measured variables included priority status (routine or stat), ward designation, date and time for requisition form printing on the ward, accession of the specimen at the laboratory, and results reporting. Midnight blood draws were defined as routine laboratory orders with requisition-printed time between 11:00 PM and 2:00 AM on the interventional wards from November 16 to 31, 2011. Morning blood draws were defined as routine laboratory orders with requisition-printed time between 4:00 AM and 8:00 AM. Those time frames were determined by the pilot intervention data and were estimated to capture approximately 95% of intended laboratory tests.

**Patient and Staff Survey**

Patient preference for midnight or morning blood draws was assessed using a paper-based questionnaire in August and December 2011. The survey was conducted in a nonrandom fashion in all study wards. Survey completion was voluntary and no participant characteristics were collected. House staff, nurses, and PCAs who participated in the study were surveyed regarding the feasibility and impact of routine morning blood draws using an online questionnaire after the study period in December 2011.

**Measured Outcomes**

The primary outcomes of interest were the proportion of morning test results available by 9:00 AM and total turnaround times for the entire institution. Laboratory delivery time and processing time were also measured to better characterize the effect of the intervention. Secondary outcomes were the number of total and stat laboratory orders, discharge time, and patient and staff preference for midnight vs morning blood draws.

**Statistical Analysis**

Both the daily average of laboratory tests (total, routine, stat, morning, and midnight) and the daily percentage of stat laboratory orders between the observation (November 1-15) and the intervention (November 16-30) periods were compared. For the entire institution, requisition-printed time was divided into 4-hour periods and the proportion of orders based on the period was compared. The proportion of morning tests whose results were reported by 9 AM before (November 16-21) and after label process correction (November 22-30) was compared with the observation period (November 1-15).

Turnaround times were analyzed using an ordinary linear regression adjusted for the ward identification. Blood samples were clustered by ward and the adjustment allowed for accounting for any variation. Turnaround times before (November 16-21) and after label process correction (November 22-30) were compared with the observation period (November 1-15) for the morning specimens. Because the midnight specimens were available only after the intervention, turnaround times were compared before and after label process correction for the midnight blood draws. Total, delivery, and processing times were calculated and analyzed separately.

Comparisons were made using the Student t test for continuous variables and \( \chi^2 \) test for proportions unless specified otherwise. The results for continuous variables are described as mean ± standard deviation. All statistical analyses were performed with JMP 9.0 software (SAS Institute, Cary, NC) and STATA version 12.1 (Stata Corp, College Station, TX). All statistical tests were two-sided, and \( P < .05 \) was considered significant.

**Results**

**All Institution**

During the observation period, 711 laboratory tests were ordered each day, with 84 (12%) specimens being drawn from 12:00 to 4:00 AM and 393 (55%) from 4:00 to 8:00 AM. During the intervention period, 688 tests were ordered each day, with 208 (30%) being drawn from 12:00 to 4:00 AM and 264 (38%) from 4:00 to 8:00 AM. Although no significant difference was seen in the total number of laboratory test orders (\( P = .47 \)), stat orders per day decreased during the intervention period compared with the observation period (301 ± 53 vs 344 ± 55, \( P = .04 \)) [Figure 2] and [Table 1].

Compared with the observation period (58.9%, \( n = 4,075 \)), morning specimen results were similarly available by 9:00 AM during the intervention period before the label change (59.2%,
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For morning specimens, no significant change in total turnaround time was observed until the label process change was implemented. After the process improvement (November 22-30), turnaround time decreased by 25.8 minutes compared with the observation period (158 vs 184 minutes, \( P < .001 \)). The 25.8-minute decrease was observed because of decreases in both delivery time by 11.7 minutes (88 vs 99 minutes, \( P = .03 \)) and processing time by 14.7 minutes (70 vs 85 minutes, \( P < .001 \)). Similar changes were observed in the nonintervention wards, where the total turnaround time decreased by 19.1 minutes (158 vs 178 minutes, \( P < .001 \)).

**Intervention Wards**

During the observation period, 233 laboratory tests were ordered per day (November 1-15) on the five wards, with 123 (53%) specimens being drawn in the morning. During the intervention period, 228 tests were ordered per day (November 16-30), with 21 (9%) in the morning and 121 (53%) at midnight. Although no significant change was seen in the total laboratory test orders (\( P = .48 \)), stat orders per day decreased during the intervention period compared with the observation period (58 ± 11 vs 77 ± 13, \( P < .001 \)) (Table 1).

For morning specimens, no significant change in total turnaround time was observed until the label process change was implemented. After the process improvement change (November 22-30), morning blood specimen turnaround time decreased by 41.5 minutes compared with the observation period (149 vs 191 minutes, \( P = .003 \)). This 41.5-minute decrease was observed again in a reduction in delivery time by 27.2 minutes (79 vs 106 minutes, \( P = .03 \)) and a reduction

### Table 1

**Comparison of Daily Average Number by Priority and Stat Proportion of Laboratory Orders**

<table>
<thead>
<tr>
<th></th>
<th>Observation Period (Mean ± SD)</th>
<th>Intervention Period (Mean ± SD)</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entire institution</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>711 ± 87</td>
<td>688 ± 87</td>
<td>.47</td>
</tr>
<tr>
<td>Routine</td>
<td>367 ± 40</td>
<td>386 ± 43</td>
<td>.21</td>
</tr>
<tr>
<td>Stat</td>
<td>344 ± 55</td>
<td>301 ± 53</td>
<td>.04</td>
</tr>
<tr>
<td>Stat/total (%)</td>
<td>48.1 ± 3.2</td>
<td>43.6 ± 3.4</td>
<td>.01</td>
</tr>
<tr>
<td><strong>Intervention wards</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>233 ± 20</td>
<td>228 ± 19</td>
<td>.48</td>
</tr>
<tr>
<td>Routine</td>
<td>156 ± 16</td>
<td>170 ± 16</td>
<td>.02</td>
</tr>
<tr>
<td>Stat</td>
<td>77 ± 13</td>
<td>58 ± 11</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Stat/total (%)</td>
<td>33.0 ± 4.5</td>
<td>25.2 ± 4.2</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

SD, standard deviation.

*Numbers may not add up due to rounding.

### Table 2

**Change of Turnaround Times for Morning and Midnight Blood Orders**

<table>
<thead>
<tr>
<th></th>
<th>Turnaround Times</th>
<th>Observation Period, min</th>
<th>Prelabeled Correction, min</th>
<th>Change (95% CI)</th>
<th>( P )</th>
<th>Postlabeled Correction, min</th>
<th>Change (95% CI)</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entire institution</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morning laboratory</td>
<td>Total</td>
<td>184</td>
<td>179</td>
<td>–4.6 (–17.2 to 8.1)</td>
<td>.47</td>
<td>–25.8 (–36.6 to –15.0)</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>tests(^b)</td>
<td>Delivery</td>
<td>99</td>
<td>112</td>
<td>12.7 (–1.7 to 27.1)</td>
<td>.08</td>
<td>88</td>
<td>–11.7 (–22.3 to –1.2)</td>
<td>.03</td>
</tr>
<tr>
<td></td>
<td>Processing</td>
<td>85</td>
<td>66</td>
<td>–18.6 (–22.0 to –15.2)</td>
<td>&lt;.001</td>
<td>70</td>
<td>–14.7 (–17.9 to –11.5)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Nonintervention wards</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morning laboratory</td>
<td>Total</td>
<td>178</td>
<td>176</td>
<td>–1.9 (–11.6 to 7.8)</td>
<td>.69</td>
<td>158</td>
<td>–19.1 (–26.5 to –11.8)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>tests(^b)</td>
<td>Delivery</td>
<td>94</td>
<td>109</td>
<td>14.7 (3.8 to 25.6)</td>
<td>.01</td>
<td>88</td>
<td>–5.7 (–11.9 to 0.5)</td>
<td>.07</td>
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<tr>
<td></td>
<td>Processing</td>
<td>84</td>
<td>67</td>
<td>–16.6 (–20.8 to –12.5)</td>
<td>&lt;.001</td>
<td>70</td>
<td>–13.7 (–17.2 to –10.2)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Intervention wards</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morning laboratory</td>
<td>Total</td>
<td>191</td>
<td>198</td>
<td>6.8 (–37.5 to 51.2)</td>
<td>.69</td>
<td>149</td>
<td>–41.5 (–59.7 to –23.3)</td>
<td>.003</td>
</tr>
<tr>
<td>tests(^b)</td>
<td>Delivery</td>
<td>106</td>
<td>131</td>
<td>25.1 (–31.3 to 81.5)</td>
<td>.28</td>
<td>72</td>
<td>–27.2 (–51.0 to –3.4)</td>
<td>.03</td>
</tr>
<tr>
<td></td>
<td>Processing</td>
<td>87</td>
<td>63</td>
<td>–23.8 (–30.0 to –17.6)</td>
<td>&lt;.001</td>
<td>72</td>
<td>–12.5 (–23.8 to –3.1)</td>
<td>.02</td>
</tr>
<tr>
<td>Midnight laboratory</td>
<td>Total</td>
<td>328</td>
<td></td>
<td></td>
<td></td>
<td>172</td>
<td>–156.3 (–227.1 to –85.2)</td>
<td>.004</td>
</tr>
<tr>
<td>tests(^c)</td>
<td>Delivery</td>
<td>245</td>
<td></td>
<td></td>
<td></td>
<td>76</td>
<td>–169.8 (–232.5 to –107.0)</td>
<td>.002</td>
</tr>
<tr>
<td></td>
<td>Processing</td>
<td>82</td>
<td></td>
<td></td>
<td></td>
<td>97</td>
<td>14.6 (–2.4 to 31.7)</td>
<td>.08</td>
</tr>
</tbody>
</table>

CI, confidence interval.

*Numbers may not add up due to rounding.

\(^b\) Time estimates for prelabel and postlabel correction periods were compared with the observation period to estimate the changes for morning laboratory tests.

\(^c\) Time estimates for postlabel correction period were compared with prelabel correction period to estimate the changes for midnight laboratory tests.
in processing time by 13.5 minutes (73 vs 87 minutes, \( P = .02 \)). Similarly, total turnaround time for midnight specimens decreased by 155.1 minutes after the label process change compared with before (172 vs 328 minutes, \( P = .004 \)). The significant decrease was observed only in the delivery time by 169.8 minutes (76 vs 245 minutes, \( P = .002 \)) for midnight specimens (Table 2).

Differences in discharge time between intervention period (\( n = 443 \)) and observation period (\( n = 457 \)) were not significant (16:23 vs 16:07, \( P = .22 \)).

**Patient and Staff Survey**

In prestudy and poststudy surveys of patients (\( n = 100 \) and \( n = 102 \)), 41% and 34% of patients, respectively, preferred midnight draws, 22% preferred morning draws in both surveys, and 37% and 44% stated no preference. In the house staff survey (\( n = 22 \), response rate 51%), 82% reported that midnight blood draws would improve patient care and 91% reported that midnight blood draws could replace 6:00 AM blood draws. In the nursing staff survey (\( n = 45 \), response rate 47%), 73% and 69%, respectively, reported the same. Of the surveyed nursing staff, 56% reported that patients were more agreeable to midnight blood draws compared with morning draws whereas 16% reported the opposite and 24% reported no difference. Similarly, 49% reported higher success rates for blood draws at midnight while 22% reported the opposite and 13% reported no difference. Sixty percent agreed that midnight blood draws improve distribution of workload and 73% agreed that they improve efficiency of care.

**Discussion**

This study demonstrated that implementation of midnight blood draws in selected hospital wards resulted in a more balanced laboratory workload and improved the availability of test results early in the morning. Of equal importance, the intervention also reduced the utilization of stat laboratory orders. Patients, providers, and nursing staff reported positive feedback overall. To our knowledge, such interventions have not been reported elsewhere.

The results suggest that staggering laboratory orders may have a significant implication for hospital resource management. Similar interventions have been shown to be effective in other areas, such as handling emergency department crowding by controlling inflow and outflow.\(^9,19\) We demonstrated that such an approach can be applied to the laboratory ordering process by systematically organizing blood draw times. Redesigning inflow of laboratory orders may also be effective in reducing inappropriate stat laboratory orders. Reduction of excessive stat order requests supports safe and efficient patient care.\(^20,21\) and may reduce laboratory costs.\(^22\)

Further, the study has potential implications for improving patient-centeredness of blood draw practices for hospitalized patients. Although we acknowledge that midnight may not be the best time for patients, the trial of midnight blood draws questioned the rationality of early morning blood draws. In fact, patients reported a potential preference for midnight blood draws as opposed to morning blood draws, but this result requires careful interpretation because of methodologic limitations. We hypothesize that this result may reflect the fact that the morning blood draws tend to occur earlier than 6:00 AM while many patients are still asleep and that the midnight draw was considered a reasonable alternative. To further improve patient-centeredness, earlier evening blood draws, such as 9:00 PM, could be considered.

Midnight blood draws may raise several concerns about implementation. First, some physicians may feel that midnight blood test results are too old and order repeat tests in the morning. Our results, however, did not show any evidence of additional laboratory ordering, because the number of daily orders did not change before and after the intervention. Second, abnormal test results may not be noticed in a timely manner if the ordering physician did not review them until the morning. Our hospital has overnight physician coverage and the laboratory reports highly abnormal values to the staff immediately; therefore, we did not feel the second issue posed a problem. For unreported abnormal values that may have clinical significance, daytime providers reviewed these results within a few hours of the reporting time. However, hospitals without sufficient in-house overnight provider coverage may have difficulty with our approach. Third, midnight draws may not be appropriate for some laboratory tests, such as tests that require drug trough levels. Finally, from an administrative view, staffing the laboratory overnight may be a challenge for some institutions.

Our study has methodologic limitations. First, neither the ward selection nor the patient preference survey was randomized, and thus the validity of study results may be limited. Second, we used requisition-printed time as a proxy for blood draw time, and used it to define midnight and morning blood draws. This approach limited accuracy of our data and analysis. However, it was unlikely to have introduced a bias in the overall results because we can reasonably assume that the degree of bias remained the same throughout the study period. Third, because we compared results over two different periods, the observed difference may be partially the result of a secular trend. Fourth, factors such as number or severity of hospitalized patients may have confounded the study results. Lastly, our intervention had no long-term follow-up. Therefore, it is not possible to comment on the long-term sustainability of this particular intervention. Although the intervention may not be feasible at other institutions that do not share the challenges of timely blood work results, the
favorable patient survey results could be used as impetus to consider these changes.

This study demonstrates that moving routine blood draw time to midnight on selected floors improved the efficiency of laboratory order processing and decreased stat laboratory orders. Although modifying the timing of routine laboratory tests is a novel yet imperfect solution, this study indicates a potential path for redesigning inpatient blood draw practice. Future research can evaluate if changing the timing of blood draws affects more clinical aspects of patient care, such as sleep quality or patient satisfaction. Measuring more discrete outcomes, such as cost reduction or decrease in laboratory error, could also be assessed in future studies. Conventional practices in medicine, such as routine morning blood draws, are not necessarily logical, evidence-based, or patient-centered. Reevaluation of such routine practices in health-care delivery is warranted.

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References