Original Article

Procedural time of day: A predictor of ERCP outcomes?

Eric M. Nelsen,1,5,* James H. Tabibian,2,3 Felicity B. Enders,4 Todd H. Baron2

A B S T R A C T

Background: Emerging data suggest time of day of endoscopic procedures may affect outcome due to endoscopist fatigue and decreased concentration. We therefore investigated whether afternoon endoscopic retrograde cholangiopancreatography (ERCP) adversely affects patient outcome.

Methods: One thousand and six consecutive inpatient and outpatient ERCPs performed at the Mayo Clinic, Rochester from August 2010 to April 2011 were identified and the medical records were reviewed for demographic, clinical, and procedural data. The primary outcome was adverse event (AE) rate. The secondary outcome was procedural success rate. ERCP complexity was graded using published consensus guidelines. Univariate and multivariate analyses were performed to assess for predictors of and differences between AM and PM ERCP outcomes.

Results: Of the 1006 ERCPs included, 512 (50.8%) were performed in the AM and 494 (49.1%) in the PM. All ERCPs were performed with monitored anesthesia care. In univariate analysis, AE rates were not significantly different between AM and PM ERCPs, 8.4% versus 8.7%, respectively (P = 0.85). Procedural success rates were also not significantly different between AM and PM ERCPs, 96.1% versus 96.2%, respectively (P = 0.95). These differences remained nonsignificant for inpatient and outpatient ERCPs as well as in patients with surgically altered anatomy. By multivariate analysis, the time of day remained a nonsignificant predictor of AE and procedural success rates; performance of a sphincterotomy and individual endoscopist were found to impact AE rate.

Conclusion: Based on this large, retrospective study, it appears there are no significant differences between AM and PM ERCP AE rates and procedural success rates. Future studies should investigate the impact time of day has on endoscopic procedural outcomes in other practice settings, where scheduling practices, use of anesthesia support, endoscopist experience, and safeguards to minimize endoscopist fatigue may be different.

Copyright © 2013, Society of Gastrointestinal Intervention. Published by Elsevier. All rights reserved.

Keywords: Endoscopic retrograde cholangiopancreatography, Endoscopy, Outcomes, Time of day

Introduction

Prevention of medical and procedural error is being emphasized in nearly all disciplines of medicine and surgery. Provider fatigue has been identified as a source of such error and has been a central focus of improving safety.1,2 Within gastroenterology, procedure-related quality measures, including preventable errors and patient outcomes, continue to gain attention and importance.3,4 There are emerging data that time of day may be associated with differences in outcomes of some endoscopic procedures.5-7 In one study, PM colonoscopies were not only associated with higher completion rates but also less adequate bowel preparation compared to AM procedures.6 However, another study showed that in a short shift (3 hours) model, which ostensibly reduces endoscopist fatigue and procedural monotony, there were no differences in polyp detection rates as a function of time of day.8

Endoscopic retrograde cholangiopancreatography (ERCP) is a technically demanding and high-risk procedure that requires substantial training and volume to maximize success and safety. In several large studies, relatively high adverse event (AE) rates have been observed following ERCP compared to other endoscopic procedures9-11; however, only recently has time of day been studied with respect to ERCP outcomes. In the only published study in which the relationship between time of day and ERCP outcomes was assessed, no association was found between cannulation success, procedure completion rate, procedure length, or AE rate and time of day12; however, this study may have been underpowered to detect small but clinically important differences, and was limited to outpatients and those without surgically-altered upper gastrointestinal (GI) anatomy.

In this study, we sought to determine whether there is a difference in outcomes between ERCPs performed in the AM compared
to the PM in consecutive inpatients and outpatients undergoing ERCP at a tertiary care center.

**Methods**

**Patients and procedures**

The study population consisted of adults who underwent ERCP at the Mayo Clinic, Rochester. After institutional review board approval, consecutive inpatient and outpatient ERCPs performed between August 2010 and April 2011 were identified, and electronic medical and endoscopy database records were reviewed for pertinent procedural, clinical, and demographic data. Patients with surgically altered upper GI and/or pancreaticobiliary anatomy (specifically, Roux-en-Y with or without gastric bypass, Whipple, and Bilroth II) were included. Advanced endoscopic procedures that did not involve ductal cannulation (e.g., pancreatic necrosectomy) were excluded.

ERCPs were performed by one of five senior therapeutic endoscopy staff with or without the involvement of one of two advanced endoscopy fellows. Patients were divided into two groups, those who underwent ERCP before 12 PM (AM) and those who underwent ERCP after 12 PM (PM), based on procedure start time. All ERCPs were performed with anesthesia support.

**Outcomes and variables**

The primary study outcome was AE rate. AEs were identified by review of the medical record as well as an existing institutional AE infrastructure. The existing institutional AE infrastructure is a documentation system that records all AEs from all endoscopic procedures. AEs were defined using previously established criteria and included bleeding, perforation, pancreatitis, and cholangitis.

Our secondary outcome included procedural success rates. Procedural success was defined as cannulation of either duct, depending on procedural indication, and completion of the intended intervention as indicated by the procedural indication and findings.

Data on outcomes were abstracted using a standardized data collection form and sorted and extracted using an algorithmic software tool developed by members of the study team. Variables and outcomes were as follows: patient age, gender, setting (i.e., inpatient vs. outpatient), indication for ERCP, serum hemoglobin, platelets, creatinine, and international normalized ratio (INR), total bilirubin from 798 patients, INR from 738 patients, and outcomes were as follows: patient age, gender, setting (i.e., inpatient vs. outpatient), indication for ERCP, serum hemoglobin, platelets, creatinine, and international normalized ratio (INR), total bilirubin from 798 patients, INR from 738 patients, and demographic data. Patients with surgically altered upper GI and/or pancreaticobiliary anatomy (specifically, Roux-en-Y with or without gastric bypass, Whipple, and Bilroth II) were included. Advanced endoscopic procedures that did not involve ductal cannulation (e.g., pancreatic necrosectomy) were excluded.

**Data analysis**

All continuous variables were expressed as mean ± standard deviation (SD). Continuous variables were compared between AM and PM groups using a Wilcoxon rank sum test, while categorical variables were expressed with the frequency and percentage and compared using the Chi-square test. A separate subgroup analysis was performed for inpatient status and patients with altered upper GI anatomy.

Multivariate logistic regression was performed to assess for differences between AM and PM outcomes adjusting for important clinical variables based on previous literature as well as variables that were significantly different in univariate analysis. Separate models were developed for the outcomes of AE rate and procedural success rate. The initial multivariate model for AE rate included time of day, complexity, age, inpatient status, endoscopist, duration of procedure, and performance of sphincterotomy. Complexity and inpatient status were removed from the model due to lack of statistical significance. The initial multivariate model for procedural success rate included time of day, complexity, inpatient status, age, and performance of sphincterotomy. Complexity and inpatient status were again removed from the model due to lack of statistical significance. A smaller set of variables were used for procedural success model due to the low percentage of unsuccessful procedures.

All tests of statistical significance were two-sided, and P < 0.05 were considered statistically significant. All statistical analyses were performed using JMP statistical discovery software (JMP version 8.0; SAS, Cary, NC, USA).

**Results**

A total of 1006 ERCPs were included in the study, 512 (50.8%) were performed in the AM and 494 (49.1%) in the PM. Baseline demographic, clinical characteristics, and procedural indications were similar between the AM and PM groups, although patients in the PM group were slightly older (Table 1). Indications for ERCP were similar in both groups (Table 1). AM ERCPs involved biliary balloon dilation, biopsies, and brushings and had fellow involvement, while PM ERCPs more often involved performance of sphincterotomy (Table 2); notably, overall average procedural complexity grade was not significantly different between AM and PM ERCPs, 2.28 versus 2.29, respectively (P = 0.96). Procedural duration was longer for the AM procedures, 43.2 minutes versus 38.1 minutes, respectively (P = 0.01) (Table 2).

With respect to the primary outcome, there was no significant difference in AE rates between AM and PM ERCPs in univariate analysis (Fig. 1). The number of each AE is provided in Table 3. The secondary outcome, procedural success rate between AM and PM ERCPs in univariate analysis was also not different (96.1% vs. 96.2%, respectively; P = 0.95). There were 11 total deaths recorded within

**Table 1 Baseline Clinical Characteristics and Procedural Indications in am and pm ERCP Groups**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>AM ERCP (n = 512)</th>
<th>PM ERCP (n = 494)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (y), mean (SD)</td>
<td>58 (17.2)</td>
<td>62.3 (18.3)</td>
</tr>
<tr>
<td>Male, n (% male)</td>
<td>289 (56.5)</td>
<td>253 (52.1)</td>
</tr>
<tr>
<td>Labs, mean (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INR</td>
<td>1.17 (0.3)</td>
<td>1.22 (0.37)</td>
</tr>
<tr>
<td>Platelets</td>
<td>229 (110)</td>
<td>230 (112)</td>
</tr>
<tr>
<td>Hemoglobin</td>
<td>12.4 (1.8)</td>
<td>11.7 (1.9)</td>
</tr>
<tr>
<td>Creatinine</td>
<td>0.98 (0.51)</td>
<td>1.02 (0.8)</td>
</tr>
<tr>
<td>Total bilirubin</td>
<td>3.35 (5.26)</td>
<td>4.73 (6.16)</td>
</tr>
<tr>
<td>ERCP indication, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biliary stones</td>
<td>98 (19.4)</td>
<td>157 (15.6)</td>
</tr>
<tr>
<td>Benign strictures</td>
<td>184 (18.3)</td>
<td>129 (12.8)</td>
</tr>
<tr>
<td>Malignant strictures</td>
<td>91 (9)</td>
<td>137 (13.6)</td>
</tr>
<tr>
<td>Primary sclerosing cholangitis</td>
<td>93 (9.2)</td>
<td>33 (3.3)</td>
</tr>
<tr>
<td>Ampullary carcinoma</td>
<td>22 (2.2)</td>
<td>13 (1.3)</td>
</tr>
<tr>
<td>Miscellaneous (e.g., bile leaks)</td>
<td>24 (2.4)</td>
<td>26 (2.6)</td>
</tr>
</tbody>
</table>

*Serum laboratory test values are missing from multiple patients: results were only taken from the day of or within 1 week prior to ERCP. INR from 738 patients, platelets from 863 patients, Hgb results from 872 patients, Cr from 859 patients, total bilirubin from 798 patients.

ERCP, endoscopic retrograde cholangiopancreatography; INR, international normalized ratio; SD, standard deviation.
deaths from ERCP complications, one was related to an AM ERCP, and complications related to HIV/AIDS, and one unknown cause. Of the one from pneumonia (present prior to procedure), one from com-
angiocarcinoma, one from adenocarcinoma of unknown primary, three from metastatic pancreatic cancer, one from chol-
direct result of procedural complications (1 pancreatitis; 1 perfor-

14 days of ERCP (2 in the AM group and 9 in the PM group); two were direct result of procedural complications (1 pancreatitis; 1 perfor-
ation). The other deaths included one from a subdural hematoma, three from metastatic pancreatic cancer, one from chol-
acciocarcinoma, one from adenocarcinoma of unknown primary, one from pneumonia (present prior to procedure), one from comp-
lations related to HIV/AIDS, and one unknown cause. Of the deaths from ERCP complications, one was related to an AM ERCP, and one was related to a PM ERCP.

We performed stratified analyses based on a priori subgroups to determine whether inpatient status or surgically altered anatomy were confounders. When evaluating inpatient and outpatient ERCPs and patients with and without altered anatomy separately, there was no significant association between time of day and AE or procedural success rates in either subgroup (data not shown).

Each endoscopist was assigned a number and their AE and procedural success was calculated individually. There was no signi-
cific difference among endoscopist AE or procedural success; however, the range of AE rates varied between 5% and 11.5%. The mean procedural complexity varied among the five different endoscopists but did not correlate with AE rate (Table 4).

In multivariate analysis of AE rate, multiple models were con-
structed. The final model for AE rate included time of day, patient age, endoscopist, procedural duration, and sphincterotomy. Time of day remained nonsignificant in the adjusted model, while indi-
individual endoscopist and performance of sphincterotomy were both associated with AE with significant OR (Table 5).

In multivariate analysis of procedural success rate, we again con-
structed multiple models, with the final model adjusting for time of day, sphincterotomy, and patient age. Similar to AE rate, procedural success rate was not predicted by time of day in any of the models, while sphincterotomy was associated with a higher procedural success rate (Table 6).

Of note, there was no significant difference in AE rate for pa-
ents with surgically altered anatomy in the AM (7%) and PM (14%) groups, respectively (P = 0.22).

Discussion

In this study, we investigated the potential association of timing of ERCP (AM versus PM) with AE rate and with procedural success rate. The results of our study indicate there are no significant dif-
cences between AM and PM ERCPs in either of these two main study outcomes. Instead, we found two other variables to be associated with outcomes: individual endoscopist and performance of sphincterotomy, and AE rate, and performance of sphincterotomy was associated with procedural success rate. To date, this is the largest study of ERCP outcomes as a function of time of day. In a study of this sample size, we had 80% power to detect a difference in AE rate from 8.4 for AM procedures versus 15% for PM procedures. Similarly, for procedural success, we had 80% power to detect a difference by time of 96.1% versus 91% for AM and PM, respectively.

We investigated whether there are differences in AM versus PM ERCP outcomes based on previously reported differences in other types of endoscopic procedures (e.g., rates of colonoscopy completion and polyp detection) as a function of time of day.5-7 Factors attributed to worse endoscopy (colonoscopy) outcomes in afternoon procedures include increasing endoscopist fatigue, although no study has been performed which specifically measures self-recorded or observed endoscopist fatigue throughout the day. In the only previously published study of ERCP outcomes based on time of day, no differences were detected between morning and afternoon procedures, although the sample size was limited and only included outpatient procedures.12 By including a larger num-

Table 2 ERCP Characteristics

<table>
<thead>
<tr>
<th>AM ERCP</th>
<th>PM ERCP</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade of complexity, mean (SD)</td>
<td>2.37 (1.02)</td>
<td>2.37 (0.93)</td>
</tr>
<tr>
<td>Sphincterotomy, n (%)</td>
<td>157 (30.7)</td>
<td>228 (46.2)</td>
</tr>
<tr>
<td>Balloon dilatation, n (%)</td>
<td>183 (35.7)</td>
<td>143 (28.9)</td>
</tr>
<tr>
<td>Biliary stenting, n (%)</td>
<td>239 (46.7)</td>
<td>258 (52.2)</td>
</tr>
<tr>
<td>Biliary biopsies, n (%)</td>
<td>79 (15.4)</td>
<td>51 (10.3)</td>
</tr>
<tr>
<td>Brushings, n (%)</td>
<td>138 (27)</td>
<td>77 (15.6)</td>
</tr>
<tr>
<td>Fellow involvement, n (%)</td>
<td>210 (41)</td>
<td>128 (26)</td>
</tr>
<tr>
<td>Procedure duration, min (SD)</td>
<td>43.2 (32.9)</td>
<td>38.1 (30.1)</td>
</tr>
</tbody>
</table>

P values are based on Wilcoxon rank sum test for continuous variables and Chi-square test for categorical variables.

ERCP, endoscopic retrograde cholangiopancreatography; SD, standard deviation.

Table 3 Types and Frequency of AEs in am and pm ERCP Groups

<table>
<thead>
<tr>
<th>AM ERCP (n = 512)</th>
<th>PM ERCP (n = 494)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEs, n (%)</td>
<td></td>
</tr>
<tr>
<td>Bleeding</td>
<td>11 (25.6)</td>
</tr>
<tr>
<td>Cholangitis</td>
<td>14 (32.5)</td>
</tr>
<tr>
<td>Pancreatitis</td>
<td>13 (30.2)</td>
</tr>
<tr>
<td>Perforation</td>
<td>8 (18.6)</td>
</tr>
<tr>
<td>Total AEs</td>
<td>43</td>
</tr>
</tbody>
</table>

The n = 512 is the total number of procedures.

AE, adverse event; ERCP, endoscopic retrograde cholangiopancreatography.

Fig. 1. Primary and secondary endoscopic retrograde cholangiopancreatography (ERCP) outcomes, AM vs PM.
function of time of day, we have found that there were no signifi-
cant differences in AE or procedural success rates between AM and
PM ERCPs. Future studies should investigate the association be-
tween ERCP outcomes and time of day in other practice settings,
where scheduling practices, use of anesthesia support, endoscopist
experience, and safeguards to minimize AEs and endoscopist fa-
tigue may be different.

Conflcits of Interest
The authors declare that they have no conflicts of interest.

References
1. Gaba DM, Howard SK. Patient safety: fatigue among clinicians and the safety of
2. Taffinder NJ, et al. Effect of sleep deprivation on surgeons’ dexterity on lapa-
3. Cohen J, Poles MA. Getting the word out about quality measures. Gastrointest
873–85.
5. Sanaka MR, et al. Adenomas are detected more often in morning than in af-
6. Sanaka MR, et al. Afternoon colonoscopies have higher failure rates than
7. Chan MY, Cohen H, Spiegel BM. Fewer polyps detected by colonoscopy as the
day progresses at a Veteran’s administration teaching hospital. Clin Gastro-
8. Munson GW, Barewood GC, Francis DL. Time of day variation in polyp detec-
tion rate for colonoscopies performed on a 3-hour shift schedule. Gastrointest
Endosc. 2011;73:467–75.
9. Colton JB, Curran CC. Quality indicators, including complications, of ERCP in
a community setting: a prospective study. Gastrointest Endosc. 2009;70(3):
457–67.
10. Loperfildo S, et al. Major early complications from diagnostic and therapeutic
12. Mehta PP, et al. Effect of the time of day on the success and adverse events of
14. Sallinen M, et al. The effects of sleep debt and monotonous work on sleepiness
565–7.
16. George TJ, et al. Association of operative time of day with outcomes after
17. Sanaka MR, et al. Diagnostic and therapeutic yield is not influenced by the
timing of small-bowel enteroscopy: morning versus afternoon. Gastrointest