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Analyzing and Improving Endoscopy Unit Efficiency in an Academic Tertiary Care Facility

Research Article

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Abstract

Background and Aims: Demand for endoscopy continues to increase, and it is critical to identify factors limiting practice efficiency. The aims of our study were twofold: to identify major bottlenecks in our workflow, and to quantify differences between scheduled procedure times (SPT) and actual procedure times (APT) at our high-volume academic tertiary care endoscopy center.

Methods: We categorized and quantified reasons for delay to the start of the first case of the day through our electronic medical record. To compare SPT and APT, we collected data on all endoscopies from May 2019 to February 2020 and determined mean time discrepancies of our ten most frequently performed procedures.

Results: The mean preoperative time was 67 minutes. A median of 27 minutes were spent with nursing for preoperative documentation. 74% of first cases started late, and approximately 10% of inpatient cases rolled over to the next day. The most common factors were patient and gastroenterologist tardiness, causing mean delays of 35 and 22 minutes respectively. 48% of cases went over their SPT. Inpatient esophagogastroduodenoscopy (EGD), colonoscopy, and endoscopic retrograde cholangiopancreatography (ERCP) went a mean of 21.3 ($p<0.01$), 19.4 ($p<0.01$), and 15.8 ($p<0.01$) minutes over their SPT, respectively. Outpatient colonoscopy and ERCP went a mean of 5.23 ($p<0.01$) and 19.7 ($p<0.01$) minutes over their SPT, respectively.

Conclusion: Potential targets to improve inefficiency include patient and GI physician tardiness and reducing nursing preoperative documentation time. Inpatient procedures including EGD, colonoscopy, and ERCP along with outpatient colonoscopy and ERCP were significantly delayed and would benefit from additional scheduled time.

Keywords: Endoscopy; Quality improvement; Efficiency

Abbreviations

OTFS: On-Time First Case Starts; TAT: Turnaround Time; SPT: Scheduled Procedure Time; APT: Actual Procedure Time; TCT: Total Case Time; EGD: Esophagogastroduodenoscopy; ERCP: Endoscopic Retrograde Cholangiopancreatography; UMMC: University of Maryland Medical Center; GI: Gastroenterology; IMPRV: Identify, Measure, Process, Re-think, and Validate; EMR: Electronic Medical Record

Introduction

Healthcare costs continue to rise in the United States, and yearly estimates from 2018 account for 11.0 million colonoscopies, 6.1 million esophagogastroduodenoscopies (EGD), 313,000 flexible sigmoidoscopies, 178,400 upper endoscopic ultrasound examinations, and 170,000 endoscopic retrograde cholangiopancreatography (ERCP) procedures [1]. Nationwide, annual expenditures on gastrointestinal diseases account for as much as $135.9 billion [1]. The most up to date

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estimates from 2012 place indirect and direct costs from outpatient endoscopic procedures at $32.4 billion annually [2]. Gastrointestinal procedures represent the largest percentage of Medicare claims at ambulatory surgery centers, and this trend is likely to continue [3].

As the demand for endoscopic procedures continues to grow, it is necessary to evaluate our current systems in search of opportunities to improve time and cost efficiency. Improving efficiency is imperative to improving quality of care for patients. The National Academy of Sciences Institute of Medicine includes efficiency as one of their key elements of quality care delivery, striving for a "continuous decrease in waste" [4]. Major challenges in achieving efficiency revolve around the appropriate use of limited resources including staff, facilities, equipment, and time [5]. Key targets to improve efficiency in the endoscopy unit include pre- and post-procedure wait time, first case start time, and scheduled procedure time [6]. Certain targets such as procedure time are more difficult to adjust in comparison to more malleable factors such as turnover time. With improved scheduling and estimates of procedure time, a more accurate plan for each day can be created.

Each endoscopy center faces varied challenges and bottlenecks in their workflow. Kaushal et al. found that their endoscopy unit bottlenecks were delays in the pre- and post-procedure recovery rooms, while room turnaround time (TAT) and room-per-endoscopist ratio were not driving parameters in efficiency [7]. In contrast, Yang et al. [8] identified TAT as a cause for their unit's decreased efficiency [8]. Decreasing room TAT is a common target to improve the timing and volume of procedures that can be completed[9]. Actual procedure times are longer than the scheduled procedure times at these centers, and this is likely a common occurrence in other endoscopy centers [7-9]. Such varied findings highlight the various processes in which each center approaches the issue of endoscopy unit efficiency. Among other studies, implicating factors include personnel utilization, patient scheduling, procedure delays, sedation, and recovery room delays [10]. Academic medical centers regularly have delays between 30-50% of all endoscopic procedures. Common causes of delays include physician unavailability and patient flow processes that include registration time, admission, transportation, and scheduling [8,11].

Different strategies have been described for improving endoscopy unit efficiency. For example, some centers utilize a two-rooms-per endoscopist model. However, in many tertiary-care hospitals, space is at a premium [12]. While training providers to reduce procedure time seems like a viable strategy, Zamir et al. [9] found an over three-fold variation in procedure volume score among their endoscopists that is difficult to control from a systems-based approach [9]. The variability in procedure volume score, and likely procedure time, may be attributed to numerous factors such as endoscopist experience with specific procedures, time in practice, and advanced training. These factors are challenging to alter by changing a scheduling system or adding additional rooms to a unit. There may also be causes inherent to the procedures themselves that introduce variation, such as rare cases, altered anatomy, high risk procedures, or the use of intricate equipment.

Uncertainty remains in the search for the best way to improve efficiency in endoscopy units. The answer most likely varies due to individual factors unique to each site. The aim of this study is twofold: to identify bottlenecks in the staff workflow and to quantify differences between scheduled and actual procedure times at our high-volume tertiary care endoscopy center. The hope is not only to improve the quality of care for our patients, but to add to the growing body of data on endoscopy unit efficiency and provide a framework for future improvements. Improved efficiency enhances patients' experiences, improves employee workplace satisfaction, and allows more patient access to necessary endoscopic procedures.

Methods and Materials

Study setting and patient population

This study was conducted at the University of Maryland Medical Center (UMMC), an 800-bed tertiary care academic hospital. There are two separate endoscopy units. Each unit has two procedure rooms for a total of four endoscopy rooms. The two procedure rooms on the upper floor are designed for interventional procedures such as ERCP and EUS or for patients with more advanced comorbidities that will possibly require general anesthesia. The procedure rooms on the lower floor are designed for patients undergoing general gastrointestinal procedures such as EGD or colonoscopy who have less significant comorbidities (American Society of Anesthesiologists Classification I, II, or III). Each procedural unit is staffed with one anesthesiologist that oversees two nurse anesthetists. The endoscopy team consists of the attending endoscopist with or without a gastroenterology (GI) fellow, an endoscopy procedure nurse, an endoscopy recovery nurse, and a GI trained technician. In the lower floor endoscopy unit, there are four intake bays and four recovery bays. In the upper endoscopy floor, there are four intake bays and a separate post-anesthesia care unit shared with a minimally invasive operating room suite. GI has four assigned recovery bays. It has long been realized that the space design on two floors impacts efficiency because it requires duplication of teams and equipment. Unfortunately, a large, unified space has been challenging to obtain.

Inpatients are transported to one of the endoscopy unit pre-procedure bays from the wards while outpatients are registered by a receptionist on a separate floor. All patients have their intake performed in the pre-procedural bays unless they have critical care or infection prevention issues that require their intake to occur directly in the room. A total of four to five nurses are routinely assigned for the pre- and post-management of patients in the admission/recovery area. The majority (70%) of interventional and general outpatient endoscopic procedures are open access, referring to patients who are directly referred for their procedure without being physically seen prior to their procedure by a GI physician at UMMC. Every procedure requires an updated history and physical examination by both the endoscopist and anesthesiologist upon admission to the endoscopy unit. If a full history or physical had been documented by the provider within 30 days, that document can be addended with any additional information. Procedural and anesthesia written consents are also obtained. A comprehensive intake is performed by nursing on patient arrival. Following the initial preoperative assessment (e.g. vital signs, review of medications, intravenous line placement), patients are then transported to the endoscopy room by the nurse, nurse anesthetist, and/or endoscopy technician assigned to that room. After their procedures, patients are sent to the recovery area for post-procedural monitoring prior to returning to the wards or being discharged from the endoscopy unit. Outpatient flow through the endoscopy unit is depicted in the flow diagram in Figure 1. On the typical day, outpatient cases are scheduled for the morning and inpatient cases are performed in the afternoon. Emergency cases (unstable cholangitis or unstable bleeding) take precedence over more stable outpatients and inpatients. With the model employed at UMMC, inpatient procedures often get bumped because of delays accruing throughout the day.

Identify, Measure, Process, Re-think, and Validate (IMPRV) synopsis

The IMPRV toolkit was designed by the Center for Performance Improvement at UMMC as a methodology for teams to increase quality, eliminate waste, improve the customer and staff experience, and increase operational efficiency. The following methods were developed based on the IMPRV model in conjunction with our quality improvement department.

Citation: Schliep M, Wu A, Abutaleb A, et al. Analyzing and Improving Endoscopy Unit Efficiency in an Academic Tertiary Care Facility. Int J Gastroenterol Liver Dis. 2021;1(1):01–07. DOI: 10.51626/ijeti.2021.01.00001

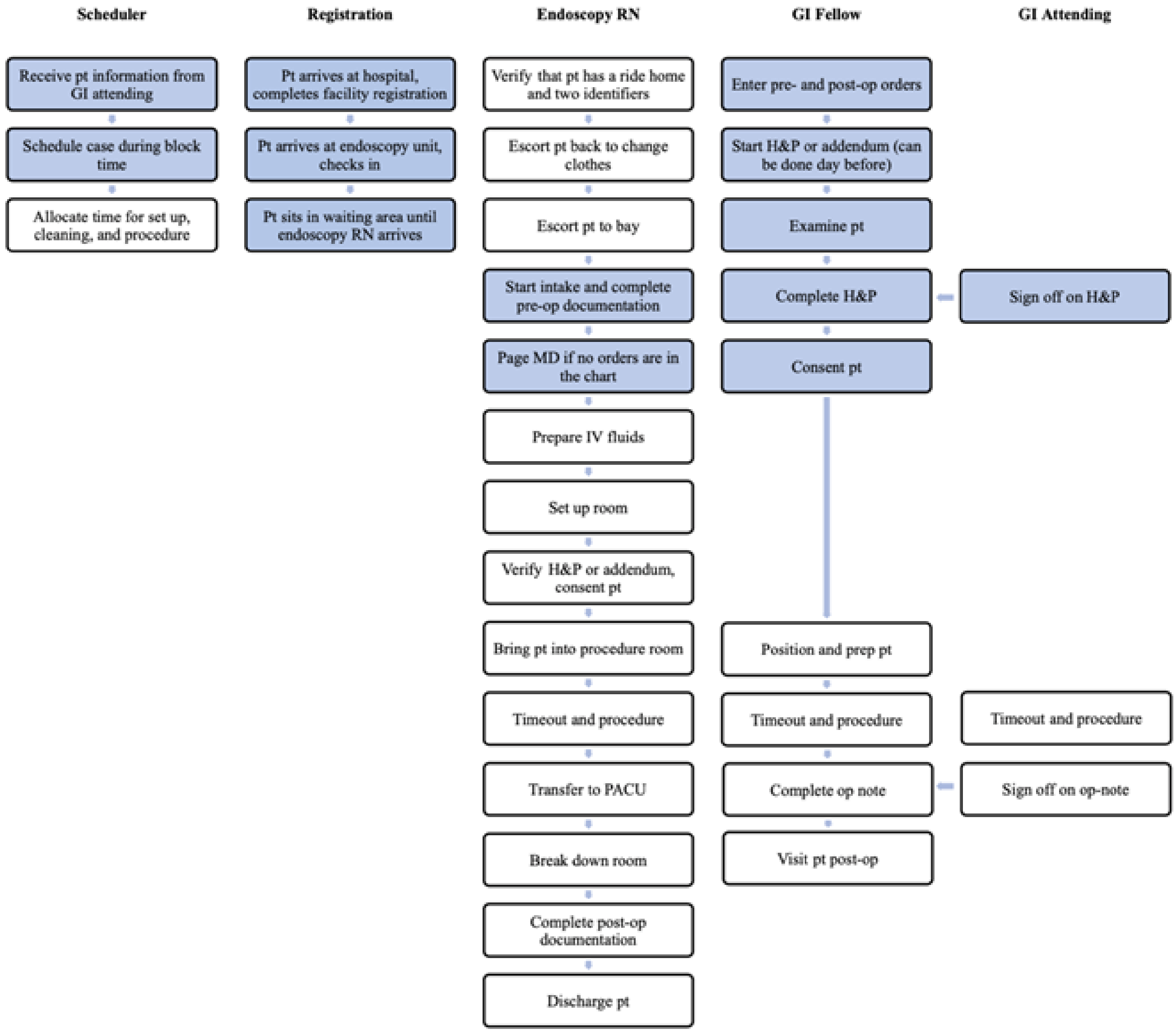

Figure 1: Operations "swim lanes" for the scheduler, registration, endoscopy RN, GI fellow, and GI attending with identified areas of potential delay highlighted in blue.
Abbreviations: pt: Patient; OP: Operative; PACU: Post Anesthesia Care Unit; H&P: History and Physical; RN, registered nurse; GI, gastroenterology.

Identifying first case bottlenecks

We mapped out hospital staff workflow from the time of patient arrival to our facility to the start of their endoscopic procedure (Figure 1). We quantified delays to the start of the first case of the day for inpatient and outpatient endoscopy procedures from May 1, 2019 to January 31, 2020 and categorized the reasons for delay through our electronic medical record (EMR), Epic (Epic Systems Corporation; Verona, Wisconsin).

On-time first case starts (OTFS) were defined as cases that started within 5 minutes of the scheduled appointment. Therefore, delays were defined as cases that started greater than 5 minutes after the scheduled appointment. Room turnaround time (TAT), defined as the period between the end of the first case to the start of the second case, was also quantified through data in our EMR. TAT encompasses room clean up and trash removal, set up by nursing and anesthesia, and preoperative documentation for the second patient (Figure 2). Preoperative documentation must be completed by the nurse, GI physician, and anesthesiologist.

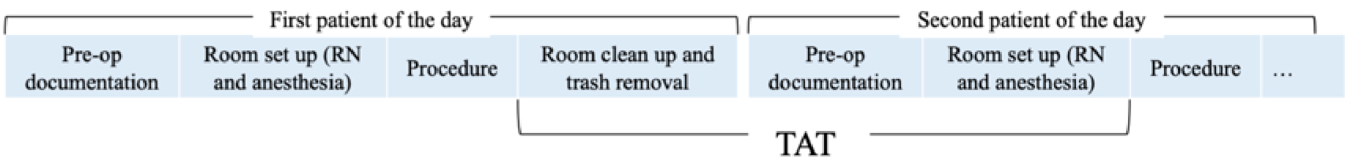

Figure 2: Visualization of Turnaround Time (TAT).
Abbreviations: op: Operative; RN: Registered Nurse

Scheduled vs. actual procedure times

To compare discrepancies between scheduled procedure time (SPT) and actual procedure time (APT), we collected data on 2496 endoscopy cases from August 1, 2019 to February 12, 2020. SPT is an estimate of how long the procedure alone will take and is determined by the scheduler in conjunction with the provider. Variability exists in SPT as providers attempt to estimate how factors, for example altered anatomy or degree of bleeding, may alter the procedure time. APT is defined as the time from "scope in" to "scope out" and is determined by recorded data in the EMR. Total case time (TCT) is defined as the sum of set up time, SPT, and clean up time, and is determined by our schedulers with time allocated for each step (Figure 3). "On time" procedures are defined as procedures that ended within 5 minutes over or under the SPT.

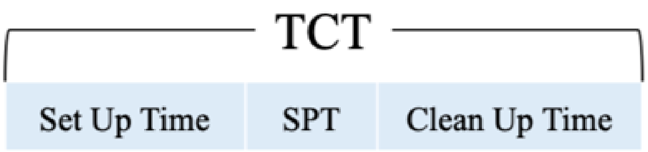

Figure 3: Visualization of Total Case Time (TCT) and Scheduled Procedure Time (SPT)

Statistical analysis

Our data were expressed as means and medians. Basic descriptive statistics were performed with Microsoft Excel. Differences between means were calculated using a paired t-test. A p value less than 0.05 was considered statistically significant.

Results

Identifying first case bottlenecks

From May 1, 2019 to January 31, 2020, there were 599 first cases recorded and 441(74%) did not start on time. 88% of inpatient (n=25) and 73% of outpatient (n=574) cases did not start on time within 5 minutes of the scheduled start time (Table 1). Approximately 10% of inpatient cases rolled over to the next day. The most common causes of delays in OTFS were patient tardiness (33%, n=142) and GI physician tardiness (26%, n=109), resulting in means of 35 and 22 minutes of delay per case, respectively. Less common types of delays included anesthesia physician tardiness (4.7%, n=20), missing consent paperwork from either GI and anesthesia (3.5%, n=15), and difficulty obtaining intravenous access in the patient (2.8%, n=12) (Table 2).

Table 1: On Time First Start Delays by Inpatient and Outpatient.

	Inpatient, n (%)	Outpatient, n (%)	
On time	3 (12%)	155 (27%)	
Delayed	22 (88%)	419 (73%)	
Total	25	574	599

Within our standard workflow, the mean preoperative time was 67 minutes. The median registration time was 17 minutes. The median total preoperative documentation time was 50 minutes, of which 27 minutes were with nursing, 5 minutes with GI, and 5 minutes with anesthesia (Figure 4). The remaining 13 minutes were spent waiting, during which the patient was not interacting with a health care provider.

Scheduled vs. actual procedure times

From August 1, 2019 to February 12, 2020, there were 2496 endoscopy cases performed. The top three most frequently performed procedures were EGD (n=660), colonoscopy (n=574), and ERCP (n=349), making up 63% of all procedures. Of these cases, 1199 (48%) were over the SPT and 705 (28%) were under the SPT. 592 (24%) were completed within 5 minutes of the SPT. APT for inpatient procedures went a mean of 19.8 ± 28.0 minutes over SPT (n=545), and APT for outpatient procedures went a mean of 6.0 ± 22.4 minutes over SPT (n=1951). There was a statistically significant difference between SPT and APT in both inpatient ($p<0.01$) and outpatient ($p<0.01$) procedures (Table 3). Mean SPT and APT for the most commonly performed procedures are shown in Table 4.

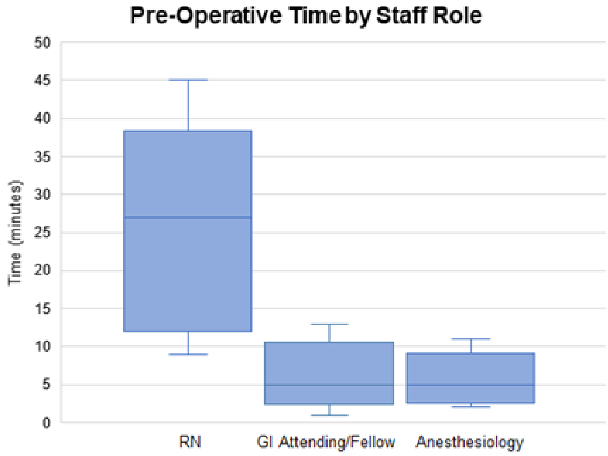

Figure 4: Preoperative time by staff role.

Abbreviations: RN: Registered Nurse; GI, Gastroenterology

Table 2: On Time First Start Delays by Reason.

Reason	Procedures (%) (Total n=427)
Patient	175 (41%)
Arrived late	142
Difficult IV access	12
Other[a]	21
GI Attending or Fellow	128 (30%)
Arrived late	109
Incomplete or missing consent form	9
Other[b]	10
Anesthesiology	32 (7.5%)
Arrived late	20
Incomplete or missing consent form	6
Other[c]	6
Facility / Registration	18 (4.2%)
Equipment (malfunction or unavailable)	10 (2.3%)
Staffing shortage	6 (1.4%)
Unspecified or other	58 (14%)

[a]Abnormal lab value, need additional labs/tests, medical interpreter needed, not NPO, waiting for family members.

[b]Delayed by previous case, missing orders, equipment changed, discussion with family.

[c]Requested outside paperwork, computer malfunction.

IV: Intravenous; GI: Gastroenterology; NPO: Nil Per os

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Table 3: Mean SPT and APT for inpatient and outpatient cases.

	SPT, in min Mean, SD	APT, in min Mean, SD	p value[a]
Inpatient (n=545)	31.9 ± 17.4	51.7 ± 29.4	**<0.01**
Outpatient (n=1951)	40.5 ± 16.7	46.5 ± 28.6	**<0.01**

[a]p value derived from paired t-test.

SPT, schedule procedure time; APT, actual procedure time.

Table 4: Mean SPT and APT for the ten most frequently performed procedures.

Procedure	SPT, in min	APT, in min	Difference, in min	p value[a]
	Mean, SD (range)	Mean, SD (range)	Mean, SD	
EGD (n=660)				
Inpatient (n=183)	24.8 ± 9.95 (5-60)	46.1 ± 33.1 (11-242)	21.3 ± 31.7	**<0.01**
Outpatient (n=477)	37.9 ± 6.51 (5-50)	38.7 ± 21.1 (10-188)	0.828 ± 21.1	0.39
Colonoscopy (n=574)				
Inpatient (n=37)	38.7 ± 15.1 (25-105)	58.1 ± 24.7 (24-124)	19.4 ± 24.1	**<0.01**
Outpatient (n=537)	38.1 ± 4.45 (15-55)	43.3 ± 14.8 (12-114)	5.23 ± 15.2	**<0.01**
ERCP (n=349)				
Inpatient (n=93)	48.7 ± 9.59 (20-80)	64.5 ± 26.0 (29-177)	15.8 ± 28.2	**<0.01**
Outpatient (n=256)	39.8 ± 5.17 (25-100)	59.6 ± 26.2 (15-142)	19.7 ± 25.5	**<0.01**
EUS upper (n=165)				
Inpatient (n=22)	34.8 ± 18.3 (20-90)	66.8 ± 34.2 (26-164)	32.0 ± 31.5	**<0.01**
Outpatient (n=143)	40.3 ± 3.76 (25-70)	48.2 ± 22.4 (19-133)	7.93 ± 21.8	**<0.01**
EGD with biopsy (n=123)				
Inpatient (n=30)	17.3 ± 9.17 (5-35)	43.0 ± 19.4 (17-87)	25.6 ± 22.0	**<0.01**
Outpatient (n=93)	38.5 ± 5.03 (20-55)	35.7 ± 14.7 (12-92)	-2.87 ± 15.1	0.069
EGD guided dilatation (n=79)				
Inpatient (n=1)	30.0 ± 0	52.0 ± 0	22.0 ± 0	-
Outpatient (n=78)	38.3 ± 5.26 (10-40)	34.7 ± 14.4 (16-119)	-3.59 ± 14.8	**0.036**
Colonoscopy with polypectomy (n=57)				
Inpatient (n=2)	35.0 ± 7.07 (30-40)	58.5 ± 6.36 (87-90)	23.5 ± 13.4	0.24
Outpatient (n=55)	39.7 ± 1.50 (30-40)	53.3 ± 16.4 (28-90)	13.6 ± 16.5	**<0.01**
Enteroscopy upper small bowel with and without balloon (n=56)				
Inpatient (n=9)	43.3 ± 7.91 (35-60)	52.1 ± 14.7 (27-74)	8.78 ± 16.3	0.14
Outpatient (n=47)	39.9 ± 4.83 (25-65)	46.7 ± 13.9 (26-90)	6.85 ± 13.3	**<0.01**
Flexible Sigmoidoscopy (n=46)				
Inpatient (n=30)	39.3 ± 12.4 (15-95)	32.6 ± 16.7 (11-83)	-6.73 ± 21.4	0.096
Outpatient (n=16)	24.7 ± 10.1 (10-45)	27.1 ± 9.84 (16-53)	2.44 ± 13.1	0.47

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EGD with Radiofrequency Ablation (n=40)				
Inpatient (n=0)	-	-	-	-
Outpatient (n=40)	38.5 ± 4.51 (25-40)	41.1 ± 11.7 (20-84)	2.59 ± 11.7	0.17
[a]p value derived from paired t-test.				
SPT: Schedule Procedure Time; APT: Actual Procedure Time; EGD: Esophagogastroduodenoscopy; ERCP: Endoscopic Retrograde Cholangiopancreatography; EUS: Endoscopic Ultrasound				

Inpatient procedures

All inpatient procedures with more than 20 cases recorded during the study had statistically significant differences in SPT compared to APT (Table 4). For inpatient procedures, EGD (n=183) took a mean of 46.1 (±33.1) minutes and went a mean of 21.3 (±31.7) minutes over the SPT (p<0.01). Colonoscopy (n=37) took a mean of 58.1 (±24.7) minutes and went a mean of 19.4 (±24.1) minutes over the SPT (p<0.01). ERCP (n=93) took a mean of 64.5 (±26.0) minutes and went a mean of 15.8 (±28.2) minutes over the SPT (p<0.01). EUS upper (n=22) took a mean of 66.8 (±34.2) minutes and went a mean of 32.0 (±31.5) minutes over the SPT (p<0.01). Flexible sigmoidoscopy (n=30) took a mean of 32.6 (±16.7) minutes and went a mean of 6.73 (±21.4) minutes under the SPT (p=0.09). This was not considered statistically significant.

Outpatient procedures

For outpatient procedures, there was a statistically significant difference in SPT and APT for colonoscopy, colonoscopy with polypectomy, ERCP, EUS upper, and upper small bowel enteroscopy (Table 4). Colonoscopy (n=537) took a mean of 43.3 (±14.8) minutes and went a mean of 5.22 (±15.2) minutes over the SPT (p<0.01). Colonoscopy with polypectomy (n=55) took a mean of 53.3 (±16.4) minutes and went a mean of 13.6 (±16.5) minutes over the SPT (p<0.01). ERCP (n=256) took a mean of 59.6 (±26.2) minutes and went a mean of 19.7 (±25.5) minutes over the SPT (p<0.01). EUS upper (n=143) took a mean of 48.2 (±22.4) minutes and went a mean of 7.93 (±21.8) minutes over the SPT (p<0.01). Enteroscopy of the upper small bowel with and without balloon (n=47) took a mean of 46.7 (±13.9) minutes and went a mean of 6.85 (±13.3) minutes over the SPT (p<0.01).

EGD (n=477) took a mean of 38.7 (±21.1) minutes and went a mean of 0.828 (±21.1) minutes over the SPT (p=0.39). EGD with biopsy (n=93) took a mean of 35.7 (±14.7) minutes and went a mean of 2.87 (±15.1) minutes under the SPT (p=0.07). EGD with radiofrequency ablation (n=40) took a mean of 41.1 (±11.7) minutes and finished on time with a mean of 2.59 (±11.7) minutes over the SPT (p=0.17). Flexible sigmoidoscopy (n=16) took a mean of 27.1 (±9.84) minutes and finished on time within a mean of 2.44 (±13.1) minutes of the SPT (p=0.47). By definition, these were not statistically significant.

Discussion

In the United States, rising healthcare costs and demand for endoscopic procedures necessitate time and cost efficiency in order to maintain a high quality of care for patients. A review of existing literature brings to light the issue of endoscopy unit inefficiency across the United States as well as in other countries [7-12]. Each endoscopy unit faces unique challenges to achieve efficiency. We collected and analyzed performance data in our high volume, tertiary care hospital endoscopy unit.

OTFS and TAT are commonly used as markers of endoscopy unit efficiency [6]. Intuitively, delays in OTFS may cause a domino effect that results in subsequent delays throughout the day and may even impact schedules for the following day as a result of case bumping [9]. Increased TAT results in lost time that could have been used for additional procedures. Per Yong et al. [11] nearly a third of endoscopy cases at their academic medical center were delayed by at least 15 minutes, with physician delays found in about two thirds of those cases [11]. Similarly, a study at Hotel-Dieu Hospital in Kingston, Ontario found that while their center's procedure times were within their acceptable limits, delays related to patient arrival and endoscopist tardiness resulted in longer times spent in endoscopy rooms [13]. In our study, the majority (74%) of our inpatient and outpatient cases did not start on time. As a result, about 10% of inpatient cases rolled over to the next day, likely resulting in extended hospital stays and additional healthcare expenditures. The most common factors for delays in OTFS were patient and GI physician tardiness (Table 2). It is difficult to fully tease out the reasons for patient and GI physician tardiness given limitations in the data collected in our study. Though some instances had additional details recorded, the majority did not. Of those with explanations, primary contributors to patient tardiness included traffic, public transportation, and distance traveled. We suspect that the registration process for outpatient procedures contributed to patient tardiness as well. Reasons for physician tardiness are varied. They include late arrival to the endoscopy unit, but physician tardiness can occur while the physician is in the endoscopy unit. Performance of other responsibilities while awaiting completion of the preoperative process, such as patient calls and team presentations, can cause physician delays. Physician recognition and education of their contribution to delays will likely improve workflow. To address patient tardiness and assist patients with on time arrival, one intervention could be phone and/or email contact on the day prior to the procedure to serve as a reminder. This strategy has been shown to reduce endoscopy procedure no-shows, increase revenue, and improve the scheduling system [14]. Requesting that patients arrive an additional amount of time before their procedures is another option. Currently, we request that our patients arrive 60 minutes prior to their procedure time. Increasing arrival time to 75 minutes is warranted based on our data.

When evaluating TAT, our study found that the preoperative process took a median of 50 minutes and was therefore a major cause of delay. Of those 50 minutes, the majority of time (25 minutes) was spent with nursing for preoperative documentation. Nursing has a greater burden of responsibilities during the preoperative period compared to other roles. Options for addressing long preoperative assessment times include obtaining patient data electronically prior to their procedure date, streamlining staff roles, and double-teaming patients by merging some swim lanes found in Figure 1. With advances in the EMR, algorithms to auto-complete preoperative documentation based on prior visits could also assist in reducing TAT.

Our schedulers use a preset scheduling system that introduces inefficiency into our workflow and does not account for variability in case complexity, setting, or provider experience. Currently, our endoscopy unit scheduler allocates 60-minute blocks for TCT regardless of procedure type. However, we found that nearly half of our cases went a statistically significant amount of time over their SPT. The mean APT for all of our inpatient procedures with more than 20 cases went a statistically significant amount of time over the

SPT. Our three most commonly performed procedures were EGD, colonoscopy, and ERCP and were similar in length when compared to other studies [8,11]. This demonstrates a need to more accurately and reliably schedule endoscopic procedures. We plan to reevaluate our scheduling system in an attempt to create dynamic time blocks based on the procedure type and if it is inpatient or outpatient.

Novel strategies to remedy these scheduling conflicts range from a redistribution of cases, IT solutions, and physician education and training [15]. Hester et al. [16] proposed an information management system to actively monitor clinical data, integrating with the EMR to combine anesthesia and endoscopy suite team scheduling to preemptively anticipate preoperative planning and any needed staffing adjustments [16]. Over the long term, an integrated system could actively refine our daily workflow by identifying specific procedures and providers who may need additional time or assistance with cases. Discrete event simulation is a modeling tool that was successfully used by Sauer et al. to analyze patient cycle time and determine the ideal number of preparation and recovery rooms and improve efficiency [17].

Our study has several strengths. First, our study provides a detailed, comprehensive assessment of numerous parameters from a large sample of over 2000 endoscopic procedures over an 8-month period. Our study also included inpatient and outpatient procedures, providing a realistic and practical model for tertiary care facilities. The high acuity of patients in our facility contributes to the variety and complexity of endoscopic procedures performed, which certainly serves as a challenge to scheduling. However, this also makes our study widely representative of the cases that tertiary care facilities may see. By using our EMR to track time stamps, we are able to accurately collect data on scheduled versus actual procedure time without bias. With this in mind, our study had several limitations. While the EMR is able to provide certain pieces of objective data, large portions of our data set relied on staff members tracking and reporting the timing of unit workflow at each step as outlined in Figure 1. Consequently, bias or human error may have been present when staff members were required to enter data about their colleagues. It is also possible that coding procedures introduced inaccuracy if the actual procedure varied from the anticipated procedure due to findings encountered during the procedure. For example, a routine upper endoscopy that turned into an upper endoscopy with a stricture dilation.

Conclusion

In summary, the most common reasons for inefficiency in our endoscopy unit are OTFS delays from patient and GI physician tardiness, TAT delays due to nursing preoperative work, and inaccurate SPT for our most commonly performed procedures. From this study, we have determined potential areas of improvement to increase overall unit efficiency. Going forward, we plan to change how we communicate with patients about arrival times, streamline the nursing preoperative documentation process, and add time to the SPT for specific procedures. Further research is required to measure the effect of planned interventions to reduce delays, with the overall goal of maintaining high quality care for our patients.

Conflict of Interest

- **Specific author contributions:** Analysis and interpretation of data (MS, AW, AA, SG), manuscript drafting and serial revisions of the manuscript (MS, AW, AA, EG), conception of the study design (AA, SG, CB, JM, EG), collection of data (MS, AW, SG, CB). All authors (MS, AW, AA, SG, CB, JM, EG) have approved the final submitted manuscript.
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