

Evaluation of interventional endoscopy unit efficiency metrics at a tertiary academic medical center

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Background and study aims: There is an increasing demand for interventional endoscopic services and the need to develop efficient endoscopic units. The aim of this study was to analyze performance data and define metrics to improve efficiency in a single academic interventional endoscopy center.

Patients and methods: The prospective operations performance data (6-month period) of our interventional endoscopy unit (EU) was analyzed. First-case start time (FIRST) delay was defined as any time the first patient of the day entered the endoscopy room after the scheduled time. Non-endoscopy time (NET) and total time (TT) were defined as non-procedural and total time elapsed in the EU, respectively. Time-interval between successive patients (TISP) was defined as the time from one patient departure from the room until the time of arrival of the next patient in the room.

Results: A total of 1421 patients underwent 1635 endoscopic procedures. FIRST was delayed (54.2% cases) by 13.6 min (range 1–53), but started within 15 min of the scheduled time in 85% of the cases. NET accounted for 9.1 hours (67.2%) of 13.5 hours TT/day. TISP (37.1 min, range 5–125) comprised 54.2% of the NET, and was delayed (> 30 min) in 49.8% of cases. “Patient flow” processes (registration, admission, transportation, scheduling) accounted for 50.1% of TISP delays.

Conclusions: Delays in NET, specifically TISP, rather than FIRST, were identified as a cause for decreased efficiency. “Patient flow” processes were the main reasons for delays in TISP. This study identifies potential process measures that can be used as benchmarks to improve efficiency in the EU.

Introduction

Quality assurance and performance improvement are concepts that have become increasingly common in medicine as a consequence of the new changes in health care delivery. Indeed, recent actions, including the Patient Protection and Affordable Care Act, are part of the national effort to promote high-quality health care by linking the performance of provider practices to reimbursement [1]. These initiatives to maintain the highest standard of care while restraining costs represent the new reality in the practice of gastroenterology and endoscopy.

In light of these challenges, in 2006, a joint task force of experts from the professional gastrointestinal societies developed quality measures for endoscopy [2]. The objective of this collaboration was to establish pre-, intra-, and post-procedural indicators that could serve as a framework to improve the overall quality of endoscopic services.

The joint task force recognized that while some of these recommendations were supported by evidence, a substantial majority were based on expert consensus. Furthermore, among the many potential quality end points, it remains uncertain which would be most useful and feasible for widespread adoption.

In the past decade, there has been a steadily increasing demand for gastrointestinal specialty care and particularly for endoscopic services [3, 4]. With ongoing advances in therapeutic endoscopy, there has been a concomitant trend towards minimally invasive interventional endoscopy for various gastrointestinal illnesses historically reserved to surgery [5, 6]. Hence, there is a growing need for more efficient endoscopy units (EU) that are able to provide high-quality endoscopic services, maximizing patient satisfaction while still managing costs. While there have been a few studies on the efficiency in the EU, there is no clear consensus on how to optimize the delivery

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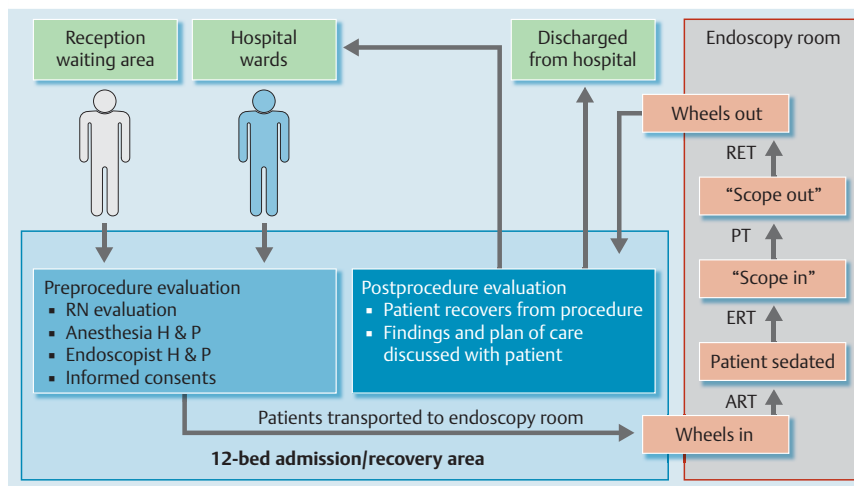


Fig. 1 Diagram outlining the “flow” of patients in our interventional endoscopy unit.

of endoscopic services in this setting [7–10]. Recently, Kaushal and colleagues [11] attempted to establish a validated methodology to evaluate and improve operational performance in their endoscopy unit. Unlike previous studies [7,9] which have emphasized room-turnover time and room-to-endoscopist ratio as important parameters for efficiency in the EU, these authors identified the pre-procedure/recovery room as the bottleneck of the operation and stressed the importance of developing a methodology to further identify other potential factors. The apparent conflicting reports and variability among different centers emphasize the absence of a definite framework for how to improve EU efficiency. This may be even more evident and challenging in large academic centers with a focus on interventional endoscopy. Indeed, there is a current lack of data on the performance of interventional units, which highlights the ongoing need to collect operational data to develop metrics that can be used to identify areas for improvement. Ideally, it would be desirable to establish *processes*, intermediate indicators that capture how well a system performs, and use these to identify aspects of an EU that must receive attention in order to improve outcome measures such as throughput level [12]. The aim of this study was to: (1) analyze operations performance data; and (2) define metrics that can be used as benchmarks to improve efficiency in a single academic interventional endoscopy center.

Patients and methods

Study setting and patient population

This study was conducted at the University Of Florida Hospital (UF Health), an 852-bed tertiary-care referral teaching hospital. Gastrointestinal endoscopy at UF Health is performed at two locations: an outpatient endoscopy center (EC) and the main endoscopy unit (EU). The EC is located in a physically separate building near the hospital and is equipped with four rooms for general endoscopic procedures (upper endoscopy and colonoscopy) for average risk outpatients (ASA Class 1 and 2) [13]. This location was not included for purposes of this study on interventional endoscopy unit efficiency.

The EU at UF Health is located in the hospital building. It consists of 4 endoscopy rooms for both outpatient and inpatient endoscopic procedures; including two rooms equipped with fluoroscopy units and utilized for interventional endoscopic procedures on inpatients and outpatients. Typical procedures in these rooms include interventional endoscopy such as endoscopic retrograde cholangiopancreatography, endoscopic ultrasound

(EUS), upper endoscopy/colonoscopy for luminal stenting, Barrett’s esophagus ablation, complex endoscopic dilation, procedures requiring fluoroscopic guidance, endoscopic mucosal resection, and endoscopic submucosal dissection (ESD). All procedures in these interventional endoscopy rooms are performed under deep sedation (anesthesiologist administered propofol) or general anesthesia (except for a small number of cases done with moderate sedation for rectal EUS and flexible sigmoidoscopy). Typically, a nurse anesthetist is physically present in each endoscopy room at all times and supervised by one attending anesthesiologist assigned for the EU for that day. The endoscopy team is composed of the attending endoscopist, one endoscopy nurse, and a technician.

Inpatients are transported to one of the EU pre-procedure slots from the wards while outpatients are registered by a receptionist in the waiting area. All patients are admitted to the 12-bed admission/recovery area prior to their procedure. A total of 4 to 6 nurses are routinely assigned for the pre- and post-management of patients in the admission/recovery area. The majority (70%) of outpatient interventional endoscopic procedures are open access (patients are directly referred for their procedure without being physically seen previously at UF Health). Regardless, a history and physical examination are done on all patients separately by both the endoscopist and anesthesiologist upon admission to the EU. Procedural and anesthesia written consents are also obtained. Following initial preoperative assessment (e.g., vital signs, review of medications, intravenous line placement), the 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 same admission/recovery area for post-procedural monitoring prior to returning to the wards or discharged from the EU. Patient flow through the endoscopy unit is depicted in the flow diagram in [Fig. 1](#).

Study design

This study was part of a quality improvement (QI) initiative in the Interventional Endoscopy Program at UF Health and was approved by the Institutional Review Board at the University of Florida. As part of the ongoing effort to identify and develop operational measures for the EU, multiple performance parameters are prospectively tracked and collected in a hospital-mandated electronic database. The information was obtained daily by a circulating nurse and entered into the electronic record. The avail-

Table 1 Definition of process measures.

First case start time (FIRST)	Time the first scheduled patient of the day entered the endoscopy room ("wheels in" time)
Anesthesia ready time (ART)	Time elapsed from patient entry into the endoscopy room ("wheels in" time) to the time reported by the anesthetist that the patient is appropriately sedated
Endoscopist ready time (ERT)	Time after patient was appropriately sedated till insertion of the endoscope
Procedure time (PT)	Time from endoscopy start to endoscopy completion (time from scope insertion to withdrawal)
Room exit time (RET)	Time elapsed between withdrawal of the endoscope to patient departure ("wheels out" time) from the endoscopy room.
Time interval between successive patients (TISP)	Time from patient departure from endoscopy room ("wheels out time") until the time of arrival of the next patient in the room ("wheels in" time)
Non-endoscopy time (NET)	Non-procedural time (ART + ERT + RET + TISP)
Total time (TT)	Total time in the EU (NET + PT)

FIRST, first case start time; ART, anesthesia ready time; ERT, endoscopic ready time; PT, procedure time; RET, room exist time; TISP, time interval between successive patients; NET, non-endoscopy time; TT, total time; EU, endoscopy unit

able information in the electronic database included scheduled and actual procedure start times, time elapsed between the end of one procedure and the start of the next, duration of the procedure, and names of the anesthesiologist(s) and endoscopist(s) involved in the case. The database defined delayed time interval between successive patients (wheels out to wheels in) as a period longer than 30 minutes, based on hospital policy. A reason for delay was documented in the database. This prospective database was reviewed for procedures performed in the two interventional endoscopy rooms from January 1, 2013 through June 30, 2013. This 6-month period encompassed a total of 140 days in which endoscopic procedures were performed in the interventional rooms. Other sources of data reviewed in this study included medical records and chart review for clinical data including patient demographics, endoscopy reports, clinic and hospital notes. Patient comorbidities were classified based on the validated Charlson comorbidity index [14].

Definitions

Process measures. The EU process measures are defined and summarized in **Table 1**.

Delays. First-case start time (FIRST) was considered delayed if it started any time after the scheduled time (no grace time allowed per hospital policy). Time-interval between successive patients (TISP) was considered delayed if it was greater than 30 minutes per hospital policy.

Throughput level. Room throughput level was defined as the number of patients done per room per day whereas EU throughput was the combined throughput of both rooms.

Adverse events. Endoscopic adverse events were assessed based on previously established criteria by the American Society of Gastrointestinal Endoscopy (ASGE) [15].

Statistical analysis

Summary data were expressed as the mean, median and range. Frequencies and percentages using basic descriptive statistics were performed with GraphPad Prism version 6.0 for Windows; GraphPad Software, San Diego, California.

Results

During the 6-month study period (140 endoscopy days), 1421 patients (52.5% male; median age 63 years [range 18–91]) underwent a total of 1635 endoscopic procedures in the two interventional endoscopy rooms at our EU. Informed consent and

Table 2 Characteristics of patients undergoing interventional procedures at the UF Health endoscopy unit.

Patient characteristics (n = 1421)	
Age, median (range), y	63 (18–91)
Gender, n (%)	
Female	675 (47.5)
Male	746 (52.5)
BMI, median (range), kg/m ²	26.8 (10.8–63.8)
Charlson comorbidity index, median (range)	4 (0–16)
ASA score, median (range)	3 (1–4)
Endotracheal intubation, n (%)	271 (19)
Outpatient, n (%)	953 (67.1)
Inpatient, n (%)	468 (32.9)

BMI, body mass index; ASA, American Society of Anesthesiologists

documented appropriate indications were available for all procedures. Patient characteristics are summarized in **Table 2**. Mean Charlson comorbidity index and median ASA class were 3.9 (range 0–16) and 3 (range 1–4) respectively. Most procedures were performed for outpatients (953/1421; 67.1%). Endotracheal intubation was performed in 19% (271/1421) of patients. Distribution of interventional procedures is shown in **Table 3**. Most patients undergoing interventional endoscopy (1381/1421; 97.2%) received deep sedation (anesthesiologist administered propofol) or general anesthesia. A small subset of patients received moderate sedation with a combination of fentanyl and midazolam (40/1421), most of these representing those undergoing rectal EUS and/or flexible sigmoidoscopy. All procedures were performed by five faculty interventional endoscopists.

Process measures

There were a total of 262 first cases scheduled in the interventional endoscopy rooms during the study period. The majority of TT in the EU consisted of NET (67.2%) compared to PT (32.8%). The TT and NET per day (in hours) were 13.5 and 9.1 respectively. Performance data are shown in **Table 4**. The mean procedure time per case was 27.5 minutes (range 12–246). The wide range in procedure time can be accounted for in part by the diversity of procedures (i.e., Barrett's esophagus with ablation to POEM and ESD). In general, patients were sedated (anesthesia ready time) within 10.9 (mean) minutes (range 0–100) from the time they entered the endoscopy room and procedure started 4.7 (mean) minutes (range 0–32) thereafter (ERT). Upon completion of the procedure (withdrawal of the endoscope), the patient was transported to the admission/recovery area once cleared by the anes-

Table 3 Types of endoscopic procedures performed in two interventional endoscopy rooms.

Type of procedure (n = 1635)	N (%)
EGD	647 (39.6)
ERCP	329 (20.1)
EUS	315 (19.3)
Colonoscopy	242 (14.7)
Small bowel enteroscopy	71 (4.4)
Flexible sigmoidoscopy	31 (1.9)

EGD, esophagogastroduodenoscopy; ERCP, endoscopic retrograde cholangiopancreatography; EUS, endoscopic ultrasound

Table 4 Mean duration of process measures per case.

Process measure	Mean (range), minutes
Anesthesia ready time (ART)	10.9 (0–100)
Endoscopist ready time (ERT)	4.7 (0–32)
Room exit time (RET)	9.0 (1–172)
Procedure time (PT)	27.5 (8–246)
Time between procedures (TBP)	37.1 (5–125)

ART, anesthesia ready time; ERT, endoscopist ready time; RET, room exit time; TBP, time between procedures

Table 5 Reasons for delayed (> 30 min) time between procedures (TBP) in two interventional advanced endoscopy rooms.

Reason	N = 551 (%)
Pre-op evaluation/transport delay/patient late	163 (29.6)
Schedule/case order change	118 (21.4)
Anesthesiologist-related	88 (16)
Endoscopist-related	50 (9)
Case swung due to emergency	39 (7)
Patient-related medical comorbidities	30 (5.4)
Unknown	29 (5.3)
Equipment-related	13 (2.3)

thesiologist. This time period was defined as the room-exit time and accounted for 9.0 (mean) minutes (range 1–172). The time from patient departure from the endoscopy room until the time of arrival of the next patient in the room (TISP) took an average of 37.1 minutes (range 1–125).

The contribution of each process measure to the total NET is shown in **Fig. 2**. Among all process measures, TISP (56.5%) represented most of the NET while ERT accounted for only 8.3%.

Delays

FIRST was delayed in 142/262 (54.2%) cases by an average of 13.6 (range 1–53 min). TISP was delayed (> 30 minutes) in almost half the cases (551/1106; 49.8%) by an average of 37.1 minutes (range 5–125 minutes). Patient flow (patient registration, admission and/or transportation to the EU) and scheduling changes represented the majority (281/551; 50.1%) of TISP delays, whereas anesthesiologist and endoscopist related reasons accounted for only 16% and 9% respectively (**Table 5**).

Throughput level

The room throughput level was similar in the two rooms (4.9 and 4.8 procedures per room per day).

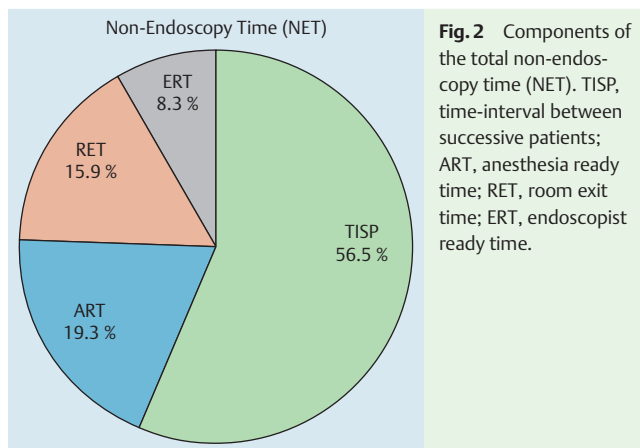


Fig. 2 Components of the total non-endoscopy time (NET). TISP, time-interval between successive patients; ART, anesthesia ready time; RET, room exit time; ERT, endoscopist ready time.

Adverse events

The incidence of mild to moderate adverse events (AEs) was 0.5% (7/1421) with no serious or fatal events. AEs included unanticipated endotracheal intubation because of cardiopulmonary issues (n = 3) and case cancellation due to unstable cardiac arrhythmias or hypertension (n = 4).

Discussion

The increasing demand for gastrointestinal endoscopic services over the years dictates the need for more efficient endoscopy units while still striving to provide high-quality health care. The published literature on this topic is varied and limited, especially with regard to interventional endoscopy units. We therefore collected and analyzed performance data in our tertiary-care referral interventional EU in an effort to identify measures to improve efficiency.

FIRST traditionally has been a benchmark for surgical operating rooms, and by extension, also applied to EU efficiency. Intuitively, delays in first-case start time can potentially create a ripple effect leading to subsequent delays and wasted resources. Likewise, in our institution, there is a strong hospital policy-driven focus on prompt FIRST. In our study, we demonstrated that FIRST was delayed (any time after scheduled start) in 54.2% (142/262) of the cases by an average of 13.6 minutes. Nonetheless, the majority of the cases (222/262; 85%) started within 15 minutes of the scheduled start time, which is in line with the improved FIRST (79% within 15 minutes) reported in an endoscopy suite after specific interventions were undertaken to reduce gastroenterologist and anesthesia-related causes [16]. Thus, while efforts should be placed on minimizing delays in FIRST, a reasonably prompt FIRST as a surrogate marker for a “good start” does not necessarily translate into EU efficiency and should be coupled with many other performance parameters.

Previous studies have suggested that decreasing the duration of procedures has a low yield in improving the efficiency in the EU [17, 18]. Furthermore, attempting to reduce procedure length has other significant clinical implications, including the potential for compromising quality of health care delivery. Hence, emphasis should be placed on identifying non-procedural performance parameters for targeted intervention.

In this study, we defined non-endoscopy time (NET) as the non-procedural time elapsed in our EU. Our findings showed that the total NET per day in both rooms combined comprised over two-

thirds of the total time (TT) in the EU. Indeed, 9.1 out of 13.5 hours per day in the EU were spent on non-procedural processes, whereas the mean EU throughput for both rooms combined was 9.7 cases per 13.5-hour day (0.72 cases/hour). Based on these data, a gross estimation suggests that decreasing NET by 20% (1.8 hours or 109 minutes) potentially allows 2.5 more cases (based on a rate of 0.72 cases/hour) to be done per day; thus representing an increase of roughly 25% from the current EU throughput. While this is a simplistic approach to a more complex issue, it serves to highlight the impact of NET on EU efficiency.

Given that NET as a whole represents the bulk of the time in the EU, we examined different NET parameters that could be targeted for improvement. Time-interval between successive patients (TISP), defined as the time from patient departure from the endoscopy room (“wheels out time”) until the time of arrival of the next patient in the room (“wheels in” time), comprised 56.5 % of the total NET. Our analysis demonstrated that TISP was delayed (>30 minutes; range 5–125 minutes) in almost 50% of the time. Yong et al reported that TISP in their endoscopy unit was delayed (>15 min) 30.9% of the time and they identified physician-related reasons as the most common cause (70.5%) [19]. In contrast to these findings, our study indicated that in aggregate, anesthesiologist- and endoscopist-related reasons accounted for only 25% of the TISP delays. A previous report by Zamir and Rex had shown a trend toward improved procedure volume scores for endoscopists who used other individuals to sedate their patients [7]. In our EU, we have a dedicated certified RN anesthetist for each room and one anesthesiologist, who oversees patient sedation in the EU. Even though many patients referred to the EU are direct access, this multidisciplinary approach allows the endoscopists to focus on other activities (e.g., generating procedure reports, obtaining pre-op assessment and consent, discharging patients post-procedure). The parallel processing of tasks among providers has been shown to improve efficiency in the operating room [20,21] and may potentially account for the low physician-related NET in this study.

Delay in the admission/recovery room area in the endoscopy center has been recognized as a major factor impacting TISP and EU efficiency [11]. However, multiple processes are involved in this complex transition zone, making the accurate measure of modifiable variables extremely challenging. By applying a time and motion study model, Day and colleagues demonstrated an increase in procedure volume by increasing pre-procedure personnel [22]. However, the authors recognize that no clear evidence exists about how to optimize pre-procedure processes and implementation can be challenging. Increasing the physical space in the admission/recovery room area and/or number of pre-op/recovery rooms is often costly and not feasible in most units. Several studies have suggested sedation recovery time as a rate-limiting step in this equation and have advocated the use of propofol to help decrease recovery time and TISP [23,24]. Grossman and colleagues [10] modeled an ambulatory surgery center and revealed that a 50% reduction in recovery time increased the room throughput and shortened overall length of stay of patients. Similarly, Day et al demonstrated that a reduction in recovery time to 30 minutes was associated with an increase in the number of procedures performed per week in the endoscopy unit [22]. In our interventional endoscopy rooms, propofol is routinely used, thus sedation recovery time was unlikely to be a significant factor in TISP delays.

Our study indicates that delays associated with “patient flow” processes (patient registration, admission and/or transportation to the EU, schedule changes) were in aggregate (50.1%) the most common reason for prolonged TISP. The challenges of “patient flow” through our unit are in part associated with the provision of endoscopic services to a diverse population consisting of both outpatients and inpatients. Given the nature and indications for inpatient procedures, these cases are mostly added on to the schedule with short notice (less than 12–24 hours). Because there is no dedicated block time for inpatient procedures in the schedule, integrating inpatient cases into the schedule template disrupts the flow of outpatients. While most inpatient cases are added to the end of the day when feasible, sometimes this is not possible due to the nature or urgency of the procedure. In those circumstances, there can be a disruption in the flow of outpatients, resulting in significant delays and patient dissatisfaction. Moreover, time associated with inpatient transportation to and from the wards to the EU was commonly recognized as a cause for prolonged TISP in this study. The increased length of stay of inpatients in the EU due to slow transit halts patient flow, as registered outpatients cannot be admitted until an admission/recovery bed becomes vacant. On the other hand, patient (e.g., medical comorbidities) or equipment (e.g., nonfunctional, unavailability) factors did not commonly (7.8%) delay TISP.

In light of these findings, we propose potential strategies that may improve “patient flow” processes and reduce TISP and thus increase efficiency. Currently, outpatient and inpatient procedures are performed in both interventional endoscopy rooms in no particular order. By preemptively reserving a time block each day for inpatient procedures, we may potentially reduce scheduling conflicts with the outpatient template and thus prevent short-notice changes that result in delays in outpatient admissions, prolonged TISP, reduced throughput and intuitively patient dissatisfaction. Using a “time and motion” analysis model, Harewood and colleagues [9] demonstrated that utilizing personnel to preconsent patients increased efficiency in the EU. Our endoscopy center is an open-access unit (some referred outpatients are directly scheduled for interventional endoscopic procedures without a prior clinic visit), which does not readily allow for pre-procedural education and informed consent of outpatients prior to arriving to the EU. On the other hand, inpatients referred for procedures are evaluated by the gastroenterology consultation service. By educating inpatients regarding their procedures and routinely obtaining informed consent in advance, length of stay in the EU could possibly be reduced. Also, pre-procedure anesthesia evaluation is routinely performed on inpatients requiring interventional endoscopic procedures. This assessment is often repeated by the “anesthesiologist of the day” prior to the procedure, thereby increasing NET in the EU. Hence, we believe that the development of a “gastrointestinal anesthesia team” that performs pre-procedure evaluation and also provides anesthesia for the procedure may circumvent this hurdle. Furthermore, by completing the necessary pre-procedural assessment prior to their arrival in the EU, inpatients could be directly transported into the endoscopy room and thus the assessment/recovery area could be used only for outpatients.

Improving inpatient transportation time can be a complex and daunting endeavor, as the limited transportation personnel are assigned to the entire hospital and not solely to the EU. Adding more transporters may hasten inpatient transit time and improve efficiency, but that strategy may be prohibitively costly. Alternatively, because IV access, pre-procedural and pre-sedation

evaluation can all be completed in the wards, inpatient transit can be streamlined directly into the endoscopy room and back to the wards, thus possibly reducing traffic and congestion through the admission/recovery room area. Future studies are needed to confirm whether these proposed interventions can reduce TISP and impact efficiency and throughput in the EU.

Our findings should be interpreted in light of the strengths and limitations of the study. The main strengths of our study are the comprehensive and detailed assessment of numerous performance parameters collected prospectively from a large sample of 1421 patients who underwent 1635 endoscopic procedures over a 6-month period. The measures included in our study are in line with the feasible and actionable metrics recently proposed for analyzing the efficiency in an endoscopy unit [12] but we acknowledge that many of the process measure indicators need to be validated before they can be widely applied to all EUs. Furthermore, unlike past studies [11], another strength of our study was the inclusion of inpatient endoscopy procedures in the analysis, as this is an integral when interpreting and evaluating operational efficiency in the EU. Although the results from our single endoscopy unit in an academic tertiary-referral center may not be generalizable to ambulatory surgical centers, this is the first study that has focused on identifying efficiency metrics in an interventional endoscopy setting based on the analysis of the available operational data set in our institution.

Our study also has various limitations. We acknowledge that our results are based on the analysis of recorded information available in the prospective database and that there are other additional variables that may affect efficiency that were not captured. Because the aim of the study was to identify potential process measures that can be used to assess EU efficiency, we recognize that our results are primarily descriptive, no pre- or post-intervention analysis was performed, and thus any causal inferences are limited. Also, cost implications of these metrics were not evaluated. However, given the scarcity of data on efficiency in interventional endoscopy centers, we believe that our findings successfully identified possible benchmarks for future interventions. In summary, delays in non-endoscopy time, specifically time interval between successive patients, rather than FIRST, were identified as possibly the main factor affecting efficiency in our interventional endoscopy unit. "Patient flow" processes (registration, admission, transportation) and not physician-related factors were the main reason for delays in the time interval between successive patients. By monitoring performance parameters in our interventional endoscopy unit, we have measured potential process measures that may be applicable as benchmarks to measure efficiency in other academic interventional endoscopic centers. Future studies are needed to develop simulation models or introduce actual strategies to help improve areas of suboptimal performance in the endoscopy unit with the ultimate goal of providing valued quality care to our patients.

Competing interests: None

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