Impact of fentanyl in lieu of meperidine on endoscopy unit efficiency: a prospective comparative study in patients undergoing EGD

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Background: Turnaround time is an important component of endoscopy unit efficiency. Any reduction in the total time from patient arrival in the endoscopy room to departure from the recovery area may translate into better endoscopy unit efficiency.

Objective: To evaluate the effects on endoscopy unit efficiency of a change in narcotic choice for moderate sedation in patients undergoing EGD at an ambulatory surgery center.

Design: Prospective, comparative, quality-improvement project.

Setting: Endoscopy unit of a tertiary-care academic medical center.

Patients: We enrolled consecutive patients (n = 1963) who underwent outpatient EGD by 1 of 5 endoscopists between November 2008 and November 2010.

Intervention: Moderate sedation with midazolam plus fentanyl versus meperidine.

Main Outcome Measurements: Sedation-dependent endoscopy unit efficiency and total procedure time (induction-to-intubation, intubation-to-extubation, and extubation-to-discharge).

Results: Fentanyl was associated with reduced total procedure time by 10.1 minutes resulting from both shorter induction-to-intubation time and extubation-to-discharge time ($P < .001$). The mean (± SD) sedation-dependent endoscopy unit efficiency was 3.2 (± 1.9) procedures per hour for the meperidine group and 3.9 (± 2.7) procedures per hour for the fentanyl group ($P = .012$); this would translate into possibly increasing the endoscopy suite efficiency by 22%. Based on dosage equivalency conversion, equal doses of fentanyl and meperidine were used. No sedation-related complications or need for reversal agents were recorded.

Limitations: No randomization was performed.

Conclusion: Compared with meperidine, fentanyl in combination with midazolam was associated with significantly shorter total procedure time. By improving the turnaround time, sedation-dependent endoscopy unit efficiency may be improved by 22%. (Gastrointest Endosc 2013;77:883-7.)

Moderate sedation is used for most endoscopic procedures in the United States. The American Society for Gastrointestinal Endoscopy recommends the use of analgesic and sedative drugs together.[1,2] Worldwide, moderate sedation for EGD is achieved most commonly by using propofol alone or the combination of midazolam with an opioid, specifically fentanyl or meperidine. In the United States, the combination of opioid (meperidine or fentanyl) and midazolam is favored.[3-5]

Fentanyl has greater synergy with benzodiazepines, faster onset, and shorter duration of action when compared with meperidine.[6] Because of these pharmacologic

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characteristics, fentanyl may be a better opioid choice for shorter endoscopic procedures like EGD. Robertson et al[7] and Hayee et al[8] have shown that the use of fentanyl has been associated with faster recovery time and therefore shorter total procedure time for both EGD and colonoscopy. In addition, Robertson et al found that the mean endoscopy time was shorter by almost 2 minutes in the fentanyl arm, although this difference was not statistically significant.[7]

A persistent effort to improve the quality of endoscopy service delivery is a necessity from an overall health care system perspective. The demand for endoscopies has been increasing, and improving endoscopy unit efficiency is an important goal in order to provide optimal health care.

Endoscopy unit efficiency has been measured previously[9] as volume of endoscopic procedures per unit of time. There have been no studies thus far evaluating the effect on endoscopic unit efficiency of moderate sedation with fentanyl and midazolam in EGD. The primary aim of our quality-improvement project was to determine whether fentanyl with midazolam as agents for moderate sedation in EGD are associated with improved sedation-dependent endoscopy unit efficiency when compared with meperidine with midazolam.

Furthermore, sedation studies published to date have not evaluated induction time as well as endoscopy and recovery time as separate components of total procedure time. Induction time may have significant impact on room turnover time, which has been found to be the main limiting factor of endoscopy unit efficiency.[9] The secondary aim of our project was to investigate each of the components of the total procedure time in more detail.

Take-home Message

- The use of fentanyl in place of meperidine for moderate sedation during EGDs was associated with a decreased total procedure time, by significantly shorter induction-to-intubation time and faster recovery time without affecting patient tolerance or successful completion of the procedure.
- By decreasing the induction-to-intubation time and therefore the turnover time, the use of fentanyl in place of meperidine for moderate sedation may improve the volume and efficiency of an endoscopy unit performing EGDs by 22%.

METHODS

A nonrandomized, prospective, quality-improvement study was completed between November 1, 2008 and November 1, 2010 at our academic, tertiary-care referral center. The study was exempt by the Mayo Clinic Arizona Institutional Review Board because it was a quality-improvement project. Consecutive, unselected adults (aged ≥18 years) who underwent routine outpatient EGDs by 1 of 5 experienced endoscopists (R.I.H., L.A.H., M.E.H., S.F.P., J.A.L.) were included in the study. The protocol for moderate sedation consisted of meperidine with midazolam from November 1, 2008 to November 1 2009 and fentanyl with midazolam from November 1, 2009 to November 1, 2010. No exclusion criteria were used in order to maintain application to ordinary clinical practice. The amount of medications given was left to the endoscopists' discretion.

Induction began when the first dose of intravenous sedation was given with either midazolam or an opioid. Procedure times were recorded per usual practice from insertion to withdrawal of the upper endoscope. As in our customary practice, patients received 2 L supplemental oxygen, and vital signs were monitored every 5 minutes during the procedure and every 15 minutes in the recovery area: oxygen saturation was measured by pulse oximeter, cardiac function was measured by telemetry (monitoring cardiac rhythm in lead II), and blood pressure was measured by automatic inflatable cuff. The Aldrete score was measured once in the before-procedure area at the arrival to the recovery area and every 15 minutes thereafter.

The endoscopy registered nurse documented the doses of narcotics and midazolam each time a medication was requested by the endoscopist. After the EGD, patients were taken to the after-procedure recovery area that is part of the endoscopy suite. The recovery time ended when the recovery nurse deemed the patient ready for discharge home based on assessment of standard endoscopy suite criteria: the Mayo Clinic Modified Discharge Scoring System. This scoring system requires that (1) the patient is able to take and retain fluids (eg, absence of intractable nausea and/or vomiting), (2) there is minimal or no bleeding, (3) the patient's mobility has been determined as safe for discharge (eg, patient is able to ambulate with minimal assistance if tolerated by physical status and the procedure), and (4) pain is adequately assessed and managed. All patients were discharged in the company of a designated responsible adult.

Data collection included demographics (age, sex, body mass index), doses of meperidine or fentanyl and midazolam, sedation-related cardiopulmonary complications, patient's tolerance assessed by the endoscopy nurse and the endoscopist at the end of the procedure (Table 1), procedure completed as intended and total procedure time (induction-to-discharge time) with its components (induction-to-intubation, intubation-to-extubation, and extubation-to-discharge). Dosage equivalency conversion between fentanyl and meperidine was calculated by using a 1:1.33 ratio (1 mg of meperidine = 1.33 mcg of fentanyl).[6]

Endoscopy unit efficiency was defined as the number of procedures performed per unit of time.[9] The room turnover time was defined as extubation-to-induction (next patient) plus induction-to-intubation.[9] The total turnover time was

TABLE 1. Procedure tolerance criteria

Excellent	Comfortable throughout the entire procedure after initial dose of medication given
Good	Comfortable throughout most of the procedure, needed minimal amount of additional medication and verbal reassurance
Fair-moderate discomfort	Uncomfortable throughout parts of the procedure, needed moderate amount of additional medication and verbal reassurance
Poor	Uncomfortable throughout most of the procedure, required increased amount of additional medication and verbal reassurance
Poor-combative	Uncomfortable throughout all of the procedure, required increased amount of additional medication, unable to verbally reassure, combative
Uncomfortable	Uncomfortable throughout most of the procedure but able to tolerate discomfort without additional medications per patient request

not thought to be the best measure of the effects of sedation on endoscopy unit efficiency, because it includes the time from extubation of one patient to induction of the next patient, and this time is dependent on the efficiency of the endoscopy room processes rather than the effects of sedation alone. Accordingly, we defined *sedation-dependent endoscopy unit efficiency* as induction-to-intubation combined with intubation-to-extubation, excluding the time of extubation-to-(next patient)-induction. Specifically, sedation-dependent endoscopy unit efficiency was calculated as 60 minutes divided by (induction-to-intubation time plus intubation-to-extubation time).

All statistical analyses were completed by using SAS (SAS System for Windows, version 9.2; SAS Institute, Inc, Cary, NC) or IBM SPSS (SPSS version 20; Chicago, Ill). Continuous data are presented as mean ± standard deviation (SD) or 95% confidence intervals (CI). Categorical data are summarized as frequencies and percentages. Generalized estimating equations were used to adjust for non-independence within endoscopist clusters for procedural level data. The differences between continuous variables were assessed by using *t* tests. The chi-square test was used to assess differences in distributions of categorical variables. Results were considered statistically significant for a (2-tailed) *P* value of $< .05$.

RESULTS

A total of 7262 EGD procedures were performed in our endoscopy unit during the study period. Of these, 1963 routine outpatient EGDs (27%) were performed by 1 of 5 experienced physicians participating in the project, and patients received either fentanyl or meperidine in addition to midazolam for procedural sedation. Among these 1963 EGD procedures, there were 1344 patients in the meperidine group and 619 patients in fentanyl group. There were no statistically significant differences with respect to age, sex, body mass index, and anesthesia sedation assessment classification between the two groups (Table 2).

TABLE 2. Baseline characteristics of patients

	Meperidine	Fentanyl	*P* value
No. of patients	1344	619	
Age, mean (SD), y	59 (16)	57 (17)	.111
Male sex, no. (%)	544 (40)	232 (38)	.214
BMI, mean (SD), kg/m^2	26.6 (5.6)	26.8 (5.5)	.630
ASA class, no. (%)			.274
I	206 (15)	75 (12)	
II	1082 (81)	517 (84)	
III	47 (4)	24 (4)	
IV	0 (0)	0 (0)	

SD, Standard deviation; *BMI,* body mass index; *ASA,* anesthesia sedation assessment.

Table 3 shows the procedure-related outcomes. Compared with meperidine, fentanyl was associated with significantly shorter mean (95% CI) total procedure times (69.7, 95% CI, 67.9-70.9 vs 79.8, 95% CI, 78.2-81.1 minutes); a mean reduction of 10.1 minutes per procedure. This significantly shorter duration was consistent across all its different components but mainly in the induction-to-intubation times (8.8 vs 14.9 minutes). The intubation-to-extubation (9.7 vs 10.4 minutes) and extubation-to-discharge (51.2 vs 54.5 minutes) times also were significantly shorter with the use of fentanyl.

The mean (95% CI) doses of meperidine and fentanyl administered during EGD procedures were 66, 95% CI, 64-67 mg and 87, 95% CI, 82-90 mcg, respectively; based on dosage equivalency conversion, there was no statistically significant difference between the total mean (95% CI) doses given (86, 95% CI, 82-90 vs 87, 85-90; $P = .648$). Fentanyl was administered by the endoscopy nurse more frequently per each procedure when compared with meperidine (2.5 [1.7] vs 2.0 [1.2] times; $P < .001$). Mean (95%

TABLE 3. Procedure-centered outcomes

Variable, mean (95% CI), minutes	Meperidine	Fentanyl	*P* value
Total procedure time	79.8 (78.2-81.1)	69.7 ([67.9-70.9)	< .001
Induction to intubation time	14.9 (14.2-15.7)	8.8 (8.3-9.2)	< .001
Intubation to extubation time	10.4 (10.1-10.8)	9.7 (9.3-10.0)	.004
Extubation to discharge time	54.5 (53.4-55.5)	51.2 (49.9-52.5)	< .001

TABLE 4. Patient-centered outcomes

Variable, no. (%)	Meperidine	Fentanyl	*P* value
EGD completed as intended	1321 (98)	606 (98)	.687
Tolerance			.449
Excellent	157 (12)	67 (11)	
Good	1103 (82)	509 (82)	
Fair-moderate discomfort	34 (2.5)	25 (4)	
Poor	5 (0.4)	0 (0)	
Poor-combative	9 (0.7)	3 (0.5)	
Uncomfortable	2 (0.1)	1 (0.2)	

CI) total midazolam doses were significantly higher in the fentanyl group: 6.0, 95% CI, 5.8-6.1 mg vs 5.2, 95% CI, 5.1-5.3 mg; $P < .001$.

The mean (± SD) sedation-dependent endoscopy unit efficiency was 3.2 (1.9) procedures per hour for the meperidine group and 3.9 (2.7) procedures per hour for the fentanyl group ($P = .012$). Improved sedation-dependent endoscopy unit efficiency with fentanyl would translate into potentially 7 additional EGDs per endoscopist per day, thus possibly increasing the efficiency of the endoscopy suite by 22%.

Patient-centered outcomes including procedure tolerance and completion of procedure were similar in both groups (Table 4). There were no cases of sedation-related cardiopulmonary complications or requirement for reversal agent use.

DISCUSSION

Improving endoscopy unit efficiency will allow endoscopists to continue to deliver high-quality care even as the demand for endoscopy grows and the pressure to manage costs becomes ever greater. This is the first quality-improvement project that assessed sedation-dependent endoscopy unit efficiency by comparing the use of meperidine with fentanyl in conjunction with midazolam for patients undergoing routine outpatient EGD.

Endoscopy room turnover time has been reported to be the main limiting factor in endoscopy unit efficiency.[9] We found that induction-to-intubation time was 6.1 minutes shorter with fentanyl when compared with meperidine ($P < .001$). If the extubation-to-(next patient)-induction component of room turnover time remains constant, the use of fentanyl could be associated with increased endoscopy unit efficiency of 22%.

Extubation-to-discharge (recovery) time was significantly shorter by 3.3 minutes, which is consistent with results of previous studies.[7,8] In addition, the actual procedure time (intubation-to-extubation) was 0.7 minutes shorter in the fentanyl group, which was statistically significant. The clinical significance of this relatively short difference in procedure time is not clear.

With the use of the dosage equivalency conversion, there was no statistically significant difference between the pharmacologically equivalent sedation doses of meperidine and fentanyl given ($P = .648$). The fentanyl group received more midazolam when compared with meperidine (6.0 vs 5.2 mg; $P < .001$). Even though this difference is statistically significant, it is likely not clinically meaningful because procedure tolerance and sedation-related adverse events were similar in both groups.

The main limitation of our project was the lack of randomization. A prospective, randomized, controlled trial should be done in the future to validate and generalize the findings from this project. However, studying consecutive patients done by the 5 endoscopists might better reflect the nature of patients undergoing outpatient EGD in clinical practice because we had no exclusion criteria. Additionally, there were no age, sex, or body mass index differences between the groups. There were unexpectedly more patients in the meperidine group. On review, we recognized that one of the study endoscopists using fentanyl required a medical leave during part of the project, thereby resulting in more patients in the meperidine group. However, we do not believe this led to significant unrecognized bias, because we have used generalized estimating equations to adjust for individual endoscopist variability on the overall differences in measured outcomes. Another limitation is that we did not measure the extubation-to-(next patient)-induction component of room turnover time but measured instead

the times required for patients to undergo each step of the procedure from induction to intubation, intubation to extubation, and extubation to discharge. Nonetheless, we believe that sedation-dependent endoscopy unit efficiency is better captured by measuring the time from induction to extubation, because the time from extubation of one patient to intubation of the next is dependent on organizational processes within the endoscopy unit rather than time required for sedation and recovery.

Our study was strengthened by the large sample size studied, lack of exclusion criteria, and prospective data collection for a quality improvement project. Another strength was the assessment of the length of the EGD procedure times in 3 separate phases that have not been evaluated thus far.

In summary, this is the first quality-improvement project showing that the use of fentanyl in place of meperidine for moderate sedation during EGDs is associated with decreased total procedure time by significantly shorter induction-to-intubation time and faster recovery time without affecting patients' tolerance or successful completion of the procedure. By decreasing the induction-to-intubation time and therefore the turnover time, we improved the volume and efficiency of our endoscopy unit performing EGDs by 22%. Endoscopists who customarily use meperidine for moderate sedation might consider switching to fentanyl for EGD to improve the efficiency of their endoscopy units. In addition, future studies should be done to evaluate whether this benefit would hold true for other endoscopic procedures.

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