In outpatient gastrointestinal (GI) endoscopy, for which postanesthesia care unit (PACU) stays are expected to be brief, sedative choices by anesthesia providers can affect costs. The purpose of this project was to evaluate the cost of propofol monotherapy compared with combination sedation consisting of propofol with any of the following: midazolam, fentanyl, dexmedetomidine, and/or ketamine. A total of 277 patients who underwent outpatient GI endoscopy were included in this retrospective medical record review. Patients were separated into 2 groups: propofol monotherapy (n = 233) or combination sedation (n = 44). Outcomes included PACU length of stay, episodes of postoperative nausea and vomiting (PONV), PACU costs, and medication costs. The average PACU length of stay was 35.0 minutes for propofol monotherapy and 35.75 minutes for combination sedation (P = .918). The average PACU cost was $566.37 for propofol monotherapy and $578.44 for combination sedation (P = .918). The average cost for sedatives was $3.13 for propofol monotherapy and $3.34 for combination sedation (P = .964). There was 1 incident of nausea among all patients. There were no significant differences in PACU length of stay, PACU cost, medication costs, and episodes of PONV between propofol monotherapy and combination sedation for outpatient GI endoscopy.

Keywords: Combination sedation, cost evaluation, gastrointestinal endoscopy, propofol monotherapy.
Patients who received propofol monotherapy experienced fewer episodes of PONV compared with patients who received propofol combined with midazolam and/or fentanyl, and fentanyl and midazolam without propofol. According to the data, sedation with a low dose of midazolam and/or opioid combined with propofol was superior to a standard combination of midazolam and an opioid for endoscopy regarding recovery times. However, the study findings showed that patients who received propofol monotherapy experienced fewer episodes of PONV compared with patients who received combination sedation. Yoon et al performed a systematic review to compare the efficacy and safety of propofol monotherapy compared with combination sedation. Yoon and colleagues found that propofol monotherapy had comparable efficacy and safety vs combination sedation in relation to recovery time and procedure time. In this study, the use of adjunct medication with propofol reduced the total dose of propofol used.

Medication choices by anesthesia providers can affect the PACU length of stay by causing patients to be too sedated for safe discharge home or by increasing PONV, ultimately influencing costs. Anesthesia providers can potentially decrease costs by implementing anesthetic techniques that are cost-effective and also decrease PONV and the PACU length of stay. Given the inconclusive evidence discovered through a review of literature and the fact that medication choices can considerably affect postprocedure outcomes, it is justified to examine anesthesia techniques and how those techniques affect PONV, PACU length of stay, and costs. The purpose of this project was to analyze the cost associated with using intravenous (IV) propofol monotherapy compared with using IV combination sedation consisting of a variety of combinations of propofol, midazolam, fentanyl, dexmedetomidine, and ketamine in patients undergoing GI endoscopy.

Materials and Methods
Following approval from the Doctor of Nursing Practice (DNP) Project Committee, University DNP Topic Approval Committee, hospital Quality Improvement Review Committee, chief anesthesiologist, and CRNA clinical director, a retrospective analysis was conducted on all patients who underwent outpatient GI endoscopy over a 14-day period during 2018 in the GI suite of a 249-bed acute care hospital. Patients were classified into 2 groups. The first group consisted of patients who received IV propofol monotherapy for their endoscopy. The second group consisted of patients who received IV combination sedation for their endoscopy. The sedation technique in each group was based on the provider’s choice. The sedative drugs that were chosen for the combination sedation group were based on practice behaviors of the anesthesia providers at the facility where this project was conducted.

Variables measured were the PACU length of stay, episodes of PONV, antiemetics administered, and anesthetics administered. Medications were directly compared by examining costs associated with each medication. Additional patient information that was collected included patient age, gender, and ASA physical status classification. Episodes of PONV were evaluated by the cost to manage episodes pharmacologically and the relationship to sedation technique. Medication administration data were collected from the electronic health record to calculate the

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<table>
<thead>
<tr>
<th>Outcome/medication</th>
<th>Cost, US $/mL&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>PACU length of stay</td>
<td>16.18/min</td>
</tr>
<tr>
<td>Dexmedetomidine</td>
<td>1.19</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>0.32</td>
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<tr>
<td>Ketamine</td>
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<tr>
<td>Midazolam</td>
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<tr>
<td>Ondansetron</td>
<td>0.15</td>
</tr>
<tr>
<td>Propofol</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Table 1. Postanesthesia Care Unit (PACU) and Medication Costs
<sup>a</sup>Unless otherwise indicated.
cumulative dose of sedative agents administered for each patient. Medication costs were obtained from the hospital's pharmacy and used to calculate the total cost of each medication administered in price per milliliter. Episodes of PONV were collected from patient electronic health records. Data on the length of PACU stay and the use of antiemetic medications were incorporated into the cost analysis. The length of PACU stay was determined from the times for the patient's admission to and discharge from the PACU documented in the electronic health record. The cost of PACU stay, obtained from the hospital's billing department, was calculated per minute of PACU stay.

Measurement of cost incorporated the price of total medications administered and the cost of the length of PACU stay for each patient. Table 1 lists the costs of medications administered during the time of data collected for this project as well as the cost of PACU stay per minute. The 2 groups of sedation techniques were evaluated by comparing cost per patient of medications administered, episodes of PONV, and cost of PACU stay. The cost analysis was based on total costs, including costs related to medication administration and PACU stay.

The data were analyzed using appropriate statistical analysis based on the variable being examined. Various parameters were summarized using descriptive statistics. Mean and standard deviation were used for quantitative variables. For continuous data, such as age, a Student t test was used. Categorical data, such as procedure and ASA classification, were compared using the χ² test. Considering that there was only 1 occurrence of nausea, the Fisher exact test was used. The Mann-Whitney (U) test was used to compare cost parameters due to nonnormal distribution between the 2 groups. A P value of less than or equal to .05 was considered significant.

### Results

**Patient Characteristics.** This project included 277 patients who underwent outpatient GI endoscopy over a 14-day period. The propofol monotherapy group consisted of 233 patients, and the combination sedation group consisted of 44 patients. Patient characteristics are found in Table 2. There were no statistically significant differences between the 2 groups in ASA classification, gender, and age.

- **Postoperative Nausea and Vomiting.** Among all 277 patients, there was no vomiting. There was 1 incident of nausea, which occurred in the combination sedation group. This patient had been prophylactically treated for PONV with ondansetron. An antiemetic was administered prophylactically for 36.5% of all patients, 77.3% of patients in the combination sedation group, and 28.7% of patients in the propofol monotherapy group.

- **PACU Length of Stay and PACU Costs.** The average PACU length of stay for both groups was 35.12 minutes (SD = 6.45 minutes), 35.0 minutes (SD = 6.24 minutes) for the propofol monotherapy group, and 35.75 minutes (SD = 7.51 minutes) for the combination sedation group. When standard deviation between the 2 groups was assessed, the data were more uniform in the propofol monotherapy group compared with the combination sedation group. The maximum PACU length of stay was 65 minutes, which was for a single patient in the propofol monotherapy group. There was no significant difference in the PACU length of stay between groups (P = .918).

Regarding the 65-minute outlier from the propofol monotherapy group, aside from having an ASA classification of 3, there were no definitive patient characteristics that justified why this patient had the maximum PACU stay. The patient's first sedation score recorded in the PACU was 10 of 10, which is the highest possible score and an appropriate score to be discharged home. Therefore, it is reasonable to assume that the patient did not have a prolonged PACU stay because of sedation administration but rather nonanesthesia factors. With the outlier corrected...
for, the average PACU stay for the propofol monotherapy group decreased to 34.8 minutes (SD = 5.93 minutes). The average PACU length of stay was nearly 1 minute shorter than the combination sedation group with the outlier removed. Regarding the standard deviations, the propofol monotherapy group had PACU stays that were more uniform than the combination sedation group, giving a more consistent PACU length of stay. Additionally, when the outlier was removed, the maximum PACU length of stay was attributed to the combination sedation group, which was 60 minutes. This patient was female, had an ASA classification 3, underwent esophagogastroduodenoscopy (EGD), and received ondansetron prophylactically. She was not considered an outlier because her sedation scores were 5 of 10 for the first 45 minutes of her PACU stay. Her sedation scores during the first 45 minutes in the PACU indicated that she was obtunded and somnolent and she coughed but not on command.

The highest recorded PACU cost of $1,051.70 was in the propofol monotherapy group, which is consistent with the longest PACU stay being in this group. Based on the cost per minute, the average PACU cost was $568.28 (SD = $104.35). The average PACU cost for the propofol monotherapy group was $566.37 (SD = $100.99) and was $578.44 (SD = $121.43) for the combination sedation group. There was no significant difference in PACU cost between groups (P = .918). After removal of the outlier in the propofol monotherapy group, the average PACU cost of the propofol monotherapy group decreased to $564.37, which was $14.07 less than the combination sedation group. The highest recorded PACU cost was then attributed to the combination sedation group, which was $970.80.

• **Drug Costs and Drug Doses.** When the data for both groups was combined, the average sedative cost for both groups was $3.16 (SD = $1.63), $3.13 (SD = $1.56) for the propofol monotherapy group and $3.34 (SD = $1.99) for the combination sedation group. There was no significant difference in sedative costs between groups (P = .964). Costs for sedative drugs and antiemetics were included in total drug costs. The average total drug cost was $3.37 (SD = $1.62) for both groups, $3.22 (SD = $1.56) for the propofol monotherapy group, and $3.57 (SD = $1.91) for the combination sedation group. There was no significant difference in total drug costs between groups (P = .475).

Table 3 summarizes the average dose and cost for each of the medications administered to all patients in both groups. One of the main reasons that providers use adjuvant sedative agents instead of propofol monotherapy is because it allows a decreased dose of propofol. In this project, the average dose of propofol in the propofol monotherapy group was greater than the combination sedation group, but when you consider the administration of the other medications, combination sedation can quickly become more expensive. For example, if an anesthesia provider administers 20 mL of propofol and 2 mL of dexmedetomidine, the drug costs increase to $4.58.

• **Total Costs.** When the costs related to sedative drugs, antiemetic medications, and PACU length of stay were combined for both groups, the average total cost was $571.56 (SD = $104.43) for both groups, $569.59 (SD = $101.08) for the propofol monotherapy group, and $582.01 (SD = $121.42) for the combination sedation group. There was no significant difference in total costs between both groups (P = .975). With the outlier corrected for, the average cost for the propofol monotherapy group decreased to $567.5 (SD = $96.13), which was $14.51 less than the combination sedation group. The highest recorded total cost was then attributed to the combination sedation group, which was $973.39.

Table 4 summarizes all variables that were evaluated for combined groups, the propofol monotherapy group, and the combination sedation group.

**Discussion**
This project examined the impact that sedative techniques had on healthcare costs, PACU length of stay, and...
PONV in patients undergoing outpatient GI endoscopy. In this project, there were no statistically significant differences in PACU length of stay, PACU costs, medication costs and total costs for patients undergoing outpatient GI endoscopy who received propofol monotherapy compared with combination sedation.

A key finding of this project was that there was 1 incident of nausea in the combination sedation group and no instances of vomiting between either group. Propofol monotherapy has been reported to be associated with lower rates of PONV compared with combination sedation in other studies. Watkins and colleagues compared fentanyl plus midazolam to propofol monotherapy in patients who had colonoscopies and reported that patients in the fentanyl plus midazolam group were significantly more likely to report feeling more nauseated \((P = .003)\) compared with those receiving the propofol monotherapy. Zhang et al. also reported that compared with combination sedation, propofol was associated with significantly lower rates of nausea \((P = .011)\) and vomiting \((P = .048)\). On the basis of this information and the results from this project, prophylactic antiemetics may not be warranted for outpatient GI endoscopy in patients who do not have a documented history of PONV.

The results of this project showed no difference in the PACU length of stay between patients who received propofol monotherapy vs combination sedation. In a randomized controlled trial that evaluated propofol monotherapy vs a combination of propofol with midazolam and/or fentanyl in patients undergoing GI endoscopy, Padmanabhan and colleagues found that time to PACU discharge \((22\text{ vs }21\text{ minutes}; P = .9188)\) and time to hospital discharge \((64\text{ vs }65\text{ minutes}; P = .4603)\) were similar between both groups. Their trial results are consistent with the findings of this project. However, our findings varied from other studies reviewed. Poulos and colleagues performed a retrospective cohort study that evaluated procedural efficiency in patients who had received propofol alone, propofol with midazolam and/or fentanyl, or midazolam with fentanyl as sedation for either EGD or colonoscopy. Recovery time was shorter for patients undergoing colonoscopy or EGD who received propofol monotherapy compared with the other 2 groups \((P < .05\text{ for both colonoscopy and EGD})\). Propofol alone resulted in quicker recovery and discharge from the PACU.

In our comparison of PACU costs and medication costs, there were no statistically significant differences between propofol monotherapy and combination sedation for patients undergoing outpatient GI endoscopy. Our findings were consistent with those of Uzman and colleagues, who performed a prospective, randomized, double-blind study comparing propofol vs midazolam and meperidine in 100 patients scheduled for diagnostic upper GI endoscopy. Their study found no significant difference in cost between the propofol vs combination sedation. However, our results vary from other reviewed studies. Vargo et al. provided a provider-perspective economic model that assessed the ability of propofol and fospropofol disodium to increase practice efficiency. They found that the use of propofol or fospropofol disodium can improve efficiency by enhancing recovery times for patients undergoing GI endoscopy. Using this economic model, Vargo and colleagues found that for every 2 colonoscopies completed with midazolam and meperidine, at
least 3 colonoscopies could be completed with propofol. Considering these findings, faster procedural and recovery times could help decrease costs and allow the opportunity for additional procedures to be performed, which has the potential to increase institutional revenue.

As shown in this project and current anesthesia practice trends, propofol monotherapy has become the anesthetic technique of choice for most anesthesia providers. Financial considerations are an increasingly important factor in healthcare decision making. Although this project did not achieve statistical significance between either sedative method, this project may still have operational importance to consider in GI suites. In the GI suite where this project was performed, an average of 20 cases are performed each day, with a range of 9 to 40 cases per day. With relatively short procedures, such as colonoscopy and EGD, where there are large volumes of procedures being performed each day, saving 6.5 minutes in the PACU length of stay could be enough to make a financial impact. By decreasing the PACU length of stay, more procedures could be performed, or staff could end their shifts at the scheduled times. Additionally, as found in this project, most of total costs came from PACU costs, with drug costs contributing minimally to overall costs. This finding further supports the efforts to determine the anesthetic technique that will result in the fastest recovery time in order to have the greatest financial impact.

There are limitations to this project that need to be considered. First, there was a large discrepancy in sample sizes between the 2 groups. The propofol monotherapy group was 5 times the size of the combination sedation group. This difference between groups was attributed to a previous project done in the GI suite at this facility that analyzed PONV, pain, and sedation scores in the PACU. After this earlier project, there was a practice change among anesthesia providers at this facility, which resulted in most anesthesia providers converting to propofol monotherapy for GI endoscopy. There was also a substantial difference in the number of patients who underwent colonoscopy vs EGD. For all patients, colonoscopy accounted for approximately 77% of all procedures and EGD accounted for 23% of all patients. These factors may have affected the reliability of the results. Another limitation was that data were collected by retrospective medical record review. As a result, providers’ documentation was relied on for data collection. Because the data used to calculate the length of PACU stay was documented before collection for this project, the PACU staff may not have perceived a need to be precise in documenting the exact time of patient discharge. There may also be confounding factors that were not factored into the data analysis. Regarding costs, there may be additional considerations to cost analysis rather than solely the PACU length of stay, PONV, and sedative or antiemetic costs, such as pain management, which may have resulted in incomplete analysis of cost for both anesthetic techniques. Last, even though propofol monotherapy was associated with reduced rates of PONV, 28.7% of these patients still received prophylactic antiemetics. This negatively affected the propofol monotherapy group when total costs were assessed because this may be an unnecessary additional cost added to this group. All these variables may have affected the results.

Furthermore, additional variables could have been collected to provide a more complete analysis of data. However, this was not anticipated when the data were retrospectively collected. It is important to mention that regarding the sedation cost, propofol was associated with the highest recorded cost, which was $13.12. This could have been related to the fact that this procedure was longer than other procedures, therefore requiring a larger sedative dose, which would relate to an increase in drug costs. However, at the time of the retrospective medical record review, procedure length was not a variable that was collected. It is important to note that the patient with the highest drug costs did not have a prolonged PACU stay, which was 30 minutes. Analysis of sedation scores solely for PACU lengths of stay that were outliers could have had an unanticipated impact on this analysis. It is possible that more PACU lengths of stay were influenced by factors other than awakening from sedation. However, this could not be examined without recording sedation scores for each patient in the PACU, which was not done at the time of data collection.

In conclusion, the results of this retrospective analysis found no statistically significant differences in the PACU length of stay, PACU cost, medication costs, and presence of PONV between propofol monotherapy and combination sedation for outpatient GI endoscopy. Considering that zero patients experienced PONV when using propofol monotherapy, it is reasonable to conclude that when providers use this sedative method, prophylactic antiemetic administration may be unnecessary to manage these patients without a documented history of PONV. Although there were no episodes of vomiting and only 1 episode of nausea in the combination sedation group, further investigation needs to be performed to determine if PONV prophylaxis is necessary in this patient population given the small sample size in the combination sedation group. Although statistically significant differences were not found in the outcomes measured, considering current practice trends, the findings in other studies, and the limitations of this project, additional research is needed to examine the effects of these 2 sedation techniques on costs, PONV, and PACU length of stay in this patient population.

REFERENCES


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DISCLOSURES

The authors have declared no financial relationships with any commercial entity related to the content of this article. The authors did not discuss off-label use within the article.