Impact of anesthesia technique on post-operative opioid use in open gynecologic surgery in an enhanced recovery after surgery pathway

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HIGHLIGHTS

- There is a gap in knowledge pertaining to the extent intra-operative anesthetic technique contributes to opioid consumption in enhanced recovery after surgery programs.
- This study showed that a total intravenous anesthesia technique led to a significant decline in post-operative opioid administration compared with the combined and inhalational techniques.
- Further studies are needed to clarify the potential role of total intravenous anesthesia as an opioid-sparing strategy.

ABSTRACT

Objective To examine the effect of anesthesia technique in an enhanced recovery after surgery (ERAS) pathway on post-operative opioid use.

Methods Patients undergoing open gynecologic surgery under an ERAS pathway from November 2014 through December 2018 were included retrospectively. All patients received pre-operative analgesia consisting of oral acetaminophen, pregabalin, celecoxib, and tramadol extended release, unless contraindicated. Patients received local wound infiltration with bupivacaine; the post-operative analgesic regimen was standardized. Patients were categorized by anesthesia technique: (1) inhalational, (2) total intravenous anesthesia (TIVA), and (3) combined technique. The primary outcome was post-operative opioid consumption measured as morphine equivalent dose, recorded as the total opioid dose received post-operatively, including doses received through post-operative day 3.

Results A total of 1184 patients underwent general anesthesia using either inhalational (386, 33%), TIVA (349, 29%), or combined (449, 38%) techniques. Patients who received combined anesthesia had longer surgery times (p=0.005) and surgical complexity was higher among patients who underwent TIVA (moderate/higher in 76 patients, 38%) compared with those who received inhaled anesthesia (intermediate/higher in 41 patients, 23%) or combined anesthesia (intermediate/higher in 72 patients, 30%). Patients who underwent TIVA anesthesia consumed less post-operative opioids than those managed with inhalational technique (0 (0–46.3) vs 10 (0–72.5), p=0.009) or combined anesthesia (0 (0–46.3) vs 10 (0–87.5), p=0.029). Similarly, patients who underwent the combined technique had similar opioid consumption post-operatively compared with those who received inhalational anesthesia (10 (0–87.5) vs 10 (0–72.5), p=0.34).

Conclusions TIVA technique is associated with a decrease in post-operative consumption of opioids after open gynecologic surgery in patients on an ERAS pathway.

INTRODUCTION

Enhanced recovery after surgery (ERAS) pathways have gained significant popularity over the last decade, incorporating evidence-based practices to minimize perioperative stress, bowel dysfunction, infection, and pain, and to promote early mobilization and recovery.[1 2] In gynecologic surgery ERAS guidelines, established by a consensus review of experts, promote multiple recommendations to achieve these goals specific to this surgical subspecialty.[3] One important component of these guidelines aiming to improve perioperative recovery is the anesthetic management. General anesthesia may be administered with inhalational anesthetics, total intravenous anesthesia (TIVA), or a combination of the two approaches. For an inhalational technique, volatile agents such as sevoflurane, desflurane, isoflurane, or nitrous oxide are available. A TIVA technique is based on the use of propofol as the main anesthetic agent and incorporation of intravenous pharmacologic adjuncts (dexmedetomidine, ketamine, magnesium, dexamethasone, and/or lidocaine) with mechanisms of action that work synergistically to provide analgesia, anti-inflammatory effects, and an opioid-sparing approach, while at the same time avoiding the use of inhalational agents.[4] Apart from the opioid-sparing characteristics of multimodal intravenous regimens offered by TIVA, it is also advisable to avoid inhalational agents because of the higher risk of postoperative nausea and vomiting.[5]

The new focus on decreasing post-operative opioid administration, due in large part to the national opioid epidemic and crisis, has led anesthesiologists to use different non-opioid medications to treat nociceptive pain.[4] Non-opioid alternatives for multi-modal analgesia include non-steroidal anti-inflammatory drugs

such as acetaminophen, gabapentin, dexmedetomidine, ketamine, lidocaine, magnesium, and dexamethasone. When used together as part of a multimodal analgesia technique, analgesics with different mechanisms of action may be additive or synergistic, a concept which lays the foundation for post-operative pain management within ERAS pathways.[5] Opioids are known to cause multiple side effects classified in the literature as opioid-related adverse drug events; used alone for post-operative analgesia they may lead to nausea/vomiting, sedation, constipation, ileus, and fatigue. To our knowledge, there is no previously published data in gynecologic oncologic surgery that has specifically evaluated the impact of anesthesia technique on opioid administration and consumption, or its impact on patient outcomes. To this end, we tested the hypothesis that the use of the TIVA technique would decrease post-operative opioid consumption in patients in an ERAS pathway undergoing open gynecologic surgery. Our primary objective was to determine the post-operative opioid consumption when using inhalational, TIVA, or combined anesthesia techniques.

METHODS

Study Design

The Institutional Review Board at The University of Texas MD Anderson Cancer Center approved the protocol (Protocol PA16-0082). Analysis included patients who underwent open gynecologic surgery under an ERAS pathway from November 2014 through December 2018. Anesthesiologists followed three basic management principles: goal-directed fluid management, multimodal analgesia by way of pre-operative analgesic administration, and an intra-operative opioid-sparing approach.

Anesthesia Technique

Patients were grouped into the inhalational group if the entire anesthetic comprised an inhalational anesthetic with opioids and no incorporation of any intra-operative analgesic adjuvant (ie, dexmedetomidine, ketamine or lidocaine) intravenous infusion. The TIVA group consisted of cases which were performed under a TIVA technique (mainly propofol infusion plus analgesic adjuncts at standard doses) for the entire duration of the surgery with no inhalational agent being used at any point in the case. The most common intra-operative analgesic infusions were ketamine and/or dexmedetomidine. In some cases, based on patient characteristics, standardized doses of other adjuvants were utilized in TIVA cases as part of the analgesic armamentarium of ERAS (eg, lidocaine and magnesium sulfate). Finally, the combined group comprised cases in which there was any combination of intravenous analgesic adjuvants (eg, ketamine 3–5 µg/kg/min or dexmedetomidine 0.2–0.3 µg/kg/hour) being administered with an inhalational agent (eg, sevoflurane or desflurane). In the TIVA and combined groups the intravenous anesthetic adjuvants used were not standardized and were at the discretion of the provider administering the anesthetic. The specific intra-operative anesthesia technique was at the discretion of the anesthesiologist, mainly based on clinical judgment and experience. Some factors that usually help anesthesiologists decide which anesthetic technique to use include the presence of co-morbidities (pulmonary and cardiovascular) and a history of nausea and vomiting.

Inclusion and Exclusion Criteria

Participants had to be 18 years or older and undergo a midline incision for an exploratory laparotomy for gynecologic surgery. For patients undergoing multiple surgeries at different time points, only the first surgery was included in the analysis. Patients on long-acting or scheduled opioid medications (four or more times a day for ≥7 days for short-acting opioid medications) were considered chronic opioid users with a history of chronic pain and were excluded. Patients undergoing pelvic exenteration or abdominal wall hernia repairs were excluded, as we could not ensure full participation in the ERAS pathway due to co-management with surgeons outside of our service line. In addition, patients undergoing emergency surgery were excluded. Surgical complexity was assessed by using the surgical complexity score which was categorized into three groups: low complexity (0–3), intermediate (4–7), and high (>7) according to previous publications.[6]

Analgesic Regimens

All patients on the ERAS pathway received multimodal pain management in the immediate pre-operative period: 1000 mg orally of acetaminophen, 300 mg orally of tramadol extended release, 400 mg orally of celecoxib, and 75 mg orally of pregabalin, unless the patient had a contraindication. Also, all patients received local wound infiltration with 60 mL of 0.25% bupivacaine (150 mg total) at the end of the surgical procedure. The postoperative analgesic regimen was standardized with standing orders of pregabalin 75 mg orally every 12 hours from post-operative day (POD) 0 until POD 2, ibuprofen 800 mg orally daily from POD 1, and acetaminophen 1000 mg orally every 6 hours from POD 0. If this standardized analgesic regimen was not enough to control the pain, opioids were administered per order set. Of note, none of the patients in our study received epidural analgesia, erector spinae blocks, or transversus abdominis blocks either prior to surgery or in the post-operative period.

Data Collection

Data were collected and managed using a REDCap (Research Electronic Data Capture) database as part of Quality Improvement study (QI-6033).[7] Data including demographic and clinical characteristics, surgical procedure, surgical complexity, length of stay, re-admissions, re-operations, and post-operative management (including pain medications, fluids, diet, and mobilization) were collected. Intra-operative opioid administration was recorded. Opioid consumption data were also collected on the day of surgery (POD 0) including opioids administered at the post-anesthesia care unit, and during the first 3 days (POD 3) after surgery. Morphine equivalent dose (MED) was calculated using a standard opioid equivalent dose based on the conversion table provided in the Compendium of Pharmaceutical & Specialties (Canadian Pharmacists Association 2008).[8]

Statistical Analysis

The primary objective was to compare post-operative opioid consumption when using inhalational, TIVA, or combined anesthesia techniques. Descriptive statistics were used to summarize the demographic and clinical characteristics of patients overall and by anesthesia technique. A χ^2 or Fisher's exact test were used to compare categorical variables among the anesthesia techniques.

A Kruskal-Wallis test was used to compare continuous variables among the anesthesia techniques (eg, amount of intra- and post-operative MED). For both the intra- and post-operative MED, post-hoc pairwise two-sided multiple comparison analysis was performed using the Dwass, Steel, Critchlow-Flinger method. P values <0.05 were considered statistically significant. All statistical analyses were performed using SAS 9.4 for Windows (SAS Institute Inc, Cary, NC).

RESULTS

Patient Characteristics

A total of 1184 patients underwent non-emergent open gynecologic surgery and were included in the analysis. Clinical and demographic characteristics of this cohort are summarized in Table 1. Overall median age was 58.8 years (range 18–87): for the inhalational group it was 60 years (range 20–86), for the TIVA group it was 58 years (range 18–80), and for the combined group it was 58 years (range 18–87) (p=0.055). In regards to body mass index, the overall median was 28 kg/m^2 (range 14.8–66.1): for the inhalational group it was 28.5 kg/m^2 (range 16.1–63.5), for the TIVA group it was 27.4 kg/m^2 (range 14.8–62.7), and for the combined group it was 28.3 kg/m^2 (range 15.8–66.1) (p=0.21). The American Society of Anesthesiologists (ASA) scores for the three groups were not different, with more than 90% of patients having an ASA 3 or 4. As for the intravenous anesthetics used intra-operatively in the TIVA group, the combination of ketamine plus dexmedetomidine plus lidocaine was used in 98 cases (28%), ketamine plus dexmedetomidine in 39 patients (11%), dexmedetomidine alone in 77 patients (22%), ketamine alone in 54 patients (15%), dexmedetomidine plus lidocaine in 56 patients (16%), and ketamine plus lidocaine in 25 (7%). In addition, there was no difference between the groups in the Charlson Comorbidity Index (p=0.20). Surgical complexity was higher (p=0.011) among patients who underwent TIVA (moderate/higher in 76 patients, 38%) compared with those who received inhaled anesthesia (intermediate/higher in 41 patients, 23%) or combined anesthesia (intermediate/higher in 72 patients, 30%).

Anesthesia Techniques

A total of 1184 patients underwent general anesthesia using either inhalational (386, 33%), TIVA (349, 29%), or combined (449, 38%) techniques. Patients who received combined anesthesia had longer surgery times compared with the other anesthetic techniques (p=0.005): inhalational 212 min (range 72–619), TIVA 216 min (range 33–722), and combined 230 min (range 55–885). Patients who underwent inhalational anesthesia technique were more likely to have a lower surgical complexity score (p=0.011). Opioid-free anesthesia (no intraoperative opioids) was observed in 41 cases, which differed significantly among the anesthesia techniques (p<0.001): inhalational (n=0, 0%), TIVA (n=33, 9.5%), and combined (n=8, 1.8%). Table 1 shows specific clinical and baseline characteristics of each group.

Primary Outcome

There was a significant difference in the amount of post-operative opioids received between the anesthesia technique groups (p=0.007). Patients who underwent the TIVA anesthesia technique received less post-operative opioids (MED) than those who underwent inhalational technique (0 (0–46) vs 10 (0–73), p=0.009) or combined anesthesia (0 (0–46) vs 10 (0–88), p=0.029). Patients who underwent the combined technique had similar opioid consumption post-operatively compared with those who received inhaled anesthesia (10 (0–88) vs 10 (0–73), p=0.34)

The distribution of post-operative MED by anesthesia technique is demonstrated in Table 2 and illustrated in Figure 1. Patients who received TIVA had significantly less median MED on POD 0 (7.5 (0–18.7)) and POD 1 (7.5 (0–27.5)), compared with the combined technique on POD 0 (10 (5–22.5)) and POD 1 (15 (0–37.5)), and with the inhalational technique on POD 0 (10 (5–20), p=0.011) and POD 1 (7.5 (0–30), p=0.011). The proportion of patients who did not receive any post-operative opioids (n=545, 46%) varied among the general anesthesia techniques (p=0.03). Approximately half of the patients who received TIVA did not receive any opioid post-operatively (n=181, 51.9%), 170 patients (43.6%) in the inhalational anesthetic group, and 194 (43.2%) in the combined anesthetic group.

DISCUSSION

Our study showed that in open gynecologic surgery in an institution with an established ERAS pathway, the anesthesia technique has an impact on post-operative opioid administration. We demonstrated that the TIVA technique led to a decline in post-operative opioid administration compared with the combined and inhalational technique. In addition, we also determined that the combined technique is not associated with a post-operative reduction in opioid administration when compared with an inhalational technique.

ERAS guidelines for gynecologic surgery establish the importance of both a standard anesthetic protocol and the use of opioid-sparing multimodal post-operative analgesia.[3] The summary and recommendation established is that the use of short-acting anesthetics (commonly used in TIVA) and a multimodal post-operative analgesic protocol successfully reduces opioid administration, both during hospitalization and at discharge. Usually multimodal analgesic regimens are accomplished using non-opioid oral medications (eg, gabapentin, acetaminophen, ketorolac) peri-operatively and incisional injection of local anesthetic (either standard bupivacaine with adjuncts or liposomal bupivacaine) to decrease the need for systemic medications.[9] The evidence level for the use of multimodal analgesia is high and decreases opioid administration.[3]

Several non-opioid intravenous anesthetic adjuncts may be used in combination with propofol to provide TIVA or with an inhalational agent to administer a combined technique; these include, but are not limited to, dexmedetomidine, ketamine, magnesium, dexamethasone, and lidocaine. In addition to its direct sedative-analgesic properties, dexmedetomidine, an α-2 agonist, also reduces opioid requirements and minimum alveolar concentration levels for inhalational anesthetics.[10] Ketamine may have benefits in reducing chronic post-operative pain, but the optimum treatment duration and dose for different operations is not yet identified.[11 12] The N-methyl-D-aspartate receptor antagonist action of ketamine provides analgesia, hence potentially reducing the need for opioids. Intravenous lidocaine infusion decreases intra-operative anesthetic requirements, lowers pain scores, reduces post-operative analgesic requirements, and improves return of bowel function, and has

Table 1 Patient characteristics

Characteristic	Overall N=1184	Volatile N=386 (33%)	Total intravenous N=349 (29%)	Combined N=449 (38%)	P value
Age					0.055
Mean (SD)	57.03 (12.92)	58.28 (12.91)	56.60 (12.40)	56.29 (13.26)	
Median (min, max)	58.0 (18.0, 87.0)	60.0 (20.0, 86.0)	58.0 (18.0, 80.0)	58.0 (18.0, 87.0)	
BMI (kg/m^2)					0.214
Mean (SD)	29.58 (7.68)	29.79 (7.78)	28.90 (7.20)	29.93 (7.92)	
Median (min, max)	28.0 (14.8, 66.1)	28.5 (16.1, 63.5)	27.4 (14.8, 62.7)	28.3 (15.8, 66.1)	
ASA score					0.872
I/II	110 (9.5%)	38 (9.9%)	30 (8.8%)	42 (9.5%)	
III/IV	1,054 (90.5%)	345 (90.1%)	311 (91.2%)	398 (90.5%)	
Charlson Comorbidity Index					0.202
0	120 (10.1%)	36 (9.3%)	33 (9.5%)	51 (11.4%)	
1–2	451 (38.1%)	132 (34.2%)	143 (41.0%)	176 (39.2%)	
3+	613 (51.8%)	218 (56.5%)	173 (49.6%)	222 (49.4%)	
Ethnicity					0.081
Hispanic or Latino	190 (16.0%)	67 (17.4%)	53 (15.2%)	70 (15.6%)	
Not Hispanic or Latino	948 (80.1%)	308 (79.8%)	274 (78.5%)	366 (81.5%)	
Unknown	46 (3.9%)	11 (2.8%)	22 (6.3%)	13 (2.9%)	
Race					0.096
White or Caucasian	809 (68.4%)	264 (68.4%)	253 (72.7%)	292 (65.2%)	
Black or African American	138 (11.7%)	43 (11.1%)	34 (9.8%)	61 (13.6%)	
Asian	64 (5.4%)	18 (4.7%)	12 (3.4%)	34 (7.6%)	
Native Hawaiian/Other Pacific Islander	2 (0.2%)	1 (0.3%)	1 (0.3%)	0 (0%)	
American Indian/Alaskan Native	4 (0.3%)	2 (0.5%)	1 (0.3%)	1 (0.2%)	
Other	132 (11.2%)	52 (13.5%)	35 (10.1%)	45 (10.0%)	
Unknown	33 (2.8%)	6 (1.6%)	12 (3.4%)	15 (3.3%)	
Any previous abdominal surgery (yes)	874 (73.8%)	284 (73.6%)	257 (73.6%)	333 (74.2%)	0.978
Prior chemotherapy (yes)	456 (38.5%)	143 (37.0%)	147 (42.1%)	166 (37.0%)	0.258
Prior radiotherapy (yes)	33 (2.8%)	13 (3.4%)	7 (2.0%)	13 (2.9%)	0.527
Tumor type					0.249
Malignant primary	735 (62.1%)	234 (60.6%)	226 (64.8%)	275 (61.2%)	
Malignant recurrent	146 (12.3%)	38 (9.8%)	48 (13.8%)	60 (13.4%)	
Neoplasm primary	61 (5.2%)	19 (4.9%)	19 (5.4%)	23 (5.1%)	
Neoplasm recurrent	1 (0.1%)	0 (0%)	0 (0%)	1 (0.2%)	
Benign	220 (18.6%)	85 (22.0%)	52 (14.9%)	83 (18.5%)	
None	21 (1.8%)	10 (2.6%)	4 (1.1%)	7 (1.6%)	
Estimated blood loss (mL)					0.248
Mean (SD)	427.09 (550.22)	437.73 (525.85)	383.12 (462.73)	452.23 (627.16)	
Median (min, max)	250 (5, 5550)	250 (5, 3000)	250.0 (10, 3500)	250 (10, 5550)	
OR time (minutes)					0.005
Mean (SD)	242.03 (106.16)	229.27 (92.06)	234.79 (96.45)	258.62 (121.62)	
Median (min, max)	218.5 (33.0, 885.0)	212 (72, 619)	216 (33, 722)	230 (55, 885)	

Continued

Table 1 Continued

Characteristic	Overall N=1184	Volatile N=386 (33%)	Total intravenous N=349 (29%)	Combined N=449 (38%)	P value
Surgical complexity					0.011
Low	415 (68.7%)	133 (76.4%)	121 (61.4%)	161 (69.1%)	
Intermediate	174 (28.8%)	37 (21.3%)	73 (37.1%)	64 (27.5%)	
High	15 (2.5%)	4 (2.3%)	3 (1.5%)	8 (3.4%)	

ASA, American Society of Anesthesiologists ; BMI, body mass index; OR, operating room.

been linked to a decreased length of hospital stay.[13] It is noteworthy to mention that the analgesic effects of these agents last up to 24–48 hours after surgery, thus it is likely that their analgesic duration explains the post-operative reduction in opioid consumption seen in this study. Furthermore, opioid-free anesthesia was more commonly seen among patients who received TIVA which might be due to the opioid-sparing properties of ketamine and dexmedetomidine. We also observed that the procedures in the TIVA group had higher complexity, which may be due to the faster emergence from anesthesia provided by TIVA, particularly in longer procedures (or in those of higher complexity); therefore, it is sometimes the preferred anesthetic choice in those cases.

It has been reported that 6% of opioid-naive patients will become chronic opioid users after surgery, while the rate is as high as 21% for those who require chemotherapy after surgery.[14 15] Reducing opioid administration among surgeons and anesthesiologists is an important facet of opioid reduction. A large, prospective initiative evaluated patient opioid use after surgery elective procedures and found that a large proportion of patients used little or no opioids after surgery.[16] In gynecologic surgery, Hillman et al evaluated patient characteristics and opioid use prior to discharge after open gynecologic surgery under an ERAS pathway and found that nearly half of the patients did not consume any opioids on the day before discharge.[17] The success of implementation of an ERAS pathway strongly relies on high levels of compliance among all members of the team. In a recent study by Iniesta et al,[18] the authors demonstrated that after implementation of an ERAS pathway the overall compliance was 72.3%, and those patients with compliance rates >80% had significantly lower complication rates and shorter length of stay. However, one element to highlight from that study was that when comparing pre-operative, intra-operative, and post-operative compliance with ERAS guidelines, the lowest level of compliance was in the intra-operative team. Therefore, further efforts must be made to improve this deficiency, and consideration of dedicated anesthesia teams that emphasize the importance of the implementation of multimodal analgesia, goal-directed fluid therapy, and opioid-sparing techniques, as well as consideration of an increase in the use of TIVA anesthesia techniques, should be encouraged.

The strengths of our study lie in the fact that our ERAS pathway implementation has been in place for over 5 years, and these data reflect opioid use under conditions when non-opioid pain control modalities are optimized. For our anesthesiology group, there has been an emphasis on pre-operative multimodal analgesia, goal-directed fluid management, and intra-operative opioid-sparing. In addition, this study is one of the largest series evaluating the impact of an intra-operative anesthetic approach on opioid administration and consumption in the post-operative period in patients undergoing gynecologic surgery. Our group has also maintained a database that is routinely audited, and data accuracy assessment is regularly performed against source documents. In addition, our study is a pragmatic/real life representation of anesthetic delivery describing techniques not often considered in previous studies.

We do recognize limitations such as the fact that these conclusions may not be broadly applicable to all practice environments, especially those where ERAS pathways do not yet exist or are in their infancy. In addition, we did not include information about premedication, opioids for induction of anesthesia, and other intra-operative factors that might have influenced post-operative opioid consumption, such as the amount of opioids given during surgery by anesthesiologists and the timing of administration. However, we want to emphasize that both groups had similar compliance with all the ERAS components according to our institutional protocol. Also, we did not extract information about the dose of ketamine and dexmedetomidine, which could impact post-operative analgesia. However, we would expect to see higher total doses of those adjuvants in the TIVA group because the anesthesia was mainly based on intravenous agents. Moreover, we did not look at opioid-related adverse events in the patient groups or chronic opioid users,

Table 2 Numerical summary of post-operative morphine equivalent dose by anesthesia technique

	Volatile		Total intravenous		Combined		
	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	P value
POD 0	10 (5–20)	15.3 (18.9)	7.5 (0–18.7)	12.3 (14.8)	10 (5–22.5)	15.3 (17.6)	0.011
POD 1	7.5 (0–30)	20.4 (28.7)	7.5 (0–27.5)	18.0 (25.2)	15 (0–37.5)	22.7 (27.3)	0.013
POD 2	7.5 (0–25)	18.4 (32.2)	5.0 (0–20.0)	13.8 (21.7)	7.5 (0–27.5)	17.0 (23.8)	0.187
POD 3	7.5 (0–30)	20.3 (32.3)	0 (0–15.0)	15.9 (28.6)	7.5 (0–30.0)	17.2 (25.5)	0.089
Cumulative	10 (0–72.5)	57.7 (103.5)	0 (0–46.25)	39.0 (68.7)	10 (0–87.5)	56.6 (90.4)	0.007

POD, post-operative day.

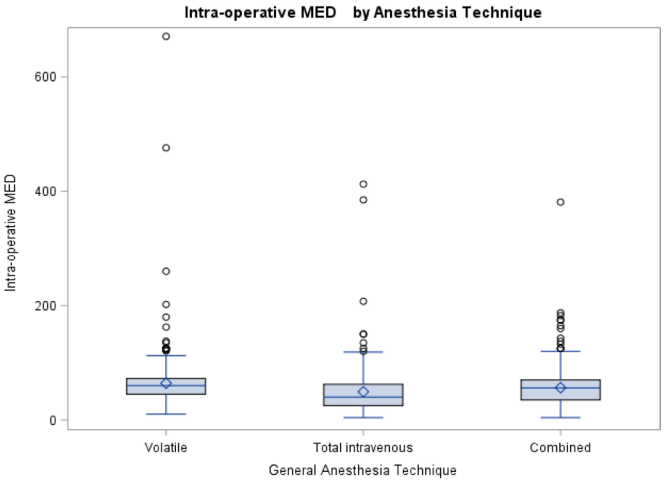

Figure 1 Boxplot of distribution of post-operative MED by anesthesia technique. Even though overall opioid use is decreased due to an ERAS pathway, the TIVA group has a cumulative decrease in post-operative administration. ERAS, enhanced recovery after surgery; MED, morphine equivalent dose; TIVA, total intravenous anesthesia.

which would have given this study more clinical relevance. Other limitations of the study include its retrospective design, exclusion of chronic opioid users, and the fact that anesthesiologists performed anesthetic techniques according to their discretion. Lastly, this study only addressed patients undergoing open gynecologic surgery, and patients undergoing minimally invasive surgery were not included. Although this study has a number of limitations, we encourage other authors to conduct further studies in order to clarify the potential role of TIVA as an opioid-sparing strategy.

Our study sheds light on the possible advantage of a TIVA technique in reducing opioid administration and consumption, and future prospective randomized trials on the effect of intra-operative technique are warranted to confirm whether TIVA administration provides a consistent opioid-sparing effect in the post-operative phases of care. In addition, our group is currently exploring patterns of practice among different anesthesiologists in our team to determine anesthetic techniques and to evaluate individual compliance.

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