An Analysis of Anesthesia-Controlled Operating Room Time After Propofol-Based Total Intravenous Anesthesia Compared with Desflurane Anesthesia in Ophthalmic Surgery: A Retrospective Study

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BACKGROUND: Anesthetic techniques can contribute to reduction of anesthesia-controlled time to improve operating room (OR) efficiency. However, little is known about the difference in anesthesia-controlled time between propofol-based total IV anesthesia (TIVA) and desflurane anesthesia (DES) techniques for ophthalmic surgery under general anesthesia.

METHODS: We performed a retrospective analysis using hospital databases to compare the anesthesia-controlled times of ophthalmic surgery patients receiving either TIVA via target-controlled infusion with propofol/fentanyl or desflurane/fentanyl-based anesthesia between January 2010 and December 2011. The various time intervals (surgical time, incision to surgical completion and application of dressings; anesthesia time, start of anesthesia to extubation; extubation time, surgery complete and dressings applied to extubation; time in OR, arrival in the OR to departure from the OR; postanesthetic care unit (PACU) stay time, arrival in the PACU to discharge from the PACU to the general ward; and total surgical suite time, arrival in the OR to discharge from the PACU to the general ward) that comprise a patient's hospital stay and the incidence of postoperative nausea and vomiting were compared between the 2 anesthetic techniques.

RESULTS: We included data from 1405 patients, with 595 patients receiving TIVA and 810 receiving DES. The extubation time was faster (TIVA-DES = −1.85 minutes, 99.2% confidence interval [CI], −2.47 to −1.23 minutes) and the PACU stay time was shorter (TIVA-DES = −3.62 minutes, 99.2% CI, −6.97 to −0.10 minutes) in the TIVA group than in the DES group. However, there was no significant difference in total surgical suite time between groups (TIVA-DES = −5.03 minutes, 99.2% CI, −11.75 to 1.69 minutes). We performed the random-effects analyses while stratifying for procedure and showed that the extubation time in the TIVA group was faster by 14% (99.2% CI, 9% to 19%, $P < 0.0001$) relative to the DES group, and the PACU stay time was faster by 5% (99.2% CI, 1% to 10%, $P = 0.002$). Significantly fewer patients suffered postoperative nausea and vomiting and required rescue therapy in the TIVA group than in the DES group (11.3% vs 32.2%, risk difference 21.0%, 95% CI, 16.9% to 25.1%, $P < 0.001$ and 23.9% vs 54.0%, risk difference 30.1%, 95% CI, 18.3% to 42.0%, $P = 0.002$, respectively).

CONCLUSIONS: In our hospital, the use of TIVA reduced the mean time to extubation by at least 9% and PACU stay time by more than 1% when compared with the use of DES anesthesia for ophthalmic surgery. (Anesth Analg 2014;XXX:00–00)

For surgical cases requiring general anesthesia, components of nonsurgical operating room (OR) time include induction of anesthesia (measured from the arrival of the patient in the OR until the start of positioning), extubation (time from application of the surgical dressing to extubation), and exit from the OR. The interval between the end of surgery and extubation (extubation time) is of special interest to surgeons and anesthesia care providers because it is affected by anesthetic drugs.[1–4] Cases with prolonged tracheal extubation times are rated by anesthesiologists as having poor recovery from anesthesia.[1] When surgeons score anesthesiologists' attributes on a scale from 0 ("not important") to 4 ("a factor that would make me switch groups/hospitals"), the average score for "patient quick to awaken" is 3.9.[4]

In Taiwan, Diagnosis Related Groups have taken part in hospital billing services since 2010, and this new billing system no longer conforms to the economic benefits of current anesthesia in the OR. Instead, with predetermined payments based on the diagnosis, the most cost-effective anesthetic techniques should be determined. Economical anesthetic drugs and short anesthesia-controlled times are required to remain competitive in the operating field.[5]

Total IV anesthesia (TIVA) via a target-controlled infusion (TCI) system incorporating the combined use of propofol and remifentanil has been shown to provide more rapid emergence than other anesthesia techniques.[6,7] In a randomized controlled study, earlier discharges were

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reported when propofol was compared with desflurane (DES) for laparoscopic cholecystectomy.[8] However, other investigators described faster recovery times when inhaled techniques were used,[3,9,10] but found no difference in recovery of cognitive function.[11] A meta-analysis comparing OR recovery times for DES and propofol reported that DES proportionally reduced the mean time to extubation and time to follow commands relative to propofol (21% and 23%).[3] However, no ophthalmic studies were included in this meta-analyses. After reviewing previous randomized studies[8,12–24] of extubation times comparing TIVA with inhaled anesthesia with DES (Table 1), we found no comparisons between TIVA with propofol and inhaled anesthesia for the improvement of anesthesia-controlled times in ophthalmic surgery under general anesthesia. Moreover, different propofol delivery techniques, such as TCI and syringe pump infusion, were used in the studies, and only a few studies reported results for TIVA with a TCI system. This study was designed to determine whether the use of TIVA with TCI is better than DES anesthesia in reducing anesthesia-controlled OR time in patients having ophthalmic surgery.

METHODS

This study was approved by the Ethics Committee (TSGHIRB No: 100-05-168) of Tri-Service General Hospital, Taipei, Taiwan (Chairperson, Professor Pauling Chu) on August 29, 2011.

Medical records and electronic hospital databases were collected and reviewed for all patients undergoing elective ophthalmic surgery from January 2010 to December 2011. Our study included 1405 patients who received TIVA or DES anesthesia. Exclusion criteria were patient age younger than 18 years, emergent surgeries, combined propofol and DES anesthesia, combined inhaled anesthesia with TIVA, other inhaled anesthesia besides DES, failure to extubate, patient not sent to the postanesthetic care unit (PACU), or incomplete data. The various time intervals that comprise a patient's hospital stay, postoperative nausea and vomiting (PONV), and rescue therapy for PONV were documented. The incidence of PONV indicates patients who had nausea or vomiting before discharge from the PACU.

For the purposes of this study, the following times (minutes) were calculated: (1) surgical time, incision to surgical completion and application of dressings; (2) anesthesia time, start of anesthesia to extubation; (3) extubation time, surgery complete and dressings applied to extubation; (4) time in OR, arrival in the OR to departure from the OR; (5) PACU stay time, arrival in the PACU to discharge from the PACU to the general ward; and (6) total surgical suite time, arrival in the OR to discharge from the PACU to the general ward.

Patient Groups

No medication was administered before induction of anesthesia; however, regular monitoring, such as electrocardiography (lead II) and measurement of pulse oximetry, noninvasive arterial blood pressure, respiratory rate, and end-tidal carbon dioxide pressure ($EtCO_2$), was performed. In all patients, anesthesia was induced with propofol and fentanyl. The patients were then tracheally intubated and maintained with the anesthetics DES or propofol and the analgesic fentanyl.

Total Intravenous Anesthesia and Target-Controlled Infusion with Propofol (TIVA Group)

In our clinical practice, TIVA was induced with fentanyl ($2\ \mu g \cdot kg^{-1}$) and lidocaine (2%, $1.5\ mg \cdot kg^{-1}$). Afterwards, continuous infusion of propofol (Fresenius 1%) was initiated

Table 1. Characteristics and Times from End of Surgery to Extubation of Previous Randomized Studies Comparing Propofol to Desflurane

Reference / year	*n* Propofol	*n* Desflurane	Remifentanil	TCI	Titrated BIS or AEP	Propofol (minutes) mean (SD) extubation	Desflurane (minutes) mean (SD) extubation	Surgical procedure
13/1997	14	14				9.9 (6.5)	6.9 (3.0)	General surgery (elderly)
14/1998	40	40				8.9 (5.3)	5.1 (3.3)	Ambulatory surgery
15/1998	30	30				5.6 (2.9)	4.4 (1.5)	Ambulatory surgery
16/2000	11	12			Yes	13.2 (7.6)	5.6 (1.4)	Laparoscopic gastroplasty (obesity)
17/2001	32	31	Yes	Yes		10.4 (3.0)	10.2 (5.1)	Ambulatory oral surgery
18/2001	25	25	Yes			5.5 (3.3)	5.7 (2.5)	Laparoscopic cholecystectomy
19/2002	30	30			Yes	8.7 (3.8)	6.1 (3.1)	Urologic surgery
20/2003	40	40	Yes			10.5 (5.9)	8.3 (6.1)	Gynecological surgery
20/2003	40	40	Yes		Yes	6.8 (4.6)	6.5 (4.1)	Gynecological surgery
21/2004	18	18	Yes	Yes		13.2 (2.3)	7.5 (1.3)	Spinal surgery
22/2006	25	25	Yes		Yes	6.9 (2.6)	6.4 (2.6)	Ambulatory surgery
12/2007	30	30		Yes	Yes	8.2 (3.0)	13.7 (5.0)	Laparoscopic gynecological surgery
23/2007	100	100				6.2 (3.2)	2.3 (1.6)	Laparoscopic cholecystectomy
24/2007	20	20	Yes			6.8 (3.7)	7.3 (3.4)	Septorhinoplasty
8/2009	30	30		Yes		6.4 (4.2)	7.6 (0.7)	Laparoscopic cholecystectomy

To identify published manuscripts comparing extubation time after desflurane and propofol in humans, we searched PubMed on November 8, 2013 with the following terms in any field: desflurane AND (propofol OR Diprivan) AND (extubation OR extubate), limited to humans.
n = sample size; TCI = target-controlled infusion; SD = standard deviation.

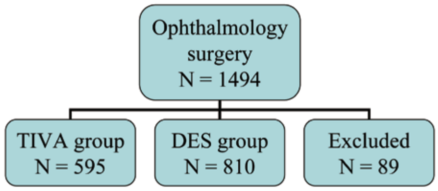

Figure 1. Flow diagram. TIVA = total intravenous anesthesia; DES = desflurane anesthesia.

using a TCI system programmed with the Schnider model (Fresenius Orchestra Primea, Fresenius Kabi AG, Bad Homburg, Germany) with the effective target concentration (Ce) 4 μg·mL^{-1}. Rocuronium (0.6 mg·kg^{-1}) was administered when patients lost consciousness, followed by tracheal intubation. Anesthesia was maintained using TCI with propofol Ce 3 to 4 μg·mL^{-1} and an oxygen flow of 0.3 L·min^{-1}. Repetitive bolus injections of rocuronium and fentanyl were prescribed as needed throughout the procedure.

Inhaled Anesthesia with Desflurane (DES Group)

In the DES group, anesthesia was induced with fentanyl (2 μg·kg^{-1}), lidocaine (2%, 1.5 mg·kg^{-1}), and propofol (2 mg·kg^{-1}). After loss of consciousness, rocuronium (0.6 mg·kg^{-1}) was administered, and tracheal intubation was performed. Anesthesia was maintained with 8% to 12% DES in an oxygen flow of 300 mL·min^{-1} under a closed system without nitrous oxide, and repetitive bolus injections of rocuronium and fentanyl were prescribed as needed throughout the procedure.

In our clinical practice, IV dexamethasone (5 mg) was added after tracheal intubation for preventing PONV. Maintenance of the Ce for the TCI propofol was adjusted at the range of 0.2 μg·mL^{-1} according to the hemodynamics, and maintenance of the DES concentration was adjusted at the range of 0.5% according to the hemodynamics. If 2 increments or decrements did not successfully stabilize the hemodynamics, the ranges of the Ce for the TCI propofol and the DES concentration were increased 0.5 μg·mL^{-1} and 2%, respectively. The ventilation rate and maximum airway pressure were adjusted to maintain the $EtCO_2$ pressure at 35 to 45 mm Hg. Cisatracurium (2 mg, IV) was administered as required by the return of neuromuscular function.

At the end of the operation, DES or propofol was discontinued, and the lungs were ventilated with 100% oxygen at a fresh gas flow of 6 L·min^{-1}. When the patient regained consciousness with spontaneous and smooth respiration, the endotracheal tube was removed.

Statistical Analysis

Data are presented as mean and standard deviation, or number of patients or percentage. Demographic data were compared using the Student t test or the χ^2 test. Analyses of the operation times were performed in the log-scale (Appendix). The significance of the differences in the perioperative variables between groups was evaluated by 99.2% confidence intervals (CI) of the differences that were constructed by the generalized pivotal quantity approach[3,25] (R, version 3.0.1, "pairwise CI" package).

Data in this study were stratified according to surgical procedure in all analyses to avoid Simpson's paradox.[26] To facilitate interpretation of the results, we used meta-analysis methods to pool the stratification results, as described by Ledolter and Dexter.[25] Heterogeneity among 3 groups was estimated using I^2 and Cochran Q test. A random-effects model based on the Mantel-Haenszel method was applied, and the τ^2 statistic was estimated by the DerSimonian-Laird method. When the test of heterogeneity in a specific perioperative variable was not significant, we considered that results of pooled analyses were more nearly representative of population parameters. Otherwise, the stratification results were considered.

The significance tests of the perioperative variables were adjusted by the Bonferroni method, and we considered a P value of $<0.05/6 = 0.008$ as significant for avoiding errors of multiple testing in this study. Finally, the log ratio of means and 99.2% CI are presented to explain clinical meanings. Statistical analyses were performed with R 3.0.1 statistical software with the "metafor" package.

Table 2. Patient's Characteristics, PONV Incidence and Management, and Hospital Days

	TIVA (n = 595)	DES (n = 810)	P value
ASA I/II/III	114/336/145	168/440/202	
Gender (M/F)	343/248	476/334	0.780
Age (y/o)	55.2 ± 16.2	55.3 ± 16.3	0.900
Height (cm)	164.7 ± 6.5	163.6 ± 7.7	0.872
Weight (kg)	63.5 ± 9.6	62.3 ± 8.1	0.852
PONV	67 (11.3%)	261 (32.2%)	<0.001
Rescue for PONV	16 (23.9%)	141 (54.0%)	0.002
Hospital days	4 (2–10)	4 (2–11)	0.796

Data are shown as mean ± SD or numbers (%).
TIVA = total IV anesthesia; DES = desflurane anesthesia; PONV = postoperative nausea and vomiting.

RESULTS

Eighty-nine patients were excluded from the analysis. Of those excluded, 12 patients received combined inhaled anesthesia with propofol, 62 patients received sevoflurane anesthesia, and 15 patients had incomplete data (Fig. 1).

Our study included 1405 patients, with 595 receiving TIVA and 810 receiving DES anesthesia. There was no significant difference in patient demographics and hospital stays between groups (Table 2). The extubation time was faster (TIVA-DES = −1.85 minutes, 99.2% CI, −2.47 to −1.23 minutes, Table 3) and the PACU stay time was shorter (TIVA-DES = −3.62 minutes, 99.2% CI, −6.97 to −0.10 minutes, Table 3) in the TIVA group than in the DES group. The surgical time, anesthesia time, time in OR, and total surgical suite time were not significantly different, but there were narrow CIs between groups (Table 3). The only consistent result for different ophthalmic procedures was faster extubation in the TIVA group than in the DES group (TIVA-DES in glaucoma surgery = −1.75 minutes, 99.2% CI, −2.78 to −0.77 minutes; TIVA-DES in vitrectomy = −1.84 minutes, 99.2% CI, −2.76 to −0.93 minutes; TIVA-DES in other ophthalmic surgeries = −2.03 minutes, 99.2% CI, −3.76 to −0.47 minutes, Table 3).

Table 4 shows the assessment of heterogeneity among 3 surgery procedures between the 2 anesthetic techniques. The heterogeneity assessment of pooled analyses revealed that extubation time and PACU stay time were homogenous and showed that the TIVA group had faster extubation time by

Table 3. Comparisons of Various OR Time Intervals Between Different Anesthetic Techniques and Different Surgical Procedures

	TIVA		DES		Difference		
	Mean	SD	Mean	SD	Estimate	99.2% CI	
Overall	*n* = 596		*n* = 810				
Surgical time (min)	129.1	39.9	129.2	45.6	−0.20	−6.21	5.74
Anesthetic time (min)	151.0	40.4	151.9	45.8	−0.96	−6.71	5.06
Extubation time (min)	9.1	3.1	10.9	4.4	−1.85*	−2.47	−1.23
Time in OR (min)	166.4	41.0	167.8	46.4	−1.43	−7.50	4.65
PACU stay time (min)	68.7	20.1	72.3	19.7	−3.62*	−6.97	−0.10
Total surgical suite time (min)	235.1	45.0	240.1	50.8	−5.03	−11.75	1.69
Glaucoma surgery	*n* = 219		*n* = 276				
Surgical time (min)	110.0	28.5	112.7	33.5	−2.81	−10.01	4.22
Anesthetic time (min)	131.4	29.2	135.2	33.4	−3.85	−11.16	3.22
Extubation time (min)	8.9	3.3	10.6	4.0	−1.75*	−2.78	−0.77
Time in OR (min)	146.3	29.5	150.6	33.9	−4.34	−11.64	2.94
PACU stay time (min)	68.6	19.4	71.8	20.4	−3.36	−9.31	2.52
Total surgical suite time (min)	214.8	35.5	222.4	40.9	−7.61	−17.02	1.44
Vitrectomy	*n* = 259		*n* = 382				
Surgical time (min)	144.0	39.3	135.6	45.2	7.93	−1.25	16.86
Anesthesia time (min)	166.2	39.6	158.5	45.1	7.52	−1.47	16.51
Extubation time (min)	9.2	3.1	11.0	4.3	−1.84*	−2.76	−0.93
Time in OR (min)	182.1	40.2	174.7	46.1	7.35	−1.62	16.52
PACU stay time (min)	69.2	21.0	72.8	19.0	−3.55	−8.69	1.60
Total surgical suite time (min)	251.3	44.1	247.4	50.6	3.79	−5.93	13.57
Other surgeries	*n* = 118		*n* = 152				
Surgical time (min)	132.1	44.4	142.9	56.2	−10.86	−27.64	5.82
Anesthesia time (min)	154.1	44.7	165.9	57.0	−11.76	−28.98	4.83
Extubation time (min)	9.2	2.9	11.1	5.2	−2.03*	−3.76	−0.47
Time in OR (min)	169.1	45.2	181.9	56.9	−12.65	−29.16	3.54
PACU stay time (min)	67.9	19.5	71.9	20.2	−4.07	−12.08	4.01
Total surgical suite time (min)	237.0	47.9	253.7	58.4	−16.72	−34.08	0.70

Data are shown as mean and standard deviation (SD). Estimate of difference and 99.2% CI was calculated based on generalized pivotal quantities.
TIVA = total IV anesthesia; DES = desflurane anesthesia; PACU = postanesthetic care unit; OR = operation room; 99.2% CI = 99.2% confidence intervals.
*$P < 0.008$.

Table 4. The Random-Effects Analysis Stratified by Procedure

	Pooled exp (difference)					
	Estimates	99.2% CI		*P* value	I-square	*P* value for Q test
Surgical time	1.01	0.91	1.12	0.8438	82.77%	0.0030
Anesthetic time	1.00	0.91	1.09	0.9492	83.09%	0.0027
Extubation time	0.86	0.81	0.91	0.0000	0.00%	0.7762
Time in OR	0.99	0.91	1.08	0.8319	83.96%	0.0020
PACU stay time	0.95	0.90	0.99	0.0020	0.00%	0.9080
Total surgical suite time	0.98	0.92	1.04	0.3799	80.78%	0.0055

P values < 0.008 were considered significant. I-square and Q-test are the measures of heterogeneity among 3 surgery procedures.
DES is reference, e.g., TIVA group had faster extubation time by 14% (0.86) and PACU stay time by 5% (0.95) relative to the DES group; 99.2% CI = 99.2% confidence intervals.
PACU = postanesthetic care unit; OR = operation room; exp = exponential of analysis in the log-scale (proportions); TIVA = total IV anesthesia.

14% (99.2% CI, 9% to 19%, $P < 0.0001$) and PACU stay time by 5% (99.2% CI, 1% to 10%, $P = 0.002$) relative to the DES group.

Table 5 gives summary statistics for the 6 OR time intervals among surgery procedures and the 2 anesthesia groups. The stratified analysis by surgical procedures showed that the TIVA group had slower surgical time by 8% (99.2% CI, 2% to 15%, $P = 0.0008$), slower anesthesia time by 6% (99.2% CI, 1% to 12%, $P = 0.0031$), and slower time in OR by 5% (99.2% CI, 0% to 11%, $P = 0.0054$) in vitrectomy surgery compared with the DES group. These results were similar to those for the Mann-Whitney *U* test (Table 5). Only 1 of 18 tests obtained different conclusion.

The percentage of patients suffering PONV and requiring rescue therapy in the TIVA group was significantly less than in the DES group (11.3% vs 32.2%, risk difference 21.0%, 95% CI, 16.9% to 25.1%, $P < 0.001$, and 23.9% vs 54.0%, risk difference 30.1%, 95% CI, 18.3% to 42.0%, $P = 0.002$, respectively).

DISCUSSION

The major findings in this retrospective study show that propofol-based TIVA by TCI reduced the mean time to extubation (14%) and PACU stay time (5%) relative to DES in patients undergoing ophthalmic surgery. These findings are not consistent with the limited information obtained from previous randomized trials. However, our results are important because the extubation time and PACU stay time differed significantly among types of surgery and anesthetic drugs.

Table 5. Summary Statistics for the 6 Operating Room Time Intervals Among Surgery Procedure and 2 Anesthesia Groups

	TIVA		DES		Difference [ln(TIVA) – ln(DES)]		Exp (difference)			*P* value	Mann-Whitney *P*-value
	Mean	SD	Mean	SD	Mean	SE	Estimates	99.2% CI			
Surgical time											
Vitrectomy	144.0	39.3	135.6	45.2	0.0802	0.0239	1.08	1.02	1.15	0.0008	0.0006
Glaucoma	110.0	28.5	112.7	33.5	−0.0139	0.0235	0.99	0.93	1.05	0.5542	0.7136
Others	132.1	44.4	142.9	56.2	−0.0576	0.0435	0.94	0.84	1.06	0.1855	0.2903
Anesthetic time											
Vitrectomy	166.2	39.6	158.5	45.1	0.0597	0.0202	1.06	1.01	1.12	0.0031	0.0018
Glaucoma	131.4	29.2	135.2	33.4	−0.0223	0.0199	0.98	0.93	1.03	0.2625	0.3609
Others	154.1	44.7	165.9	57.0	−0.0568	0.0356	0.94	0.86	1.04	0.1106	0.2209
Extubation time											
Vitrectomy	9.2	3.1	11.0	4.3	−0.1459	0.0317	0.86	0.79	0.94	<.0001	<.0001
Glaucoma	8.9	3.3	10.6	4.0	−0.1651	0.0362	0.85	0.77	0.93	<.0001	<.0001
Others	9.2	2.9	11.1	5.2	−0.1198	0.0535	0.89	0.77	1.02	0.0251	0.0025
Time in OR											
Vitrectomy	182.1	40.2	174.7	46.1	0.0520	0.0187	1.05	1.00	1.11	0.0054	0.0022
Glaucoma	146.3	29.5	150.6	33.9	−0.0241	0.0182	0.98	0.93	1.02	0.1854	0.2460
Others	169.1	45.2	181.9	56.9	−0.0604	0.0344	0.94	0.86	1.03	0.0791	0.1840
PACU stay time											
Vitrectomy	69.2	21.0	72.8	19.0	−0.0629	0.0266	0.94	0.88	1.01	0.0180	0.0470
Glaucoma	68.6	19.4	71.8	20.4	−0.0453	0.0302	0.96	0.88	1.04	0.1336	0.0969
Others	67.9	19.5	71.9	20.2	−0.0562	0.0408	0.95	0.85	1.05	0.1684	0.0445
Total surgical suite time											
Vitrectomy	251.3	44.1	247.4	50.6	0.0215	0.0148	1.02	0.98	1.06	0.1454	0.1616
Glaucoma	214.8	35.5	222.4	40.9	−0.0315	0.0156	0.97	0.93	1.01	0.0432	0.0443
Others	237.0	47.9	253.7	58.4	−0.0622	0.0261	0.94	0.88	1.01	0.0171	0.0172

P values <0.008 were considered significant.

DES is reference, e.g., TIVA group had slower surgical time by 8% (1.08), slower anesthesia time by 6% (1.06), and slower time in OR by 5% (1.05) in vitrectomy surgery compared with the DES group; 99.2% CI = 99.2% confidence intervals.

TIVA = total IV anesthesia; DES = desflurane anesthesia; PACU = the postanesthetic care unit; OR = operation room; Exp = exponential of analysis in the log-scale (proportions).

On any workday, the cost of a change in OR time depends on the total OR hours for which the drug or device reducing OR time is used.[2] If the workday were filled exactly, reducing OR time would not result in an increase in OR productivity because the value of the resulting underutilized time is negligible on the day of surgery. Reductions in OR time reduce direct labor costs either when the OR has overutilized time or when there is appropriately more than 8 hours of staffing planned for the OR and the staffing can be reduced to 8 hours.[27–29] The reduction in direct cost will be largest for facilities at which all ORs consistently are used for more than 8 hours daily. Among those ORs, each 1-minute reduction in OR time results in an overall 1.1- to 1.2-minute reduction in regularly scheduled labor costs.[27,29] Prolonged time to extubation has been defined as the occurrence of a 15-minute or longer interval from the end of surgery to removal of the tracheal tube.[2,30,31] In a cohort study of cases with prolonged tracheal extubation times, Epstein et al.[32] showed that the prolonged tracheal extubation times should be treated as proportionally increased OR variable costs. Consequently, small reductions in OR time achieved by reducing the extubation time and PACU stay time, as reported in this study, would reasonably be treated as having economic benefit, since our OR workday is longer than 8 hours. Additionally, the intangible value of time saved may be achieved from more predictable recovery (e.g., fewer frustrated surgeons complaining of the delay on beginning the next case).

Differences in OR recovery times between anesthetic drugs are extensively studied because they can limit OR throughput, based on data showing that nonanesthesia OR personnel must wait for the patient to be extubated during emergence in most (> 66%) cases.[33,34] Masursky et al.[30] described that longer times to extubation are associated with an increased chance of at least one person waiting or being idle in the OR (slowing workflow). Cases with prolonged tracheal extubation times also have longer times from OR exit to the start of the surgeon's next case in the OR.[2] Recently, Dexter and Epstein[35] showed that the mean times from end of surgery to OR exit were at least 12.6 minutes longer for prolonged extubations compared with extubations that were not prolonged. Therefore, selection of an anesthetic technique associated with faster extubation is related to rapid OR workflow and decreases the time from OR exit until the start of the surgeon's next case.[2,30] An anesthetic technique with shorter extubation times would decrease waiting time for the OR staff and decrease the time from the end of surgery until OR exit.[35]

The extubation times differ significantly among anesthetic drugs.[2,3,36] Propofol has become popular for general anesthesia, especially in the ambulatory setting. It is often used in combination with remifentanil because both drugs have been reported to enable rapid emergence and early return to normal activities.[18,36] Remifentanil was not available in Taiwan until now. However, in our previous studies, we showed that the combination of propofol and fentanyl was cost saving and resulted in faster emergence and extubation in long-term spinal surgery when compared with DES and sevoflurane anesthesia.[37] In this retrospective study with patients undergoing ophthalmic surgery, we also found that propofol-based TIVA by TCI reduced the mean time to extubation and PACU stay time relative to DES. Our findings were different from the results of a meta-analysis[3] comparing the OR recovery time of DES with that of propofol. The different type of surgery (ophthalmic surgery) might explain the differences in findings. For the purpose of smooth emergence and extubation in patients undergoing ophthalmic surgery, we did not use high gas flow after turning off DES, and we turned off the anesthetic drugs later than in breast, gynecologic, and spine surgeries to prevent coughing and straining during emergence, which takes about 5 minutes. Finally, we used closed-circuit anesthesia in the DES patients, which would also prolong neuromuscular blockade and delay extubation times.[38]

In this retrospective study, all patients received IV dexamethasone to prevent PONV. Nevertheless, we still found that the incidence of PONV and the need for antiemetics were significantly less in the TIVA patients than in the DES patients. TIVA with propofol has been documented as reducing the incidence of PONV in the early recovery period.[39,40] Use of the TCI anesthetic technique and the associated reduction in PONV would decrease the workload of the PACU staff, resulting in shorter PACU stays compared with DES anesthesia.

A retrospective study design may lead to bias regarding standardization and comparability of study groups. For the purpose of this study, retrospective analysis of data offered a major advantage, namely that anesthetic management was performed by the attending anesthesiologist according to clinical demands and was not determined by a study protocol. The study, performed under real clinical conditions, reflects more precisely the clinically relevant benefit that may be expected with the use of new drugs or devices.

In conclusion, our results showed that propofol-based TIVA by TCI reduced the mean time to extubation by at least 9% and PACU stay time by more than 1% relative to DES in ophthalmic surgery. Propofol-based TIVA by TCI also decreased PONV, an anesthesia-related complication. However, the modest reduction in extubation time (1.85 minutes) and PACU stay time (3.62 minutes) will have an economic impact on increasing OR productivity and reducing labor costs because our ORs are consistently used for more than 8 hours daily.

APPENDIX

In terms of the proper distributions of our data, no matter normal or log-normal, none of them were perfectly fit. However, we have compared all results between 2 methods by using the Mann-Whitney *U* test and the results were similar. Only 1 out of 18 tests obtained different conclusion. These results were also consistent with another analytical method by using the generalized pivotal quantity approach. All conclusions were the same except for "Time in OR" in the vitrectomy group. So we decided to apply log-normal because the results were robust and it may be the more appropriate approach.

The figures of different pages were order to surgical time, anesthetic time, extubation time, time in OR, PACU stay time, and total surgical suite time.

Tests of assumptions of log-Normality and homogeneity of variances in log scale between treatments.

Treatment	*n* DES	*n* TIVA	Anderson-Darling test DES						Anderson-Darling test TIVA						Levene's test					
			Time 1	Time 2	Time 3	Time 4	Time 5	Time 6	Time 1	Time 2	Time 3	Time 4	Time 5	Time 6	Time 1	Time 2	Time 3	Time 4	Time 5	Time 6
Vitrectomy	382	259	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	0.018	0.008	0.011	0.019	0.013
Glaucoma	276	219	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.028	0.061	0.600	0.080	0.888	0.319
Others	152	118	0.002	0.002	<0.001	<0.001	<0.001	0.007	0.030	0.018	<0.001	0.017	<0.001	0.018	0.008	0.005	<0.001	0.014	0.700	0.097

The Anderson-Darling test for normality was applied after log transformation. Levene's test compared variance in the log scale between the 2 groups.
TIVA = total intravenous anesthesia; DES = desflurane anesthesia; *n* = sample size; Time 1 = Surgical time; Time 2 = Anesthetic time; Time 3 = Extubation time; Time 4 = Time in OR; Time 5 = PACU stay time; Time 6 = Total surgical suite time.

DISCLOSURES

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Attestation: Zhi-Fu Wu has reviewed the original study data and data analysis, and approved the final manuscript.
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