

A prospective observational study of the use of desflurane anesthesia in Indian adult inpatients undergoing surgery: The Registry in India on Suprane Emergence registry

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Abstract

Background and Aims: Limited registry studies are available on the use of anesthetic agents. This registry was conducted to evaluate emergence outcomes in Indian adult patients undergoing surgery with desflurane anesthesia.

Material and Methods: This multicenter, prospective, non-interventional, observational study (Registry in India on Suprane Emergence [RISE] registry) included adult inpatients who received desflurane as general anesthetic for surgical procedure of ≥ 2 h. Patients were stratified by age into three groups: ≥ 18 –40 years, ≥ 41 –65 years, and > 65 years. Data on patients' demographics, practice, and usage pattern of medications were collected. The primary efficacy outcomes were time to extubation, time to response to verbal command, and time to orientation.

Results: Of 236 patients screened, 201 (≥ 18 –40 years, $n = 70$; ≥ 41 –65 years, $n = 65$; > 65 years, $n = 66$) were enrolled in the study. Mean time to extubation observed in ≥ 18 –40 years group was 7.2 ± 4.1 min, ≥ 41 –65 years was 11.6 ± 8.99 min, and > 65 years was 12.0 ± 10.5 min. Mean time to response to verbal command was 7.4 ± 4.3 min for ≥ 18 –40 years, 10.9 ± 8.5 min for ≥ 41 –65 years, and 10.0 ± 5.4 min for > 65 years. Mean time to orientation was 13.0 ± 7.0 min for ≥ 18 –40 years, 16.1 ± 12.0 min for ≥ 41 –65 years, and 17.0 ± 8.6 min for > 65 years. Incidence of nausea and retching/vomiting was observed in 8% of patients each in the postoperative period, and these complications were seen more in the > 65 years age group. Overall, desflurane treatment maintained hemodynamic stability and no major airway events were reported.

Conclusions: The RISE registry data suggest that desflurane-based anesthesia provides early recovery with stable hemodynamics without any airway adverse events, in a wide variety of surgical procedures.

Key words: Anesthesia recovery, desflurane, observational study, optimized pathways, registry

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Introduction

The observational clinical registries are effective modes to collect scientific and clinical data and to evaluate outcomes such as safety of drugs or devices, clinical practices, emergence outcomes, and variance in therapeutic approach. The registry studies supplement randomized controlled trials to determine the outcomes of medical practice. A patient registry is an observational study in a real-life setting to collect data to evaluate specified outcomes for a defined population and serves a predetermined clinical purpose. However, anesthesia registries evaluating the practice pattern and emergence outcomes are uncommon. Anesthesia Quality Institute in collaboration with the American Society of Anesthesiologists (ASA) is currently running the Anesthesia Incident Reporting System and the National Anesthesia Clinical Outcomes Registry in the United States of America.^[1]

In India, a multicenter, prospective, observational registry was maintained for the assessment of emergence outcomes in Indian adult patients undergoing surgery with desflurane anesthesia (Registry in India on Suprane Emergence [RISE]). Desflurane has low solubility in blood and body tissues, which facilitates rapid induction of and recovery from anesthesia. The use of desflurane is not widespread in India and its utilization patterns are lacking. The first clinical registry of anesthesia in India RISE was set up to study the patterns of desflurane-based anesthetic usage in centers across the country, with anesthesiologists sharing their routine clinical practice data. Data related to practice, usage patterns, and recovery profiles in patients undergoing surgical procedures of ≥ 2 h duration were recorded in the registry.

Material and Methods

The RISE Registry was a multicenter, prospective, non-interventional, observational registry implemented at 12 centers (Chennai, Delhi, Mumbai, Kolkata, Bengaluru, and Pune) in India between November 2013 and September 2015. This registry was a voluntary, physician-directed program that included adult inpatients (≥ 18 years of age) with ASA Physical Status I, II or III, who were scheduled to receive desflurane as general anesthetic for surgical procedure of ≥ 2 h, and who were expected to be transferred to Postanesthesia Care Unit (PACU) after surgery or eligible for PACU bypass or who were planned to undergo extubation in the operative room (OR). Patients were excluded if they had known or suspected susceptibility to malignant hyperthermia, known sensitivity to desflurane or other halogenated agents, or in whom general anesthesia was contraindicated. The RISE was designed to stratify the

data into three groups based on patients' age: ≥ 18 –40 years, ≥ 41 –65 years, and > 65 years.

All patients participating in the registry provided written informed consent. The protocol was approved by the Ethics Committee of participating sites, and the study was conducted in accordance with the Declaration of Helsinki, International Conference on Harmonisation, and Good Clinical Practice guidelines.

Anesthesia delivery was in accordance with the site's routine clinical practice and standard of care. No diagnostic, therapeutic, or experimental interventions were specified, and no restrictions were placed on the use of concomitant medications or other treatments. Balanced anesthesia technique was practiced at all centers. Four-to-eleven volume percent desflurane was administered by inhalation, using a specific vaporizer designed for desflurane (Dräger D-Vapor, Dräger Medical GmbH, Lübeck, Germany) and using modern anesthesia workstations. Anesthesia was maintained with opioids, neuromuscular (NM) blockers, and an anesthetic gas mixture of 2–6 volume percent desflurane in oxygen and nitrous oxide/medical air. There were no restrictions on the use of concomitant medications or other treatments.

On enrollment, data on demographics, surgical procedure, anesthetic practices, current medications, and recovery outcomes were collected.

Study outcomes

The primary outcomes were time to extubation (time from discontinuation of desflurane to extubation), time to response to verbal command (time from discontinuation of desflurane until response to command [e.g., squeeze finger or open eyes]), and time to orientation (time from discontinuation of desflurane to awareness of place, time, date).

The secondary outcomes included time taken from discontinuation of desflurane to readiness for discharge from OR to PACU, time taken from discontinuation of desflurane to readiness for discharge from PACU, and average wake-up time (time of first response to command to time of discontinuation of desflurane) of patients after general anesthesia with desflurane stratified by age.

Safety outcomes assessed during the OR and PACU stay included adverse events (AEs) and changes in vital signs and oxygen saturation.

Statistical analysis

No formal sample size calculation was performed. Approximately 200 patients with equal number of patients across the age

groups: ≥ 18 –40 years, ≥ 41 –65 years, and > 65 years were planned to be enrolled in this registry. Continuous data were summarized using descriptive statistics and expressed as mean (standard deviation [SD]), median (range), and 95% confidence interval, and categorical data were expressed as number of patients and percentages. For comparisons among the age groups, one-way ANOVA or Kruskal–Wallis test was performed depending on the normality assumptions. $P < 0.05$ was considered as statistically significant. All statistical analyses were performed using SAS® software version 9.4 (SAS Institute, Cary, NC, USA).

Results

Patients' characteristics

A total of 236 patients were enrolled, of which 201 (≥ 18 –40 years: $n = 70$; ≥ 41 –65 years: $n = 65$; > 65 years: $n = 66$) completed the study [Figure 1]. The mean \pm SD total anesthetic duration and total desflurane exposure time was 229.98 (92.34) min and 226.56 (92.48) min, respectively. Total surgical time was 192.7 ± 81.3 min [Table 1]. Nitrous oxide was used in only half the anesthetics [Table 1]. Continuous epidural analgesia was used as supplement in five patients. The observations were not evenly distributed across all centers.

Efficacy outcomes

There was a significant difference among the three age groups with respect to primary efficacy end-points

such as time to extubation ($P < 0.0001$), time to response to verbal command ($P = 0.001$), and time to orientation ($P < 0.01$) [Table 2]. The mean \pm SD time of extubation was significantly longer in the > 65 years age group (12.0 ± 10.5 min) when compared with ≥ 18 –40 years age group (7.2 ± 4.1 min; $P < 0.0001$) however non-significant when compared with ≥ 41 –65 years (11.6 ± 8.99 min). Similarly, time to orientation was significantly longer in the > 65 years age group (17.0 ± 8.6 min) compared with ≥ 18 –40 years age group (13.0 ± 7.0 min; $P < 0.001$) however non-significant when compared with 41–65 years group (16.1 ± 12.0 min). Overall, the primary efficacy end-points were similar in the 41–65 year and > 65 years age groups.

The average time taken from desflurane discontinuation to readiness for discharge from OR or PACU was significantly

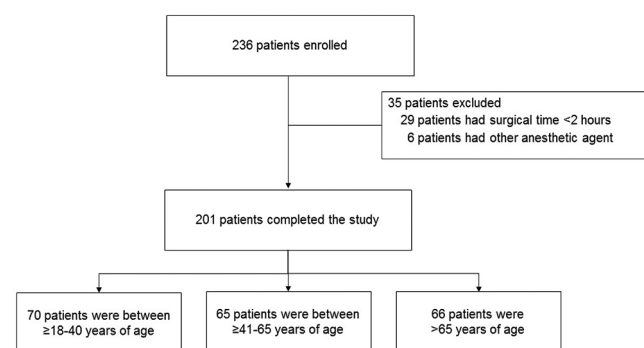


Figure 1: Patient flowchart

Table 1: Patients' demographics and baseline characteristics (full analysis set)

Characteristics	≥ 18 –40 years ($n=70$)	≥ 41 –65 years ($n=65$)	> 65 ($n=66$)	Total ($n=201$)
Age, years (mean \pm SD)	30.1 \pm 6.5	51.4 \pm 7.3	71.7 \pm 5.6	50.6 \pm 18.3
Gender, n (%)				
Men	40 (57)	22 (34)	32 (49)	94 (47)
Women	30 (43)	43 (66)	34 (51)	107 (53)
Total surgical time (mean \pm SD), min	178.2 \pm 59.6	197.0 \pm 97.1	204.3 \pm 83.2	192.7 \pm 81.3
Use of nitrous oxide, n (%)				
Yes	42 (60)	25 (38)	35 (53)	102 (51)
No	28 (40)	40 (62)	31 (47)	99 (49)
Surgery type, n^a	75	69	69	213
Neurosurgery	36	12	33	81
Oncological surgery	2	13	20	35
Obstetric/gynecologic surgery	10	18	3	31
Gastrointestinal/abdominal surgery	10	9	7	26
Orthopedic surgery	3	3	4	10
Urologic surgery	3	6	2	11
Eye/ear/nose/throat surgery	4	2	0	6
Plastic/cosmetic surgery	2	1	0	3
Others	1	2	0	3
Bariatric surgery	1	1	0	2
Head and neck surgery	2	0	0	2
Transplant surgery	0	2	0	2
Vascular surgery	1	0	0	1

^aPatients may have undergone one or more surgery. SD = Standard deviation

different among all age groups; the time taken from desflurane discontinuation to readiness for discharge from PACU and the time taken from extubation to readiness for discharge from PACU were longest in the >65 years group. The average wake-up time of patients after general anesthesia with desflurane was almost similar among all the three age groups [Table 2].

In this database, depth of anesthesia monitoring was used in 131 patients [Supplementary Table 1]. In patients where depth of anesthesia monitor was used, the time taken to orientation was earlier as compared to patients, in whom depth of anesthesia monitor was not used. Patients, in whom depth of anesthesia monitor was not used, were however extubated earlier. These changes were prominent in >65 years age group.

The average fresh gas flow (FGF) used during maintenance was 0.9 L/min ranging from 0.3 to 4.0 L/min. The mean \pm SD end-tidal concentration (ETC) of desflurane was maintained at $4.4\% \pm 1.1\%$ in the 18–40 years group, $4.9\% \pm 1.2\%$ in the 41–65 years group, and $4.1\% \pm 1.1\%$ in the >65 years group. On further analysis based on the FGF rate (used at the time of extubation), the time to extubation was found to be similar across the flow rate used (0–5 L/min: 11.7 ± 8.6 ; 5–10 L/min: 11.1 ± 8.4 ; ≥ 10 L/min: 11.4 ± 13.5). The time to response to verbal command was found to be shorter with the increase in FGF rate (0–5 L/min: 12.3 ± 8.9 ; 5–10 L/min: 8.6 ± 4.5 ; ≥ 10 L/min: 8.1 ± 5.3). Similarly, time to orientation was shorter for FGF rate of ≥ 10 L/min (14.2 ± 9.5) when compared with 0–5 L/min (16.9 ± 11.5) and 5–10 L/min (17.0 ± 9.6). Overall, increase in FGF rate showed early recovery outcomes in this registry [Supplementary Table 2].

Usage pattern of medications

The age-wise usage pattern of premedications, analgesics, opioids, and antiemetics is provided in Table 3. During maintenance of anesthesia, opioids used were morphine (43 patients) and fentanyl (133 patients). After stopping desflurane flow, the FGF was increased to 0–5 L/min in 58 patients, 5–10 L/min in 56 patients, and ≥ 10 L/min in 26 patients.

Intermediate-acting agents (atracurium, vecuronium, and rocuronium) were used for NM blockade. The NM blocker was administered as intermittent bolus in 98 patients and as infusion in 74 patients; 29 patients did not receive any NM blocker. The average time interval between the last dose of NM blocker and administration of reversal of NM blockade in patients receiving bolus doses was 96.0 ± 66.0 min and for those receiving infusion was 36.0 ± 30.6 min. The mean \pm SD dose of NM reversal drug neostigmine administered was 2.6 ± 0.3 mg and glycopyrrolate administered was 0.4 ± 0.1 mg [Table 4]. The postoperative nausea and vomiting (PONV) prevention medication was used in 127 patients during intraoperative and postoperative period, of which 94 patients received ondansetron. The mean \pm SD time of ondansetron administration till the completion of surgery was 48.3 ± 47.7 min. Mild to moderate nausea was observed in 8% ($n = 16$) patients in the postoperative period, but none of the patients had severe nausea. Of 16 patients who experienced nausea, eight did not receive PONV medications. Similarly, retching/vomiting was observed in 8% ($n = 16$) patients, of which 12 patients did not receive PONV medications. Retching/vomiting was observed to be higher (15%) in >65 years age group versus the other two age groups [Table 5].

Table 2: Primary and secondary efficacy end-points (full analysis set)

	$\geq 18-40$ years ($n=70$)	$\geq 41-65$ years ($n=65$)	>65 years ($n=66$)	P
Primary end-point				
Time to extubation, min	7.2 ± 4.1	11.6 ± 8.99	12.0 ± 10.5	<0.0001
Time to response to verbal command, min	7.4 ± 4.3	10.9 ± 8.5	10.0 ± 5.4	0.001
Time to orientation, min	13.0 ± 7.0	16.1 ± 12.0	17.0 ± 8.6	<0.01
Secondary end-point				
Time taken from desflurane discontinuation to readiness for discharge from OR to PACU, min	11.0 ± 5.1	17.1 ± 10.5	16.4 ± 10.2	<0.0001
Time taken from desflurane discontinuation to readiness for discharge from PACU, min	39.7 ± 32.0	68.6 ± 59.98	99.5 ± 154.3	<0.01
Time taken from extubation to readiness for discharge from PACU, min	32.5 ± 30.9	56.9 ± 58.6	87.4 ± 152.1	0.02
Average wake-up time of patients after general anesthesia with desflurane, min	7.4 ± 4.3	10.9 ± 8.5	10.0 ± 5.4	-
Average duration of anesthesia after general anesthesia with desflurane, min*	214.1 ± 69.0	231.5 ± 109.7	245.3 ± 93.9	0.14

*Average duration of anesthesia after general anesthesia with desflurane = (time of discontinuation of desflurane) – (time of start of administration of induction agent).
OR = Operative room, PACU = Post-anesthesia Care Unit

Table 3: Usage pattern of premedication, analgesics, opioids, and antiemetics (full analysis set)

	≥18-40 years (n=70)	≥41-65 years (n=65)	>65 years (n=66)	Total (n=201)
Premedication, n (%)				
Antisialagogue	21 (30)	32 (49)	16 (24)	69 (34)
Benzodiazepine	9 (13)	14 (22)	13 (20)	36 (18)
Opioids	63 (90)	56 (86)	65 (98)	184 (92)
Antiemetics	25 (36)	37 (57)	31 (47)	93 (46)
H ₂ antagonist	44 (63)	44 (68)	36 (55)	124 (62)
Use of analgesics, n (%)				
Paracetamol - part of multimodal analgesia during maintenance	27 (39)	18 (28)	23 (35)	68 (34)
Other common NSAIDs - part of multimodal analgesia during maintenance	20 (28.6)	24 (36.9)	14 (21.2)	58 (29)
Analgesic supplementation in the PACU	8 (11.4)	9 (13.9)	8 (12.1)	25 (12)
Use of opioids				
Morphine during maintenance, n (%)	17	10	16	43
Total dose (mean±SD), mg	6.8±3.1	6.5±2.3	6.3±2.7	6.5±2.7
Fentanyl during maintenance, n (%)	55	40	38	133
Total dose (mean±SD), mg	0.1±0.1	0.1±0.2	0.4±1.1	0.4±2.9
Time of last dose of opioid to extubation-bolus (mean±SD), min	96.0±66.0	138.0±87.6	156.0±97.8	126.0±88.2
Time of last dose of opioid to extubation-infusion (mean±SD), min	48.0±NE	42.0±29.4	90.0±48.6	60±40.8
Use of antiemetics				
PONV medication during postoperative period, n (%)	3 (4)	2 (3)	1 (2)	6 (3)
Time of administration of ondansetron to completion of surgery (intraoperative) (mean±SD), min	47.1±40.2	66.6±70.7	33.5±22.3	48.3±47.7

NE = Not estimable, NSAIDs = Nonsteroidal anti-inflammatory drugs, PACU = Postanesthesia care unit, PONV = Postoperative nausea and vomiting, SD = Standard deviation

Safety outcomes

The proportion of patients reporting at least one AE was higher among >65 years age (12/66; 18%) and ≥41–65 years groups (10/65; 15%) compared with ≥18–40 years age group (6/70; 9%). The study drug-related AEs were observed in 5 (7%) patients in ≥18–40 years, 8 (12%) patients in ≥41–65 years, and 10 (15%) patients in >65 years age group. The most commonly reported AE (>5 patients) among all the age groups was hypotension [Table 6]. Overall, a stable hemodynamics was observed and no major airway-related events, such as coughing, bronchospasm, or copious secretion of varying severity, were reported. No deaths or SAEs were reported in the registry.

Discussion

The RISE registry was conducted to provide insights on variance in routine anesthesia practice in India. Optimization of perioperative anesthesia technique is critical for improved anesthesia recovery outcomes of patients. The primary recovery outcome end-points, i.e., mean time between stoppage of desflurane and first response by the patient, mean time to extubation, and mean time to orientation and the secondary recovery end-points,

were significantly longer in the older age group compared with younger age group. However, the total number of subjects was small, and thus, a conclusion cannot be drawn about recovery characteristics based on these data. In a study conducted by Magni *et al.*, in craniotomy patients, desflurane resulted in recovery time (mean ± SD: 12.4 ± 7.7 min) similar to that of our findings.^[2] The observations were not evenly distributed across all centers as all followed independent protocols.

Use of low FGF of anesthetic gases offers the advantages of improved anesthesia gas dynamics, better mucociliary clearance, reduction in body heat and water loss, reduction in inhalational anesthesia agent consumption by more than 75% and ecological protection by emission of smaller amounts of ozone-depleting and heat-trapping greenhouse gases.^[3] The average total FGF in our registry, during maintenance of anesthesia, was 0.9 L/min. However, the range varied from 0.3 to 4.0 L/min. A higher blood-alveolar concentration gradient facilitates expiration of inhalation agent from the returning pulmonary blood flow. Raising FGF adequately enhances recovery. In the registry, after stopping desflurane flow, the FGF was kept 0–5 L/min in 58 patients, 5–10 L/min in 56 patients, and increased to ≥10 L/min only in 26 patients. Few centers continued low FGF, of 0–5

Table 4: Usage pattern of neuromuscular blockers and reversal drug (full analysis set)

	≥18-40 years (n=70)	≥41-65 years (n=65)	>65 years (n=66)	Total (n=201)
Use of neuromuscular blockers				
Number of patients received intermittent bolus (during maintenance), %	47 (67)	23 (35)	28 (42)	98 (49)
Dose, mg	17.4±32.97	18.5±20.1	29.5±51.4	21.1±37.0
Number of patients received infusion (during maintenance), %	15 (21)	34 (52)	25 (38)	74 (37)
Dose (mg)	58.8±41.9	69.6±49.0	68.1±30.3	66.9±41.7
Average dose of muscle relaxant per h (during maintenance), mg	9.5±13.4	14.3±9.8	14.3±17.3	12.6±13.9
Time of last bolus dose of muscle relaxant to extubation, min	96.0±76.2	114.0±73.2	114.0±74.4	108.0±75.6
Time of last infusion dose of muscle relaxant to extubation, min	42.0±30.0	42.0±37.8	48.0±23.4	42.0±31.8
Time of last bolus dose of muscle relaxant to reversal drug, min	84.0±54.0	114.0±72.6	114.0±73.2	102.0±66.6
Time of last infusion dose of muscle relaxant to reversal drug, min	36.0±30.6	36.0±34.8	48.0±24.6	36.0±30.6
Use of reversal drug				
Time of reversal drug to extubation, min	3.7±2.5	5.1±6.6	6.1±9.1	4.9±6.7
Time of reversal drug to response to verbal command, min	3.9±2.7	4.6±5.7	4.3±4.3	4.2±4.4
Time of reversal drug to orientation, min	9.2±5.8	9.6±10.1	11.0±7.7	9.9±8.1
Neostigmine dose, mg	2.6±0.3	2.6±0.3	2.6±0.3	2.6±0.3

Data are expressed as mean±SD unless otherwise indicated. SD = Standard deviation

Table 5: Nausea, retching or vomiting during post anesthesia care unit stay (full analysis set)

Other efficacy outcomes	≥18-40 years (n=70)	≥41-65 years (n=65)	>65 years (n=66)	Total (n=201)
n	70	64	66	200
Nausea during PACU stay, n (%)				
Absent	64 (91)	59 (91)	61 (92)	184 (92)
Mild	4 (6)	3 (5)	4 (6)	11 (6)
Moderate	2 (3)	2 (3)	1 (2)	5 (3)
Retching/vomiting during PACU stay, n (%)				
Absent	67 (96)	61 (94)	56 (85)	184 (92)
Mild	1 (1)	3 (5)	10 (15)	14 (7)
Moderate	2 (3)	0	0	2 (1)

PACU = Postanesthesia Care Unit

L/min, even after cutting off the desflurane early as they practiced a modification of the coasting technique. Early recovery from desflurane is facilitated by increasing the FGF to >10 L/min.

There is evidence that cerebral suppression-based anesthesia depth monitoring, such as bispectral index (BIS), helps reduce intraoperative awareness and also that the agent ETC monitoring is a viable alternative for patients receiving potent inhaled anesthetics.^[4,5] Besides awareness prevention, use of anesthesia depth monitoring helps avoid anesthetic overdosing, thereby achieving earlier recovery and preventing PONV.^[4] Greater intraoperative depth of anesthesia was observed to lead to better postoperative analgesia^[6,7] but could not be confirmed by a study, in which both BIS and ETC of desflurane were measured.^[8] Anesthesia depth monitoring was done for 131 patients in the RISE registry; however, no

significant difference in the recovery outcomes was observed in these patients when compared with the patients who were not monitored for depth of anesthesia [Supplementary Table 1]. In addition, the last ETC before desflurane discontinuation did not have any significant correlation with the early recovery outcomes [Supplementary Table 3]. The B-Aware, B-Unaware, BAG-RECALL, MACS, and other trials failed to demonstrate superiority of brain function monitoring over ETC monitoring.^[6] The current quantitative indices based on frontal electroencephalography (EEG) have limitations.^[9] The ASA published advisory on awareness thus does not make brain monitoring obligatory to prevent awareness or reduce anesthetic consumption for general anesthesia.^[10] Future anesthetic practice may include routine monitoring of the depth of anesthesia, with a comprehensive approach, using both ETC and EEG monitoring.^[4]

Table 6: Summary of adverse events (safety population)

	≥18-40 years (n=70)	≥41-65 years (n=65)	>65 years (n=66)	Total (n=201)
Patients with ≥1 AE, n (%)	6 (8.6)	10 (15.4)	12 (18.2)	28 (13.9)
AEs, n (%)				
Hypotension	5 (7.1)	7 (10.8)	9 (13.6)	21 (10.4)
Hypertension	0	1 (1.5)	1 (1.5)	2 (1.0)
Tachycardia	1 (1.4)	1 (1.5)	0	2 (1.0)
Pain	0	1 (1.5)	1 (1.5)	2 (1.0)
Bradycardia	0	0	1 (1.5)	1 (0.5)
Extrasystoles	0	0	1 (1.5)	1 (0.5)
Hypothermia	0	0	1 (1.5)	1 (0.5)
Endotracheal intubation complication	0	0	1 (1.5)	1 (0.5)
Hypercapnia	0	0	1 (1.5)	1 (0.5)
Delirium	0	0	1 (1.5)	1 (0.5)
Hypokalemia	0	0	1 (1.5)	1 (0.5)
Metabolic acidosis	0	0	1 (1.5)	1 (0.5)
Patients with ≥1 study drug-related AE	5 (7.1)	8 (12.3)	10 (15.2)	23 (11.4)
Hypotension	5 (7.1)	7 (10.8)	8 (12.1)	20 (10.0)
Hypertension	0	1 (1.5)	1 (1.5)	2 (1.0)
Extrasystoles	0	0	1 (1.5)	1 (0.5)
Delirium	0	0	1 (0.5)	1 (0.5)

AEs = Adverse events

Inspired and ETC of desflurane were measured in all patients. The mean concentration of desflurane used in the registry essentially remained almost similar across age (in the range of 4–5 volume percent). The MAC of desflurane has been estimated as 6.2%–7.3% at 18–30 years age, 5.8%–6.3% at 31–65 years age, and 5.2% at >65 years age.^[11] Opioid co-administration reduces the MAC of inhalational agents, and it is estimated that 3 mcg/kg fentanyl reduces the MAC to 3.1% and 6 mcg/kg reduces it to 2.3% at >65 years age group.^[11] Usage of higher amounts of inhalational anesthetics may increase the incidence of postoperative cognitive dysfunction.^[12] However, in this registry, only one patient in >65 years group encountered delirium, which may be attributed to the use of benzodiazepine.^[13]

Nitrous oxide has been used for more than 150 years without any reported case of death.^[14] Myles *et al.* challenged its safety in the ENIGMA trial^[15] and its use went into disrepute immediately thereafter. The subsequent larger trial by the same group (ENIGMA II) failed to show that its use is unsafe.^[16] A new evidence has in fact suggested potential beneficial effects of nitrous oxide on the central nervous system, cardiovascular system, and acute/chronic pain.^[14,17] Nitrous oxide use enables about 0.5 MAC of extra anesthetic to be given to a patient without causing a decrease in BIS.^[8] Use of nitrous oxide reduces MAC of inhalational anesthetics, thereby permitting the use of lower ETC of the agent. Despite the change in the status of nitrous oxide, its usage was limited to only half the anesthetics in our registry.

Addition of nonsteroidal anti-inflammatory drugs (NSAIDs) augments the analgesia of opioids. The NSAID use also

helps reduce postoperative analgesic requirement. Multimodal analgesia during surgery has gained increasing acceptance in the last decade. In our registry, 68 patients received paracetamol, while 58 patients received other common NSAID as a part of multimodal analgesia, while 75 patients were not administered NSAID. Multimodal pain management helps decrease the incidence and severity of opioid-associated AEs, improve patient comfort and recovery experience, and reduce costs and length of stay.^[18] Increasing the alveolar ventilation results in rapid expulsion of the waste anesthetic gases and prevents rebreathing.

Nausea (mild to moderate, not severe) and retching/vomiting were observed in 8% patients in the postoperative period, and retching/vomiting was significantly higher (15%) in the >65 years age group compared with other age groups. PONV medication was administered in 127 patients, of which 94 patients received ondansetron before induction of anesthesia, which is also reflected as large SD in the time of the doses. The peak effect of ondansetron occurs after 10 min of administration and the elimination half-life is about 4 h, and thus, the drug should ideally be administered late (just before completion of surgery) to prevent PONV.^[19] Furthermore, of 16 patients who experienced nausea, eight patients did not receive PONV medication, and similarly, 12 of 16 patients who experienced retching/vomiting did not receive PONV medications. Therefore, the incidence of nausea and retching/vomiting in this study could be associated with lack of preventive measures.

Patients were evaluated by site-specific discharge scores to determine readiness of discharge and the pain scores used at

centers were different, and thus, the PACU discharge and pain scores could not be analyzed and have not been presented.

Desflurane anesthesia provided stable vital signs, intraoperative hemodynamics, and oxygen saturation. There were no major adverse airway events reported in this registry. In the >65 years group, three events were considered as “probably related to use of desflurane” (extrasystole, delirium) and one was considered as “related to use of desflurane” (hypotension). All other events were considered as unrelated or unlikely to be related to desflurane use.

The limitations of the registry were as follows: No protocol was imposed on the participants and the concomitant drugs to be used were not specified, and thus, the data were scattered and difficult to analyze. A limited number of individuals were enrolled as it was the first attempt to maintain a registry, and thus, statistically, relevant data could not be brought out. The data of opioids and NM blockers could not be completely analyzed as multiple drugs were used. The monitoring protocols were similar, but the equipment used and the scoring criteria were different, and as a result, PACU and brain function monitoring data could not be analyzed. Furthermore, data on body temperature were not collected in this registry, which could have provided information on its influence on the recovery parameters.

Conclusion

This anesthesia registry to study the practice patterns of anesthesia delivery using desflurane-based general anesthesia was successfully maintained.

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Conflicts of interest

Sibasish Dey, Kuljinder Singh, and Ashok Kumar Moharana are employees of Baxter (India), Pvt. Ltd.

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Supplementary Table 1: Recovery parameters by depth of anesthesia monitoring

	≥18-40 years (n=70)	≥41-65 years (n=65)	>65 years (n=66)	Total (n=201)
Depth of anesthesia monitored	51	29	51	131
Time to extubation, min	7.4±4.4	13.7±10.8	11.5±7.8	10.4±7.9
Time to response to verbal command, min	7.2±4.6	11.0±10.1	9.9±5.5	9.1±6.7
Time to orientation, min	13.6±7.3	20.0±15.0	17.4±8.1	16.5±10.1
Depth of anesthesia not monitored	19	36	15	70
Time to extubation, min	6.7±3.4	9.8±6.9	13.7±17.0	9.8±9.6
Time to response to verbal command, min	7.9±3.4	10.8±7.1	10.2±5.3	9.9±5.99
Time to orientation, min	11.6±6.3	12.9±7.8	15.6±10.3	13.1±8.0

Data are expressed as mean±SD. SD=Standard deviation

Supplementary Table 2: Recovery parameters by fresh gas flow rate

	≥18-40 years (n=70)	≥41-65 years (n=65)	>65 years (n=66)	Total (n=201)
0-5 L/min	19	24	15	58
Time to extubation, min	8.8±4.5	12.7±11.7	13.7±5.5	11.7±8.6
Time to response to verbal command, min	9.5±4.95	13.9±11.6	13.3±7.4	12.3±8.9
Time to orientation, min	14.2±6.2 ^a	17.5±15.7	19.1±7.7	16.9±11.5 ^b
5-10 L/min	23	14	19	56
Time to extubation, min	8.2±4.7	15.0±7.3	11.8±11.2	11.1±8.4
Time to response to verbal command, min	7.5±4.7	10.9±4.4	8.4±3.95	8.6±4.5
Time to orientation, min	13.8±8.7	19.8±9.1	18.8±10.4 ^c	17.0±9.6 ^d
≥10 L/min	8	7	11	26
Time to extubation, min	5.9±1.8	9.3±6.7	16.7±19.2	11.4±13.5
Time to response to verbal command, min	6.8±3.2	6.3±6.2	10.2±5.6	8.1±5.3
Time to orientation, min	11.8±6.4	13.6±11.7	16.5±10.2 ^e	14.2±9.5 ^f

Data are expressed as mean±SD. ^an=18, ^bn=57, ^cn=18, ^dn=55, ^en=10, ^fn=25. SD = Standard deviation

Supplementary Table 3: Recovery parameters by last end-tidal value before desflurane discontinuation

	≥18-40 years (n=70)	≥41-65 years (n=65)	>65 years (n=66)	Total (n=201)	Correlation with last end tidal value	P
End tidal desflurane concentration	69	62	66	197		
Time to extubation, min	7.2±4.1	11.4±8.6	12.0±10.5	10.2±8.4	0.0553	0.4403
Time to response to verbal command, min	7.4±4.3	10.6±7.8	10.0±5.4	9.3±6.1	0.1656	0.0201
Time to orientation, min	13.1±7.0 ^a	16.1±11.8	17.0±8.6 ^b	15.3±9.4 ^c	0.0918	0.2043

Data are expressed as mean±SD. ^an=67, ^bn=64, ^cn=193. SD = Standard deviation