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ORIGINAL RESEARCH

Desflurane Safety Revisited: A Pharmacovigilance Study Detecting Potential Safety Signals from FAERS Data

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Purpose: Desflurane is a widely used volatile anesthetic with multiple clinical advantages, but comprehensive pharmacovigilance analyses are needed to optimize its safety profile. This study aimed to analyze and classify adverse events(AEs) associated with desflurane in the Food and Drug Administration Adverse Event Reporting System(FAERS) database and evaluate potential safety signals.

Patients and Methods: We analyzed FAERS reports from 2004Q1 to 2025Q1 where desflurane was the primary suspect(PS) drug. Cases were classified using Medical Dictionary for Regulatory Activities (MedDRA27.1) terminology and processed following FDA-recommended deduplication strategy. Four disproportionality analyses were conducted: Reporting Odds Ratio (ROR), Proportional Reporting Ratio (PRR), Bayesian Confidence Propagation Neural Network (BCPNN), and Multi-item Gamma Poisson Shrinker (MGPS).

Results: Among 1,191 cases, bradycardia was most frequent (n = 39; ROR = 38.72, 95% CI 28.14–53.28) with 79.4% classified as serious. Notable findings included anaphylactic shock (n = 23; 69.6% serious), bronchospasm (n = 22), and malignant hyperthermia-(MH) (n = 20; 25% mortality). Acute respiratory distress syndrome (ARDS) (n = 2) and disseminated intravascular coagulation (DIC) (n = 2) were documented - a previously unreported association with desflurane exposure.

Conclusion: Our analysis reveals clinically significant safety signals associated with desflurane, including cardiovascular, anaphylactic, and respiratory complications that may require enhanced perioperative monitoring. The study underscores the critical importance of sustained post-marketing surveillance for detecting rare but serious safety signals, not typically evident in pre-approval clinical trials.

Keywords: desflurane, nociception, pharmacovigilance, FAERS, anaphylactic shock, DIC

Introduction

As the cornerstone of modern surgical practice, general anesthesia enables safe and painless performance of complex invasive procedures. Desflurane mediates its antinociceptive action primarily by inducing general anesthesia and unconsciousness, thereby abolishing nociceptive awareness. Research demonstrates desflurane's capacity to reduce pain signal propagation via inhibition of spinal cord dorsal horn neurons.[1]

Among volatile anesthetics, desflurane has emerged as particularly valuable in neurosurgical[2,3] and cardiac procedures,[4] owing to its low blood-gas partition coefficient and stable hemodynamic profile - properties that facilitate precise anesthetic depth control. However, its clinical application remains controversial due to its pungent odor and airway irritability, which frequently induce coughing, breath holding, and laryngospasm[5] during induction, particularly in pediatric and non-intubated patients.[6] Comparative studies have demonstrated a higher incidence of postoperative nausea and vomiting (PONV) with desflurane than with propofol or sevoflurane.[3,7] Like other volatile anesthetics, desflurane

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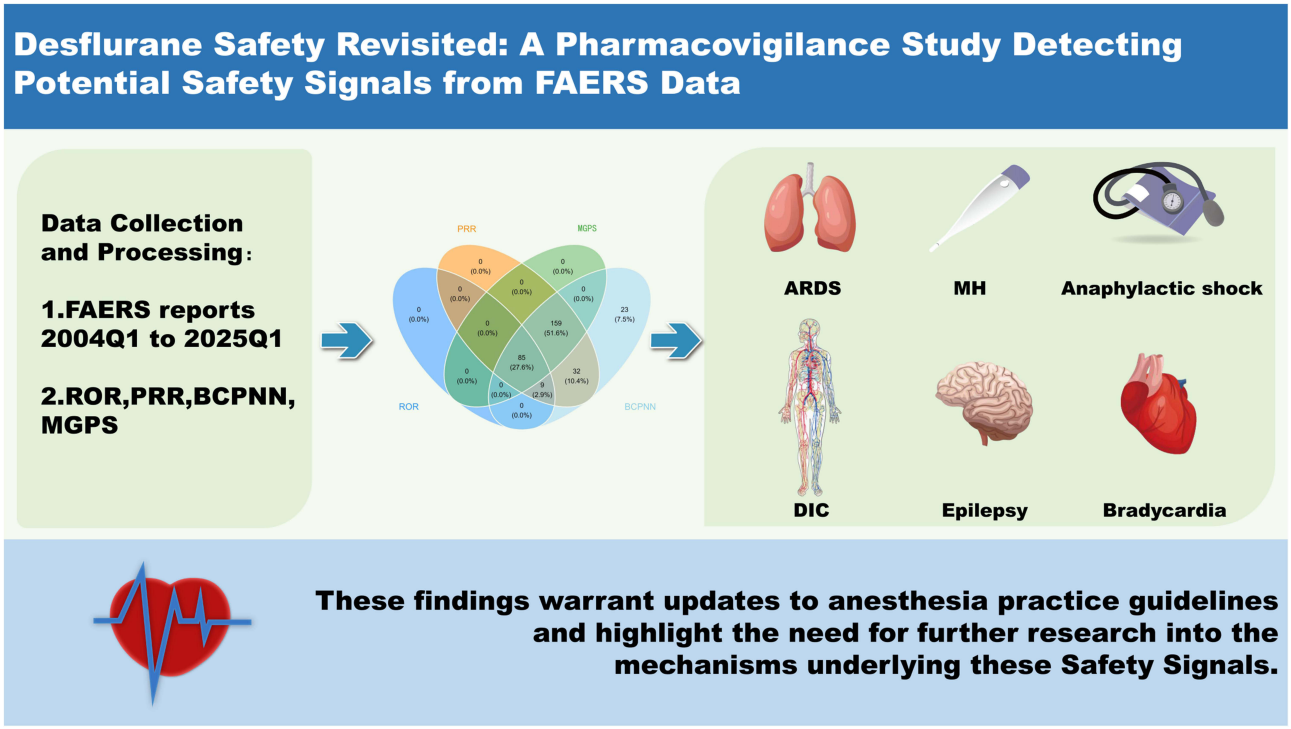
Graphical Abstract



may trigger malignant hyperthermia in susceptible individuals,[8] while preclinical investigations have raised concerns about potential neurotoxic effects in the developing brain.[9]

Despite these documented concerns, the existing literature is fragmented, based primarily on controlled trials with limited sample sizes or isolated case reports. This highlights a significant gap in comprehensive evaluations of desflurane's safety profile in real-world clinical practice.

FAERS is a critical pharmacovigilance resource that aggregates post-marketing adverse event reports submitted by healthcare professionals, patients, and manufacturers. Prior studies have demonstrated its value in detecting potential drug safety issues,[10] such as the identification of laryngospasm, bronchospasm, and DIC as safety signals associated with sugammadex,[11] or the elevated risks of propofol administration in epileptic patients.[12] These findings have provided crucial guidance for perioperative medication decisions. It is important to acknowledge the inherent limitations of the FAERS database, which lacks critical patient-specific details such as pharmacokinetic/pharmacodynamic variables (genetic polymorphisms, organ function) and formulation characteristics (excipients). These factors may influence the incidence and severity of reported adverse events. The value of this analysis lies in identifying potential safety signals for further investigation once more detailed clinical information becomes available.

Given substantial gaps in knowledge regarding desflurane's safety profile, real-world evidence from pharmacovigilance databases offers essential insights by aggregating spontaneous adverse event reports across diverse populations. Such data are particularly valuable for detecting rare complications that may not manifest in controlled trials.[13]

This study leverages the FAERS database to systematically investigate three key aspects: (1) the population distribution of desflurane-associated AEs; (2) the system organ class classification of these events; and (3) the demographic characteristics of patients experiencing severe AEs. Our findings aim to inform evidence-based anesthetic practice and enhance regulatory oversight.

Materials and Methods

Data Collection

We analyzed reports from the FAERS database spanning Q1 2004 to Q1 2025. The database contains seven structured files, including demographic information (DEMO), drug exposure details (DRUG), reported adverse events (REAC), indications for use (INDI), therapy dates (THER), patient outcomes (OUTC), and report sources (RPSR).

Signal Detection and Processing

Duplicate reports were removed using FDA-recommended deduplication based on CASE ID and FDA receipt date (FDA DT), with exclusion of reports containing missing or inconsistent critical fields. Adverse events were coded using MedDRA version 27.1 Preferred Terms, and desflurane cases were identified using both generic ("DESFLURANE") and brand ("SUPRANE") names, retaining only primary suspect cases.

Statistical Analysis

Four disproportionality analysis methods were employed: ROR (threshold: ROR ≥3 with 95% CI lower limit >1), PRR (thresholds: PRR ≥2, χ^2 ≥4, and ≥3 cases), BCPNN (thresholds: IC025 >0), and MGPS (thresholds: EBGM05 >2). Detailed methodology is provided in Table 1.

Statistical analyses examined demographic characteristics (age, sex, reporter type), clinical outcomes (hospitalization, life-threatening events, death), AEs frequency by occurrence and System Organ Class(SOC), and signal concordance through Venn diagram analysis of serious/rare AEs identified by all four methods. All analyses were conducted using R software (v4.5.0).

Results

Data Processing Results

A total of 22,775,812 DEMO records were extracted from the FAERS database. After applying FDA-recommended deduplication criteria, 3,749,303 records were excluded, yielding 19,026,509 unique entries. Using MedDRA for AEs mapping, 56,998,621 REAC records were obtained. By setting "DESFLURANE" and "SUPRANE" as preferred terms (PS), 511 DRUG records and 1,191 REAC records were identified. The data screening and analysis flowchart is illustrated in Figure 1.

Table 1 Summary of Four Disproportionality Analysis Methods Employed for Pharmacovigilance Signal Detection

Method	Formula	Threshold
ROR	ROR = ad/bc	a ≥ 3 and 95% CI (lower limit) > 1
	95% CI = $e^{\ln(ROR)\pm1.96(1/a+1/b+1/c+1/d)^{0.5}}$	
PRR	PRR = a (c + d)/c/(a+b)	PRR≥2, $\chi2$ ≥ 4, N ≥ 3
	$\chi2$ = [(ad-bc)^2](a+b + c + d)/[(a+b) (c + d) (a+c) (b + d)]	
BCPNN	IC = log2a (a+b + c + d) (a+c) (a+b)	IC025 > 0
	95% CI = E (IC) ± 2V(IC)^0.5	
MGPS	EBGM = a (a+b + c + d)/(a+c)/(a+b)	EBGM05 > 2
	95% CI = $e^{\ln(EBGM)\pm1.96(1/a+1/b+1/c+1/d)^{0.5}}$	

Notes: *a* denotes the number of reported cases of the target adverse event associated with the target drug; *b* represents the number of reported cases of other adverse events associated with the target drug; *c* indicates the number of reported cases of the target adverse event linked to non-target drugs; and *d* corresponds to the number of reported cases of other adverse events associated with non-target drugs.

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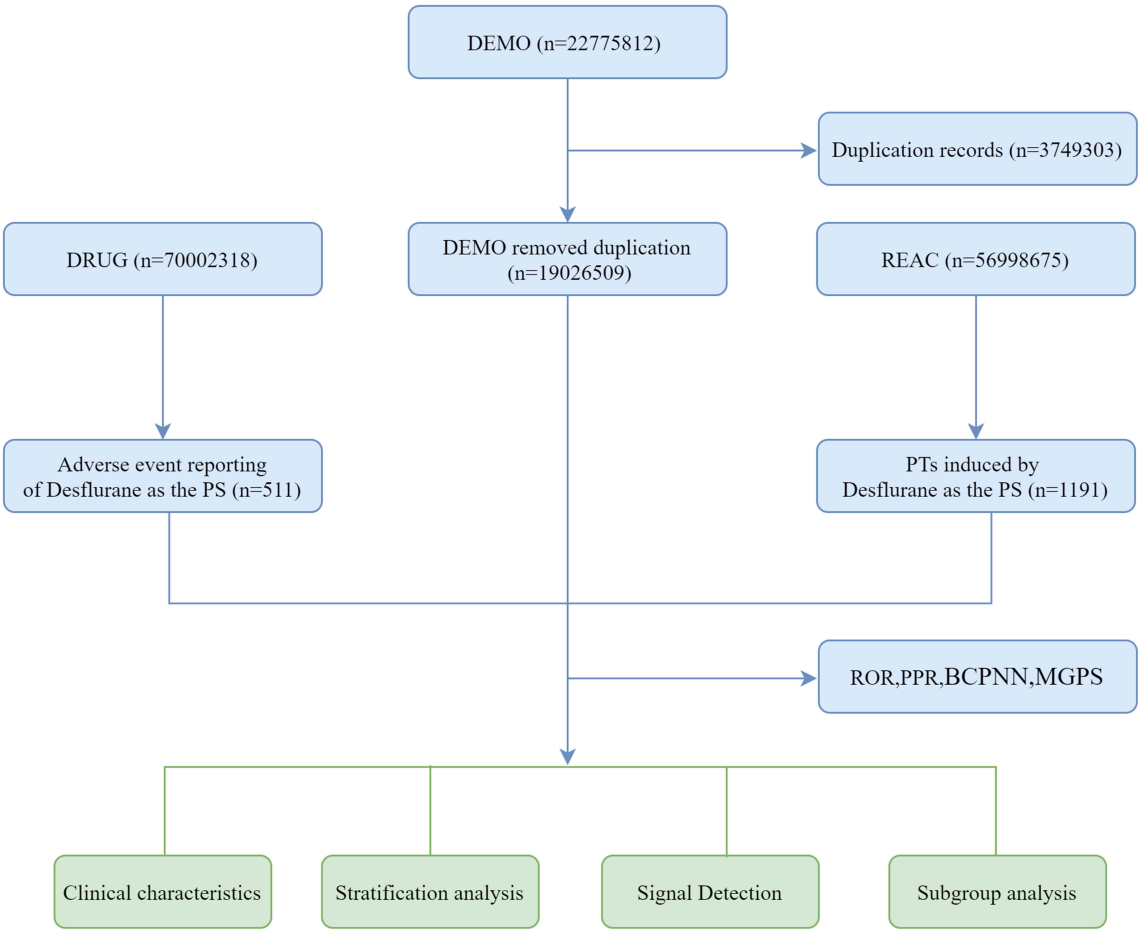

Figure 1 Flowchart of data screening and analytical process.

Demographic Baseline Characteristics

Among patients experiencing AEs associated with desflurane, 200 (39.2%) were female, 181 (35.5%) were male, and 129 (25.3%) had no gender specification in the FAERS database. Regarding weight distribution, 21 (4.1%) patients weighed <50 kg, 9 (1.8%) weighed >100 kg, and 125 (24.5%) fell within the 50–100 kg range, while the majority (69.6%) lacked weight documentation. Age-wise, adults aged 18–64.9 years (38.0%) exhibited the highest incidence of AEs, whereas elderly patients (>85 years) accounted for only 1%. These findings suggest that caution remains warranted when administering this inhalational anesthetic to adult populations. Serious AEs were reported in 303 cases (59.4%), including 18 fatalities (3.5%). Among reporters, health professionals (27, 5.3%), pharmacists (28, 5.5%), and physicians (235, 46.1%) constituted the primary sources, underscoring the reliability of these AE reports. Detailed demographic data are presented in Table 2.

Distribution of Adverse Events

Analysis of 1,191 AE reports revealed the most frequent AEs (Figure 2): bradycardia (n=39), post-procedural complication (n=32), cardiac arrest (n=25), anaphylactic shock (n=23), hypotension (n=22), bronchospasm (n=22), malignant hyperthermia (n=20), unwanted awareness during anesthesia (n=19), fetal exposure during pregnancy (n=19), and tachycardia (n=16). Stratified by System Organ Class (SOC) (Figure 3), the highest AE frequencies were observed in: Injury, poisoning and procedural complications (n=180), Respiratory, thoracic and mediastinal disorders (n=144), Cardiac disorders (n=138), Investigations (n=114), Nervous system disorders (n=87), General disorders and administration site conditions (n=81), Hepatobiliary disorders (n=62), Vascular disorders (n=58), Eye disorders (n=47), and Immune system disorders (n=36).

Table 2 Demographic Characteristics of Patients Experiencing Desflurane-Associated Adverse Events

Dimension	Classification	Numbers (%)
Sex		
	Female	200 (39.2%)
	Male	181 (35.5%)
	Unspecified	129 (25.3%)
Weight		
	<50 kg	21 (4.1%)
	>100 kg	9 (1.8%)
	50~100 kg	125 (24.5%)
	Unspecified	355 (69.6%)
Age		
	<18 year	60 (11.8%)
	>85 year	5 (1.0%)
	18~64.9 year	194 (38.0%)
	65~85 year	93 (18.2%)
	Unspecified	158 (31.0%)
Outcome		
	Death	18 (3.5%)
	Disability	3 (0.6%)
	Hospitalization	44 (8.6%)
	Life-Threatening	20 (3.9%)
	Other	425 (83.3%)
Serious Case(YES or NO)		
	NO	492 (96.5%)
	YES	18 (3.5%)
Reporter type		
	Consumer	17 (3.3%)
	Health Professional	27 (5.3%)
	Pharmacist	28 (5.5%)
	Physician	235 (46.1%)
	Unspecified	203 (39.8%)

Signal Detection Analysis

Using four disproportionality algorithms (ROR, PRR, BCPNN, MGPS), statistically significant safety signals were identified as follows: ROR (n=94), PRR (n=95), BCPNN (n=96), and MGPS (n=119). Venn diagram analysis yielded 85 safety signals common to all four methods (Figure 4). These safety signals spanned multiple organ systems, including Respiratory, thoracic and mediastinal disorders, Hepatobiliary disorders, Renal and urinary disorders, Nervous system disorders, Cardiac disorders, and Vascular disorders, with critical involvement of Blood and lymphatic system disorders and Immune system disorders(Supplementary Table 1).

Respiratory, thoracic, and mediastinal disorders: Bronchospasm (n=22) and laryngospasm (n=10) were the most prevalent safety signals, exhibiting high signal strengths with ROR (95% CI) of 80.23 (52.6–122.36) and 190.45 (102.08–355.32), respectively. These severe events may acutely impair pulmonary ventilation, leading to sustained hypoxemia and, if unmanaged, respiratory failure.

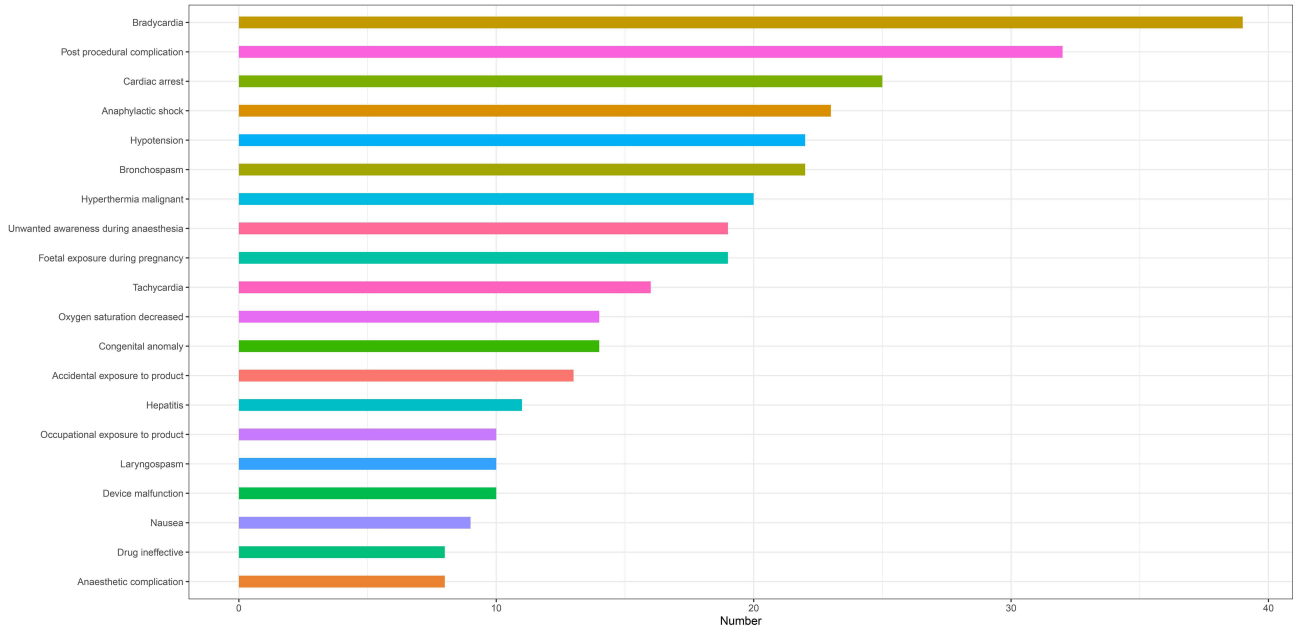

Figure 2 Top 20 most frequently reported adverse events (AEs).

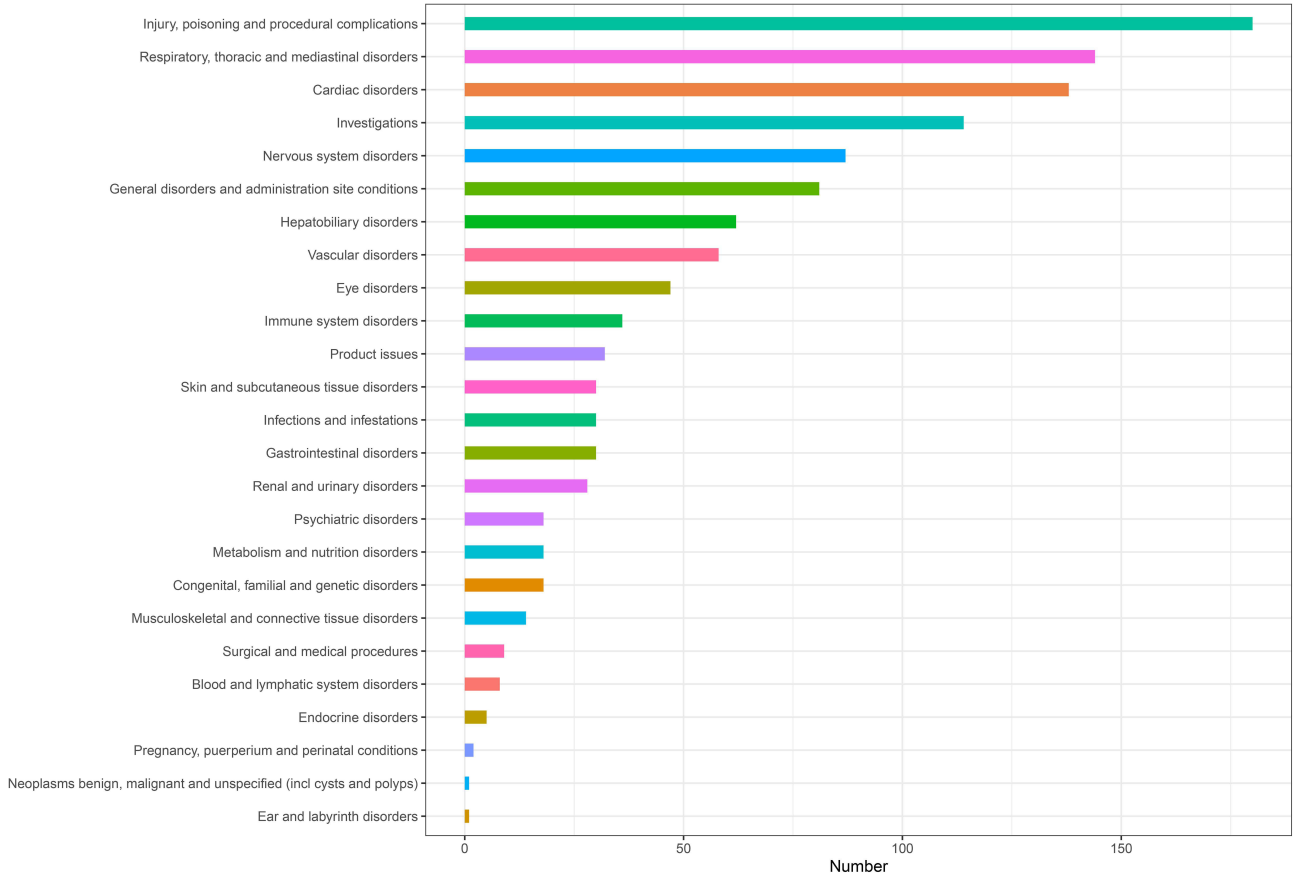

Figure 3 Frequency distribution of adverse events by System Organ Class (SOC).

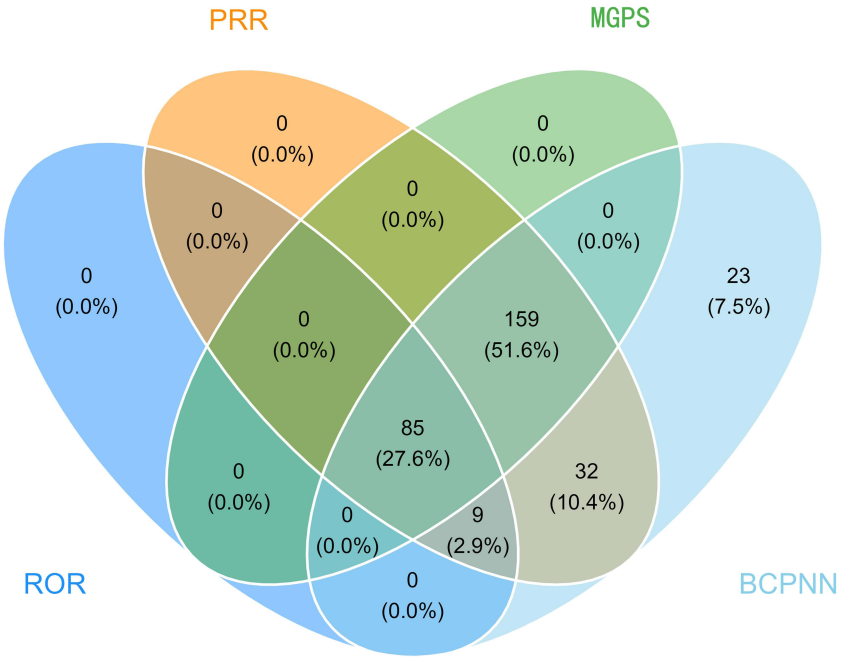

Figure 4 Venn diagram of adverse events with positive signals across all four algorithms.

Hepatobiliary and renal disorders: Hepatitis (n=11), hepatotoxicity (n=8), hepatic failure (n=6), anuria (n=3), and oliguria (n=3) were flagged as significant signals, with ROR (95% CI) values of 22.59 (12.47–40.91), 19.28 (9.62–38.66), 10.29 (4.61–22.95), 17.66 (5.69–54.86), and 24.88 (8.01–77.27), respectively.

Nervous system disorders (7.3% of total safety signals): Epilepsy (n=2), hypoxic-ischemic encephalopathy (n=3), altered consciousness (n=3), brain edema (n=3), seizure-like phenomena (n=3), encephalopathy (n=3), intracranial hypertension (n=3), and hepatic encephalopathy (n=3) were detected as signals.

Cardiac and vascular disorders: Bradycardia (n=39), cardiac arrest (n=25), tachycardia (n=16), torsade de pointes (n=6), hypotension (n=22), shock (n=5), circulatory collapse (n=3), and blood pressure fluctuations (n=3) were identified as significant safety signals.

Life-threatening safety signals: Disseminated intravascular coagulation (n=3), anaphylactic shock (n=23), and anaphylactic reaction (n=8) also demonstrated strong signal associations.

Mortality Cases Associated with Malignant Hyperthermia

Among the five fatal cases attributed to malignant hyperthermia (Table 3), all patients were aged 18–65 years, with two cases reporting body weights within the 50–100 kg range. The cohort comprised three females and two males. Regarding administration, four cases explicitly documented inhalation as the route of delivery, with one specifying a concentration of 5 VOL% and another reporting a flow rate of 1 L/min.

Table 3 Clinical Characteristics of Fatal Cases Associated with Malignant Hyperthermia

PT	Primaryid	AGE(Year)	WT	SEX	GetData Year(Year)	ROUTE	DOSE_VBM	Reportertype
Hyperthermia malignant	91011241	18~64.9	Missing	Female	2013	INHALATION		Physician
	93,513,681	18~64.9	50~100 kg	Female	2013	INHALATION	5 VOL%	Physician
	118,642,251	18~64.9	Missing	Male	2015	Respiratory (inhalation)		Physician
	142,413,363	18~64.9	50~100 kg	Female	2017	Respiratory (inhalation)	FLOW RATE 1 L/MIN	Physician
	149,217,561	18~64.9	Missing	Male	2018	Unknown		Physician

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Subgroup Analysis: Severe vs Non-Severe Cases

To further delineate the clinical implications of reported safety signals, cases were stratified into severe and non-severe subgroups (Figure 5). Notably, bradycardia (31 severe vs 8 non-severe cases, 79.4%), delayed recovery from anesthesia (6 vs 2, 75%), and device-related issues (6 vs 1, 85.7%) exhibited a higher propensity for severe outcomes, corroborated by elevated ROR values. These findings underscore the necessity of vigilant intraoperative heart rate monitoring to mitigate bradycardia-related complications, as well as heightened postoperative vigilance for delayed emergence. Additionally, preoperative equipment checks are imperative, given the potential for device failures to precipitate life-threatening events. In contrast, fetal exposure during pregnancy (2 severe vs 7 non-severe cases, 22.2%) demonstrated a lower association with severe outcomes; however, the limited sample size precludes definitive conclusions, warranting further investigation into the safety of desflurane in obstetric anesthesia.

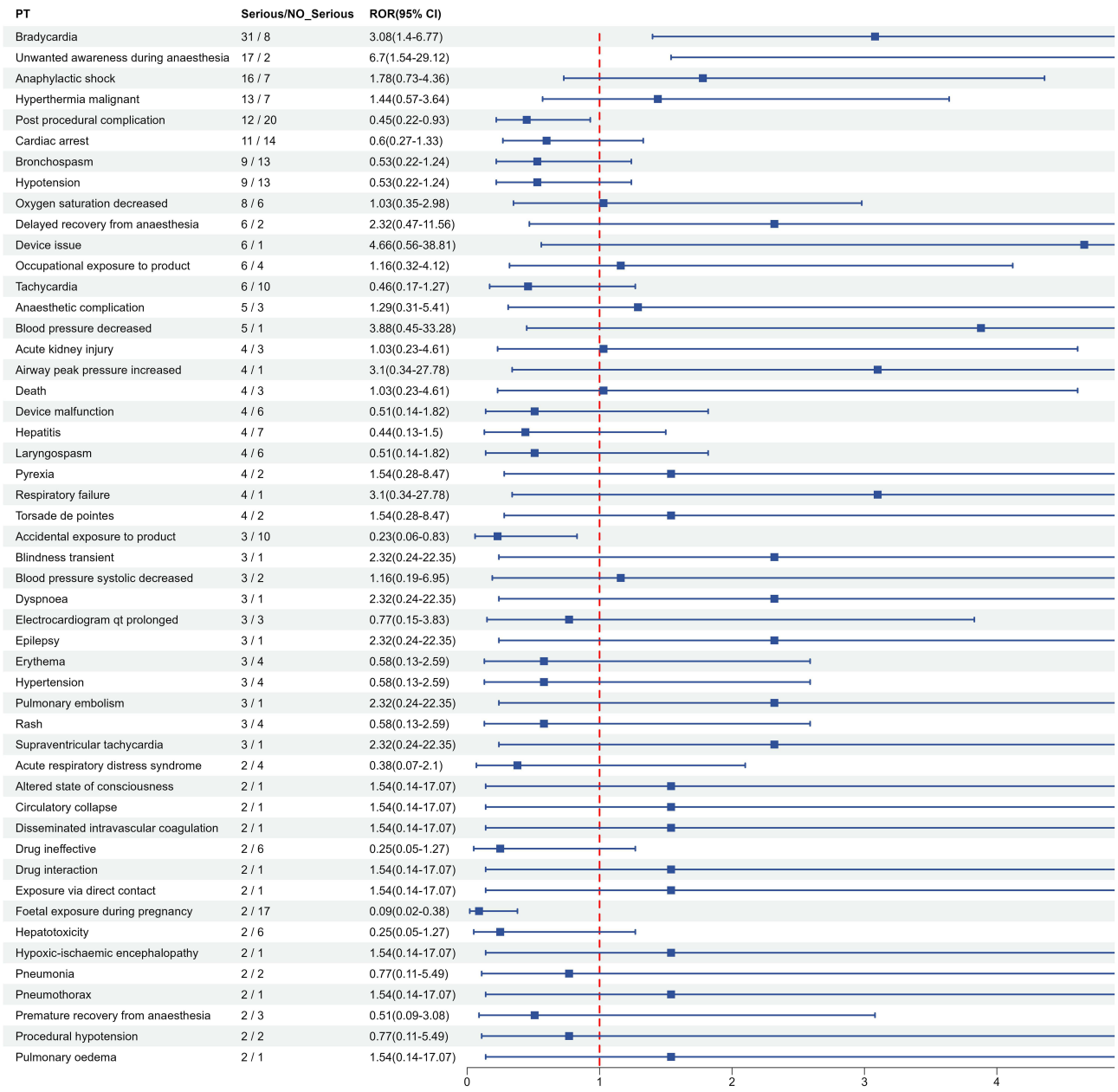

Figure 5 Comparative analysis of severe versus non-severe adverse event subgroups.

Discussion

The evolution of anesthetic agents has revolutionized surgical outcomes, significantly reducing mortality and morbidity associated with intraoperative pain and stress responses.[14] Desflurane is a widely used volatile anesthetic with several pharmacological advantages, including rapid induction, low blood-gas solubility, and minimal metabolism, making it particularly suitable for surgical procedures requiring precise anesthetic control.[3,15] Its rapid washout renders it especially useful in ambulatory and neurosurgical settings,[16] where prompt postoperative extubation[17] and efficient operating room turnover[18] are critical.

However, despite these benefits, desflurane is associated with dose-dependent AEs. Feyzullah et al[19] demonstrated through acoustic voice analysis that desflurane anesthesia may cause clinically subtle vocal deterioration. Other reported AEs include airway irritation, hemodynamic instability, and rare but life-threatening complications such as MH.[20] Given its widespread clinical use, systematic pharmacovigilance is essential to identify and mitigate these risks. FAERS provides a valuable real-world dataset for evaluating desflurane's safety profile beyond controlled clinical trials.

Our analysis of FAERS reports from Q1 2004 to Q1 2025 identified significant AEs associated with desflurane, including bradycardia, anaphylactic shock, bronchospasm, MH, and DIC. These findings underscore the need for enhanced perioperative monitoring and updated safety protocols to minimize patient harm.

Cardiovascular Adverse Events: Bradycardia as the Most Common Complication

Our study revealed bradycardia as the most frequently reported AEs (n=39), with 79.4% of cases classified as severe, potentially leading to life-threatening events or prolonged hospitalization. This aligns with prior research[21] indicating that desflurane induces transient sympathetic activation followed by parasympathetic dominance, resulting in sinus bradycardia. Direct myocardial depression[22] and baroreflex modulation may further contribute to this effect. Pediatric and elderly patients, due to reduced autonomic reserve, are at higher risk.[23] Continuous ECG monitoring is therefore imperative, particularly in high-risk populations,[24,25] and atropine should be readily available to manage severe bradycardia.

Anaphylactic Shock: A Severe and Concerning Reaction

FAERS documented 23 cases of anaphylactic shock, 69.6% of which were severe and required emergency intervention.[26] This rapid-onset, potentially fatal reaction is often misattributed to other intraoperative events. IgE-mediated hypersensitivity to fluorinated anesthetics has been previously reported,[27] warranting preoperative allergy screening in patients with a history of drug reactions.[28] Immediate administration of epinephrine and corticosteroids is critical if anaphylaxis is suspected.[26,29]

Neurological Adverse Events: Rare but Clinically Significant

Although neurological AEs were uncommon (7.3%), two cases of seizures were reported. A systematic review (2003–2020)[16] suggested minimal AEs when desflurane was used for anesthesia maintenance in supratentorial brain tumor surgeries. However, Wang et al[9] found that desflurane-based anesthesia comparably affected postoperative sleep quality to propofol-based total intravenous anesthesia. Thus, caution is advised in epileptic patients, and intraoperative stereotactic EEG (SEEG) or subdural EEG (SDE) monitoring may be beneficial.[30]

Respiratory Complications: Bronchospasm and Laryngospasm

Bronchospasm (n=22) and laryngospasm (n=10) were the most frequent respiratory AEs, consistent with desflurane's known airway-irritating properties. Notably, two cases of ARDS were identified—a complication not previously documented in desflurane's labeling. Direct tracheobronchial irritation may trigger reflexive bronchoconstriction, while inflammatory cytokine release could contribute to ARDS. Further evaluation is needed for patients with asthma or reactive airway disease.

Life-Threatening Complications: Malignant Hyperthermia and DIC

Twenty MH cases were reported, including five fatalities, aligning with label warnings. Dantrolene must be immediately available when using desflurane, and vigilant temperature monitoring is essential for early intervention. Additionally,

DIC (n=3, two fatal) was identified as a previously unreported AE. Characterized by systemic thrombosis and bleeding diathesis, DIC may progress to multi-organ dysfunction syndrome (MODS),[31] shock, or death.[32] Murine models using KCG and LPS[33] may aid in elucidating its pathogenesis. Unexplained intraoperative bleeding should prompt urgent coagulation testing.

Limitations

Despite its utility in post-marketing surveillance, the FAERS database presents several limitations relevant to our assessment of desflurane-associated adverse events: First, substantial underreporting and reporting bias exist, particularly for common anesthetic complications (eg, postoperative nausea) compared to rare but dramatic events (eg, malignant hyperthermia).[34] Second, critical clinical details - including exact dosing regimens, temporal relationships, and complete patient histories - are frequently missing from spontaneous reports.[35] Third, the potential confounding effects of concomitant anesthetic medications (eg, opioids, neuromuscular blocking agents) cannot be reliably assessed due to the system's passive surveillance nature.

Conclusion

Our analysis of FAERS data (2004–2025) identified significant desflurane-associated AEs, with bradycardia showing a high propensity to progress to severe outcomes without prompt intervention. Statistically robust signals (eg, anaphylactic shock, bronchospasm, and malignant hyperthermia [MH]) underscore the need for enhanced intraoperative monitoring. Rare but life-threatening events, including disseminated intravascular coagulation (DIC; n=3) - a finding not currently reflected in the drug's labeling - were identified. These findings warrant updates to anesthesia practice guidelines and highlight the need for further research into the mechanisms underlying these safety signals.

Abbreviations

AEs, adverse events; FAERS, Food and Drug Administration Adverse Event Reporting System; PS, primary suspect; MedDRA, Medical Dictionary for Regulatory Activities; ROR, Reporting Odds Ratio; PRR, Proportional Reporting Ratio; BCPNN, Bayesian Confidence Propagation Neural Network, MGPS, Multi-item Gamma Poisson Shrinker; MH, malignant hyperthermia; ARDS, Acute respiratory distress syndrome; DIC, disseminated intravascular coagulation; PONV, postoperative nausea and vomiting; SOC, System Organ Class; PTs, preferred terms; ECG, Electrocardiogram; MODS, multi-organ dysfunction syndrome.

Data Sharing Statement

The data analyzed are publicly available in the FAERS database (https://fis.fda.gov/sense/).

Ethical Approval Statement

This study utilized de-identified data from a publicly available, open-source database. In accordance with the'Ethical Review Measures for Life Sciences and Medical Research Involving Humans' (National Health Commission Order No. 4, 2023, effective February 18, 2023), research involving anonymized public datasets is exempt from additional ethical review when: (1) the data source is legally authorized for research use, and (2) individual privacy rights are fully protected (Article 32, Paragraph 1). No Institutional Review Board (IRB) approval was required for this analysis.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no competing financial or non-financial interests in this work.

References

1. Inada Y, Funai Y, Yamasaki H, Mori T, Nishikawa K. Effects of sevoflurane and desflurane on the nociceptive responses of substantia gelatinosa neurons in the rat spinal cord dorsal horn: an in vivo patch-clamp analysis. *Molecular Pain*. 2020;16:1744806920903149. doi:10.1177/1744806920903149
2. Kim YS, Kim J, Park S, et al. Differential effects of sevoflurane and desflurane on frontal intraoperative electroencephalogram dynamics associated with postoperative delirium. *J Clin Anesthesia*. 2024;93:111368. doi:10.1016/j.jclinane.2023.111368
3. Jiang Z, Wu Y, Liang F, et al. Brain relaxation using desflurane anesthesia and total intravenous anesthesia in patients undergoing craniotomy for supratentorial tumors: a randomized controlled study. *BMC Anesthesiol*. 2023;23(1):15. doi:10.1186/s12871-023-01970-z
4. Taschner A, Fleischmann E, Kabon B, et al. Effect of desflurane, sevoflurane or propofol on the incidence of postoperative delirium in older adults undergoing moderate- to high-risk major non-cardiac surgery: study protocol for a prospective, randomised, observer-blinded, clinical trial (RAPID-II trial). *BMJ Open*. 2024;14(11):e092611. doi:10.1136/bmjopen-2024-092611
5. Chen WS, Chiang MH, Hung KC, et al. Adverse respiratory events with sevoflurane compared with desflurane in ambulatory surgery: a systematic review and meta-analysis. *Eur J Anaesthesiol*. 2020;37(12):1093–1104. doi:10.1097/EJA.0000000000001375
6. Pin-On P, Leurcharusmee P, Tanasungnuchit S, Srivita K, Khunwittaya P. Desflurane is not inferior to sevoflurane in the occurrence of adverse respiratory events during laryngeal mask airway anesthesia: a non-inferiority randomized double-blinded controlled study. *Minerva anestesiologica*. 2020;86(6):608–616. doi:10.23736/S0375-9393.20.14202-0
7. Sethi N, Dutta A, Puri GD, et al. Evaluation of quality of recovery with quality of recovery-15 score after closed-loop anesthesia delivery system-guided propofol versus desflurane general anesthesia in patients undergoing transabdominal robotic surgery: a randomized controlled study. *Anesthesia Analg*. 2024;138(5):1052–1062. doi:10.1213/ANE.0000000000006849
8. Heiderich S, Thoben C, Dennhardt N, et al. Preparation of Drager Atlan A350 and General Electric Healthcare Carestation 650 anesthesia workstations for malignant hyperthermia susceptible patients. *BMC Anesthesiol*. 2021;21(1):315. doi:10.1186/s12871-021-01533-0
9. Wang X, Xiong B, Wu T, et al. Effect of desflurane maintenance on postoperative sleep quality in patients undergoing elective breast surgery: a non-inferiority randomized controlled trial. *Sleep Med*. 2024;121:287–294. doi:10.1016/j.sleep.2024.07.022
10. Godfrey H, Leibovit-Reiben Z, Jedlowski P, Thiede R. Alopecia associated with the use of semaglutide and tirzepatide: a disproportionality analysis using the FDA adverse event reporting system (FAERS) from 2022 to 2023. *J Eur Acad Dermatol Venereol JEADV*. 2025;39(2):e153–e154. doi:10.1111/jdv.20197
11. Liu H, Yang Q, Li Z, Yan S, Ming S. Systematic analysis of sugammadex-related adverse drug reaction signals using FAERS database. *Int J Surg*. 2025;111(2):1988–1994. doi:10.1097/JS9.0000000000002194
12. Zhang Y, Qian M, Zheng A, et al. The risk of propofol infusion syndrome on epilepsy patients: insights from FAERS data and published case reports. *Eur J Pharmacol*. 2025;999:177429. doi:10.1016/j.ejphar.2025.177429
13. Ellithi M, Elsallab M, Lunning MA, et al. Neurotoxicity and rare adverse events in BCMA-directed CAR T cell therapy: a comprehensive analysis of real-world FAERS data. *Transplantat Cell Ther*. 2025;31(2):71e1–71e14. doi:10.1016/j.jtct.2024.12.002
14. Ten Barge JA, Zwiers AJM, Vermeulen MJ, et al. Current anesthesia practice for preterm infants undergoing surgery for necrotizing enterocolitis: a European survey. *J Clin Anesthesia*. 2024;97:111508. doi:10.1016/j.jclinane.2024.111508
15. Dexter F, Epstein RH. Associations between fresh gas flow and duration of anesthetic on the maximum potential benefit of anesthetic gas capture in operating rooms and in postanesthesia care units to capture waste anesthetic gas. *Anesthesia Analg*. 2023;137(5):1104–1109. doi:10.1213/ANE.0000000000006610
16. Gkantinas G, Tataki E, Lykoudis PM, Lelekaki E, Kouki P. Clinical effects and adverse events associated with desflurane use in adult patients undergoing supratentorial craniotomy: a systematic review. *J Neurosurg Anesthesiol*. 2024;36(1):20–28. doi:10.1097/ANA.0000000000000905
17. Wachtel RE, Dexter F, Epstein RH, Ledolter J. Meta-analysis of desflurane and propofol average times and variability in times to extubation and following commands. *Canad J Anaesthes J Canad D'anesthesie*. 2011;58(8):714–724. doi:10.1007/s12630-011-9519-1
18. Schad S, Booke M, Thal SC, Bentley A, Booke H. Evaluation of the effectiveness of the separate anesthesia induction rooms on multidisciplinary work flow in operating rooms. *J Multidisciplinary Healthcare*. 2023;16:899–903. doi:10.2147/JMDH.S402590
19. Kolay F, Vahapoglu A, Guvenc A, Turkmen UA. The comparison between inhalation and total intravenous anesthesia effect on voice with supraglottic airway devices for short-term anesthesia. *J Voice*. 2025;39(2):571e21–571e29. doi:10.1016/j.jvoice.2022.10.009
20. Thoben C, Dennhardt N, Krauss T, et al. Preparation of anaesthesia workstation for trigger-free anaesthesia: an observational laboratory study. *Eur J Anaesthesiol*. 2019;36(11):851–856. doi:10.1097/EJA.0000000000001086
21. Joo Y, Shin BS, Cho EA, Kim DK. Comparison of desflurane and sevoflurane anaesthesia in relation to the risk of vagally mediated reflex bradycardia during gastrectomy. *J Int Med Res*. 2012;40(4):1492–1498. doi:10.1177/147323001204000428
22. Deng XQ, Yu H, Wang WJ, et al. Effect of volatile versus propofol anaesthesia on major complications and mortality after cardiac surgery: a multicentre randomised trial. *Br J Anaesth*. 2024;133(2):296–304. doi:10.1016/j.bja.2024.05.008
23. Liu W, Du M, Zhang M, et al. Impact of propofol versus desflurane anesthesia on postoperative hepatic and renal functions in infants with living-related liver transplantation: a randomized controlled trial. *BMC Med*. 2024;22(1):397. doi:10.1186/s12916-024-03622-6
24. Wade RC, Martinez FJ, Criner GJ, et al. ECG-based risk factors for adverse cardiopulmonary events and treatment outcomes in COPD. *Europ Resp J*. 2025;65(2). doi:10.1183/13993003.00171-2024

25. Lee H, Yang HL, Ryu HG, et al. Real-time machine learning model to predict in-hospital cardiac arrest using heart rate variability in ICU. *Npj Digital Med*. 2023;6(1):215. doi:10.1038/s41746-023-00960-2
26. Golden DBK, Wang J, Waserman S, et al. Anaphylaxis: a 2023 practice parameter update. *Ann Allergy Asthma Immunol*. 2024;132(2):124–176. doi:10.1016/j.anai.2023.09.015
27. Mencarelli A, Bist P, Choi HW, Khameneh HJ, Mortellaro A, Abraham SN. Anaphylactic degranulation by mast cells requires the mobilization of inflammasome components. *Nat Immunol*. 2024;25(4):693–702. doi:10.1038/s41590-024-01788-y
28. Santos AF, Riggioni C, Agache I, et al. EAACI guidelines on the management of IgE-mediated food allergy. *Allergy*. 2025;80(1):14–36. doi:10.1111/all16345
29. Dodd A, Turner PJ, Soar J, Savic L. Emergency treatment of peri-operative anaphylaxis: resuscitation council UK algorithm for anaesthetists. *Anaesthesia*. 2024;79(5):535–541. doi:10.1111/anae.16206
30. Jha R, Liu DD, Gerstl JVE, et al. Comparative effectiveness of stereotactic, subdural, or hybrid intracranial EEG monitoring in epilepsy surgery. *J Neurosurg*. 2024;141(2):372–380. doi:10.3171/2024.1.JNS232560
31. Wang G, Hao C, Yao S, et al. Exploring the mediating role of multiple organ dysfunction in sepsis-induced disseminated intravascular coagulation and its impact on worsening prognosis. *Clin Appl Thromb Hemost*. 2024;30:10760296241271358. doi:10.1177/10760296241271358
32. Matsuoka T, Yamakawa K, Iba T, Homma K, Sasaki J. Persistent and late-onset disseminated intravascular coagulation are closely related to poor prognosis in patients with sepsis. *Thrombosis Haemostasis*. 2024;124(5):399–407. doi:10.1055/a-2196-3630
33. Tang P, Huang B, Ou Q, et al. A mouse model of sepsis-associated DIC induced by Kappa-carrageenan and Lipopolysaccharides: establishment and characteristics. *J Adv Res*. 2025. doi:10.1016/j.jare.2025.03.029
34. Salah S, Kerob D, Pages Laurent C, Lacouture M, Sibaud V. Evaluation of anticancer therapy-related dermatologic adverse events: insights from food and drug administration's adverse event reporting system dataset. *J Am Acad Dermatol*. 2024;91(5):863–871. doi:10.1016/j.jaad.2024.07.1456
35. Li J, Zhang F, Eisel UL. Adverse events associated with lecanemab: a disproportionality analysis of data from the FDA adverse event reporting system. *J Alzheimers dis*. 2025;13872877251333084. doi:10.1177/13872877251333084