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Selection of anesthetic agents in day surgery

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Abstract: The rapid expansion of day surgery has shifted anesthetic practice toward greater emphasis on rapid and smooth emergence, respiratory stability, and predictable postoperative discharge. To achieve these goals, contemporary ambulatory anesthesia has increasingly adopted total intravenous anesthesia, opioid-sparing strategies, and multimodal analgesia. This review summarizes current evidence on key intravenous anesthetics, including propofol, ciprofol, and remimazolam, as well as adjuncts such as dexmedetomidine, esketamine, and oliceridine in day surgery settings. It also outlines anesthetic management considerations for special populations, including older adults, patients with obesity or obstructive sleep apnea syndrome, and those with hepatic or renal dysfunction.

Keywords: Day surgery; Opioid-sparing anesthesia; Total intravenous anesthesia; Postoperative nausea and vomiting; Enhanced recovery after surgery

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Day surgery is rapidly developing worldwide, with the types of procedures expanding from traditional outpatient minor surgeries to gynecological, urological, and certain laparoscopic minimally invasive operations [1]. Thus, patients often need to complete admission, surgery, and discharge on the same day, shifting the focus of anesthesia from intraoperative safety to comprehensive management for rapid recovery [1-2]. Influenced by the concept of enhanced recovery after surgery (ERAS), the quality evaluation of day surgery anesthesia is receiving increasing attention [1-2].

Inhalation anesthesia is more likely to induce postoperative nausea and vomiting (PONV) compared to intravenous anesthesia in some particular type of surgery [3]. The incidence of PONV in surgical patients ranges from 20% to 80%, making it a common issue affecting recovery quality in the perioperative period. Adopting total intravenous anesthesia (TIVA) or reducing opioid usage can help lower the risk of PONV [4]. In day surgery pathways emphasizing rapid awakening and turnover, TIVA, represented by propofol, is widely regarded as a preferred option due to its controllable emergence, lower incidence of PONV, and higher subjective patient comfort [5-6]. This article is a narrative review. By searching relevant domestic and international databases, it primarily includes randomized controlled trials, systematic reviews/meta-analyses, guidelines, and expert consensus from the past decade, in order to provide a comprehensive overview of the current evidence base and key points for standardized pathway practices.

1 Advantages of Intravenous Anesthesia and Progress in Key Drugs

1.1 Advantages of TIVA

The advantages of TIVA lie in its ease of control and rapid emergence. Multiple randomized controlled studies showed that TIVA, represented by propofol, could reduce the incidence of PONV within 24 hours postoperatively, decrease the need for antiemetics, and shorten the stay in the post-anesthesia care unit (PACU) in common day surgeries [5]. This advantage is particularly evident in gynecological, breast, and laparoscopic surgeries, which carry a high risk of PONV [4].

For elderly, obese patients, and those with obstructive sleep apnea-hypopnea syndrome (OSAS), intravenous anesthesia causes less airway irritation. Reducing opioid usage can decrease the incidence of hypoventilation and hypoxic events [7-8]. Therefore, in models pursuing rapid recovery, lower readmission rates, and improved patient experience, TIVA is often prioritized. Key pharmacology and safety points of intravenous anesthetics are shown in **Table 1.**

1.2 Ciprofol

Ciprofol is an intravenous anesthetic improved on the basis of propofol. By increasing the affinity for the gamma-aminobutyric acid subtype A ($GABA_A$) receptor, it requires a lower dose [9-10]. Its induction time and quality of emergence are not inferior to propofol. Compared to propofol combined with oxycodone, ciprofol combined with oxycodone showed reduced changes in mean arterial pressure and heart rate during induced abortion surgery, indicating more stable intraoperative hemodynamics with ciprofol [11]. In short procedures (such as digestive endoscopy, hysteroscopy) and in non-operating room anesthesia settings, ciprofol offers rapid onset, stable metabolism, and generally good respiratory and circulatory safety [12]. In day surgeries requiring both hemodynamic stability and sedation quality, ciprofol is expected to become another primary agent choice for TIVA.

1.3 Remimazolam

Remimazolam, an ultra-short-acting benzodiazepine, can be metabolized by tissue esterase. It's independent of hepatic and renal metabolism, can be cleared rapidly and reversed by flumazenil specifically [13-14]. Remimazolam holds significant advantages in elderly patients, those with multiple comorbidities, and those with reduced organ reserve. Compared to propofol, remimazolam achieves satisfactory sedation success rates while causing fewer hypotension and respiratory depression events, with a smoother emergence process in upper gastrointestinal endoscopy, short-duration sedation for the elderly, and some day surgeries [15-16]. For patients at higher respiratory risk, remimazolam is expected to be an important alternative option for day surgery sedation.

2 Opioid-Sparse Anesthesia: Balancing Recovery Quality and Safety

Opioids have been used for thousands of years, offering cardiovascular stability, potent analgesic effects, and the ability to eliminate emotional responses caused by pain, with no current alternatives that can fully replace them. However, traditional opioid analgesia is often accompanied by a series of side effects (such as PONV, excessive sedation, respiratory depression, urinary retention), which frequently affect discharge assessments and increase risks [17-18].

Surveys indicate that sedation for daytime gastrointestinal endoscopy in China still primarily relies on propofol combined with opioids, and incidents of hypoxia and respiratory depression are not uncommon [19]. Recent prospective studies suggest that even when titrating alfentanil doses based on weight and sedation depth, close monitoring of respiration and hemodynamics remains necessary [20]. Correspondingly, in some gynecological, urological, breast endoscopic, and small-incision surgeries, combining peripheral nerve blocks or local infiltration analgesia can significantly reduce opioid consumption and improve functional recovery quality [21]. Therefore, reducing opioid dosage, or even achieving a "near opioid-free" approach in certain scenarios, is gradually becoming an important concept in day surgery anesthesia [17-18].

Opioid-sparing anesthesia involves the combined application of different analgesic techniques or non-opioid antinociceptive drugs with different mechanisms of action—such as dexmedetomidine (DEX), non-steroidal anti-inflammatory drugs (NSAIDs), lidocaine, magnesium, ketamine, etc.—acting on different targets in the pain transmission pathway to produce additive or synergistic analgesic effects. The aim is to reduce patients' exposure to opioids and lower the risks of delayed awakening and PONV, among others. Its core revolves around the time window and risk controllability of the day surgery pathway, enabling a more refined weighing and adjustment of opioid usage. Key pharmacology and safety points of opioids are shown in **Table 1.**

2.1 DEX

DEX is a highly selective α_2-adrenergic receptor agonist with sedative-hypnotic and antinociceptive properties, causing minimal respiratory depression. When used in general anesthesia, DEX can attenuate stress and inflammatory responses during gastric cancer surgery while maintaining hemodynamic stability [22]. Appropriate use of DEX in day surgery or short-duration anesthesia can improve emergence quality, reduce agitation and early discomfort, and lower the incidence of PONV [23-24]. However, rapid loading doses can easily induce bradycardia and transient hypotension; thus, low-dose continuous infusion or effect-site titration is generally more suitable for day cases [23]. Therefore, DEX is more appropriate as an adjunct for sedation and opioid-sparing, rather than as the sole primary agent for deep sedation.

2.2 Esketamine

Esketamine, as an N-methyl-D-aspartate (NMDA) receptor antagonist, exerts effects of anti-hyperalgesia and analgesia even at low doses, demonstrating an opioid-sparing effect [25]. When used within the recommended dose range, current evidence does not suggest a significant increase in postoperative psychiatric symptoms [25-26]. From the perspective of recovery quality, the combination of esketamine with intravenous anesthetics such as propofol or remifentanil can achieve a similar depth of sedation while reducing opioid usage. This approach helps to decrease the risks of respiratory depression and PONV, as well as shorten the functional recovery time. [27]. This combination is particularly attractive for patients with pre-existing chronic pain, opioid tolerance, or those anticipated to have severe postoperative pain.

Common dosage ranges and precautions for DEX and esketamine are listed in **Table 2**.

2.3 Oliceridine

Oliceridine, as a selective G-protein biased agonist, provides therapeutic analgesic effects while reducing the adverse reactions associated with traditional opioids. Reports indicate that analgesic effects at equivalent doses are non-inferior to conventional opioids, with lower incidences of respiratory events and gastrointestinal adverse reactions [28-29]. Subgroup analyses suggest that oliceridine can reduce complications such as respiratory depression while ensuring analgesia [30], and systematic reviews also show its advantages in terms of nausea, dizziness, and respiratory depression [31]. Oliceridine has been used in short minimally invasive surgeries such as hysteroscopy, where it ensures analgesic efficacy, reduces the dosage of traditional opioids, and decreases postoperative discomfort like nausea and dizziness [32]. Overall, considering oliceridine as a potential supplement to opioid-sparing anesthesia strategies aligns with current clinical practice, though its future application in day surgery still requires substantial clinical evidence.

3 Day Surgery Anesthesia Strategies for Special Populations: Risk Management and Precise Selection

The proportion of elderly, obese, OSAS patients, and those with varying degrees of hepatic or renal impairment among day surgery patients is continuously increasing. Anesthesia plans for these populations require emphasis on individualization and safety margins.

Tab.1 Intravenous anesthetics and opioids: pharmacology and adverse reaction comparisons

Drug	Onset/ Elimination	Recovery/ Predictability	Respiratory Depression	Hemodynamics	Common Adverse Reactions	Practical Tips
Propofol	Rapid onset; Fast distribution/clearance	Fast, predictable recovery	Dose-dependent (moderate–high)	Hypotension-prone (dose-dependent)	Injection pain, hypotension	Titrate with small divided doses or to effect-site; Avoid rapid bolus loading
Ciprofol	Rapid onset; Fast clearance	Fast, predictable recovery	Comparable to or slightly lower than propofol	Relatively stable	Hypotension, dizziness (usually mild)	Consider as an alternative for patients requiring greater hemodynamic stability and more comfortable injection; Evidence across surgical types is still accumulating
Remimazolam	Rapid onset; Metabolized by tissue esterase	Reversible (flumazenil); Controllable recovery	Lower (compared to propofol)	Relatively stable	Drowsiness, occasional hypotension	Have flumazenil available; Consider for elderly/comorbid patients or those with labile hemodynamics
Remifentanil	Ultra-short-acting; Extremely rapid onset/clearance	Rapid, predictable recovery	Present (dose-dependent)	Generally minimal impact	No residual postoperative analgesia; Opioid-related PONV	Suitable for short procedures/high turnover; Requires planning for multimodal postoperative analgesia
Sufentanil	Relatively rapid onset; Slower clearance	May be delayed (dose-dependent)	High (opioid characteristic)	Hypotension/bradycardia (dose-dependent)	PONV, excessive sedation, respiratory depression	Minimize opioids in ambulatory pathways; Combine with regional blockade/non-opioid analgesia
Alfentanil	Rapid onset; Short half-life	Relatively fast recovery	Present (transient)	Minimal impact	Short analgesic duration, may require rescue	Suitable for short procedures; Combine with non-opioid analgesia to cover early postoperative period
Oliceridine	Rapid onset; Short duration	Generally, does not prolong recovery	Potentially less respiratory depression	Limited data (overall stable)	Nausea, dizziness	Limited outpatient evidence; Requires individualized assessment for high-risk patients

Tab.2 Position and dose window of dexmedetomidine and esketamine in the daytime pathway

Drug/Scenario	Suggested Dose Range (Example)	Main Benefits	Main Risks	Impact on Recovery/ Discharge	Practical Key Points
DEX (adjunct sedation/anti-PONV)	Load: optional or small slow bolus; Maintenance: 0.2–0.7 μg·kg^{-1}·h^{-1}	Sedation, analgesia, reduces PONV	Bradycardia/ hypotension	Large load or overdose may delay discharge	Avoid rapid bolus; Stop infusion before end of surgery
Esketamine (analgesic adjunct)	Slow infusion post-induction: 0.1–0.3 mg/kg	Opioid-sparing, analgesia	Delirium/ nausea	Generally, does not delay; High doses may have impact	Use low-dose micro-infusion; Combine with antiemetic

Note: Dose ranges are summarized from literature and common practice, not prescribing recommendations. Must be individualized based on weight, concomitant medications, and real-time monitoring. DEX should be primarily titrated to effect; avoid rapid bolus and stop infusion before end of surgery.

3.1 Elderly Patients

Elderly patients have high sensitivity to anesthetic drugs. Propofol is prone to cause hypotension and delayed emergence; therefore, induction doses should be appropriately reduced, and maintenance depth controlled through slow titration. Remimazolam, due to its metabolism independent of liver and kidney function, rapid clearance, and reversibility, is an important option for sedation in elderly day surgery patients [15]. Opioids are more likely to cause respiratory depression, delirium, and urinary retention in elderly patients. Intraoperative doses should be minimized as much as possible, avoiding significant fluctuations in sedation depth. Reducing the use of anticholinergic drugs also helps lower the risk of postoperative cognitive dysfunction.

3.2 Obese and OSAS Populations

Obese and OSAS patients are more susceptible to upper airway collapse and hypoventilation during induction and emergence. Traditional opioid-centric pain management often leads to respiratory function suppression in obese patients, increasing the incidence and mortality of sleep-disordered breathing. Regarding anesthesia method selection, using propofol or ciprofol-based TIVA combined with an opioid-sparing strategy can reduce airway-related complications to some extent [7-8]. Remimazolam holds potential advantages in this population due to its milder respiratory depression and good reversibility [33]. The postoperative phase should involve enhanced oxygenation and ventilation monitoring. Observation time may need to be appropriately extended based on OSAS severity to prevent delayed respiratory adverse events [34-35].

3.3 Patients with Hepatic or Renal Impairment

In patients with hepatic or renal impairment, the risks of drug accumulation and delayed emergence are increased. Remimazolam is primarily metabolized by tissue esterase, making it relatively independent of hepatic and renal function and safer for day surgery sedation [13]. In contrast, DEX, which has a longer half-life, should be used cautiously in such patients, with recommendations for dose reduction and intensified circulatory monitoring.

4 PONV Risk Stratification and Prevention Strategies

PONV is a complication that most affects patient comfort, delays discharge, and may lead to unplanned visits in day surgery. In the day surgery model emphasizing rapid recovery and high turnover, systematically reducing PONV has become an important component of the anesthesia pathway. The Apfel simplified risk score for predicting PONV, due to its simplicity and relatively high predictive accuracy, is widely used to identify high-risk PONV patients [36]. Relevant guidelines suggest [4,37]: low-risk patients generally require only a single antiemetic; medium-risk patients benefit from a combination of a glucocorticoid and a 5-hydroxytryptamine-3 (5-HT_3) receptor antagonist; for patients with a history of severe PONV or multiple overlapping high-risk factors, consider adding a neurokinin-1 (NK-1) receptor antagonist on top of the above regimen, and prioritize propofol-based TIVA, opioid-sparing techniques, and multimodal analgesia. The anesthesia team can perform risk stratification preoperatively based on the Apfel score and preemptively match an antiemetic plan, making PONV management more effective. Specific protocols are shown in **Table 3.** Besides pharmacological prophylaxis, reducing volatile anesthetic and opioid use, maintaining adequate volume status, and ensuring hemodynamic stability are also considered fundamental measures to reduce PONV.

Tab.3 Pathway anesthesia strategy by Apfel stratification for ambulatory surgery

Risk Stratification	Recommended Anesthesia Technique	Analgesia Strategy	Opioid Strategy	PONV Prophylaxis	Discharge Criteria
0 points (Low)	TIVA or low-flow inhalation, avoid NO_2	Acetaminophen ± NSAIDs	Minimal necessary opioids	Optional or single-agent prophylaxis	Aldrete score ≥ 9; Pain and nausea controlled
1–2 points (Moderate)	TIVA preferred	Baseline analgesia ± regional block	Opioid-sparing	Dual: dexamethasone + 5-HT_3 antagonist	No significant PONV within 1 h; Able to ambulate and tolerate oral intake
3 points (High)	TIVA mandatory	Regional analgesia prioritized	Minimize opioids	Triple: dexamethasone + 5-HT_3 + dopamine antagonist	PADSS score ≥ 10; Stable observation ≥ 1 h
4 points (Very High)	TIVA + strict opioid-sparing	Regional block prioritized	Alternative strategies primary	Quadruple (add NK-1 antagonist)	Continuous monitoring ≥ 2 h (especially in OSAS)

5 Integration of the Day Surgery Anesthesia Path: From Preoperative Assessment to Discharge

Focusing on the core objectives of recovery quality and predictable discharge, daytime anesthesia management needs to integrate drug selection, process design, monitoring protocols, and multidisciplinary collaboration into a continuous pathway. During the preoperative assessment phase, consideration should be

given in advance to the indicators of the Post-Anesthesia Discharge Scoring System (PADSS). Beyond routine history and physical examination, attention should be paid to PONV risk scores, previous sedation or anesthesia experiences, cardiopulmonary reserve, and comorbidities [11,15]. Regarding intraoperative strategies, multimodal analgesia and the concept of opioid-sparing anesthesia are key [17]. In some cases, appropriate use of DEX and esketamine is warranted. For procedures with limited pain stimuli, local anesthesia and nerve blocks can even serve as the primary analgesic methods. During the emergence and discharge assessment phase, commonly used PADSS incorporates comprehensive scoring across dimensions such as stable respiration and circulation, mental status, pain control, mobility, and PONV to determine if the patient meets discharge criteria [38]. See **Figure 1.**

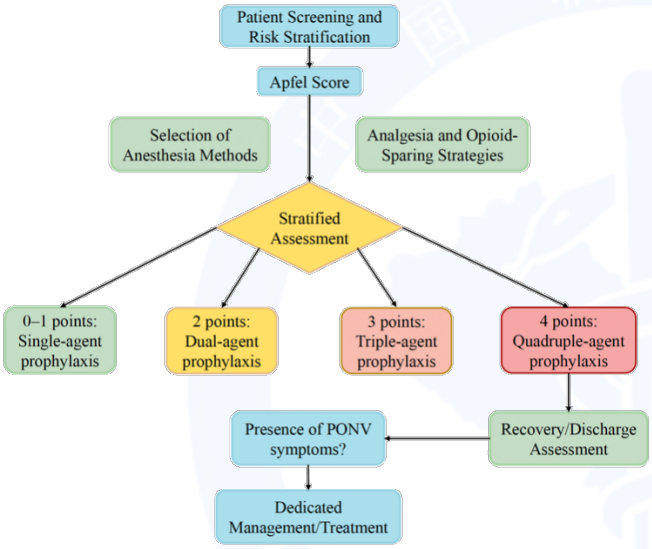

Fig.1 Outpatient anesthesia decision roadmap(execution path)

6 Future Directions: Environmentally Considerate Anesthesia and Intelligent Decision-Making

The application of ciprofol and remimazolam enriches the individualized selection of intravenous anesthesia across different populations [9,14]. The biased μ-opioid receptor agonist oliceridine offers a new potential pathway to improve the safety profile of opioid analgesia [32,39]. In the future, more real-world day surgery studies are needed to evaluate the efficacy and safety of these new agents across different surgical types and patient risk levels, in order to establish a more robust evidence base.

Environmentally considerate anesthesia is also a significant driver for transforming anesthesia practice. Reducing volatile anesthetic agent use, promoting TIVA, and optimizing the sustainability of pharmaceuticals and medical supplies are gradually being incorporated into hospital management and departmental quality control objectives [40-41]. In the day surgery setting, it is necessary to focus not only on the rapid recovery of individual patients but also on the long-term environmental impact of anesthesia practices. The application of artificial intelligence in perioperative management is under exploration. Studies have already attempted to use machine learning models to predict PACU recovery progress and discharge readiness, thereby guiding anesthesia plan optimization and recovery room resource allocation [42]. In the future, integrating real-time physiological monitoring data, pharmacokinetic models, and risk scoring tools into clinical decision support systems holds the potential to gradually shift day surgery anesthesia management from an experience-driven approach toward a data-driven, refined model.

7 Conclusion

The rapid development of day surgery has expanded the focus of anesthesia management from purely "intraoperative safety" to multiple levels including recovery quality, patient experience, and efficiency. TIVA, based on propofol, ciprofol, and remimazolam, provides a more controllable and environmentally friendly anesthesia mode for day surgery. Opioid-sparing anesthesia strategies combined with multimodal analgesia help reduce adverse reactions such as respiratory depression and PONV, enhancing discharge predictability. New or repurposed agents like DEX, esketamine, and oliceridine provide clinicians with more options for balancing sedation and analgesia.

There remains a need to develop more reliable technologies and indicators for the objective monitoring and evaluation of abnormal pain sensations (e.g., hyperalgesia/allodynia) under opioid-sparing anesthesia conditions, thereby improving the safety and effectiveness of perioperative analgesia. On one hand, it is necessary to leverage large databases to objectively document short-term and long-term benefits to implement personalized protocols. On the other hand, driven by the concepts of environmentally considerate anesthesia and intelligent tools, there is still significant room for improvement in day surgery anesthesia regarding pathway standardization, individualized adjustment, and real-world effectiveness. For different surgical types and special populations, more high-quality research is needed to further validate the external validity of opioid-sparing anesthesia and related pharmacological strategies, providing stronger evidence for daily clinical practice.

Conflict of Interest None

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·学术前沿·

日间手术麻醉药物的选择

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摘要：日间手术的快速发展，使麻醉管理更加关注苏醒质量、呼吸稳定性及出院可预测性。近年来逐渐形成了以全凭静脉麻醉、少阿片类药物麻醉和多模式镇痛为基础的日间麻醉模式。本文综述了丙泊酚、环泊酚、瑞马唑仑等静脉麻醉药，以及右美托咪定、艾司氯胺酮和奥赛利定等辅助麻醉药物在日间手术中的应用证据，并总结老年、肥胖/阻塞性睡眠呼吸暂停低通气综合征及肝肾功能受损等特殊人群的麻醉管理要点。

关键词：日间手术；少阿片类药物麻醉；全凭静脉麻醉；术后恶心呕吐；加速康复外科

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Selection of anesthetic agents in day surgery

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Abstract：The rapid expansion of day surgery has shifted anesthetic practice toward greater emphasis on rapid and smooth emergence，respiratory stability，and predictable postoperative discharge. Contemporary ambulatory anesthesia has increasingly adopted total intravenous anesthesia，opioid-sparing strategies，and multimodal analgesia. This review summarizes current evidence on key intravenous anesthetics，including propofol，ciprofol，and remimazolam，as well as adjuncts such as dexmedetomidine，esketamine，and oliceridine in day surgery settings. It also outlines anesthetic management considerations for special populations，including older adults，patients with obesity or obstructive sleep apnea hypopnea syndrome，and those with hepatic or renal dysfunction.

Keywords：Day surgery；Opioid-sparing anesthesia；Total intravenous anesthesia；Postoperative nausea and vomiting；Enhanced recovery after surgery

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日间手术在全球范围内快速发展,手术类型从传统门诊小手术逐渐扩展到妇科、泌尿外科以及部分腹腔镜微创操作[1]。在这一模式下,患者往往需要在同一就诊日完成入院、手术和出院,麻醉工作的重点也随之从术中安全延伸到快速恢复的整体管理[1-2]。在加速康复外科(enhanced recovery after surgery,ERAS)理念影响下,日间麻醉质量评价越来越受到重视[1-2]。

在部分手术类型中,吸入麻醉较静脉麻醉更易诱发术后恶心呕吐(postoperative nausea and vomiting,PONV)[3]。PONV 在手术患者中的发生率为 20%~80%,是围手术期常见的影响患者恢复质量的问题。采用全凭静脉麻醉(total intravenous anesthesia,TIVA)或减少阿片类药物的使用,有助于降低PONV风险[4]。在强调快速苏醒和周转的日间路径中,以丙泊酚为代表的TIVA,凭借苏醒可控、PONV 发生率低以及患者主观舒适度高,被广泛视为一种优选方案[5-6]。本文为叙述性综述,通过检索国内外相关数据库,重点纳入近十年的相关随机对照试验、系统评价/荟萃分析及指南和专家共识,对目前证据基础和路径化实践要点进行综合梳理。

1　静脉麻醉的优势及关键药物进展

1.1　*TIVA的优势*　TIVA的优势在于易于控制,苏醒迅速。多项随机对照研究显示,以丙泊酚为代表的TIVA在常见日间手术中,能够降低术后 24 小时的PONV发生率,减少止吐药的需求,并缩短麻醉后恢复室(postanesthesia care unit,PACU)滞留时间[5]。在PONV高风险的妇科、乳腺及腹腔镜手术中,这一优势尤为明显[4]。

对于老年、肥胖及合并阻塞性睡眠呼吸暂停低通气综合征(obstructive sleep apnea hypopnea syndrome,OSAS)患者,静脉麻醉对呼吸道刺激较小,减少阿片类药物的使用可降低通气不足和低氧事件[7-8]。因此,在追求快速恢复、降低再就诊率并提升患者体验的模式中,TIVA往往被优先考虑。静脉麻醉药的关键药理与安全要点见表1。

1.2　*环泊酚*　环泊酚是在丙泊酚基础上改良的静脉麻醉药,通过提高γ-氨基丁酸A型受体(gamma-aminobutyric acid subtype A,$GABA_A$)受体亲和力,所需剂量更低[9-10],其诱导时间和苏醒质量不逊于丙泊酚;与丙泊酚复合羟考酮相比,环泊酚复合羟考酮在人工流产手术中平均动脉压和心率变化减小,表明环泊酚术中循环更稳定[11]。在消化内镜、宫腔镜等短程操作以及非手术室麻醉环境中,环泊酚起效迅速、代谢稳定,呼吸和循环安全性总体良好[12]。在需兼顾循环稳定性和镇静质量的日间手术中,环泊酚有望成为另一种TIVA主药选择。

1.3　*瑞马唑仑*　瑞马唑仑为超短效苯二氮䓬类药物,经组织酯酶水解,不依赖肝肾代谢,清除迅速,可被氟马西尼特异性逆转[13-14]。在高龄、多病共存及器官储备降低的患者中具有明显优势。在上消化道内镜、老年短程镇静及部分日间手术中,与丙泊酚相比,瑞马唑仑在达到满意镇静成功率的同时,低血压和呼吸抑制事件更少,苏醒过程平稳[15-16]。对于呼吸风险较高的患者,瑞马唑仑有望成为日间镇静过程中的一个重要备选方案。

关键药理与安全要点见表1。

2　少阿片类药物麻醉:恢复质量与安全性的平衡

阿片类药物的使用已有上千年的历史,具有心血管稳定性和强效的镇痛作用,并能够消除由疼痛引起的情绪反应,目前仍无其他药物可替代。然而,传统阿片类镇痛常伴发一系列的副作用(如PONV、过度镇静、呼吸抑制、尿潴留),往往影响出院评估并增加风险[17-18]。

国内调查显示,我国日间胃肠道内镜镇静仍以丙泊酚联合阿片类药物为主,低氧和呼吸抑制事件并不少见[19]。近期前瞻性研究提示,即便根据体重和镇静深度滴定阿芬太尼剂量,仍需对呼吸和血流动力学进行严密监测[20]。与此相对应的,在部分妇科、泌尿外科、乳腺内镜及小切口手术中,联合外周神经阻滞或局部浸润镇痛,可以显著减少阿片类药物的用量并改善功能恢复质量[21]。因此,减少阿片类药物的用量,乃至在部分场景下实现“近似无阿片类药物”方案,逐渐成为日间麻醉的重要思路[17-18]。

少阿片类药物化是联合应用不同镇痛技术或作用机制不同的非阿片类抗伤害感受药物如右美托咪定(dexmedetomidine,DEX)、非甾体抗炎药、利多卡因、镁剂、氯胺酮等,作用于疼痛传导通路的不同靶点,发挥镇痛的相加或协同作用,以期减少患者在阿片类药物

中的暴露，降低延迟苏醒和PONV等风险。其核心是围绕日间路径的时间窗口和风险可控性，对阿片类药物的使用进行更加精细化的权衡和调节。阿片类药物的关键药理与安全要点见表1。

2.1　DEX　DEX是一种高选择性的α_2肾上腺素受体激动剂，具有镇静催眠和抗疼痛伤害性感受作用，且呼吸抑制作用轻微。DEX用于全身麻醉时，可以减轻胃癌手术中的应激和炎症反应，且血流动力学稳定[22]。在日间手术或短程麻醉中合理应用DEX，可改善苏醒质量，减少躁动和早期不适，且降低PONV发生率[23-24]。然而，快速负荷剂量易诱发心动过缓和短暂低血压，小剂量持续输注或按效滴定通常更适合日间病例[23]。因此，DEX更适合作为镇静与阿片节省的辅助药，而非深镇静的唯一主药。

2.2　艾司氯胺酮　艾司氯胺酮作为N-甲基-D-天门冬氨酸（N-methyl-D-aspartate，NMDA）受体拮抗剂，在低剂量范围内即可发挥抗痛觉敏化和镇痛作用，具有阿片类药物节省效应[25]。在推荐剂量范围使用时，现有证据并未提示术后精神症状明显增加[25-26]。从恢复质量的角度，将艾司氯胺酮与丙泊酚或瑞马唑仑等静脉麻醉药联合，可在取得类似镇静深度的同时减少阿片用量，从而降低呼吸抑制和PONV风险并缩短功能恢复时间[27]。对于既往存在慢性疼痛、阿片类药物耐受或预计术后疼痛较重的患者，这种组合更具吸引力。

DEX和艾司氯胺酮的常用剂量范围及注意事项见表2。

2.3　奥赛利定　奥赛利定作为选择性G蛋白激动剂，产生治疗性镇痛效果的同时减少了阿片类药物的不良反应。据报道等效剂量奥赛利定的镇痛效果不劣于常规阿片类药物，而呼吸事件和胃肠道不良反应发生率低[28-29]，亚组分析提示奥赛利定均能在保证镇痛的前提下，减少呼吸抑制等并发症[30]，系统综述亦显示其在恶心、头晕和呼吸抑制方面具有一定优势[31]。奥赛利定已用于宫腔镜等短程微创手术，其可保证镇痛效果，减少传统阿片类药物用量，降低术后恶心、头晕等不适[32]。综合来看，将奥赛利定视为少阿片类药物麻醉策略的潜在补充，符合当前临床实践，未来在日间手术中的应用仍需大量临床证据。

3　特殊人群的日间麻醉策略：风险管理与精准化选择

日间手术患者中，老年、肥胖、OSAS以及肝肾功能不同程度受损的比例不断上升，这些人群的麻醉方案需要强调个体化和安全边界。

3.1　老年患者　老年患者对麻醉药物的敏感性增加，丙泊酚容易引起低血压和苏醒延迟，因此诱导剂量应适当下调，并通过缓慢滴定控制维持深度。瑞

表1　静脉麻醉药与阿片类药物：药理与不良反应对照

Tab.1　Intravenous anesthetics and opioids: pharmacology and adverse reaction comparisons

药物	起效/消除	苏醒/可预测性	呼吸抑制	血流动力学	常见不良反应	实践提示
丙泊酚	起效快；分布/清除快	苏醒快、可预测	剂量相关（中-高）	易低血压（剂量相关）	注射痛、低血压	小剂量分次或效应室滴定；避免快速负荷
环泊酚	起效快；清除快	苏醒快、可预测	相当或略低于丙泊酚	较平稳	低血压、头晕（一般不重）	需循环更平稳、注射更舒适人群替代；跨术式证据仍在积累
瑞马唑仑	起效快；组织酯酶代谢	可逆（氟马西尼）；苏醒可控	较低（与丙泊酚相比）	较平稳	嗜睡、偶见低血压	备氟马西尼；老年/合并症或血流动力学易波动者可考虑
瑞芬太尼	超短效；起效/清除极快	苏醒迅速、可预测	存在（剂量相关）	一般影响小	术后无残余镇痛；阿片类药物相关PONV	适合短程/高周转；术后需提前布局多模式镇痛
舒芬太尼	起效较快；清除较慢	可能延迟（剂量相关）	较高（阿片类药物特征）	低血压/心动过缓（剂量相关）	PONV、镇静过深、呼吸抑制	日间路径尽量少阿片；联合区域阻滞/非阿片类药物镇痛
阿芬太尼	起效快；半衰期短	苏醒较快	存在（短时）	影响较小	镇痛时效短、可能需补救	适合短程操作；与非阿片类药物镇痛联用以覆盖术后早期
奥赛利定	起效快；作用短	一般不延长苏醒	潜在更少呼吸抑制	数据有限（总体稳定）	恶心、头晕	门诊证据有限；高风险患者需个体化评估

表2　DEX与艾司氯胺酮在日间路径中的定位与剂量窗

Tab.2　Position and dose window of DEX and esketamine in the daytime pathway

药物/场景	建议剂量窗（示例）	主要益处	主要风险	对复苏/出院的影响	实践要点
DEX（辅助镇静/抗PONV）	负荷可略或小剂量缓推；维持0.2~0.7 $\mu g \cdot kg^{-1} \cdot h^{-1}$	镇静镇痛、降PONV	心动过缓/低血压	负荷大或过量可延迟出院	避免快速负荷；术末提前停药
艾司氯胺酮（镇痛辅助）	诱导后低速输注0.1~0.3 mg/kg	少阿片、镇痛	谵妄/恶心	一般不延迟；高剂量可影响	小剂量微泵；合并止吐

注：剂量窗为文献汇总与常用实践范围，非处方建议；须结合体重、合并用药与实时监测个体化调整。DEX以按效滴定为主，避免快速负荷，术末提前停药。

马唑仑因其代谢不依赖肝肾、清除迅速且可逆，是老年日间镇静中的一个重要选项[15]。阿片类药物在老年患者中更易导致呼吸抑制、谵妄和尿潴留，术中应尽量减少剂量，避免镇静深度大幅波动，同时减少抗胆碱药物的使用，有助于降低术后认知功能障碍风险。

3.2　肥胖和OSAS人群　肥胖及OSAS患者在诱导和苏醒阶段更易出现上气道塌陷和通气不足。传统以阿片类药物为主的疼痛治疗往往引起肥胖患者呼吸功能抑制，导致睡眠呼吸紊乱发病率和死亡率增加。在麻醉方式选择方面，采用丙泊酚或环泊酚TIVA，并配合少阿片类药物麻醉策略，可一定程度减少气道相关并发症[7-8]。瑞马唑仑在此类人群中因呼吸抑制轻、可逆性好而具有潜在优势[33]。术后阶段应加强氧合和通气监测，根据OSAS严重程度适当延长观察时间，以防止迟发性呼吸不良事件的发生[34-35]。

3.3　肝肾功能受损患者　在肝肾功能受损患者中，药物蓄积和苏醒延迟的风险增加。瑞马唑仑主要通过组织酯酶代谢，相对不依赖肝肾功能，日间镇静中较为安全[13]。相反，半衰期较长的DEX在此类患者中应慎重应用，建议降低剂量并加强循环监测。

4　PONV风险分层与预防策略

PONV是日间手术中最影响患者舒适度、延迟出院并可能引起再就诊的并发症。在强调快速康复和高周转的日间模式下，系统性降低PONV已成为麻醉路径的重要内容。预测PONV的Apfel简化风险评分凭借操作简便、预测准确度较高，被广泛用于识别PONV高风险患者[36]。相关指南建议[4,37]：低风险患者一般仅需单一止吐药即可，中风险患者联合糖皮质激素和5-羟色胺3（5-hydroxytryptamine$_3$，5-HT$_3$）受体拮抗剂，对既往有严重PONV史或多重高危因素叠加的患者，可考虑在上述基础上加入神经激肽（neurokinin，NK）-1受体拮抗剂，并优先选择丙泊酚TIVA、少阿片类药物及多模式镇痛方案。麻醉团队可在术前依据Apfel评分进行风险分层并预先匹配止吐方案，使PONV管理更为有效，具体方案见表3。除药物预防外，减少挥发性麻醉剂和阿片类药物使用、维持足够容量状态和血流动力学稳定，也被认为是降低PONV的基础措施。

5　日间麻醉路径整合：从术前评估到出院

围绕恢复质量和可预测出院这一核心目标，日间麻醉管理需要将药物选择、流程设计、监测方案和多学科协作整合为一个连续的路径。术前评估阶段，预先考虑麻醉后出院评分系统（Post-Anesthesia Discharge Scoring System，PADSS）各项指标，在常规病史和体格检查之外，应注重PONV风险评分、既往镇静或麻醉体验、心肺储备以及合并症情况[11,15]。术中策略方面，多模式镇痛和少阿片类药物理念是关键[17]。在部分病例中，适量应用DEX和艾司氯胺酮。对于疼痛刺激有限的操作，局部麻醉和神经阻滞甚至可以成为主要镇痛手段。在苏醒与出院评估阶段，常用的PADSS将呼吸循环稳定、意识状态、疼痛控制、活动能力以及PONV等维度纳入综合评分，用以判断患者是否达到出院条件[38]。

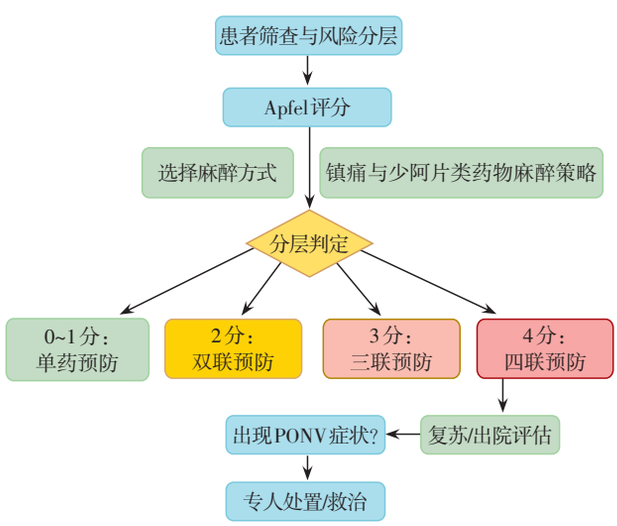

图1　门诊麻醉决策路线图（执行路径）

Fig.1　Outpatient anesthesia decision roadmap (execution path)

表3　日间手术按Apfel分层的路径化麻醉策略

Tab.3　Pathway anesthesia strategy by Apfel stratification for day surgery

风险分层	推荐麻醉方式	镇痛策略	阿片类药物策略	PONV预防	出院标准
0分（低）	TIVA或低流量吸入，避免一氧化二氮	对乙酰氨基酚±非甾体抗炎药	少量必要阿片类药物	可不预防或单药	Aldrete评分≥9分；疼痛、恶心可控
1~2分（中）	TIVA优先	基础镇痛±区域阻滞	少阿片类药物	双联：地塞米松+5-HT$_3$拮抗剂	1 h内无明显PONV；可行走、口服
3分（高）	TIVA必选	区域镇痛优先	最小化阿片类药物	三联：地塞米松+5-HT$_3$拮抗剂+多巴胺拮抗剂	PADSS评分≥10分；稳定观察≥1 h
4分（极高）	TIVA+严格少阿片类药物	区域阻滞优先	替代策略为主	四联（加入NK-1拮抗剂）	连续监测≥2 h（尤其OSAS）

注：剂量与给药时机需结合术式与患者特征本地化调整；避免止吐机制重复。

6　展望:绿色麻醉与智能化决策

环泊酚和瑞马唑仑的应用,使静脉麻醉在不同人群中的个体化选择更加丰富[9,14];偏向性μ受体激动剂奥赛利定,则为提高阿片类药物镇痛安全性提供了新的可能路径[32,39]。未来,需要更多基于真实世界的日间手术研究,评估这些新药物在不同手术类型、不同风险层级患者中的效果和安全性,以形成更稳固的证据基础。

绿色麻醉同样是推动麻醉模式变革的重要动力。减少挥发性麻醉剂使用、推广TIVA、优化药物和耗材的可持续性,正在逐步纳入医院管理和科室质量控制目标[40-41]。在日间手术场景中,既要关注个体患者的快速恢复,也需要兼顾麻醉实践对环境的长期影响。人工智能在围手术期管理中的应用正在探索。已有研究尝试利用机器学习模型预测PACU恢复进程和出院准备度,从而指导麻醉方案优化和恢复室资源配置[42]。将来,若能把实时生理监测数据、药代动力学模型和风险评分工具整合到临床决策支持系统中,有望使日间麻醉管理从经验主导逐步走向数据驱动的精细化模式。

7　结　语

日间手术的迅速发展,使麻醉管理的关注点从单纯的"术中安全"扩展到恢复质量、患者体验和效率等多个层面。以丙泊酚、环泊酚和瑞马唑仑为基础的TIVA,为日间麻醉提供了更加可控、环境友好的麻醉模式;少阿片类药物麻醉策略与多模式镇痛,有助于减少呼吸抑制和PONV等不良反应,提升出院可预测性;DEX、艾司氯胺酮及奥赛利定等新型或新用法药物,使临床在镇静与镇痛平衡上具备更多选择。

目前还需要开发更可靠的技术和指标进行客观监测及评价少阿片类药物麻醉条件下的痛觉异常,从而提高围术期镇痛的安全性与有效性。一方面,有必要利用大型数据库客观记录短期和长期的益处,以实施个体化方案;另一方面,在绿色麻醉理念和智能化工具的共同推动下,日间麻醉在路径标准化、个体化调节和真实世界效果之间仍有很大提升空间。对于不同手术类型和特殊人群,需要更多高质量研究进一步验证少阿片类药物麻醉及相关药物策略的外部效度,为日常临床实践提供更有力的依据。

利益冲突　无

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