

# Advances in the use of intravenous techniques in ambulatory anesthesia

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**Summary statement:** Advances in the use of intravenous techniques in ambulatory anesthesia has become important for the anesthesiologist as the key perioperative physician in outpatient surgery. Key techniques and choices of anesthetics are important in accomplishing fast track goals of ambulatory surgery.

**Purpose of review:** The anesthesiologist in the outpatient environment must focus on improving perioperative efficiency and reducing recovery times while accounting for patients' well-being and safety. This review article focuses on recent intravenous anesthetic techniques to accomplish these goals.

**Recent findings:** This review is an overview of techniques in intravenous anesthesia for ambulatory anesthesia. Intravenous techniques may be tailored to accomplish outpatient surgery goals for the type of surgical procedure and individual patient needs. Careful anesthetic planning and the application of the plans are critical to an anesthesiologist's success with fast-track ambulatory surgery.

**Conclusion:** Careful planning and application of intravenous techniques are critical to an anesthesiologist's success with fast-track ambulatory surgery.

**Keywords:** intravenous anesthesia, outpatient anesthesia, fast-track surgery

## Introduction

The growth and increasing popularity of fast-track surgery is not surprising, considering the advances in minimally invasive surgical techniques<sup>1</sup> and economic demands of today's health care state. Fast-track surgery was first introduced in the early 1990s to improve surgical throughput and operating room efficiency.<sup>2</sup> The principal goals of fast-track surgery are to improve operating room efficiency, facilitate early discharge from the hospital, and early resumption of activities of daily living.

In ambulatory anesthesia, anesthesiologists have evolved from physicians primarily focused on providing optimal intraoperative management and minimizing postoperative pain to perioperative physicians responsible for managing patients with co-existing medical conditions before, during, and after surgery.<sup>3,4</sup> Perioperative physicians play a key role in outpatient surgery through their choice of preoperative medications, intraoperative intravenous anesthetics and techniques, and prophylactic medications to minimize side effects (eg, nausea and vomiting, pain, dizziness), as well as the administration of adjunctive intravenous medications to maintain the function of major organ systems during and after surgery.

In addition to providing the best possible intraoperative anesthetic management, fast-track criteria require rapid emergence as well as the avoidance of postoperative side effects. The anesthesiologist should be well equipped with a practical understanding

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of intravenous techniques to optimally care for patients in ambulatory operations, as covered in this article.

## Preoperative preparation

A smooth ambulatory operation is facilitated by optimal preoperative assessment and optimization of the patient's health. Proper preparation of the patient for surgery with appropriate education and health optimization results in reducing ambulatory surgery risks, improving patient outcomes, and a surgical experience that is reflected in an improved patient satisfaction score.

## Preoperative medication

When indicated, intravenous medication is given preoperatively primarily to reduce anxiety, provide sedation, reduce sympathetic surges, and decrease postoperative side effects without delaying emergence from anesthesia.<sup>5</sup> Benzodiazepines are the most commonly used anxiolytics (eg, midazolam 10–20 µg/kg intravenously [IV]) and small doses can facilitate the perioperative fast-tracking process by minimizing anxiety and anxiety-related complications, while improving patient satisfaction.<sup>6</sup> Both beta blockers and alpha-2-agonists are increasingly popular adjuvants to outpatient anesthetic techniques as they provide anesthetic and analgesic sparing effects in addition to their hemodynamic uses.<sup>7–10</sup> Premedication with the alpha-2-agonists, dexmedetomidine (2.5 µg/kg IV), or clonidine (5 µg/kg PO), has been associated with a reduction in postoperative nausea and vomiting (PONV), intraoperative blood loss, and the use of perioperative opioid analgesics.<sup>10–12</sup> The inhibitory effect of these alpha-2-agonist agents on the hypothalamo-pituitary stress and sympathoadrenergic response<sup>13</sup> facilitates glycemic control in diabetic patients<sup>14</sup> and reduces acute coronary events postoperatively.<sup>15</sup>

Beta blockers suppress perioperative increases in circulating catecholamines and prevent adverse cardiovascular events in elderly patients undergoing non-cardiac surgery.<sup>7</sup> Beta blockers are effective in decreasing coronary demand and increasing supply to reduce cardiac events in surgical patients with coronary artery disease, and should be continued in all patients on chronic beta blocker therapy.<sup>16,17</sup> Perioperative beta blockade can improve hemodynamic stability during emergence and in the early postoperative period with little risk, provided there are no contraindications, including bradycardia, heart block, heart failure, hypotension, chronic obstructive pulmonary disease, and asthma.<sup>16</sup> Beta blockers in the ambulatory setting provide anesthetic and opioid-sparing effects, lead to a faster emergence and reduce postoperative side effects.

## Fast-tracking intravenous anesthetic techniques

The ideal fast-track intravenous technique should provide optimal surgical conditions and intraoperative amnesia and analgesia, but notably a short recovery period with no adverse anesthetic effects.

## Monitored anesthesia care

Compared with general anesthesia, monitored anesthesia care (MAC) techniques are often accomplished utilizing local anesthesia infiltration or peripheral nerve blocks in combination with intravenous sedative medications and may facilitate fast-track recovery.<sup>18</sup> Many different local anesthetic techniques can be applied; however, the simplest local technique with operator familiarity should be utilized to minimize side effects and risk of complications (namely, local anesthetic systemic toxicity from overdose or intravascular injection).<sup>19</sup>

Utilization of a MAC technique for hernia repairs, colorectal, and hand surgery is associated with a decrease in postoperative pain, opioid-sparing benefits, reduced PONV, and other opioid-related side effects.<sup>19,20</sup> Under MAC, local anesthetic infiltrations and/or peripheral nerve blocks using bupivacaine or ropivacaine are performed with no other anesthetic, or under general anesthetic; sedation may be added with midazolam and a variable rate of propofol infusion.<sup>21</sup> Additionally, dexmedetomidine<sup>22</sup> and ketamine<sup>23</sup> may be utilized as alternatives to opioid analgesics, to reduce opioid side effects and ventilator depression.<sup>24</sup> The leading cause of serious patient injuries during general anesthesia sedation cases is ventilator depression, and is most likely caused by over sedation and lack of vigilance.<sup>25</sup>

Intravenous MAC techniques can facilitate a fast-track recovery following ambulatory surgery and the patient may routinely bypass the postanesthesia care unit (PACU) or be discharged home earlier because of the fast emergence and low incidence of postoperative side effects. Newer intravenous agents as well as utilization of local anesthetics provides for opioid-sparing techniques. Although risks are lessened, intraoperative vigilance should always be maintained to avoid respiratory complications in the outpatient setting.<sup>26,27</sup>

## General anesthesia

In spite of the advantages of regional, local infiltration, and MAC anesthetic techniques, many operations require a general anesthetic, and many patients and surgeons may refuse anything other than a general anesthetic. Propofol is clearly the intravenous induction medication of choice for outpatient

anesthesia due to its low side effect profile and fast onset.<sup>28</sup> For maintenance, utilizing the most insoluble inhalational anesthetics available, desflurane (3%–6%) and sevoflurane (0.75%–1.8%), may be advantageous over propofol infusions because of rapid emergence.<sup>29–32</sup> However, a skillfully timed infusion of propofol may also provide rapid emergence. Remifentanyl infusions ( $0.05\text{--}0.20\ \mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ) may also be considered, and have been demonstrated as superior to nitrous oxide when utilized as an adjuvant.<sup>33,34</sup>

Short-acting beta blockers (eg, esmolol, labetalol, metoprolol) may be utilized as alternatives to opioid analgesics for treating transient, acute sympathetic responses.<sup>35–37</sup> Utilizing a laryngeal mask airway instead of an endotracheal tube, when possible, is desirable in a fast-track anesthetic as endotracheal tubes were demonstrated to lead to a higher incidence of nausea/vomiting and sore throat.<sup>38</sup> If an endotracheal tube is required, neuromuscular drug selection should be tailored to the patient's co-existing disease with kidney and liver metabolism as important considerations.<sup>39</sup> Sugammadex, a novel cyclodextrin compound, is a promising new medication, which may be of great interest to fast-track anesthesia since it can rapidly reverse steroid-based, non-depolarizing neuromuscular blockade.<sup>40</sup>

Although inhalational agents for maintenance may facilitate a faster emergence (versus propofol), the incidence of PONV in the early postoperative period is increased.<sup>41</sup> Prophylactic antiemetic medications should be employed to mitigate this side effect. A combination of low-dose droperidol (0.625 mg IV) and dexamethasone 4–8 mg IV<sup>42,43</sup> should be considered. A 5-HT<sub>3</sub> antagonist (ondansetron 4 mg IV) should also be considered for patients at high risk or in the event that one of the previously two agents is not available as part of a multimodal antiemetic regimen.<sup>44</sup> The neurokinin-1 antagonist class of drugs may play an important role in PONV management in the future. Efforts to reduce opioid use will minimize postoperative pain and side effects associated with opioids, inclusive of the following classes: non-steroidal anti-inflammatory drugs (NSAIDs), cyclooxygenase-2 (COX-2) inhibitors, intravenous acetaminophen, glucocorticoids, alpha-2-agonists, local anesthetics, and ketamine.<sup>45,46</sup>

Short-acting intravenous medications and inhalational agents and prophylactic medications may facilitate fast emergence and minimize side effects, allowing fast tracking of outpatient surgery.<sup>36,47–49</sup> The use of cerebral monitoring devices may also be of benefit toward fast-track goals to help calibrate a more precise anesthetic dosage.<sup>50–54</sup> In spontaneously breathing and non-paralyzed patients, however, the use of cerebral monitoring devices has been questioned.<sup>55</sup>

## Postoperative care

Poorly controlled nausea and vomiting and poorly controlled pain have been demonstrated to delay discharge following outpatient surgery.<sup>56</sup>

## Optimizing pain management

Improving postoperative pain management accelerates rehabilitation of activities of daily living that can otherwise be delayed for weeks following an elective operation.<sup>57–59</sup> According to a review by Liu and Wu,<sup>60</sup> there is “insufficient evidence to conclude that analgesic techniques influence postoperative mortality or morbidity” due to the low incidences of anesthetic complications. On the contrary, excessive administration of opioids for perioperative analgesia may contribute to acute opioid tolerance and hyperalgesia,<sup>61–63</sup> and may also contribute to dose-related opioid side effects such as respiratory depression, sedation, urinary retention, nausea and vomiting, and ileus. These side effects and complications may delay discharge time, add to the overall cost of care, and decrease patient satisfaction.<sup>62,64</sup> Although opioid infusions are often utilized via intravenous and epidural, they do not always improve pain management due to the risk of ventilatory depression and rapid development of tolerance.<sup>63</sup> This very difficult task of balancing the utilization of opioid medications with non-opioid analgesics must be navigated by the anesthesiologist, as optimal pain management may one day be mandated by accreditation bodies as a basic human right.<sup>65</sup>

Multimodal analgesia is the utilization of multiple modalities of pain control to synergistically provide analgesia while minimizing drug-related side effects.<sup>66</sup> Utilizing multimodal techniques has been demonstrated to improve fast-track goals in early ambulatory surgery studies.<sup>67,68</sup> Fast-track plans utilize the multimodal strategy<sup>1,69</sup> because administration of a single non-opioid analgesic such as a NSAIDs may not be sufficient exclusively and utilization of only opioid-based analgesics may have severe side effects.<sup>46</sup> Partial opioid agonists such as tramadol have been associated with undesirable side effects and dissatisfaction compared to both non-opioid- and opioid-based analgesics.<sup>70</sup>

Increasingly, painful and complex operations (eg, laparoscopic hysterectomy, adrenalectomy, nephrectomy, prostatectomy, shoulder replacements, hip replacements knee reconstructions, laminectomies) are being performed with minimally invasive techniques in the outpatient setting.<sup>2,34,71</sup> Thus, the use of multimodal techniques involving both opioid and non-opioid analgesics has become increasingly important in facilitating an expedited recovery process and

improved patient satisfaction.<sup>45</sup> Pavlin et al<sup>56</sup> demonstrated that moderate-to-severe pain prolonged the postanesthesia care unit stay by 40–80 minutes. Adjunct analgesics such as NSAIDs and local anesthetics reduced pain scores, as well as help in an earlier discharge time. Further studies with regard to multimodal techniques are needed and should focus on clinically significant metrics relevant to resumption of daily activities.<sup>44</sup>

Among the multiple issues that must be accounted for in the recovery process, including PONV<sup>72</sup> and hydration status,<sup>45,64,73,74</sup> adequate pain control is of chief concern to the patient<sup>75</sup> as well as their health care providers.<sup>76</sup>

Opioid analgesic medications will continue to play a role in management of perioperative pain. However, the role of non-opioid-based analgesic medications in perioperative pain management will likely expand as the number of minimally invasive surgery operations continue to grow.<sup>1,34</sup> Non-opioid medications such as NSAIDs (PO and IV), intravenous acetaminophen, COX-2 inhibitors, local anesthetics, ketamine, alpha-2-agonists, pregabalin, gabapentin, dextromethorphan, and even magnesium, may be utilized as a part of a multimodal approach to perioperative pain management<sup>45</sup> rather than aggressive use of opioid analgesics.<sup>66,77</sup> Other intravenous medications, which do not confer analgesic benefits such as antiemetics (droperidol)<sup>78</sup> and glucocorticoids (dexamethasone,<sup>79</sup> betamethasone,<sup>80</sup> methylprednisolone)<sup>81</sup> are of great benefit in reducing side effects in the postoperative period. Novel therapies like capsaicin, derived from chili peppers, have been established to provide analgesic benefits secondary to the effect in altering the nociceptive input at peripheral nerve ending.<sup>82</sup> The practitioner should also consider other non-pharmacologic modalities for pain control such as acustimulation, which has been demonstrated to be as effective as an adjuvant.<sup>83</sup>

Bisgaard<sup>84</sup> cites that “opioids should only be used when these other non-opioid analgesic techniques fail” in their assessment of multimodal techniques for analgesia in laparoscopy. Preemptive analgesic techniques have been suggested to account for the establishment of central sensitization;<sup>77</sup> however, this remains theoretical as there is no established clinically significant advantage over providing a multimodal approach perioperatively.<sup>85</sup> Further development should be focused on safe and cost-efficient drug delivery systems in not only the postoperative but also postdischarge period.<sup>1</sup> The multimodal strategy for pain control should be well coordinated between anesthesiologists, surgeons, and nursing staff to improve the outcome of our patients.<sup>2</sup> Novel non-opioid analgesics as well as older non-opioid analgesics

such as intravenous lidocaine and infusion drug delivery systems such as the ON–Q/i–flow pump will improve our ability to provide postoperative as well as postdischarge pain management.<sup>77,86,87</sup>

A multimodal approach to pain management could synergistically provide a comprehensive plan, and quite possibly without utilization of any opioids.<sup>45,46</sup> By the selection of key intravenous medications, the anesthesiologist can successfully accomplish the goals of fast-track surgery by minimizing postoperative pain, side effects from opioid medications, and fast recovery and emergence from anesthesia. Fast-track criterion is focused on speedy recovery as well as adequate pain control and minimal side effects such as PONV.<sup>88</sup>

## Postoperative nausea and vomiting

In spite of the attention to PONV and a plethora of antiemetic medications, the incidence of PONV is relatively high, present in as high as 30% of all surgical operations.<sup>89</sup> The risk factors for PONV have been well established: female, non-smokers, history of PONV, history of motion sickness, intraoperative volatile anesthetics and high-dose opioids, and postoperative opioids.<sup>90</sup> Intravenous medications in antiemetic prophylaxis should also be approached utilizing a multimodal approach, with the options of utilizing droperidol, ondansetron, and dexamethasone.<sup>91,92</sup> Multiple drugs are recommended for patients who have at least two risk factors for PONV.<sup>93</sup> Some non-traditional therapies may also be useful, including transdermal nicotine and topical capsaicin, as additions to an antiemetic prophylaxis regimen.<sup>94,95</sup> The anesthetic technique, utilization of propofol, adequate hydration, and opioid-sparing techniques, are key strategies in minimizing PONV.<sup>96</sup> Interestingly, the use of beta blockers and alpha-2-agonists to control hemodynamic responses intraoperatively with non-opioid analgesics will also minimize emetic symptoms.<sup>36,37,45</sup> Ketorolac showed advantages over glucocorticoid steroids in preventing PONV,<sup>97</sup> likely due to its opioid-sparing effects. Further, non-pharmacologic techniques can be helpful in reducing emetic symptoms, such as acupuncture, transcutaneous electrical nerve stimulation, and acupressure.<sup>98–100</sup> A concerted effort must be made in selecting intravenous medications for prophylaxis, minimizing opioids, adequately hydrating the patient, and providing possible non-pharmacologic adjuvants in reducing the patient's risk of PONV.

## Postoperative ileus and constipation

Postoperative ileus and constipation can be the source of abdominal pain and bloating, and may delay a patient's recovery and possibly delay discharge time.<sup>101</sup> Opioid-sparing

intravenous techniques will help reduce the incidence of postoperative ileus, and utilization of a peripheral acting mu-opioid receptor antagonist (alvimopan, methylnaltrexone) may be helpful. Strategies for preventing ileus also include early oral feeding, ambulation, and minimally invasive surgical techniques.<sup>102</sup>

The duration of ileus can be decreased by combining multimodal analgesic techniques with early oral feeding and early ambulation.<sup>103</sup> Avoidance of excess fluid is also key to early recovery of bowel function as has been suggested in enhanced recovery pathways in colorectal surgery<sup>104</sup> as well as a decrease in hospital length of stay.<sup>105</sup> Peripheral mu-opioid receptor antagonists (ie, alvimopan, methylnaltrexone) may also facilitate early resumption of bowel function and may also decrease the hospital length of stay.<sup>106,107</sup> The patient should be encouraged to continue to utilize a non-opioid analgesic pain management plan after discharge to reduce the incidence of postdischarge constipation and postdischarge nausea and vomiting (PDNV).<sup>108</sup>

## Conclusion

Anesthesiologists need to be proactive in the planning and execution of fast-track ambulatory surgery programs, and must be prepared to utilize intravenous techniques tailored for this environment. The patient's co-existing diseases, and specific surgical considerations must be accounted for when selecting preoperative intravenous medications and optimal anesthetic and analgesic techniques, and coordinating a team of health care providers efficiently.<sup>109–113</sup> Pain must be addressed in a multimodal fashion and the patient's pain must be adequately controlled since it can lead to either a delay in discharge or an unanticipated hospital admission.<sup>114</sup> PONV remains a very challenging problem with high incidence in spite of many new antiemetic medications and a lot of attention paid to this problem.<sup>115,116</sup>

Inter-disciplinary collaboration in establishing an efficient outpatient surgery program and workflow is essential between physicians and nurses.<sup>117,118</sup> Anesthesiologists must be the leaders in this effort, and are the sole providers responsible for the intravenous medications and anesthetics that greatly influence the patient's outcomes.

Anesthesiologists are responsible for the success of the fast-track goals of outpatient surgery through the effective utilization of appropriate intravenous anesthetic techniques for a vast number of outpatient surgical operations. By applying the concepts of multimodal analgesia, as well as considering novel techniques to improve analgesia and minimize postoperative and postdischarge side effects, the

patient will be able to resume activities of daily living with minimal recovery time.<sup>1,79,107</sup> This is the time for anesthesiologists to assume the leadership role as the perioperative physician in directing and executing an efficient ambulatory surgery program.

## Disclosure

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this article.

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