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Review

Recent advances in ambulatory anaesthesia

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Outpatient surgery is no longer restricted to young, healthy patients having brief, minor procedures. Even high-risk patients may be acceptable candidates for ambulatory surgery if their systemic diseases are well controlled preoperatively. The development of new short-acting anaesthetics with fewer unpleasant side effects, innovations in pain management, and technological advances have all contributed to the dramatic growth of ambulatory surgery. Moreover, recent liberalization of fasting instructions for clear liquids and advances in antiemetic therapy have helped eliminate, or at least attenuate, some of the more unpleasant aspects of the anaesthetic-surgical experience. This paper highlights current practice in preoperative preparation, selection of anaesthetic techniques and agents, prevention and therapy of nausea and vomiting, and management of problems that present in the postanaesthesia care unit (PACU).

Key words: Ambulatory surgery, patient selection, procedure selection, anaesthetic technique, fasting guidelines, antiemetic prophylaxis, preemptive analgesia, postoperative complications

Although the practice of outpatient surgery dates back to the early 20th century[1,2], as recently as 1980 ambulatory surgery accounted for only 16% of total operations performed in the United States. In the past 15 years, however, explosive growth has occurred, outpatient surgeries having increased from 3 million in 1980 to 11 million in 1990. Indeed, almost 60% of elective surgery in the United States is currently performed on an outpatient basis. The expansion, while impressive, of ambulatory surgery in Europe has not been as dramatic. In the United Kingdom, for example, ambulatory surgery accounts for approximately 20% of all operations.

Another significant development in the last decade has been the increasing popularity of freestanding ambulatory surgery centres (FASCs). Because FASCs are physically separate from the hospital with its associated support services, the types of operations that can be performed in FASCs are somewhat limited. Nonetheless, almost 20% of all outpatient surgery in the United States is currently performed in such centres[3].

The stimuli for such exponential growth in day-care surgery are multiple and include cost containment, the development of new short-acting anaesthetics with fewer unpleasant side effects, innovations in pain management, and technological advances. Clearly, the use of laser and endoscopy has dramatically affected how surgery is performed; the duration of postoperative recovery has been markedly truncated, and the quality of recovery has been rendered considerably more benign.

This paper will highlight four important areas of current concern in the subspeciality of outpatient anaesthesia: preoperative preparation; selection of techniques and agents; prevention and treatment of nausea and vomiting; and postanaesthesia care unit (PACU) management.

Preoperative preparation

Screening, case selection, patient selection and testing

The era has passed when ambulatory surgery was reserved for American Society of Anesthesiologists (ASA) physical status I or II patients undergoing minor or superficial procedures of extremely brief duration. Medically stable physical status III, and occasionally even physical status IV, patients are candidates for outpatient surgery if their operative procedure is associated with both limited physiologic trespass and an uncomplicated recovery, and they reside in reasonable proximity to medical care. (In general, regardless of the patient's medical condition, appropriate ambulatory surgical procedures involve minimal blood loss or fluid shifts, produce only mild to moderate postoperative pain that

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can be adequately controlled by oral analgesics, and do not require invasive or prolonged monitoring.)

As the complexity of outpatient procedures and patients increases, screening patients has become essential to identify high-risk or inappropriate patients, to reduce inefficient, last-minute cancellations, and to minimize costly unanticipated postoperative hospital admission. Communication among patients, anaesthesiologists, surgeons, primary care physicians, and physician extenders is critical to the success of accomplishing these objectives.

Methods of preoperative screening include: health questionnaires, telephone interviews, presurgical facility visits, or a combination of these methods. Each institution must decide which approach best meets its needs. However, presurgical facility or clinic visits are becoming increasingly popular, perhaps because they provide 'one-stop shopping' for the patient. In this setting patients can confer with the anaesthesiologist, discuss postoperative pain management, undergo laboratory testing, and meet with the nursing staff to receive perioperative education. Clearly, most busy ambulatory surgery units will want to select some form of preoperative screening prior to the day of surgery to obtain the requisite medical, administrative, and financial information.

The patient's history and the findings from physical examination should determine which laboratory tests should be ordered. The ambulatory unit is not the place to screen for asymptomatic disease. Indeed, one decade ago Blue Cross/Blue Shield estimated that $30 billion is spent on preoperative testing and evaluation in the United States. This insurance conglomerate claimed, moreover, that up to $18 billion could be saved annually if only appropriate tests were performed[4]. In addition, unnecessary testing may increase potential malpractice exposure. False positive laboratory tests, for example, lead to augmented patient anxiety, increased operating room delays and other costs, and may result in invasive diagnostic tests and therapies that can actually injure patients. A recent retrospective study[5] of 325 patients having nonselective preadmission testing prior to ambulatory surgery disclosed that at least one laboratory abnormality was noted in 84% of patients. Ninety-six per cent of the abnormal results were ignored by the attending physicians. It appeared that only 1% of patients potentially benefited from extensive testing. The authors concluded, therefore, that laboratory testing should be done selectively.

Clearly, medical staff and state regulations about preoperative testing must be fulfilled. However, as a routine in asymptomatic patients, only a haemoglobin or haematocrit is recommended in women under age 50. (Indeed, some centres will require no mandated tests for young, healthy patients). An electrocardiogram (ECG) is suggested for men >45 yr and for women >50 yr. A pregnancy test may be useful in women of childbearing age who are uncertain as to whether or not they might be pregnant[6]. In symptomatic patients, more extensive testing should be ordered, consistent with the patient's history and physical findings.

Table 1. Inappropriate outpatients

Psychosocial problems
Unwilling to participate
Unable to participate
Inadequate support network
Medical problems
Unstable disease
Acute substance abuse
Complex morbid obesity
High-risk former preterm infant

The inappropriate outpatient

As mentioned, ASA physical status III and IV patients may be candidates for ambulatory surgery if their systemic diseases are well controlled preoperatively and they are having relatively noninvasive procedures (e.g. cataract removal, carpal tunnel repair etc.). Indeed, in a prospective study, Natof discovered the incidence of perioperative complications in physical status III patients was not significantly different from patients without pre-existing disease[7]. Nonetheless, there are certain patients who are inappropriate candidates for outpatient surgery (Table 1). Exclusion categories may be psychosocial as well as medical. For example, anyone unable or unwilling to follow preoperative and postoperative instructions is unacceptable, as is an individual without a responsible adult to escort the patient home and help care for him or her postoperatively. Moreover, because of the possibility of acute untoward cardiovascular lability associated with anaesthesia in a patient who has recently abused illicit drugs, we preoperatively counsel these individuals and inform them that any signs of recent drug use will result in immediate cancellation on the day of surgery. We also encourage them to enrol in a rehabilitation programme.

Other inappropriate candidates include the medically unstable patient or the morbidly obese patient who has concomitant cardiorespiratory, hepatic, renal, vascular, or endocrine disease. Morbid obesity can be defined in a variety of ways, including a body mass index (BMI) >35. BMI is calculated as weight in kg divided by height in metres squared (BMI = wt (kg)/ht (m^2)). Alternatively, morbid obesity can also be defined as an actual body weight that is twice the ideal body weight for a given height and bone structure.

Age itself is not an exclusion criterion for the geriatric patient. More important than the actual chronological age is the physiological age and functional level of the patient. It is not at all uncommon to have nonagenarians on our outpatient surgery lists. Outcome studies have demonstrated minimal correlation between patient age and rate of perioperative complications[8,9]. The ex-preterm infant, however, represents a high-risk group. These babies have a vulnerability to develop life-threatening apnoea, hypothermia and bradycardia as well as periodic breathing, perioperative aspiration, and laryngospasm. The age at which former preterm infants may be sufficiently mature for outpatient surgery varies, according to

Table 2. Premedication/preinduction options in children

Drug	*Route*	*Dosage (mg kg^{-1})*	*Onset (min)*	*Comments*
Midazolam	Intramuscular	0.1–0.2	<10	
Midazolam	Nasal	0.2	10	5 mg ml^{-1}
Midazolam	Sublingual	0.2	10	Disguise bitter taste
Midazolam	Oral	0.5–1	15–20	Disguise bitter taste
Midazolam	Rectal	0.5–1	15–20	
Sufentanil	Nasal	0.002	10	Potential stiff chest
Fentanyl	Oral transmucosal fentanyl citrate	0.015–0.020	10–20	
Ketamine	Intramuscular	2–3; 'stun dose'	3	With atropine
Ketamine	Intramuscular	5–10; induction	3	With atropine
Ketamine	Oral	6–10	20	With atropine
Methohexital	Rectal	15–30	5–10	50–100 mg ml^{-1}

From: Kallar SK, Everett LL. Controversies in ambulatory anesthesia: Premedication in adult and pediatric patients. *Anesthesiol Rev* 1992; **19**: 26–32, with permission.

the literature, from 44–60 weeks post-conception. Welborn and colleagues[10] reported no postoperative apnoea or periodic breathing in babies without concomitant disease who were older than 44 weeks post-conception. Kurth and associates[11], however, documented cases of prolonged postanaesthetic apnoea in former preterm infants whose postconceptual age was less than 55 weeks. Moreover, this potentially fatal complication occurred as late as 12 h following anaesthesia. Therefore, it seems prudent to admit patients less than 55 weeks postconceptual age so that they can be continuously monitored overnight for oxygen desaturation, apnoea, and bradycardia. The putative efficacy of intravenous (iv) caffeine to suppress postoperative apnoea in former preterm infants[12] does not mitigate this recommendation. In addition, fragile former preterm infants with a history of respiratory distress syndrome, bronchopulmonary dysplasia, ongoing apnoea, or postfeeding aspiration should be asymptomatic – regardless of postconceptual age – before being anaesthetized on an outpatient basis.

Many, if not most, anaesthesiologists at hospital-based ambulatory surgery facilities believe that malignant hyperthermia susceptibility (MHS) is not a contraindication to outpatient surgery, providing non-triggering agents are administered, and dantrolene is immediately available. Prophylactic use of dantrolene does not appear to be indicated[13], and patients should be monitored postoperatively for 4–6 h. If their perioperative course is uncomplicated, MHS patients can be discharged home, following extensive and explicit instructions, provided they can be transported quickly to a medical facility should complications develop.

NPO instructions and aspiration prophylaxis

Several recent studies have demonstrated that gastric pH and volume are not affected deleteriously by allowing clear liquids up to 2–3 h before surgery[14,15]. Therefore we permit our patients with normal gastrointestinal physiology by history to swallow unlimited amounts of clear liquids up to 3 h before surgery. 'Clear liquids' include water, coffee, tea or clear fruit juices such as apple juice or pulp-free orange juice. Moreover, because aspiration is such a rare event in outpatient surgery[16], we do not routinely administer either H_2 blockers or a combination of antacid and gastrokinetic agents to all our outpatients. If, however, the patient has a condition associated with an increased risk of aspiration (e.g., pregnancy, obesity, reflux, gastroparesis, etc.), it is our practice to administer ranitidine 150 mg orally the evening before and the morning of surgery, combined with metoclopramide 10 mg iv approximately 1 h prior to surgery. If logistical factors do not permit the administration of oral ranitidine, then we typically give iv metoclopramide 1 h preoperatively, followed by oral Bicitra 15 min prior to induction of anaesthesia.

Premedication

Often, pharmacologic premedication is not necessary for adults undergoing ambulatory surgery. The majority of adults do well with gentle reassurance coupled with a thorough explanation of what to expect perioperatively. An excessively anxious patient, however, may benefit from 2 or 3 mg of iv midazolam on arrival in the outpatient surgery unit, assuming that the patient is young, otherwise healthy, and can be appropriately monitored with pulse oximetry. With adults, preinduction medication is common. Short-acting benzodiazepines, such as midazolam, and/or short-acting opioids such as fentanyl 1–2 μg kg^{-1} or alfentanil 6–10 μg kg^{-1} iv prior to induction are highly effective in facilitating a smooth perianaesthetic course, without delaying awakening.

In children, premedication is often indicated, and a variety of premedication/preinduction options have been described by Kallar and Everett[17] (Table 2).

Anaesthetic techniques and agents

A variety of anaesthetic techniques have been used successfully in the outpatient setting, and these include general anaesthesia, regional anaesthesia, and local infiltration anaesthesia with or without sedation, also known as monitored anaesthesia care (MAC). Proponents of general anaesthesia emphasize its controllability and the speed with which it can be induced. On the other

hand, partisans for regional anaesthesia underscore the postoperative analgesia and lack of emetic symptoms generally associated with its use. Clearly all techniques have advantages and disadvantages, and the selection of technique should be individualized. Factors influencing the decision include the medical history of the patient, surgical exigencies, and personal preferences of the patient, the surgeon, and the anaesthesiologist. To a certain extent, institutional factors will also affect the decision. For example, if adequate space (i.e. a separate block room with appropriate monitoring and resuscitation equipment) and support staff are unavailable, choice of regional blocks may need to be limited to those with a rapid onset time, such as Bier block and spinal for upper and lower extremity surgery respectively, rather than axillary and epidural blocks.

Regional anaesthesia

Upper extremity blocks

In most instances, intravenous regional anaesthesia (Bier block) with 40–50 ml of 0.5% lidocaine without epinephrine will provide adequate anaesthesia for hand and forearm surgery of less than 1 h duration. Although this block is easily and quickly executed, it typically affords somewhat less profound analgesia than axillary block and may require supplementation. Bupivacaine should not be used for Bier block because of the risk of fatal cardiotoxicity associated with excessively high blood levels[18].

Axillary brachial plexus block provides excellent anaesthesia for a variety of hand and forearm procedures, with relatively few complications if toxic doses of local anaesthetics are avoided. Bourke and Furman[19] recently reported the addition of morphine 0.1 mg kg^{-1} to their local anaesthetic axillary block solution (0.55 ml kg^{-1} of 1.5% lidocaine with epinephrine 1 : 200 000) provided enhanced postoperative analgesia without an increased frequency of side effects or major complications. The major disadvantage of axillary brachial plexus blockade is its relatively slow onset.

Interscalene blocks may be useful for outpatient shoulder arthroscopy and other minor shoulder procedures, but are somewhat less predictable for more distal procedures such as hand surgery. When performed carefully, complications of interscalene block are few. However, pneumothorax, intravascular injection, Horner's syndrome, recurrent laryngeal nerve block, subarachnoid injection, and epidural injection are all possible. Vertebral artery injection with subsequent reversible 'locked-in' syndrome has been reported following interscalene brachial plexus block[20]. 'Locked-in' syndrome describes a state in which selective supranuclear motor deefferentiation in the brain stem produces tetraplegia and paralysis of lower cranial nerves (causing aphonia) without obtunding consciousness. Vertical eye movements and blinking are the only voluntary movements the patient can perform. A recent study by Urmey et al.[21] documented a 100% incidence of ipsilateral phrenic nerve blockade associated with interscalene block. Although inconsequential in healthy patients, this hemidiaphragmatic paresis may lead to respiratory compromise in those with pre-existing pulmonary disease. Pregnant patients may also be vulnerable to respiratory compromise as evidenced by a recent case report of respiratory distress subsequent to supraclavicular block of the brachial plexus that produced unilateral diaphragmatic paralysis in a pregnant patient[22]. In addition, supraclavicular blocks are usually not recommended for outpatients because of the risk of pneumothorax.

Combinations of long-acting local anaesthetics and opioids or other analgesics have been used creatively to prolong postoperative analgesia. As long as the upper extremity is protected by a padded sling, there is no need to delay discharge of a competent patient until the effects of the upper extremity block dissipate.

Lower extremity blocks

For surgery of the pelvis or lower extremities, spinal anaesthesia is rapidly executed and effective. One of its major disadvantages is postdural puncture headache (PDPH). However, using the newer 'noncutting' needles, such as the Sprotte and Whitacre needles, the incidence of headache has been dramatically reduced (0–2% for the 25 gauge Whitacre; 0–8.2% for 22 or 24 gauge Sprotte needle)[23]. Although these needles are considerably more expensive than Quincke tip needles, their use may be warranted, at least in young outpatients who are most vulnerable to PDPH (Table 3). Another concern is, of course, urinary retention. Therefore, the local anaesthetic administered should not unduly prolong recovery. Lidocaine (50–75 mg), for example, will typically provide adequate surgical anaesthesia for approximately 1½ h, whereas bupivacaine (12–15 mg) is generally reliable for operations lasting 2½ h or less. It is not unusual, however, for bupivacaine to produce urinary retention, especially in males older than 45 yr, for at least 6 h after completion of surgery. Therefore, the routine use of bupivacaine cannot be recommended for most ambulatory procedures. Rather, if a block recedes prior to completion of surgery, a brief mask anaesthetic can be administered, provided the patient has no risk factors for aspiration.

A major advantage of catheter epidural anaesthesia is the greater flexibility it affords in terms of duration of anaesthesia. However, epidural techniques require more time to achieve an adequate block than does spinal anaesthesia, and the incidence of inadvertent dural puncture with attempted epidural is in the 0.5–1% range. PDPH typically occurs in approximately 70–80% of such instances[31], and an epidural blood patch is frequently indicated in this setting.

The '3 in 1' block (femoral, obturator, and lateral femoral cutaneous nerves can all be blocked using a single perivascular injection) has been employed for outpatient knee arthroscopy. However, simple infiltration of the portals with 1% lidocaine and instillation of 0.5% bupivacaine into the intra-articular space is also a highly

Table 3. Incidence of spinal headache after dural puncture

Study	*Needle Size (gauge)*					
	25 %	*26* %	*27* %	*29* %	*22 (Whitacre)* %	*24 (Sprotte)* %
Flaaten, 1985[24]	37[a]					
Sarma, 1990[25]	18[b]	4.8[b]				
Kang, 1992[26]		11.9[c]	1.8[c]			
Dahl, 1990[27]				2[d]		
Snyder, 1989[28]		25[e]			4[e]	
Sprotte, 1987[29]						0.92
Mayer, 1992[30]			2[e]			2[e]

[a]Age range 26–46 yr; [b]Age range 18–87 yr; [c]Age < 40; [d]Age range 18–49 yr. [e]Obstetrical patients. Reprinted with permission from Zarmsky R. Anesthesia for orthopedic surgery. In: McGoldrick KE ed. *Ambulatory Anesthesiology: A Problem-Oriented Approach,* Baltimore: Williams & Wilkins, in press.

Table 4. Properties of inhaled anaesthetics

Agent	*Blood/gas partition coefficient*	*Vapour pressure (mmHg at 20°C)*	*MAC* %	*Stability*
Nitrous oxide	0.46	39 000	105	Stable
Halothane	2.4	241	0.75	Stable
Enflurane	1.9	175	1.68	Stable
Isoflurane	1.4	238	1.15	Stable
Desflurane	0.42	673	6.0	Stable
Sevoflurane	0.6	162	1.71	Unstable

effective technique and simpler to execute. Moreover, femoral-sciatic blocks are of rather limited usefulness in outpatients because of slow onset and significant postoperative motor block that can impair ambulation.

Ankle blocks can be used for foot surgery, provided the surgeon can operate without a thigh tourniquet. Epinephrine should be omitted from the local anaesthetic solution because of the proximity of injection sites to vessels supplying the digits. Although Bier blocks have been described, using a thigh tourniquet, for surgery on the lower limb, large volumes (75–100 ml) of local anaesthetic are required. Thus, toxicity could occur in the event of inadvertent tourniquet deflation early in the operative course.

General anaesthesia

In addition to safety, the anaesthetist must be concerned with rapid return of preoperative levels of function that will permit discharge on the same day. Several recent additions to our anaesthetic armamentarium have favourable pharmacokinetic profiles that facilitate our objectives of safety, rapid recovery, and minimal side effects. These drugs include both inhalational and intravenous agents.

Inhalational agents

Isoflurane and enflurane traditionally have been used successfully in outpatient surgery. An exciting question for the future is how desflurane and sevoflurane will affect our anaesthetic practice, given their decreased blood solubility and the associated prospect of more rapid emergence (Table 4).

Desflurane (I-653) is a fluorinated methyl-ethyl ether whose structure differs only slightly from isoflurane. Its low blood-gas partition coefficient (0.42) results in a rapid onset and recovery. Because of its pungent odour, however, desflurane produces varying degrees of airway irritation during induction. Although desflurane is less potent than the other volatile agents (e.g. MAC of 5–7% alone and MAC of 2–4% with fentanyl-thiopental-N_2O), it undergoes minimal (if any) metabolism, produces no unusual clinical toxicity, and is stable in the presence of soda lime. Similar to other volatile agents, desflurane appears to produce dose-related cardiovascular and respiratory depression. It has been suggested, however, that desflurane, unlike isoflurane, when combined with nitrous oxide may lead to an activation of beta-adrenergic activity as is seen with diethyl-ether[32]. Recently, Ebert and Muzi[33] also reported sympathetic hyperactivity during desflurane administration to healthy volunteers. The effects of desflurane on the cardiac response to catecholamines[34] are similar to those seen with isoflurane. Desflurane is an extremely volatile agent with a boiling point of 23°C. Because the concentration of gas within the vaporizer is exquisitely temperature-dependent, a specialized vaporizer is necessary.

Sevoflurane is a methyl-isopropyl ether whose solubility in blood approaches that of nitrous oxide. Induction of anaesthesia with sevoflurane is achieved rapidly and smoothly; coughing and breath holding are not the problems they are with isoflurane and desflurane. The MAC of sevoflurane in humans is 1.71% without nitrous

oxide and 0.66% with 65% nitrous oxide[35]. Sevoflurane appears to cause somewhat less haemodynamic perturbation than isoflurane in terms of blood pressure reduction. Heart rate appears to decrease rather than increase[36], and the arrhythmogenic dose of epinephrine exceeds that associated with isoflurane[37].

Unfortunately, sevoflurane appears to be unstable under both *in vivo* and *in vitro* conditions. The *in vitro* degradation of sevoflurane by soda lime does not appear to produce toxic metabolites[38]. Although *in vivo* degradation is enhanced by hepatic enzyme induction, studies in enzyme-induced rats, with or without concomitant hypoxia, have been unable to document hepatic or renal injury[39–41]. Typical plasma fluoride levels after sevoflurane administration to outpatients are in the range of 15–30 μM, considerably below the level associated with nephrotoxicity. The incidence of postoperative nausea and vomiting after sevoflurane is similar to that encountered with the other inhaled agents, including desflurane.

Intravenous agents

Propofol is an exciting drug from the alkyl-phenol family that has been formulated as an emulsion in an intralipid-type substance. Propofol can be used for induction of anaesthesia, maintenance of anaesthesia, or, in smaller doses, for conscious sedation. Important advantages associated with propofol as an induction agent include its rapid elimination and its lower incidence of such perioperative complications as nausea, vomiting, hiccoughing, and excitatory movement compared to thiopental, etomidate, or methohexital. Disadvantages include pain on injection and the potential for significant cardiovascular depression when given rapidly to elderly or fragile patients. Injection pain can be minimized by using larger forearm or antecubital veins rather than small dorsal hand veins. Alternatively, 2 or 3 ml of 1% lidocaine can be administered prior to propofol. Haemodynamic changes can be obtunded by using reduced doses and injecting more slowly in elderly or debilitated patients.

A variety of infusion schemes and devices exist for delivering continuous drug infusions. These work best for drugs with relatively short half-lives such as propofol, midazolam, and alfentanil. Even following a loading dose, a rapid rate of infusion will be required initially to maintain a constant blood level because the process of distribution rapidly removes the drug from the circulation. As the distribution phase nears completion, the rate of infusion can be slowed to approximate drug clearance. Although considerable interpatient variability exists with regard to desirable infusion rates, a variable-rate infusion of propofol ranging from 50–150 $\mu g\ kg^{-1}\ min^{-1}$ in combination with 70% N_2O generally results in a smooth intraoperative course and rapid recovery for patients undergoing brief procedures. The concomitant use of an inhalation agent, an opioid, or a benzodiazepine can affect dose requirements for propofol and subsequent emergence time.

Although some studies suggest that propofol can significantly decrease recovery time, and therefore be cost effective, more data are needed to compare propofol's recovery profile with traditional anaesthetic agents and techniques. The prolonged recovery reported after inhaled drugs may be due to the hangover effect of thiopental[42]. In two recent studies where isoflurane anaesthesia was induced with propofol, recovery was as fast as with propofol alone in patients undergoing outpatient gynaecologic laparoscopies[43] and in patients undergoing arthroscopic procedures of the knee[44]. Whether propofol actually possesses antiemetic properties also needs to be investigated further. One postulated mechanism is that propofol may increase prolactin levels and thus antagonize dopamine-2-(D_2) receptors[45].

Midazolam is a short-acting benzodiazepine that has strong amnestic properties. In 2–3 mg iv doses, midazolam is often used as part of a co-induction technique with propofol. The availability of flumazenil, a specific benzodiazepine antagonist, can promptly reverse any residual sedative or amnestic effects. Flumazenil should be given slowly iv in 0.2 mg incremental doses, up to a total dose of 0.8–1.0 mg.

Alfentanil, a less potent fentanyl derivative, has a more rapid onset and a shorter duration of action than either fentanyl or sufentanil. Alfentanil's limited ionization, reduced lipid solubility, small volume of distribution, and short elimination half-life (60–90 min) reduce its potential for accumulation in lipid storage sites. Its major disadvantages include its emetogenic properties and its potential for causing laryngeal and chest wall rigidity. Remifentanil (an ultra-short-acting fentanyl derivative) is currently undergoing extensive clinical evaluation during both general anaesthesia and MAC in the outpatient setting.

The concept of pre-emptive analgesia is an important clinical issue. When administering general anaesthesia, it is important to appreciate the suggestion that iv analgesia or local anaesthetic infiltration or blocks given prior to the onset of surgical incision may be more efficacious than if administered after the onset of pain[46]. Prophylactic treatment to prevent receptor activation locally and within the neuraxis may alter transmission of pain to reduce analgesic requirements. This phenomenon is known as neuroplasticity. In addition, a number of studies have suggested that pretreatment with rectal acetaminophen or nonsteroidal anti-inflammatory drugs[48] (NSAIDs) such as rectal ibuprofen[47], indomethacin or parenteral ketorolac[48] administered prior to surgery results in superior analgesia to that from similar drugs given later. Moreover, α_2-agonists (e.g. clonidine, dexmedetomidine) can be administered iv for premedication to reduce both iv and inhaled anaesthetic requirements. These adjunctive drugs also appear to decrease postoperative analgesic requirements.

Mivacurium is a short-acting nondepolarizing bis-benzyl-isoquinolinium muscle relaxant that undergoes rapid hydrolysis by plasma cholinesterase. Owing to this extensive metabolic breakdown, mivacurium has a high clearance rate and brief elimination half-life. The ED_{95} dose of 0.08 $mg\ kg^{-1}$ produces maximum blockade in approx-

imately 4 min with spontaneous recovery to 95% of control of the first twitch height in approximately 25 min. A dose of 0.2–0.25 mg kg^{-1} for intubation shortens onset time to approximately 2 min; spontaneous recovery to 95% of control takes about 30 min[49]. Intubation doses of mivacurium have approximately twice the duration of doses of succinylcholine and half those of vecuronium and atracurium. Ali and coworkers[50] have recommended continuous infusion of mivacurium when rapid spontaneous recovery from neuromuscular blockade at the termination of surgery is desirable. Continuous infusion should be initiated at a rate of 10 μg kg^{-1} min^{-1} and titrated to maintain 90–95% twitch suppression. Preliminary studies suggest that mivacurium may reduce the incidence of postoperative myalgias compared to succinylcholine, as well as nausea and vomiting, following outpatient procedures. Avoidance of reversal drugs such as neostigmine may also reduce the incidence of postoperative emesis. A potential disadvantage of mivacurium is its weak histamine-releasing properties that can be obtunded by administering bolus doses over 90 s and by avoiding overdoses.

Several new vecuronium derivatives are currently under active clinical investigation, including rocuronium (ORG 9426) that seems to have a more rapid onset than vecuronium. The investigational drugs ORG 7617 and 9616 have onset and recovery profiles that approach those of succinylcholine. However, concern has been expressed about acute haemodynamic changes associated with these investigational agents.

Monitored anaesthesia care (MAC)

A frequently performed service in the outpatient setting, MAC involves monitoring a surgical patient and may or may not involve administration of analgesics, sedatives, and other medication. In certain instances, MAC is an adjunct to local anaesthesia performed by the surgeon because the medical status of the patient is fragile.

Satisfactory sedation can typically be achieved with either propofol, midazolam, or barbiturates. A short-acting opioid may be indicated for analgesia. However, the co-administration of opioids increases the likelihood of somnolence and respiratory depression[51].

The recently approved eutectic mixture of local anaesthetics (EMLA) has been an asset for certain procedures commonly performed with MAC. EMLA, for example, has been shown to provide surface analgesia for shock-wave and laser-induced pain. Therefore, this topical ointment is gaining popularity for lithotripsy, dermatologic, and certain other superficial outpatient procedures. It is important, however, to appreciate that EMLA has a slow onset and must be applied at least one hour prior to surgical stimulation.

Prevention of nausea and vomiting

When asked which postoperative symptoms they considered the worst, patients chose nausea and vomiting most commonly and were prepared to tolerate increased pain, sedation or dysphoria to avoid this symptom[52]. In another survey, uncontrolled vomiting was responsible for almost 20% of unanticipated hospital admissions after ambulatory surgery[53]. At a time when many other complications of anaesthesia have been minimized, perioperative nausea and vomiting (PONV) is still a problem in up to 70% of patients undergoing ambulatory surgery under general anaesthesia[54].

Avoidance of predisposing factors

Unfortunately many of the predisposing factors for PONV are outside the control of the anaesthesiologist. These factors include younger age, female gender, ASA physical status categories I and II, elective surgery and longer duration of anaesthesia[55]. However, many factors related to anaesthetic technique have been shown to increase the incidence of PONV; these include the use of general anaesthesia as opposed to regional[56], the use of opioids, and, perhaps, the use of N_2O or neostigmine[57–59], an inexperienced anaesthesiologist[60], pain[61], and early feeding[62]. No consistent differences have been shown between equi-analgesic doses of different opioids, although in an individual patient there may be important differences in the emetic effects of different opioids. Partial-agonist opioids increase the incidence of PONV[63]. The use of propofol has a major beneficial effect on the incidence of PONV[58]; it is possible that findings from studies in which propofol was not used may not be relevant to current practice in ambulatory surgery where propofol is used almost universally.

Prophylaxis

No currently available drugs act on the emetic centre, the final control centre for vomiting in the brain stem. Drug therapy aims to modify sensory input by acting on the chemoreceptor trigger zone where many of the afferent impulses to the emetic centre originate. Currently available anti-emetic agents act predominately on either dopaminergic, cholinergic, histaminic or 5-HT_3 receptors. Prochlorperazine, perphenazine, droperidol (dopamine antagonists), hyoscine (cholinergic antagonist), cyclizine, promethazine (histamine antagonists), and ondansetron (5-HT_3 antagonist) have all be shown convincingly to provide effective prophylaxis against PONV[54,64]. Data are conflicting regarding the efficacy of another commonly used agent, metoclopramide, possibly because of its short duration of action[64].

Comparative studies of the efficacy of these agents are rare; a number of recent studies have confirmed the greater efficacy of droperidol compared to metoclopramide[64]. Ondansetron 8 mg was found to be more effective than droperidol 1.25 mg in preventing PONV[65], but another study from the same author found ondansetron 4 mg to be less effective than droperidol 1.25 mg[66], with no difference between the groups in sedation or well-being scores. Further comparative studies are needed to determine the optimal agent and dose for prophylaxis of PONV.

These agents, with the exception of cyclizine and ondansetron, are associated with a significant incidence of side effects, particularly sedation (leading to delayed recovery from anaesthesia) and occasional extra-pyramidal reactions. Dysphoria is a particular problem with droperidol; 23% of patients who had received 1.25 mg of droperidol[67] complained of feelings of anxiety after surgery compared to none of the controls. Nevertheless the use of prophylactic anti-emetics may speed recovery by preventing PONV[68,69].

There are theoretical advantages in using agents which block different receptors in the chemoreceptor trigger zone and this is well recognized in cancer chemotherapy patients. Only one study has confirmed this for PONV; metoclopramide combined with droperidol gave more effective prophylaxis than droperidol alone[70]. Novel approaches to the problem of PONV include the use of ephedrine[71], of transdermal sustained-release hyoscine and of acupuncture[72]. To date there are few data on the efficacy of ephedrine; its cardiovascular effects and short duration of action are likely to limit its usefulness. Transdermal hyoscine seems to be moderately effective provided it is applied several hours before the end of surgery, and it has a low incidence of side effects[64]. However, one study in children undergoing eye surgery reported that scopolamine was ineffective and produced an unacceptably high incidence of behavioural side effects typical of belladonna alkaloids, including hallucinations and extreme agitation[73]. Studies of the efficacy of acupuncture in preventing PONV have had conflicting results and its place in ambulatory practice is uncertain.

The decision to use prophylactic anti-emetics must be individualized for each patient. The incidence of PONV varies from less than 10% in patients undergoing minor procedures under propofol anaesthesia[74,75] to 71% in female patients undergoing laparoscopy under thiopentone/N_2O/volatile agent anaesthesia[54]. Few data are available on whether prophylactic anti-emetics are beneficial after the use of propofol; Watcha et al. showed that droperidol decreased the incidence of vomiting from 60 to 43% after propofol/N_2O anaesthesia for strabismus surgery (failing to achieve statistical significance)[76]. The side-effects of anti-emetics are a particular concern in ambulatory care patients. The individual anaesthesiologist must decide whether to use prophylactic anti-emetics routinely or to reserve them for patients at high risk of PONV.

To summarize our approach to a patient at high-risk of PONV after ambulatory surgery, we use regional anaesthesia if possible. If general anaesthesia is necessary, we use propofol as the induction agent and maintain anaesthesia with a volatile agent or propofol without N_2O. We supplement anaesthesia with small doses of fentanyl (1–2 μg kg^{-1}) and provide additional intraoperative and postoperative analgesia by NSAIDs or regional block if appropriate. We use droperidol 20 μg kg^{-1} as prophylaxis, a dose which decreases PONV without prolonging recovery[68]. We use parenteral opioids for postoperative analgesia only when absolutely necessary. We delay ambulation and do not insist on intake of oral fluids as a requirement for discharge.

Treatment

Fewer studies have looked at the treatment of established PONV but the available evidence confirms that agents which provide effective prophylaxis against PONV are also effective in its treatment. Ondansetron, prochlorperazine, droperidol and cyclizine have been shown to be more effective than placebo in treating established PONV[77–79]. With the exception of ondansetron all of these have the potential to cause sedation and delayed recovery, especially droperidol. An original approach to the problem of PONV was the use of sub-anaesthetic doses of propofol as treatment[80]. While boluses of 10 mg propofol were effective in 81% of cases vs. 35% for placebo, the incidence of nausea or vomiting was similar in both groups 30 min later.

Our current practice is to use cyclizine or prochlorperazine as first choice anti-emetic and use ondansetron if this is not effective. The chief (and arguably only) disadvantage of ondansetron is its price (4 mg costs IR£9.68 or US$17.00), but this amount is worthwhile if the patient can leave the hospital a number of hours earlier. Clearly, ondansetron is cheap when compared to the cost of overnight hospitalization.

Postanaesthesia care unit management

The aims of the recovery period after ambulatory surgery are to provide patient safety and comfort while minimizing costs. This requires rapid recovery without complications to allow early discharge and early return to work. The introduction of new drugs and anaesthetic techniques has revolutionized this area. Thus the rate of unanticipated hospital admission after ambulatory surgery, a key indicator of quality of care, has remained about 1% despite the increasing complexity of the procedures performed[53]. The reason for admission in 40% of the cases in the study by Gold and colleagues[53] was surgical; representative problems included bleeding, perforated uterus, extensive surgery, etc. The causes of the remaining 60% could have been related to anaesthesia. The commonest findings were uncontrolled pain (18% of all admissions), intractable vomiting (17%), urinary retention (5%), postoperative somnolence (3%), aspiration pneumonia (3%), and suspected myocardial infarction (3%). Factors found to increase the likelihood of hospital admission were the administration of a general anaesthetic, site of surgery (laparoscopy or abdominal surgery), an operating room time > 1 h, the occurrence of emesis, an ASA physical status of 2 or greater, and living more than 1 h drive from the hospital.

Another key indicator of quality of anaesthesia is the time from the end of anaesthesia until discharge. Anaesthetic factors which influence recovery time include: (i) premedication with narcotics, benzodiazepines, vagolytics; (ii) the choice of anaesthetic agents (thiopentone vs. propofol, opiates vs. volatile agents[81] etc.; (iii) the use of

anti-emetics e.g. droperidol[82]; and (iv) the use of general vs. local anaesthesia[83]. There has been interest in the use of specific antagonists to anaesthetic agents to speed recovery. Flumazenil shortened recovery time after midazolam sedation (65 vs. 87 min). However, this combination had no advantage over propofol for sedation[84, 85].

Pain control is a challenge in the ambulatory setting; potent parenteral narcotics cause sedation and PONV and are used only as a last resort. Using regional anaesthesia for surgery provides analgesia in the early postoperative period. Analgesia may be provided by regional bupivacaine or opiates[86, 87]. Nonsteroidal anti-inflammatory agents (diclofenac in Europe and ketorolac in the United States) provide analgesia without emesis[88] and may be given rectally or parenterally. A variety of oral analgesics may be used once the patient can tolerate oral fluids. If pain is uncontrolled by these methods, our approach is to relieve pain with intravenous fentanyl in the hope that other methods of analgesia will have acted before fentanyl wears off.

Recovery after ambulatory surgery may be considered as occurring in three stages: (i) phase 1 – recumbent (patient requires bed); (ii) phase 2 – sitting (patient rests in supervised area), (iii) at home. Criteria are needed to decide when patients may progress between these stages. Formal psychomotor tests may be performed but these are unnecessarily complex, time consuming, and require training. Thus they are usually reserved for research applications.

Clinical criteria are adequate and easy to use without special training. Patients may be transferred to phase 2 recovery when they are: (i) fully awake and oriented and (ii) able to stand and walk[89]. Criteria used to assess fitness for discharge home after general anaesthesia have been described by White[90]. These comprise: (i) stable vital signs >30 min; (ii) no new signs of symptoms postop; (iii) no bleeding; (iv) minimal nausea; (v) intact neural and circulatory function in operated limb; (vi) normal micturition (if a pelvic procedure was performed); (vii) oriented in person, time and space; (viii) no dizziness after >10 min sitting; (ix) pain controlled on oral analgesics; and (x) accompanied by a responsible escort. If lower extremity regional anaesthesia was used, normal muscle strength, normal sensation and, after perispinal anaesthesia, ability to micturate must have returned. As mentioned in the section on PONV, ability to tolerate oral fluids is not now considered essential for discharge[62]. It is considered acceptable to have fitness for discharge decided by a nurse applying these criteria rather than requiring examination by a doctor[90].

Discharge criteria are important for clinical and medicolegal reasons and should be documented as having been fulfilled by the patient. Other medicolegal considerations include providing written instructions for the patient concerning acceptable activities and postoperative care and providing emergency contact numbers in the event of a problem.

Audit is vital to check a unit's performance and to maintain standards. Mortality should be virtually nonexistent. Other indicators of quality of ambulatory anaesthesia are the rate of complications (in recovery and as elicited on telephone follow-up 24 h after surgery), the duration of stay in the recovery ward and the rate of unanticipated hospital admission (see above). Telephone follow-up is important to detect problems which occur after patients go home.

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