Management of anesthetic emergencies and complications outside the operating room

Marc Garnier[a,b] *and Francis Bonnet*[a,b]

Purpose of review
Anesthesia outside the operating room is commonly uncomfortable and risky. In this setting, anesthetic emergencies or complications may occur. This review aims to report the most recent updates regarding the management of prehospital anesthesia, anesthesia in the trauma and emergency rooms, and anesthesia for endoscopy and interventional radiology.

Recent findings
After tracheal intubation failure, airway control of outpatients could be achieved by pharmacologically assisted laryngeal mask insertion. Management of traumatic injured patients is best guided in the frame of checklists. Monitoring sedation in this setting is challenging notably because of the threat of haemodynamic instability. Unfortunately, BIS monitoring cannot be recommended to guide sedation in this setting. Ketamine can be used to prevent hypotension during prehospital anesthesia or procedural sedation, especially as its neuroprotective effects have been recently best understood. Target-controlled infusion propofol administration with small concentration increments is adapted to prevent hypotension and hypoxaemia during sedation for gastrointestinal endoscopy and interventional radiology. Target-controlled infusion remifentanil administration is also adapted to many procedures.

Summary
Anesthesia outside the operating room requires careful monitoring to avoid side-effects and education of nonanaesthetists when they are involved. A useful tool is to continuously improve the protocols and checklists to make anesthesia in this setting safer.

Keywords
anesthesia outside the operating room, emergency anesthesia, nonanesthesiologist-provided sedation, prehospital anesthesia, procedural sedation

INTRODUCTION

Anesthesia outside the operating room is a miscellaneous but frequently risky situation, potentially leading to an overrisk of complications [1]. Delocalization of the technical platform, absence of anesthetic colleagues in the neighbourhood, reduced access to material, drugs or help, and, sometimes, emergency context make anesthesia in this setting a balancing exercise in a single-engine plane, whereas planned anesthesia appears like a calm long-haul flight. Several different situations may be encountered such as prehospital anesthesia; anesthesia in the emergency room; anesthesia in technical platforms for bronchoscopy, digestive endoscopies, or interventional radiology. The aim of this review is to focus on the most recent data available regarding the management of anesthetic emergencies and complications outside the operating room.

PREHOSPITAL ANESTHESIA

Prehospital management of medical emergencies and trauma patients is differently organized in Western countries. However, facing an increasing number of calls, a common challenge is maintaining the capacity to provide adequate critical care to the minority of severely ill or injured patients for whom it is requested. The department of emergency care in Bristol has listed the competencies of their

[a]Anaesthesiology and Intensive Care Department, Hôpital Tenon, APHP and [b]Pierre & Marie Curie School of Medicine, Pierre & Marie Curie University (Paris VI), Paris, France

Correspondence to Dr Marc Garnier, MD, MSc, Département d'Anesthésie et Réanimation – Pôle TVAR, Hôpital TENON, 4 rue de la Chine, 75020 Paris, France. Tel: +33 1 56 01 51 53; fax: +33 1 56 01 60 97; e-mail: marcgarnier@gmail.com

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KEY POINTS

- Pharmacologically assisted laryngeal mask insertion of a second-generation device could be considered in outpatients with severely compromised airways.
- Management of traumatic injured patients is best guided in the frame of checklists, like that recently proposed by the Society of Critical Care Anaesthesiologists.
- Ketamine returns on the centre stage for prehospital and outside the operating room sedations, because of its interesting properties notably regarding its capacities to preserve haemodynamic stability and its neuroprotective effects.
- TCI propofol administration with small concentration increments is adapted to prevent hypotension and hypoxaemia during sedation for gastrointestinal endoscopy and interventional radiology.
- TCI remifentanil is also adapted for many endoscopic or interventional procedures, notably in intensive care patients.

three kinds of prehospital care providers: the paramedics, the critical care paramedics, and the prehospital critical care physicians [2]. One of the main additional competencies of critical care providers, compared with paramedics, is the ability to induce and maintain anesthesia, and to perform procedural sedation.

The prehospital critical care providers have to be perfectly trained to rapid sequence anesthetic induction (RSI) and tracheal intubation, which are the gold standard for patients requiring urgent controlled ventilation. In intubated patients, a particular attention should be given on tracheal tube cuff pressure because overinflation of the cuff is common in these circumstances. Indeed, in a prospective study performed in Switzerland, the median cuff pressure after intubation and emergency transfer was 58 cm H_2O, high above the recommended values [3]. A manometric control was used in only 2 cases of the 59 emergency transfers, leading to reduce median cuff pressure to less than 30 cm H_2O. No significant difference in cuff pressures was documented when patients were managed by anaesthetists or nonanaesthetists.

In case of failure to perform successful tracheal intubation, pharmacologically assisted laryngeal mask (PALM) insertion could be used as an alternative. PALM procedure with a second-generation airway device is a rescue technique that takes place before surgical access to the airway in difficult intubation algorithms. A consensus statement [4] regarding PALM has recently recommended that the PALM procedure could be considered in a patient with a severely compromised airway, when all routine measures have failed, and that the procedure could be located on the airway management ladder in a similar position to a surgical airway access, although it was also reported that surgical airway access was a rescue technique in case of PALM failure. No preference was expressed for any anesthetic agent, but midazolam and ketamine, the two drugs commonly used by emergency care physicians, were found appropriate for PALM insertion.

The level of sedation is actually quite difficult to assess in the setting of emergency medicine. Low levels of sedation, leading to awareness and implicit memory, are common because haemodynamic instability is considered as a threat restraining anesthetic drugs administration. Assessment of sedation is mainly based on the clinical scores. A recent BIS monitoring evaluation in prehospital patients has documented moderate agreement with Ramsay score and poor correlation coefficient for repeated measures [5]. Thus, BIS monitoring cannot be recommended to guide sedation or anesthesia in prehospital patients.

ANESTHESIA IN THE EMERGENCY AND TRAUMA ROOMS

Time is a determinant in the management of trauma injuries. An American staff has recently reported its good experience in the use of the ICU as an operative location for critically injured patients [6]. We believe that this solution could be encouraged in particular settings, for example, if an emergency operating room is not immediately available, provided a multidisciplinary written protocol have been beforehand drafted and implemented, and the surgical and anesthetic teams trained.

However, regardless of surgery location, there is a need for making rapidly the good diagnosis and simultaneously to initiate a treatment to improve the patient's condition. As a result of these constraints, management of traumatic injured patients is best guided in the frame of checklists. A guideline has been recently published in *Anesthesia-Analgesia* [7▪▪]. The checklist introduced by the Society of Critical Care Anaesthesiologists deals with the measures required before and on the patient's hospital arrival; recommendations for induction and preoperative resuscitation; and few advices for postoperative management. A special attention should be paid to the prevention of hypothermia, including the increase of the operating room temperature before the patient's arrival; to the implication of an anaesthetist from the beginning of the supportive care administration; to the concept of

hypotensive resuscitation; and to the pharmacological aspects of the rapid sequence induction. The threshold values of systolic and mean arterial blood pressures to be maintained are still a matter of controversy, although a systolic arterial pressure above 100 mmHg (especially in head trauma patients) and a mean arterial pressure above 60 mmHg appear reasonable values until definitive control of bleeding is achieved.

Etomidate remains the most frequently used anesthetic agent in the haemodynamically unstable patient, outside the operating room. However, even a single dose of etomidate may impair the hypothalamic–pituitary–adrenal axis. Clinical consequences on outcomes are unclear. An increase in morbidity has been reported, but in contrast, etomidate is less likely to cause hypotension during haemorrhagic shock, which is a major factor of poor prognosis. Ketamine could be used as an alternative because recent updates confirms that ketamine preserves cardiovascular stability via a sympathomimetic effect balancing its negative inotropic effect [8,9]. Moreover, recent data have challenged the old case–control studies, documenting that in mechanically ventilated patients, ketamine alone or in combination with other anesthetic agents can be safely used in patients with elevated intracranial pressure. Additional neuroprotective effects (in particular, prevention of neuronal apoptosis) have also been suggested [10▪].

Ketamine is also available for procedural sedation in the emergency department making physicians comfortable because it preserves spontaneous breathing and airway reflexes, and maintains cardiovascular stability. A randomized study conducted in fractured patients supports its use in this context [11]. The association of ketamine with low-dose midazolam provided less hypoxia and lower pain scores during fracture reduction than midazolam–fentanyl. A 1.0 mg/kg intravenous loading dose of ketamine in adults, possibly followed by incremental doses, could be recommended for procedural sedation in emergency patients [8]. Nevertheless, ketamine induces agitation, confusion, and hallucinations in 10–20% of the patients. 'Ketofol', a 50/50 mixture of ketamine and propofol in the same syringe, has been documented to provide better sedation consistency than propofol alone, without any increase in respiratory side-effects [12,13]. However, the risk of agitation on awakening persists. Consequently, others have advocated the use of combination of the two drugs maintaining independent dosing [14].

The need for procedural sedation outside the operating room has increased in paediatric patients, because of an increased demand of invasive diagnostic and therapeutic procedures. In this context, anaesthetists cannot perform all procedural sedation and paediatricians are increasingly involved to provide anesthesia outside the operating room. A report of more than 12 000 sedations performed by paediatricians in the USA showed that several complications were more frequent compared with procedures supervised by an anaesthetist, in particular for inadequate sedation (2.2 vs. 0.9%; $P < 0.001$) [15]. However, the definition of 'adequate' or 'inadequate sedation' is very subjective. To comply with the recommendations of the American Society of Anesthesiologists and the American Academy of Pediatrics to monitor the level of consciousness during such procedures, the great majority of physicians use sedation scales, like the 'University of Michigan Sedation Scale' and the 'Observer's Assessment of Alertness/Sedation', both validated in children. A recent, prospective, blinded study conducted in a paediatric emergency department has reported a poor correlation between BIS values and the physicians' clinical perception [16]. In this study, physicians underestimated the maximum level of sedation in about 90% of the cases, with nearly 80% of patients having BIS values less than 60 (defining profound sedation or anesthesia). The development of simple protocols for sedation outside the operating room may be useful. Ketamine can be used safely in this purpose, as it is for adult procedures. A prospective randomized study supports this thought showing that ketamine allowed faster sedation and recovery than midazolam, with an adapted level of sedation, during performance of a paediatric urodynamic procedure [17]. Another randomized double-blinded study performed during laceration repair in the paediatric emergency department has confirmed that oral ketamine in association with midazolam procures a deeper sedation than oral midazolam alone, with less intravenous drug recourse [18].

ANESTHESIA FOR ENDOSCOPIES AND INTERVENTIONAL RADIOLOGY

Complications of anesthesia for endoscopy are rare, but remain a matter of concern as the procedures they supply are not especially risky. In a recent, prospective, multicentre survey of 191 142 patients, propofol sedation-related complications occurred in only 82 procedures and deaths in six patients (3×10^{-5}) [19]. Most of the lethal complications occurred during emergency endoscopies and all occurred in ASA 3 patients. Another prospective study conducted during colonoscopies under propofol sedation reported a higher incidence of complications of about 6% [20]. If the experience of the

endoscopist impacted the incidence of overall complications, it was not the same for the anaesthesia team. This result could be, at least partially, explained by the fact that applying and monitoring adapted anesthetic protocols is more important than the operating physician himself. This is even more important for nonanaesthesiologist-provided procedural sedation (NAPPS).

Propofol target-controlled infusion (TCI) is now the reference for a series of diagnostic and therapeutic digestive endoscopic procedures. However, side-effects such as hypotension and arterial oxygen desaturation may occur. A reasonable effect-site target concentration (Ce) may prevent this risk. A recent report suggested that a propofol target concentration of 1.5–2.5 μg/ml, following a small bolus of midazolam and fentanyl, maintain a favourable balance between efficiency and tolerance [21]. Titration of the target concentration is also important for tolerance. A prospective randomized study investigating three titration regimens (by 0.1, 0.2, and 0.5 μg/ml) has been closed before ending because of safety concerns [22]. Increasing Ce by 0.5 μg/ml was significantly associated with more hypoxaemia. On the contrary, there was a trend for more frequent adjustments for 0.1 μg/ml increments, suggesting that 0.2 μg/ml was the best choice.

Using balanced sedation may reduce propofol total dose and related complications. This modality has been particularly developed in response to NAPPS. However, no difference in the efficiency, safety, procedure outcomes, and complications has been documented, comparing propofol alone or combined with midazolam and fentanyl when sedation was performed by a well trained sedation team including two sedation nurses and a recovery room nurse [23]. A meta-analysis of 22 RCTs concerning sedation for gastrointestinal endoscopy supports these results. Despite a significant reduction in the propofol total dose, no effect on the incidence of hypoxaemia, hypotension, arrhythmias, or memorization was noted when propofol was combined with other traditional sedative agents [24▪].

Eventually, the use of remifentanil TCI for sedation during flexible fiberoptic bronchoscopy was recently reported in ICU patients in a small single-centre study [25]. Remifentanil guarantees rapid onset and short duration of action, and no tissue accumulation. With a maximum target concentration of 2.5 ng/ml in mean, low levels of pain and good patient satisfaction were achieved during the procedure. This proof-of-concept is based only on a few patients, but we believe that this sedative regimen is very interesting. In fact, our team used remifentanil TCI in this indication since 8 years with very good results.

In a large series of patients scheduled for interventional radiology, serious complications occurred in less than 1% of the procedures [26]. In this retrospective study including about 39 000 procedures, 12 cases of cardiopulmonary arrests were noted. This represents a low incidence, but the 1-year mortality rate was high. Placement of intravenous devices for haemodialysis was a strong risk factor of complications (RR 5.2), involving a careful management of its sedation, in particular in the NAPPS era. To this end, review articles are published to educate radiologists to the practice of sedation [27▪]. On the other hand, anaesthetists need to be informed of the radiologic proceedings. An extended review of anesthesia for embolization of cerebral aneurysms is available in this issue. The technical aspects and anesthetic implications of other neuroradiological procedures are available in a very exhaustive and up-to-date review [28▪▪].

CONCLUSION

Anesthesia and sedation outside the operating room remains a challenge for anaesthetists who must guarantee the safety and comfort of patients sometimes in difficult conditions. Checklists and algorithms have been developed and recently updated to improve critically injured and trauma patients' care. In this setting, ketamine returns on the centre stage because of its interesting properties. During anesthetic and sedative procedures, monitoring appears as a cornerstone. Multiple demands for sedation in patients scheduled for invasive new procedures including interventional radiology require adaptation to the goal and the constraints of each procedure. In some places, a shortage of anaesthetists implies that nonanaesthetists need to be educated on the management of simple sedative procedures within a predetermined frame to avoid an increase in the incidence of complications.

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Conflicts of interest

There are no conflicts of interest.

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