Anesthesiologists on ambulances: where do we stand?

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Purpose of review
This manuscript provides a critical review of the literature regarding the staffing of emergency medical services, with particular emphasis on anesthesiologists.
Recent findings
Significant anesthesiology contributions to prehospital care include introduction of new airway management tools and improved physiological monitoring. Contributions to quality of care include patient benefit in terms of life years gained and a specific reduction in mortality from acute myocardial infarction. Intuitive concepts regarding the advantage of anesthesiologists in intubation mishaps and management of the failed airway have yet to be proven. Personnel limitations may be regional, necessitating local evaluation of anesthesiologist availability to staff ambulances. Since a major part of cost-effectiveness research is performed in the US where only paramedics staff ambulances, insufficient data exist regarding the financial implications of such practice. Burnout may be an important factor for deciding whether anesthesiologists should work in the operating room or ambulances or on an alternate basis.
Summary
Further research should be performed to evaluate the clinical and financial implications of staffing ambulances with anesthesiologists or other physicians. Randomized controlled studies using standardized intubation techniques are necessary to examine whether prehospital airway management is improved when delivered by anesthesiologists.

Keywords
ambulance, anesthesiology, endotracheal intubation, cost-effectiveness, mortality

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Abbreviations

EMS	emergency medical service
EMT	emergency medical technician
QALY	quality-adjusted life year
RSI	rapid sequence induction

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Introduction

The first ambulance – a carriage with a bed – began operating in New York City in 1912 [1]. Named 'ambulance' from the Latin 'ambulo' (to move slowly), such vehicles were initially intended for patient transfer to the hospital only. The law even gave the post office carriage priority over this 'ambulance'.

Several decades later, medical developments changed ambulance services. The introduction of electrocardiography and cardiac defibrillation altered the treatment of heart disease. Peter Safar, an anesthesiologist, introduced modern cardiopulmonary resuscitation, emphasizing the importance of chest massage and ventilation [2,3], and together with Martin McMahon, chief of the Baltimore Fire Department ambulance service, designed an ambulance equipped for airway management. Simultaneously, more civilian trauma casualties needed transport to hospitals.

The concept of true ambulatory medicine emerged in Belfast (1966) where the potential for survival in a civilian population, gained from early field intervention, was first recognized by cardiologists. Pantridge and Geddes [4] described an innovative ambulance carrying a physician and nurse with a defibrillator for use in the field and demonstrated impressive improvement in survival to hospital among myocardial infarction patients [4]. One year later similar results were obtained in the US [5].

At that time none contested the success demonstrated by early intervention. It was recognized that the many specialized physicians needed to treat relatively small numbers of patients in the prehospital setting would impose a burden on the healthcare system. Although it was clear that ambulances would not be staffed by cardiologists, medical expertise would be necessary to deliver effective ambulance-based therapy. Who then should staff ambulances?

Current practice worldwide

The use of NASA-tested telemetry to exchange data between Miami firefighters on the scene to physicians in the emergency room was a step of genius taken by Nagel [6,7]. This revolution in cardiac monitoring helped Nagel prove that ventricular fibrillation was the cause of sudden collapse and later legitimized the administration of medications and defibrillation in the field by paramedics. These actions were initially performed upon radio orders given by emergency room physicians and

were later incorporated into protocols, allowing the gradual replacement of physicians by paramedics throughout the US.

Expert organization has resulted in structured paramedic courses. Because of the predominance of cardiac disease and trauma, guidelines for the conduct of prehospital therapy were developed for these situations (e.g. Advanced Trauma Life Support [ATLS], Advanced Cardiac Life Support [ACLS]). These guidelines are integral parts of the training of emergency physicians, anesthesiologists and paramedics. Paramedics may have an advantage over physicians, since they continue to practice only protocolized prehospital medical therapy, their experience remains 'undiluted' by other demands.

Emergency medical services (EMSs) vary at the levels of responders and in the response. Responders range from basic (an emergency medical technician [EMT] trained in basic cardiac life support) through intermediate (EMT trained in defibrillation) to high level (paramedic trained in advanced cardiac life support). The response may be single or double tiered: in a single-tiered system, one unit with a paramedic/physician trained in advanced cardiac life support is dispatched; in a double-tiered system, EMTs provide the first response, followed by a paramedic/physician second response [8].

Ambulance crews in the US work with physicians 'off line'. Physicians are involved in telemetry analysis, retrospective case review and administration, but are not dispatched to the field. Several countries in Europe have only paramedics on ambulances. In some of these countries emergency physicians are dispatched to the field in a separate vehicle [9]. General practitioners, emergency physicians and anesthesiologists staff ambulances in other countries.

In a study examining whether general practitioners could perform prehospital lifesaving interventions that had been performed by an anesthesiologist, an expert panel concluded that the advanced skills, equipment or drugs provided by the anesthesiologist were crucial for 38% of the cases [10]. Anesthesiologists in the hospital where the authors practise staff one of the mobile intensive care units in Jerusalem. An exhaustive list of countries that staff prehospital transport vehicles with anesthesiologists is beyond the scope of this review, but they include Norway [11,12••], France [13], Germany [14,15], Denmark [16•] and Israel [17].

Potential advantages of staffing ambulances with anesthesiologists

Both detailed knowledge of therapeutic protocols and excellent technical skills are crucial to the prehospital management of severely ill patients.

Airway management

American Heart Association guidelines propose that advanced life support providers should have a 'regular field experience', defined as 6–12 intubations per year, as a prerequisite to maintaining skills for endotracheal intubation [18]. In a 4-year retrospective statewide assessment of endotracheal intubation performed in Maine, only a few EMS providers met minimum requirements [19•]. One might expect that in urban areas more providers meet requirements. An anesthesiologist-based service would clearly encounter no such difficulty.

Is there proof that prehospital airway management is improved by the presence of an anesthesiologist? A study comparing intubation mishaps between anesthesiologists and emergency physicians performing prehospital rapid sequence induction (RSI) of anesthesia found two failed intubations (1%) among anesthesiologists and four (2.5%) among emergency physicians. Repeat attempts at intubation and drug administration occurred in less than 2% of each group and it was concluded that RSI performed by emergency physicians was not associated with more failures or intubation mishaps than RSI performed by anesthesiologists [20]. Two important limitations must be mentioned. First, anesthesiologists were compared only with other physicians and not with paramedics. Secondly, the use of muscle relaxants, although recently studied for use in prehospital airway management by physicians [21] and paramedics [22], is controversial and not accepted for prehospital endotracheal intubation [23]. Differences in intubation practice/mishap rates between anesthesiologists and other prehospital personnel need to be compared with standard prehospital endotracheal intubation technique.

In a prospective, multicentered evaluation of prehospital management, the overall endotracheal intubation success was 87% (93% for cardiac arrests and 77% for nonarrests) [24]. Undoubtedly, prehospital endotracheal intubation conditions are more difficult, so it is not surprising that in-hospital endotracheal intubation success is higher. In a study of cases with similar trauma and injury severity scores designed to determine the impact on outcome of field endotracheal intubation by urban paramedics compared with that of hospital staff, the success rate was 81% for paramedics versus 98% for hospital staff ($P<0.05$). Intubation was facilitated by neuromuscular blockade in 76% of hospital intubations compared with none by paramedics ($P<0.05$) [25].

Data regarding pediatric endotracheal intubation by paramedics demonstrate success rates similar (82%) [26] to or lower (48%) [27] than those of adult endotracheal intubation. In their multicenter study examining utilization rate among eligible providers, Burton *et al.*

[19•] found that of 1352 ACLS providers eligible to perform endotracheal intubation, 137 pediatric endotracheal intubation encounters occurred with 1.4–2.7%/year of eligible providers attempting pediatric endotracheal intubation. The success rate of endotracheal intubation by paramedics can be significantly improved (from 48 to 90% in children younger than 18 months of age) by training in pediatric advanced life support [27]. Further research is necessary to determine whether prehospital pediatric endotracheal intubation success is improved by anesthesiologists, particularly among younger patients.

An important consideration is the time spent on performing procedures in the field. One study compared timing and organization of trauma resuscitation between two teams: one with an ATLS-trained surgeon/anesthesiologist and the other an ambulance crew only. More patients in the ATLS group were intubated prior to hospital arrival (75 versus *2%*, $P<0.05$) without significant differences in resuscitation times [28].

The results from the literature do not allow for conclusions regarding the possible advantage of endotracheal intubation by an on-board anesthesiologist. The question that remains unanswered is whether an anesthesiologist present during incidents of failed airway management makes a difference. In most failed prehospital intubations, bag–mask ventilation is used for rescue [24]. Yet, under standardized airway conditions there is little difference between anesthesiologists and ambulance personnel in airway maintenance or bag–mask ventilation [29].

Endotracheal intubation technique is an issue meriting mention. In a study examining 61 factors potentially related to failed prehospital endotracheal intubation, presence of clenched jaw/trismus and intact gag reflex were clearly related to lack of neuromuscular blocker use in prehospital intubation. Two other factors may be related: inability to pass the endotracheal tube through the vocal cords and inability to visualize the vocal cords [30•].

Limiting prehospital medications to narcotics and benzodiazepines is based on the belief that if endotracheal intubation fails, the patient probably did not need the procedure in the first place (since airway protection is preserved) and may therefore have a better chance of survival with spontaneous breathing. There is no substantiation of this theory in the literature. Contrary to existing rigid prehospital protocols for drug administration, the concept of drug mixing and adaptation of doses to individual patients based on medical status and diseases is inherent to the training of anesthesiologists. Reassessment of prehospital endotracheal intubation protocols and airway management based on current anesthesia practice has only just begun: RSI with muscle relaxants [21,22] with or without short-acting anesthetics such as etomidate [31,32]; use of laryngeal mask airways for emergency airway management [33–35]; or monitoring of prehospital ventilation with capnography [36,37].

Cardiovascular management

Myers concluded that prehospital care providers are as able to accurately interpret electrocardiograms and diagnose ST elevation myocardial infarction as physicians. Additionally, he states that 'Numerous studies have investigated the role of specially trained prehospital personnel in initiating thrombolysis. Trials outside of North America have predominantly used physicians, whereas North American studies employed paramedics. Thrombolysis has been shown to be safe and effective when started outside the hospital by physicians or paramedics, with a reduction in time to treatment and no increase in complications' [38, p. 1231]. It would seem that there is no cardiac benefit to staffing ambulances with anesthesiologists rather than paramedics. The presence of an anesthesiologist on the ambulance, however, resulted in a significant reduction in acute myocardial infarction mortality (13.3 versus 40.5%, $P<0.001$) [16•].

A significant part of prehospital management is dedicated to recognizing and managing emergency cardiac conditions (i.e. arrhythmias, ischemia) and shock. Since anesthesiologists must manage similar situations in-hospital, anesthesiology training is so targeted. Therefore, anesthesiologists may be well trained to recognize and manage extreme prehospital cardiovascular situations.

Effect on patient mortality and life years gained

Soo *et al.* [39] discovered that survival to hospital discharge increased when patients were cared for by a paramedic, compared with an EMT, and improved further when paramedics were assisted by a health professional or a medical practitioner. Since only a minority of the health professionals/medical practitioners were physicians, the authors hypothesized that either the availability of an additional team member or the knowledge that the medical practitioner had regarding the patient's medical background (allowing the choice of terminating resuscitation efforts) may have influenced resuscitation outcome.

Two studies examined the effect of an on-board anesthesiologist on mortality. A retrospective analysis of prospective data from 991 patients found that 3.3% of all primary missions were probably lifesaving from site of injury to receiving hospital. Lifesaving in 50% of these

missions was dependent on the qualifications of the anesthesiologist and a short response time [11]. In a descriptive study of emergency vehicle utilization before and after staffing of an ambulance with an anesthesiologist, mortality was reduced in patients suffering from acute myocardial infarction (13.3 versus 40.5%, $P<0.001$) and short-term mortality was reduced in patients with respiratory diseases (0 versus 2.4%, $P<0.05$) [16•].

The potential benefit of staffing an ambulance with an anesthesiologist was examined in terms of life years gained: two expert panels assessed patients evacuated by EMSs for their potential health benefit in life years gained [40] and found life years gained directly attributable to staffing of prehospital EMSs by an anesthesiologist, for every 14th patient treated [12••].

In their classic study which examined prehospital survival in victims of cardiac arrest, Eisenberg *et al.* [41] concluded that a double-tiered response system provides the best survival, as it combines the ideal of short 'downtime' and early defibrillation. Since the study was performed in the US, the value of having a field anesthesiologist was not examined. No study was located that specifically examined patient 'downtime' in relation to the presence of an anesthesiologist.

Trauma care

Conflicting data exist regarding the correlation of personnel qualification and outcome in trauma care. Adding a critical care physician to an air ambulance service for trauma patients resulted in more intubations and thoracic decompressions and significantly more fluid administration to hypotensive patients. The end result was a significantly lower mortality despite no differences between the groups in age, mechanism of injury, distance transported, response, scene or transport times [42].

Liberman *et al.* [43•] reached a different conclusion in their study comparing three Canadian cities with different providers (physicians providing ACLS, paramedics providing ACLS and EMTs providing Basic Life Support [BLS]). They found no benefit in having on-site ALS for trauma patients in urban centers with level I trauma centers.

Better trauma survival was demonstrated when patients received prehospital care from paramedics compared with those treated by emergency physicians [44]. No study examined whether such a result could be achieved by anesthesiologists. One study examined the effect of prehospital helicopter care by an anesthesiologist on the outcome of patients with severe head injury and found no benefit [45].

Staffing ambulances with anesthesiologists

Several issues must be kept in mind when considering the staffing of ambulances with anesthesiologists.

Personnel

The prime obligation of anesthesiologists is to the operating room, both for financial reasons and by training. Supply versus demand is the concept most commonly used to justify staffing allocations. In theory, when trained anesthesiologists are in abundance, the healthcare system can afford to direct anesthesiologists to prehospital medicine. National availability (the number of anesthesiologists per population) is therefore important for determining whether ambulances can be staffed by anesthesiologists. If anesthesiologist availability is the crucial factor for determining whether ambulances could be staffed by anesthesiologists, could anesthesiologists staff ambulances in the near future?

In their model based on labor supply and demand in the US, Schubert *et al.* [46] predicted a continuing national anesthesia personnel shortfall through 2005. Canadian researchers have also predicted that the shortfall in anesthesiologists will worsen [47]. Anesthesiologist shortages have also been described in France where the annual growth of anesthesiologists decreased from 9% per year before 1989, to zero in 1999, resulting in 14.75 anaesthesiologists/100 000 inhabitants in 1999 – slightly above the European average [48••]. Similar anesthesiologist shortfalls have been described in Australia, New Zealand [49], Germany [50], Denmark [51] and West Africa [52]. The increased demand for anesthesiologists comes from a combination of increased population and its demographics [53], changes in surgical technology, growth in ambulatory and office-based surgery, pain medicine, and intensive care [54]. Interestingly, several of these countries continue to staff ambulances with anesthesiologists despite staffing shortages. How can this be explained?

Although predictions of the national supply and demand of physicians are important, several factors are not taken into account in these relatively simplistic models. For example, anesthesiologist availability may not be similar in various regions of a country. In France, the geographic distribution of anesthesiologists was found to be unequal between north and south, with clustering occurring in urban regions and particularly in university centers [48••].

National models of physician availability tend to ignore potential variations in organizational models for using anesthesiologists and nurse anesthetists (e.g. California has 47 anesthesiologists/10 nurses versus Michigan which has six anesthesiologists/10 nurses) [55]. It is also reasonably safe to assume that variations in organiza-

tional models for using anesthesiologists, emergency physicians and paramedics have also been ignored.

We thus conclude that national or regional manpower considerations based on the number of anesthesiologists per population are insufficient for making decisions regarding the possibility of staffing ambulances with anesthesiologists. If such a decision is to be made, anesthesiologist availability within various hospitals in specific locations should be considered.

Cost

Probably the best studied model of prehospital costs is that of resuscitation. In their analysis based on cost data from previous studies, Lee *et al.* [8] suggested that the estimates of the cost-effectiveness of resuscitation programs for all 6-month survivors of a large international multicenter collaborative trial are US$406 605 per life saved and US$225 892 per quality-adjusted life year (QALY). This level is considerably higher than the accepted threshold of US$60 000–100 000 per QALY for implementing life sustaining measures and raises important questions regarding the need for change. The authors concluded that 'With CPR, the days of limitless bounty are fading rapidly, and we are entering an era where the drive to save "hearts too young to die" will at least be tempered by the question: "What cost to cheat death?"' [8, p. 2051]. Emergency physicians have been shown to make Do Not Resuscitate decisions [56], so a physician on board an ambulance may prove to be an important asset in tempering futile therapy with end-of-life decisions.

Nichol *et al.* [57] performed a metaanalysis of 41 series of out-of-hospital cardiac arrests to estimate the relative cost-effectiveness of potential improvements to an EMS for victims of out-of-hospital cardiac arrest. Since this study was performed in the US, the type and tier of an EMS system, response time, and rate of bystander CPR were all examined, but the presence of an anesthesiologist was not. The authors concluded that the most attractive options in terms of incremental cost-effectiveness were improved response time in a two-tier EMS system or change from a one-tier to a two-tier EMS system. Similar studies to evaluate relative cost-effectiveness should be performed regarding the composition of ambulance crews.

Economic evaluation in health care demands cost–utility analysis – a method based on the cost-effectiveness criterion of dollars per QALY [58]. The data which currently exist regarding the potential benefit of staffing ambulances with anesthesiologists are insufficient to perform economic calculations of cost-effectiveness. Further research into patient benefit in terms of QALYs, including the future consumption of those patients who would otherwise not have survived [59], needs to be performed as a prerequisite to any calculation regarding the potential cost–benefit ratio of placing an anesthesiologist on ambulances.

Burnout

Both anesthesiologists working in the operating room and ambulance personnel suffer a relatively high incidence of burnout. A recent publication demonstrated that 40% of anesthesiologists were suffering from burnout, with the highest burnout rate among residents under 30 years old [60]. Ambulance personnel are at risk for developing health symptoms due to work related stressors [61]. In fact, in the UK around 30% of a sample of ambulance personnel reported high levels of general psychopathology, burnout and posttraumatic symptoms. Burnout was associated with less job satisfaction, longer time in service, less recovery time between incidents and more frequent exposure to incidents [62]. In a survey of more than 600 EMTs from across the US, high stress levels were found, manifested primarily as somatic distress, secondarily as organizational stress and job dissatisfaction, and lastly as negative patient attitudes [63].

The degree of job stress and burnout resulting from combined work in both anesthesiology and the ambulance service has never been examined, and may be important in deciding whether anesthesiologists should work in both environments and what is the optimal practice time in either environment. Attrition rates among ambulance crews may also be modified by the personnel turnover and professional information exchanged by adding anesthesiologists to ambulance crews.

Conclusion

The efficiency of an ambulance service may be related not only to the speed of its evacuations, but also to the care provided, especially the expertise of the ambulance crews. Multidisciplinary prehospital care provided by anesthesiologists, emergency physicians and prehospital providers may provide a fertile environment for exchanging vital knowledge and practice standards, for performing quality control audits, academic research and implementing changes leading to improved prehospital care. These possible benefits must be examined in view of the increased financial burden of maintaining an anesthesiologist on-board and tailored to the possibilities offered by local staffing availability. In an ideal world, an experienced anesthesiologist with a thorough knowledge of both advanced cardiac and trauma life support may enhance ambulatory prehospital patient management. Anesthesiology staffing shortages and costs, coupled with high burnout rates, make it impossible to staff all ambulances with anesthesiologists. Nonetheless, based

on our experience, the impact of serving as part of an ambulance crew during anesthesiology training is great and should be considered by all residency programs.

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