ORIGINAL RESEARCH

Prehospital Analgesia in New South Wales, Australia

Jason C. Bendall, MBBS, MM (ClinEpi), PhD; Paul M. Simpson, MScMed (ClinEpi); Paul M. Middleton, MBBS, MM (ClinEpi), MD

Ambulance Research Institute, Ambulance Service of New South Wales, Rozelle NSW, Australia

Correspondence:
Jason Bendall, MBBS, MM (ClinEpi), PhD
Ambulance Research Institute
Ambulance Service of New South Wales
Locked Bag 105
Rozelle NSW 2039 Australia
E-mail: jbendall@ambulance.nsw.gov.au

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Abbreviations:
ALS = advanced life support
ASNSW = Ambulance Service of New South Wales
EMS = Emergency Medical Services
IN = intranasal
IV = intravenous
PHCR = patient health care records
VNRS = verbal numeric rating scale

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Abstract

Introduction: With at least 20% of ambulance patients reporting pain of moderate to severe intensity, pain management has become a primary function of modern ambulance services. The objective of this study was to describe the use of intravenous morphine, inhaled methoxyflurane, and intranasal fentanyl when administered in the out-of-hospital setting by paramedics within a large Australian ambulance service.

Methods: A retrospective analysis was conducted using data from ambulance patient health care records (PHCR) for all cases from 01 July 2007 through 30 June 2008 in which an analgesic agent was administered (alone or in combination).

Results: During the study period, there were 97,705 patients ≤100 years of age who received intravenous (IV) morphine, intranasal (IN) fentanyl, or inhaled methoxyflurane, either alone or in combination. Single-agent analgesia was administered in 87% of cases. Methoxyflurane was the most common agent, being administered in almost 60% of cases. Females were less likely to receive an opiate compared to males (RR = 0.83, 95% CI, 0.82–0.84, p <0.0001). Pediatric patients were less likely to receive opiate analgesia compared to adults (RR = 0.65, 95% CI, 0.63–0.67, p <0.0001). The odds of opiate analgesia (compared to pediatric patients 0–15 years) were 1.47; 2.10; 2.56 for 16–39 years, 40–59 years, and ≥60 years, respectively. Pediatric patients were more likely to receive fentanyl than morphine (RR = 1.69, 95% CI, 1.64–1.74, p < 0.0001).

Conclusion: In this ambulance service, analgesia most often is provided through the use of a single agent. The majority of patients receive non-opioid analgesia with methoxyflurane, most likely because all levels of paramedics are authorized to administer that analgesic. Females and children are less likely to receive opiate-based analgesia than their male and adult counterparts, respectively. Paramedics appear to favor intranasal opiate delivery over intravenous delivery in children with acute pain.

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Introduction

Provision of analgesia is a primary function of modern Emergency Medical Services (EMS) agencies. Among those calling for an ambulance, 35% to 53% have acute pain.[1,2] Approximately two in every three ambulance patients complaining of moderate to severe pain receive an analgesic agent, and the reported effectiveness of analgesia ranges from 49% to 70%.[1,3] The use of analgesia in the prehospital setting is conditional on many factors, including severity of pain, etiology, patient demography, and type of analgesia available.[4–6] In New South Wales, Australia, the majority of paramedics have several analgesic alternatives at their disposal, allowing them to tailor the analgesia to the nature of the pain and the specifics of the patient encounter. Two of these, intravenous (IV) morphine and inhaled methoxyflurane, have been used for almost 30 years in Australasia, while intranasal (IN) fentanyl has emerged more recently as an effective prehospital alternative.[3,7–10] The aim of this retrospective, descriptive study was to describe the prehospital use of morphine, fentanyl, and methoxyflurane when administered to patients with acute pain in New South Wales, Australia.

Drug	Preparation	Initial Dose	Repeat	Maximum Cumulative Dose
Methoxyflurane (adult & pediatric)	3 ml	3 ml	Nil	6 ml/day
IN fentanyl (adult ≥16 years)	30 mcg/0.1 ml	180–240 mcg	60–120 mcg every 5 min	No maximum
IN fentanyl (pediatric 6–15years)	30 mcg/0.1 ml	60–75 mcg	30 mcg every 5 min	No maximum
IN fentanyl (pediatric 1–5 years)	30 mcg/0.1 ml	30 mcg	30 mcg every 10 min	90 mcg
IV morphine (adult ≥16 years)	1 mg/1 ml	2.5–5 mg	2.5–5 mg, every 2 min	0.5 mg/kg
IV morphine (pediatric 6 months–15 years)	1 mg/1 ml	100 mcg/kg	100 mcg/kg, every 5 min	400 mcg/kg

Table 1—Administration regimes for analgesic agents in NSW
IN = intranasal; IV = intravenous; min = minutes

Methods

Study Setting

This study was conducted within the Ambulance Service of New South Wales (ASNSW), a large Australian ambulance service that responds to approximately 1.12 million cases annually, 825,000 of which are classified as "emergency responses."[11] The ASNSW provides emergency responses to a population of 7.1 million people across a geographical area of approximately 800,000 km^2 incorporating both metropolitan and rural regions.

The ASNSW operates a tiered system of prehospital clinical care. Paramedic Interns are trainee paramedics completing a three-year training program. Qualified Paramedics, who comprise the majority of the frontline workforce, are fully qualified paramedics trained to the level of advanced life support. Intensive Care Paramedics undergo additional training in the area of intensive care paramedicine. Ambulances are dispatched using a Medical Priority Dispatch System and generally are crewed by two paramedics; a single-paramedic "rapid response" unit also operates within this EMS system.

At the time of this study all ASNSW paramedics were authorized to administer inhaled methoxyflurane; qualified paramedics and intensive care paramedics also were authorized to administer morphine and/or fentanyl. Paramedics were able to administer these agents alone or, less commonly, in combination based on their own clinical judgment and experience, and were supported by protocols approved by a Medical Director. The protocol for each of the analgesic agents is described in Table 1.

Study Population and Data Collection

The data for the study were accessed from clinical information that was manually entered into the ASNSW patient healthcare record (PHCR) database from 1 July 2007 through 30 June 2008. Available data were de-identified and already existed in a database; therefore, access to and review of individual PHCRs was not undertaken. The data collection was undertaken using Microsoft Access 2007 (Microsoft Corporation, Redmond, WA, USA) query format. The fields used in the analysis were the PHCR unique number; date; patient age (years); patient gender; main condition/complaint; pain score on-scene and at arrival at the hospital; and the analgesic agent administered. Only cases in which an analgesic agent (alone or in combination) was administered were included for analysis. The analysis was limited to patients ≤100 years of age with an initial recorded pain score of ≥5 using a verbal numeric rating scale (VNRS).

Data Analysis

Statistical analysis was performed with SAS version 9.1 (SAS Institute, Cary, NC, USA). Differences in proportions were compared using chi-squared statistics, and presented as relative risk (RR) or risk difference (RD), and 95% confidence intervals as appropriate. Non-normal data are presented as median (interquartile range (IQR)). Univariate logistic regression was used to explore the effects of age on opiate use. Differences were considered statistically significant if $p < 0.05$.

Ethical Approval

This study was granted ethics approval from the Sydney South West Area Health Service Ethics Review Committee (Royal Prince Alfred Zone).

Results

During the study period, there were 97,705 cases in which patients ≤100 years of age received intravenous (IV) morphine, intranasal (IN) fentanyl, or inhaled methoxyflurane, either alone or in combination. The median age of patients in this study was 48 years (IQR = 28–75 years) with females accounting for 51% of the study population. The use of analgesic agents (alone and in combination) is shown in Table 2. A single agent was administered in the majority of patient encounters (87%). Methoxyflurane was the most commonly used analgesic agent (either alone or in combination), being administered in almost 60% (58,224) of encounters. Where a single agent was administered, methoxyflurane was the most commonly administered agent followed by morphine, then fentanyl. Where a combination of agents was used (i.e., >1) the most common combination was methoxyflurane and either fentanyl or morphine. Morphine and fentanyl where not commonly used in combination and the combined use of all agents (morphine, fentanyl, and methoxyflurane) was rare.

When a single agent was used, females were significantly less likely to receive an opiate compared to males (RR = 0.83; 95% CI, 0.82–0.84; $p < 0.0001$).

When a single agent was used, there was a statistically significant association between age and opiate use, with opiate use increasing with advancing age (trend $p < 0.0001$). The odds of receiving opiate analgesia (compared to pediatrics ≤15 years

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Group	Analgesic Agent	n (% total)	Group %
Single Agent	Morphine	22,183 (22.7)	26.1
	Fentanyl	16,213 (16.6)	19.0
	Methoxyflurane	46,714 (47.8)	54.9
	Total (Single Agent)	**85,110 (87.1)**	**100**
Combinations	Morphine & Fentanyl	1,085 (1.1)	8.6
	Morphine & Methoxyflurane	5,370 (5.5)	42.6
	Fentanyl & Methoxyflurane	5,719 (5.9)	45.4
	All agents	421 (0.4)	3.3
	Total (>1 Agent)	**12,595 (12.9)**	**100**
Grand Total (all patients)		**97,705 (100)**	

Table 2—Use of morphine, fentanyl and methoxyflurane by New South Wales paramedics from 01 July 2007 through 30 June 2008

old) were: 1.47 (95% CI, 1.39–1.55) for those age 16–39 years; 2.10 (95% CI, 1.90–2.12) for those 40–59 years; and 2.56 (95% CI, 2.43–2.70) for those age ≥60 years. Pediatric patients ≤15 years of age were less likely to receive opiate analgesia (IV morphine or IN fentanyl) than methoxyflurane (RR = 0.65; 95% CI, 0.63–0.67; $p < 0.0001$).

Where an opiate was used as the only analgesic, there was a statistically significant association between age and the opiate given, with IN fentanyl use increasing with decreasing age (trend $p < 0.0001$). Pediatric patients (0–15 years) were significantly more likely to receive fentanyl than morphine (RR = 1.69; 95% CI, 1.64–1.74; $p < 0.0001$).

Discussion

This large, retrospective study describes analgesic use in an Australian ambulance service, using data abstracted from approximately 100,000 patient records. In this ambulance service, paramedics have three primary analgesic agents at their disposal. Therefore, they are required to make a clinical decision regarding which agent, or combination of agents, they will administer.

Administration of a single agent is the most common practice occurring in 87% of cases, with administration of more than one analgesic occurring in only 13% of cases. Co-therapy using more than one of the three agents (IN fentanyl, IV morphine, inhaled methoxyflurane) in any combination has been previously shown to be no more effective than IN fentanyl or IV morphine alone.[3,7]

Methoxyflurane accounts for more than half of cases in which a single agent is used. This is not unexpected given that all paramedics in this jurisdiction can administer methoxyflurane, and that opiates are restricted to Qualified Paramedics and Intensive Care Paramedics. Given its demonstrated inferiority in efficacy compared to morphine and fentanyl in adults and children,[8] strategies to reduce the use of methoxyflurane as a first choice analgesic and increase opioid administration may be warranted in the management of moderate to severe pain.

The study found that when a single agent was used to provide analgesia, females were almost 20% less likely to receive an opiate compared to males. Similar findings have been reported in recent prehospital studies. In a study of 953 cases, Michael *et al* found that women are less likely to receive morphine for pain resulting from isolated limb injuries,[6] while Lord *et al* reported the same result in 1,766 patients with acute pain of any origin.[5] In the latter study, there were no statistically significant differences in the rates of refusal of analgesia in men and women; however, women appeared to complain of more severe pain. In contrast, a small, Emergency Department-based study of 190 patients with acute pain reported that women were more likely to receive stronger analgesia (parenteral opiates) than men.[4] This study also found that women reported greater severity of pain than men did for equivalent conditions. It is possible that females report more severe pain by means of a higher pain score, but with less distress and a more stoic disposition. In contrast, men may express pain in a more agitated and animated fashion, which could influence the clinician's choice of analgesic agent. The disparity in severity of pain reported may also reflect that expression of pain is the sum of many social, cultural and physiological influences, as is pain assessment from the point of view of the clinician providing the analgesia. The explanations for the results described above remain unclear, and further investigation is warranted.

Age appears to be an important predictor of the likelihood of receiving opiate-based analgesia and the type of opiate administered. These results show that patients <16 years of age are less likely to receive an opiate than are their adult counterparts. The likelihood of receiving opiate-based analgesia increased with age, with patients >60 years of age most likely to be administered morphine or fentanyl. In this ambulance service, advanced age is not a contraindication to administering methoxyflurane, so paramedics appear to be using clinical judgment, which more frequently results in a decision to use an opiate. The factors influencing such judgments are unclear. An Emergency Department-based study of patterns of analgesic administration found no differences between children and adults in the portion of analgesics received during initial administration. However children were more likely to receive inadequate doses of analgesics on discharge from the Emergency Department.[12] A small,

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prehospital qualitative study from New Zealand found that the need to gain intravenous access in order to administer IV morphine and difficulty in assessing pain severity were barriers to providing opiate analgesia to younger patients.[13] Difficulties in accurately assessing the severity of pain in young patients potentially could lead to under-estimation of pain severity in children and a subsequent decision to administer a non-opiate (such as methoxyflurane or nitrous oxide) and to reserve opiates for more measurable or quantifiable severe pain. While the aforementioned study cited IV access as a barrier to opioid administration, the majority of paramedics in this study were authorized to administer intranasal fentanyl during the study period. This could indicate that IV access was not necessarily a barrier to the use of an opioid for young patients. Paramedic preference when multiple analgesic options are available also could explain the higher incidence of non-opiate analgesia among pediatric patients. Anecdotal accounts of adverse effects of opiates in children may explain the higher use of non-opiate analgesia for pediatric patients when multiple options are available.

This study indicates that children are more likely to receive inhaled methoxyflurane than an opiate. With previous research indicating the inferiority of methoxyflurane to morphine and fentanyl in pediatric populations with acute pain,[8] it appears that in the prehospital setting, pediatric patients are more at risk of receiving inadequate analgesia compared to adults. This is all the more concerning given the already low rates of analgesic administration reported in prehospital and Emergency Department settings.[6,14–17] As the current study involved a patient population in which all patients had received an analgesic agent, it was not possible to report on the overall rate of analgesic administration.

This study also found that when children do receive an opiate, they are 70% more likely to receive IN fentanyl than IV morphine. Adults are less likely to receive IN fentanyl as their age increases, indicating a clear age-related effect in the type of opiate administered. The emergence of intranasal fentanyl as an effective analgesic alternative to intravenous morphine in the Emergency Department[10,18] and prehospital settings[9] represents an opportunity to increase the use of opiate analgesia in young patients with moderate to severe pain, as it alleviates key barriers such as the requirement for gaining intravenous access and "needle-phobia" from the patient's perspective. In the Emergency Department setting, the introduction of IN fentanyl for pediatric pain management has been associated with decreased time to analgesia, decreased morphine usage, and decreased IV access in patients receiving analgesia.[19]

While the analgesic agents described in this study are commonly used in Australasian ambulance jurisdictions, other options should be considered for the management of acute pain in the prehospital setting. The use of ketamine for analgesia is increasing in many jurisdictions, and the use of regional anesthesia by paramedics is being evaluated. The routine use of simple analgesics, including paracetamol and ibuprofen and non-pharmacological options such as active warming [20,21] and acupressure,[22–24] has been demonstrated to be feasible and effective in the prehospital setting.

In summary, this study has identified several important features in the use of analgesic agents by paramedics in this Australian ambulance service. Application of this information in a quality improvement context, particularly in relation to opioid administration, has the potential to impact positively on analgesic practice in prehospital setting. Identification of how analgesics are used at a service level provides opportunities to improve pain management practices. In previous studies,[3,8] it was demonstrated that methoxyflurane is less effective in the management of pain than opiates. Despite this, methoxyflurane was the most commonly used analgesic. Increasing the proportion of patients who receive opiate analgesia is likely to improve patient outcomes. The continued availability of fentanyl preparations suitable for intranasal use is likely to increase the proportion of children receiving opiate analgesia.

Limitations

This study is retrospective in nature, which introduces the potential for selection bias. However, because the paramedics providing the PHCR data were not participating in a study at the time of documentation, bias is unlikely.

The data used in the study were abstracted from an existing database of information from PHCRs. The data from the original PHCRs were manually entered into the database at a central collection point, a process that may be vulnerable to human error resulting in some inaccuracies. Similarly, the integrity of the data is reliant upon compliance with completion of key data fields on the PHCR by paramedics in the field. Any non-compliance could have resulted in pertinent data not being identified by the query used to abstract relevant records. However, the impact of any missing data would have been reduced by the large sample size used in the study. For the reasons outlined above, it is unlikely that there were systematic differences between the data analyzed and the data deemed to be missing or not eligible for inclusion.

The availability of each analgesic agent also could have influenced the decision as to which analgesic was administered. As IN fentanyl is an "off-label" preparation packaged specifically for intranasal use (600 mcg in 2 ml), availability in supply occasionally can be variable. This could have resulted in a situation in which a paramedic might not be able to administer IN fentanyl even though it might be considered to be the most appropriate analgesic for a given situation, and instead would have administered an alternative agent. Given the current data set, it was not possible to determine how often non-availability of the preferred agent played a role in which analgesic agent was ultimately administered.

The fact that methoxyflurane was the most commonly administered analgesic could be a function of the number of paramedics who are authorized to administer it. Methoxyflurane is not restricted in use according to clinical level of training in this EMS system and can be administered by almost all operational paramedics. In contrast, morphine and fentanyl can be administered only by Qualified Paramedics and Intensive Care Paramedics who have undertaken additional education and training in relation opiate-based analgesia. Despite this restriction in use, approximately 75% of paramedics were authorized to administer both fentanyl and morphine by the end of the study period, indicating that opioid analgesia would have been available as an analgesic option along with methoxyflurane in the majority of patient encounters included within this data set.

Conclusion

In this ambulance jurisdiction, analgesia most often is provided through the use of a single agent. Methoxyflurane is the most

commonly used analgesic, accounting for more than half of all cases involving only one agent administration. Females and children are less likely to receive opiate-based analgesia (morphine or fentanyl) than their male and adult counterparts respectively. Children are more likely to receive opiates via the intranasal route than intravenously when both options are available.

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