

# Efficacy of pre-hospital fracture manipulation following ketamine administration: the experience of a single civilian air ambulance trust

A Follows, R H James, J Vassallo

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## Abstract

### *Aims*

Limb fractures are common in pre-hospital care and can be associated with significant haemorrhage and neurovascular compromise. The pre-hospital management of these injuries centres around reduction and splinting. The aim of this study was to quantify the effectiveness of pre-hospital reduction of displaced fractures or dislocations and the incidence of the need for further manipulation in the emergency department.

### *Methods*

A three-year retrospective database analysis was conducted for all patients sustaining limb injuries who were attended by a single air ambulance and subsequently conveyed to the regional major trauma centre. Only patients who received ketamine, either as an analgesic or sedative, were included. Pre-hospital clinical records and emergency department (ED) notes were examined to determine outcomes.

### *Results*

Over the study period, 122 patients sustained a limb injury and received ketamine; ED notes were available for 96 (78.7%). Of these, the majority (n=51, 41.8%) received ketamine for analgesia with n=10 (8.2%) receiving it to facilitate manipulation. The principal indication for pre-hospital manipulation was neurovascular compromise (n=7, 70.0%). Of those undergoing manipulation pre-hospital, the majority (n=7, 70.0%) required further manipulation in the ED.

### *Conclusion*

Pre-hospital manipulation by our regional air ambulance is a relatively low frequency event and in those undergoing a manipulation, a high proportion require further intervention in the ED or operative intervention within the acute phase of care.

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## Introduction

In patients sustaining major trauma (defined as ISS>16), significant limb injuries (AIS>2) are reported in over 50% of cases,<sup>1</sup> with road traffic collisions having the highest relative risk for lower limb fractures.<sup>2</sup> The pre-hospital management of limb injuries involves manipulation and splintage in order to restore neurovascular integrity, prevent further blood loss, prevent damage to surrounding tissues and to relieve pain.<sup>3</sup> With over two-thirds of patients sustaining limb trauma reporting moderate to severe pain, the restoration and splintage of a limb injury is key to delivering effective pre-hospital pain management; a concept which is often insufficiently achieved.<sup>4,5</sup> This pain requires treatment not only for humanitarian reasons but because a patient in severe pain is more difficult to assess, due to difficulty in interpreting abnormal physiology and due to the potential of a painful injury to distract from pain felt elsewhere. There is also a complex response to the nociceptive stimulus associated with musculoskeletal injury. This response can result in changes to arterial blood pressure and oxygen

delivery and also to the response to haemorrhage. These changes have an impact on both morbidity and mortality.<sup>6</sup> However, the reduction process itself is associated with pain; the judicious use of analgesia and sedation facilitates fracture reduction, splintage and extrication, thereby reducing time to definitive care and intervention.<sup>7,8</sup>

The provision of safe analgesia is a fundamental principle of pre-hospital care and should be multimodal, encompassing psychological, physical (e.g. splintage) and pharmacological methods.<sup>8,9</sup> An example of a common pharmacological agent which is often used first-line in prehospital care is the opiate morphine (and, less commonly, fentanyl).<sup>5,8,10</sup> Ketamine, a *N*-Methyl-D-Aspartate (NMDA) receptor antagonist, is an alternative pharmacological agent well-established in both military and civilian pre-hospital practice.<sup>11-13</sup> Ketamine produces a range of potential endpoints ranging from analgesia to general anaesthesia depending on dose. The advantages of ketamine are its simplicity and efficacy of administration;

it affords rapid onset, easy titration and a wide margin of safety, with a relative preservation of airway reflexes and sympathetic tone.<sup>7,11-14</sup> A patient's perception of pain is frequently influenced by their levels of distress and anxiety; as a dissociative anaesthetic agent, ketamine helps in providing both analgesia and sedation, thereby aiming to reduce these effects.<sup>8</sup> For these reasons, ketamine is frequently described as the preferred pharmacological agent for facilitating the reduction or manipulation of limb injuries in the pre-hospital setting.<sup>10,11</sup>

With a paucity of literature surrounding the efficacy of pre-hospital manipulation, the primary aim of this study was to describe the efficacy of pre-hospital manipulation for patients with limb injuries treated by clinicians from a United Kingdom (UK) civilian air ambulance service.

**Methods**

A retrospective database review was conducted for all patients treated by a single civilian UK air ambulance service who had sustained limb injuries and who received ketamine (either for analgesia or procedural sedation) over a three-year study period (1 January 2016 to 31 December 2018). This air ambulance covers a single county of approximately 2,500 square miles, providing advanced pre-hospital care to an estimated population of 750,000. Within the county, two helicopters are operational; one staffed with a physician-critical care paramedic team and the other with a dual-critical care paramedic team. For patients meeting study criteria, the patient demographics, mechanism of injury, body region(s) injured, indication for ketamine administration, manipulation or splinting events (and indication), and type of clinician present (physician or critical care paramedic) were recorded

on a MS Excel spreadsheet. Where available, the doses of ketamine (and other agents if applicable) were also recorded. Hospital notes were then scrutinised by the authors (AF and JV) and the incidence of repeat manipulation was recorded. Where repeat manipulation occurred, the rationale for this was recorded; as were the pharmacological agents and doses used. The study was registered as a service evaluation with University Hospitals Plymouth NHS Trust, reference CA\_2018-19-177.

**Results**

Over the three-year study period, 263 cases were recorded as having sustained limb injuries, of which 46.4% (n=122) received ketamine either for analgesia or sedation. Approximately two-thirds (n=81, 66.4%) received ketamine for analgesia alone, with 27.9% (n=34) for sedation alone and 5.7% (n=7) for both analgesia and sedation. A physician was present for less than a third of all cases (n=33, 27.0%), and not recorded for 11 cases (9.0%). When ketamine was given for sedation, a physician was present for approximately half of administrations (n=19, 46.3%).

Hospital records (including the pre-hospital patient report form) were available for 96 cases (78.7%). Following review of pre-hospital records, three distinct groups for the administration of ketamine were identified: for analgesia (n=51, 41.8%), for facilitating splinting or extrication (n=35, 28.7%), and for manipulation (n=10, 8.2%) (see Figure 1).

In the context of manipulation (n=10), the indication was recorded for 80.0% (n=8), with the overwhelming indication being neurovascular compromise (n=7, 70.0%). One patient (10.0%) received ketamine sedation to facilitate the

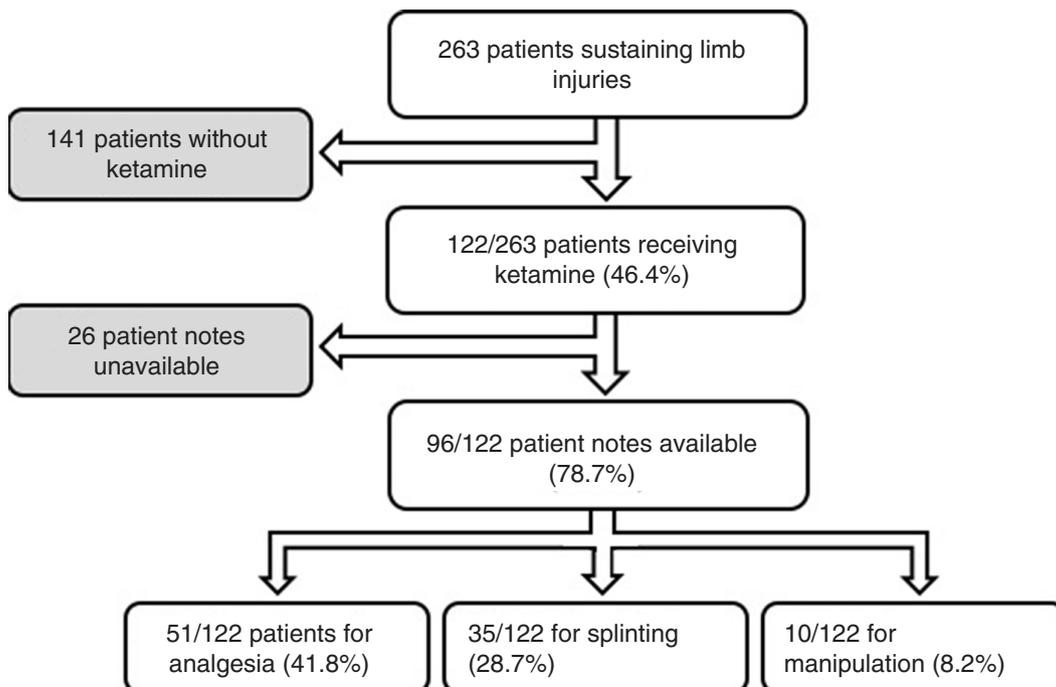


Figure 1: Flow chart of study patients.

	Indication
Pre-hospital manipulation (n=10)	Neurovascular deficit n=7 (70.0%) Reduction of dislocated prosthesis n=1 (10.0%) Not documented n=2 (20.0%)
Emergency department sedation in patients undergoing pre-hospital manipulation (n=7)	Failed reduction n=3 (42.9%) Neurovascular deficit n=2 (28.6%) Application of plaster of Paris backslab n=2 (28.6%)
Emergency department sedation without pre-hospital manipulation (n=12)	Reduction of dislocation n=6 (50.0%) Application of plaster of Paris backslab n=4 (33.3%) Open injury n=1 (8.3%) Neurovascular deficit n=1 (8.3%)

Table 1. Indication for pre-hospital manipulation and sedation in the ED.

manipulation and relocation of a dislocated hip prosthesis. The overwhelming majority of pre-hospital manipulations were subsequently repeated in the emergency department (ED) (n=7, 70.0%); three (30.0%) for failed reduction (one for a failed reduction of a dislocated hip prosthesis), two (20.0%) for neurovascular compromise and two (20.0%) for the application of a plaster splint (see Table 1).

Of those not undergoing re-manipulation in the ED (n=3, 30.0%), two (20.0%) were admitted for operative intervention having sustained open limb injuries. One (10.0%) patient was discharged in a plaster splint (without further manipulation) having sustained a neurovascularly intact, closed, comminuted fracture of the distal tibia; this patient subsequently returned for delayed operative fixation one week later. Twelve patients who did not receive pre-hospital ketamine for sedation were subsequently sedated in the ED; six (50.0%) for reduction of dislocation, four (33.3%) for the application of a plaster of Paris splint, one (8.3%) for neurovascular compromise, and one (8.3%) for an open injury.

## Discussion

Within this study we have described the frequency of manipulations within our local air ambulance service and demonstrated that ketamine is frequently used to facilitate the management of limb injuries. A high proportion of patients undergoing pre-hospital manipulation subsequently underwent further manipulation in the ED.

There are likely to be a number of reasons for this including the injury itself, technical ability of the provider performing the manipulation and the ability of the splinting device to maintain the limb following manipulation.

A significant proportion of patients sustaining isolated limb injuries report severe pain; often the principal determinant of analgesia administration is the presumptive diagnosis of fracture.<sup>4,9</sup> As a pharmacological agent, ketamine facilitates extrication from entrapment and the reduction or splintage of fractures.<sup>5,7,8,11,12</sup> Given its favourable haemodynamic

profile, ketamine is favoured in the military setting where injuries associated with hypovolaemia may frequently be encountered.<sup>8,11-12</sup>

The reduction and splintage of limb fractures is required in order to restore alignment and neurovascular integrity, while reducing further blood loss and tissue damage and helping to provide pain relief.<sup>3,15,16</sup> When present, distal neurovascular compromise constitutes a limb-threatening emergency requiring urgent manipulation, irrespective of location (pre-hospital or in-hospital).<sup>3,15</sup> Future military operations may well be conducted where evacuation timelines are protracted, leading to a requirement for Prolonged Field Care (PFC). By definition the teams undertaking the initial management of a patient will not have access to a surgical facility or in many cases a Medical Treatment Facility (MTF) of any sort. The pre-hospital management of fractures and dislocations (including safe sedation and manipulation) will therefore become part of the required skill set for those not traditionally performing these procedures (e.g. RMOs/GPs). Addressing this requirement, Defence Ketamine Training is now provided for all Level 6 pre-hospital practitioners and Medical Officers at Level 5.<sup>17</sup>

The use of splintage as a means of non-pharmacological analgesia is well established in the pre-hospital environment;<sup>3,15</sup> in this study, approximately one quarter of patients (n=35, 28.7%) received ketamine in order to facilitate the application of a splint. In the absence of neurovascular compromise, splintage represents an effective temporising method in advance of definitive care, with evidence to support traction splints reducing the incidence of neurovascular injury and the need for transfusion and, through the stabilisation of fractures, providing symptomatic pain relief.<sup>19-21</sup>

It has been previously described that fracture severity, the degree of comminution and reduced bone quality have been associated with increased rates of re-manipulation within the ED.<sup>22</sup> We acknowledge that the frequency of repeat manipulation in the ED is high in our study, and suggest that

fractures with a high degree of comminution may be more likely to result in the observed neurovascular compromise, while being inherently more difficult to reduce.

### Limitations

There are a number of limitations associated with this study. Firstly, it was undertaken in a single air ambulance service, which limits its external validity when considering other services or the military pre-hospital environment. Secondly, the retrospective nature of this study introduces the possibility of observer bias from the authors while collecting data. Lastly, although individual hospital notes were scrutinised, missing data meant that complete data were only available for 78.7% of patients, thereby introducing the potential for sample bias.

Documentation in the pre-hospital setting has previously been described as being less comprehensive than that in hospital.<sup>23</sup> Owing to the nature both of the data recorded within the notes and of that which was collected for the purpose of this study, it is not possible to establish the rationale surrounding an individual's decision-making process to splint or manipulate

fractures, nor to determine the practitioner's perceptions of manipulation success. In the cases where patients only underwent ED manipulation, it is not possible to determine the pre-hospital decision-making process when choosing not to manipulate.

Finally, a large proportion of patients with limb injuries were excluded from this study because they did not receive ketamine. Whilst ketamine is commonly used for sedation in the pre-hospital setting, it is possible other pharmacological agents were used and that this study has underestimated true rates of fracture manipulation.

### Conclusion

Within our local air ambulance service, pre-hospital fracture manipulation is a low frequency event with a high proportion requiring further manipulation in the ED or undergoing operative intervention within the acute phase of care. Whilst there are clear indications (such as neurovascular compromise) for the pre-hospital manipulation of limb injuries, clinicians should be aware that the process may not be definitive.

### Conflicts of interest

The authors declared no conflicts of interest.

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### Authors

Dr Andrew Follows

Intensive Care Unit, Southmead Hospital, North Bristol NHS Trust, Bristol, UK.

[andrew.follows@nhs.net](mailto:andrew.follows@nhs.net)

Wing Commander Robert James RAF

Emergency Department, Derriford Hospital, Plymouth, and Devon Air Ambulance Trust, UK.

Academic Department of Military Emergency Medicine, Royal Centre for Defence Medicine, Birmingham, UK.

Surgeon Lieutenant Commander James Vassallo Royal Navy

Emergency Department, Queen Alexandra Hospital, Portsmouth, UK.

Academic Department of Military Emergency Medicine, Royal Centre for Defence Medicine, Birmingham, UK.