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Pain Management Strategies and Time Spent on Scene for Pre-Hospital Analgesia Provision in an Alpine Environment: A Retrospective Study

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Abstract

Objective: The delivery of a safe an effective analgesia is a core principle and a priority of prehospital care. Analgesia in hostile environments (mountain settings, etc.) presents various challenges, and the benefit-risk ratio of the procedure should be evaluated. The objective of this study was to examine pain management strategies and the time spent on scene for analgesia provisions in an alpine environment.

Methods: We undertook a retrospective study from a single physician-staffed helicopter emergency medical service in the Swiss Alps. Patients with isolated limb injuries were included. We examined the choice and route of analgesic medication, patient monitoring, medical co-treatments and time delays during the rescue mission.

Results: Analgesia was provided to 657 (57%) of the 1156 included patients. Fentanyl was most commonly administered followed by ketamine, with or without fentanyl. Heart rhythm monitoring, oxygen administration, and saline infusion were used infrequently, but were used significantly more often in patients treated with ketamine. The median time on site was 6 minutes longer for patients receiving intravenous analgesia compared with those not receiving it.

Conclusion: Analgesia in hostile environments seems to be limited to essential procedures. The safety of this approach must be confirmed.

Keywords: Analgesia; Emergency medical service; Pain management; Prehospital emergency care; Trauma

Introduction

Analgesia is an essential part of pre-hospital medicine and its efficient provision requires specific skills and knowledge [1-3]. Several analgesic strategies exist that consider the clinical situation, situational context, staffing, competencies of the pre-hospital providers, and, finally, the availability of drugs and materials. Although the administration of analgesics or sedative drugs to an injured patient can be beneficial, it may also be a potential source of complications such as hypotension and respiratory depression or arrest. Analgesics should not be administered without a prior risk/benefit assessment [4]. The practice of wilderness medicine is complicated by hostile elements such as the cold or dangers to the patient or rescuers, as well as limitations of the type of medical materials that can be brought to the site. All of these factors must be considered, in addition to the patient's clinical situation, to define an efficient rescue strategy.

We previously showed that a large proportion of patients with isolated limb injuries experience significant pain, and the intensity of the pain was the main determinant for administering analgesia [5]. Using the same database, we investigated in greater detail the choice and route of analgesic medication, patient monitoring, medical co-treatments provided, and the time spent on-scene for analgesia provision in an alpine environment.

Methods

This study is a secondary analysis of retrospective and observational data from a single physician-staffed alpine helicopter emergency medical service (HEMS) (Air-Glaciers, Sion, Switzerland). Our primary aim was to describe the different analgesic strategies used as well as the corresponding patient monitoring and medical co-treatments provided. Our secondary outcome was to determine the time spent at the scene.

All traumatised patients with isolated limb injuries rescued between January 1, 2011 and December 31, 2012 were included. We excluded patients with polytrauma, Glasgow Coma Scale (GCS) <15 and those who were not attended by a physician during the rescue mission. An analysis of prehospital analgesia determinants from the same population has been published elsewhere [5].

The following data were abstracted: patient's age and gender, mechanism of trauma, type of activity when injured, and presumed diagnosis according to the prehospital physician at the end of the rescue mission. Injury severity was graded according to the 8-level National Advisory Committee for Aeronautics (NACA) scale from zero (no injury) to seven [6]. Pain intensity was assessed at the scene and at the hospital using the 11-point Verbal Numeric Rating Scale (VNRS), which ranges from no pain (VNRS=0) to the worst pain possible (VNRS=10). The following vital signs were collected: heart and respiratory rates, blood pressure, and transcutaneous peripheral oxygen saturation (SpO_2). The presence of an intravenous access, as

well as failed attempts, and the use of normal saline infusion were registered. Fentanyl and ketamine were the two analgesic drugs available in the medical supplies for this HEMS; midazolam could be added.

A LMA® MAD Nasal™ (Research Triangle Park, NC, USA) mucosal atomization device was available for intranasal drug administration. We extracted the type, dose, and route of administration of the delivered medication. Realisation of fascia iliaca compartment block was also registered. The following adverse events were recorded: hypotension (systolic arterial pressure <90 mmHg or need for vasopressors), bradypnea (respiratory rate <12 min^{-1}), desaturation (SpO_2 saturation <90%), and need for assisted ventilation. The time interval of the rescue mission and the need for a winching procedure on site were also recorded.

Statistical analysis

The data retrieved from the prehospital forms were inputted into a Microsoft Access database (Microsoft Office Corporation, Redmond, WA, USA) then exported to Stata version 14 (Stata Corporation, College Station, TX, USA). The study was approved by the Human Research Ethics Committee, "Commission Valaisanne d'Ethique Médicale", on May 6, 2013 (n.CCVEM 015/13). Descriptive statistics included frequencies, mean and standard deviation (SD), or median and interquartile range (IQR). Groups were compared using Pearson's χ^2 or Fischer exact tests, Student's t-test, or Wilcoxon rank-sum test as appropriate. A bilateral p value <0.05 was considered to indicate a significant difference.

Results

During the 2-year study period, 1,156 patients met the inclusion criteria (Figure 1). A majority of patient were male (60%; n=686), with a mean age of 37 (SD 19; range 3-83) years; 244 patients were aged ≤ 16 years. Most patients (79%) were injured while practising on- or off-piste alpine skiing or snowboarding. Lower limbs were more frequently injured than upper limbs (62% vs. 38%) (Table 1).

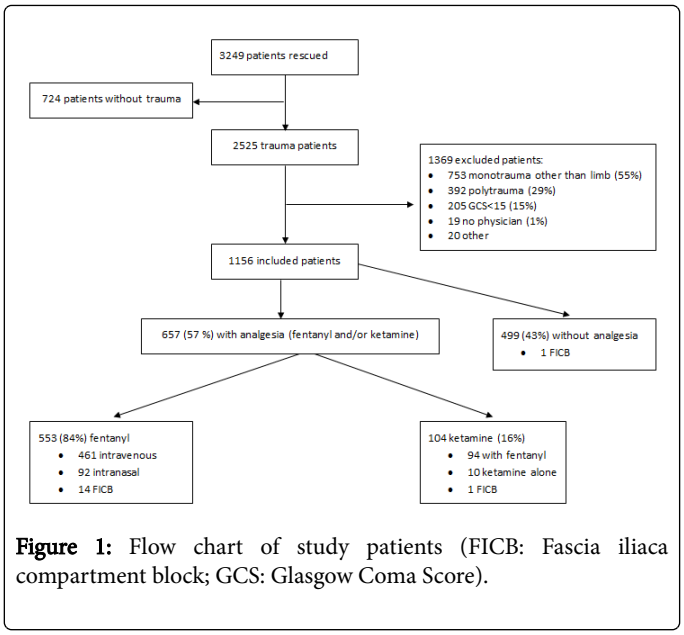

Figure 1: Flow chart of study patients (FICB: Fascia iliaca compartment block; GCS: Glasgow Coma Score).

	Study population (N=1156)	No analgesia (n=499)	Analgesia (n=657)	P value
Age, year	37 (19)	40 (18)	35 (20)	<0.001
Male	686 (60)	283 (57)	403 (62)	0.109
Event leading to trauma				0.084
Fall	1066 (92)	451 (91)	615 (94)	
Collision	37 (3)	16 (3)	21 (3)	
Other	50 (4)	30 (6)	20 (3)	
Activity at the time of injury				<0.001
Alpine Skiing	784 (68)	293 (59)	491 (75)	
Hiking	107 (9)	69 (14)	38 (6)	
Snowboarding	78 (7)	36 (7)	42 (6)	
Backcountry skiing/snowboarding	43 (4)	31 (6)	12 (2)	
Ski touring	40 (3)	32 (7)	8 (1)	
Other	97 (9)	35 (7)	62 (10)	
Injury location				<0.001
Humerus (with shoulder)	315 (27)	76 (15)	239 (36)	

Tibia/fibula	232 (20)	67 (13)	165 (25)	
Knee	188 (16)	158 (31)	30 (5)	
Femur	179 (16)	63 (13)	116 (17)	
Ankle/foot/toes	88 (8)	54 (11)	34 (5)	
Clavicle/shoulder blade	62 (5)	36 (7)	26 (4)	
Other location	92 (8)	45 (9)	47 (7)	
Presumptive diagnosis				<0.001
Fracture	441 (38)	106 (21)	335 (51)	
Dislocation	216 (19)	61 (12)	155 (24)	
Sprain or muscle/torn ligament	143 (12)	127 (26)	16 (2)	
Contusion	54 (5)	46 (9)	8 (1)	
Cut	43 (4)	30 (6)	13 (2)	
Undetermined	259 (22)	129 (26)	130 (20)	

Table 1: Characteristics of the study population and according to the analgesia provision. Values are number (proportion) or mean (standard deviation).

Intravenous access was successfully obtained for 51% of the patients (n=588) and 97.4% of them (n=573) were provided intravenous analgesia. Intravenous access failed in only 9 patients (98.5% success rate for intravenous access) and 7 of these patients received intranasal fentanyl. Only 11% (n=63) of the patients with a successful intravenous access had an IV perfusion of normal saline.

Systemic analgesia was provided to 657 patients (57%), predominantly using fentanyl followed by ketamine, with or without fentanyl. The median diminution in VNRS between the scene and the hospital was 3 (IQR 0-5) points and was significantly greater for patients who were provided analgesia than for those who were not (4 [IQR 3; 5] vs. 0 [IQR 0; 0]; p<0.001). The medical treatment characteristics associated with each of these two analgesic strategies are presented in Table 2.

	No systemic analgesia	**Fentanyl alone‡**	**Intravenous ketamine* ± fentanyl**	**P value††**
Number of observations, n (%)	499 (43)	553 (48)	104 (9)	
NACA scale				
Mean ± SD (range)	2.5 ± 0.7 (1-4)	2.9 ± 0.6 (2-4)	3.1 ± 0.6 (2-4)	0.004
Documented pain score (VNRS)				
At the scene	2.8 ± 1.8	7.2 ± 2.0	8.5 ± 1.5	<0.001
At hospital	2.5 ± 1.5	3.5 ± 1.7	2.2 ± 1.8	<0.001
Pain diminution	0.4 ± 1.4	3.7 ± 2.0	6.5 ± 2.1	<0.001
Fentanyl dose, intravenous				
Median, mg (IQR)	-	100 (100;200)	200 (100;250)	
Mean, mg ± SD (range)	-	154 ± 92 (20-600)	189 ± 89 (50-450)	
Fentanyl dose, intranasal				
Median, mg (IQR)	-	100 (75;150)	150 (100;250)†	
Mean, mg ± SD (range)	-	115 ± 72 (20-400)	167 ± 76 (100-250)	
Ketamine dose, intravenous				

Median, mg (IQR)	-	-	30 (20;50)	
Mean, mg ± SD (range)	-	-	45 ± 38 (2.5-250)	
Monitoring				
ECG monitoring, n (%)	5 (1)	27 (5)	12 (12)	0.008§
Cuff blood pressure measurement, n (%)	11 (2)	28 (5)	7 (7)	0.487
SpO2 saturation measurement, n (%)	55 (11)	28 (5)	7 (7)	0.487
Vital signs				
Heart rate, bpm ± SD	83 ± 10	87 ± 13	89 ± 13	0.156
Systolic cuff blood pressure, mmHg ± SD	138 ± 25	117 ± 21	135 ± 33	0.108
Respiratory rate (min-1)	14 ± 3	15 ± 4	15 ± 4	0.616
SpO2, % ± SD	96 ± 3	96 ± 3	96 ± 3	0.78
Co-treatments				
Oxygen administration, n (%)	16 (3)	68 (12)	46 (44)	<0.001§
Saline infusion, n (%)	4 (1)	36 (7)	23 (22)	<0.001§
Midazolam administration, n (%)	0	15 (3)	73 (70)	<0.001
Midazolam dose, mg (IQR)	-	1 (1;1)	1.5 (1;2)	<0.001
Droperidol administration, n (%)	0	27 (5)	2 (2)	0.294
Droperidol dose, mg (IQR)	-	1 (0.5;1)	0.75 (0.5;1)	0.657
Fascia iliaca compartment block realisation	1	14	1	
Adverse events				
Hypotension (SBP < 90mmHg), n (%)¶	1 (0.2)	4 (2)	1 (1)	-
Bradypnea (respiratory rate < 12 min-1), n (%)‡‡	10 (2)	12 (4)	10 (13)	0.002**
Desaturation (SpO2 saturation < 90%), n (%)‡‡	1 (0.2)	15 (5)	4 (5)	0.729
Assisted ventilation, n	0	0	0	-

Note: ECG = electrocardiogram; IQR = interquartile range; NACA = National Advisory Committee for Aeronautics; SBP= Systolic Blood Pressure; SD = standard deviation; SpO2 = transcutaneous peripheral oxygen saturation, VNRS=Verbal Numeric Rating Scale.

*91 times with fentanyl, including 3 times intra-nasally.

†n=3

‡Excluding the 3 fentanyl intra-nasal + ketamine and including fentanyl intra-nasal (n=92).

§Remains statistically significant when excluding the cases where midazolam was used

¶Including 2 patients who needed ephedrine (1 fentanyl only and 1 ketamine).

**No more significant when excluding the cases where midazolam was used (p=0.602)

††Comparison was made only between patients who were administrated analgesia.

‡‡Midazolam administration was associated with bradypnea (p<0.001) and desaturation (p=0.017) occurrences.

Table 2: Drug dose, monitoring, vital signs, co-treatments, and adverse events according to the analgesic strategy used. The p values refer to the results of comparisons between the two groups who received analgesia (fentanyl alone or ketamine ± fentanyl).

Intramuscular or intranasal ketamine were not reported. Among the 92 patients who received intranasal fentanyl, the intranasal route was used "in first intention" in 71 (77%) patients, and only 7 (8%) of them had a definitive venous access failure. The proportion of paediatric patients was significantly higher when fentanyl was given intra-nasally in comparison with the intravenous route (57% vs. 22%, p<0.001). This difference also remained statistically significant after limiting the analyses to only the 71 cases where intra-nasal fentanyl was used in first intention. Sixteen fascia iliaca compartment blocks were performed by 6 different physicians for 13 femoral shaft and 3

proximal tibia or fibula fracture suspicions. All but one of these 16 patient also received fentanyl, 13 intravenously (among them one also received intravenous ketamine) and two intra-nasally (without any intravenous access attempt).

Timing in minutes, median (IQR)	Study population	Analgesia	No analgesia	P value
Flight time to the scene	10 (6;14)	10.7 (8;13)	11.7 (8;14)	0.005
No winching	10 (8,13)	9 (8;12)	10 (8;13)	0.003
Winching†	14 (10;18)*	13.5 (10;18)	14 (10;20)	0.921
On scene time	12 (6;18)	15 (10;20)	9 (5;13)	<0.001
No winching	11 (7;16)	14 (10;19)	8 (6;11)	<0.001
Winching†	22 (13;32)*	29 (17;39)	17 (12;24)	<0.001
Flight time to hospital	7 (6;10)	7 (6;10)	8 (6;10)	0.16
No winching	7 (6;9)	7 (6;10)	7 (6;9)	0.298
Winching†	9 (7;13)*	8.5 (7;12)	9.5 (7;14)	0.517
Overall mission time	31 (25;40)	33 (27;41)	28 (23;38)	<0.001
No winching	29 (24;36)	31 (26;37)	26 (22;32)	<0.001
Winching†	49 (39;60)*	52.5 (43;65)	42 (35;53)	0.002

*p<0.001 between winch and non-winch missions.

†Winch missions also include human external cargo procedures [7].

Table 3: Delays according to analgesia provision.

The helicopter was able to land directly at the scene in 81% (n=887) of the 1,089 missions where information was available. A winching procedure was required in 15% of cases (n=166). In 3% (n=36), a stationary flight was used to load the patient into the aircraft. The different time delays according to the analgesia provision are presented in Table 3. The median time on site when intranasal fentanyl was provided in first intention was 3 minutes shorter than when the IV route (either with fentanyl or/and ketamine) was used (12 minutes [IQR 9; 16] vs. 15 [IQR 10; 21]; p<0.001), which also remained significant when missions requiring winching were excluded. The median time on site for patients who were provided fascia iliaca compartment block was 16 minutes (IQR 11; 24).

Discussion

The main strategy used for analgesia in our study was intravenous fentanyl. Intra-nasal fentanyl was used in first intention mainly for young patients or for those with venous access failure. Heart rhythm monitoring, oxygen administration, and saline infusion were used infrequently, but were used significantly more often in patients treated with ketamine. Documented complications were infrequent and no serious adverse effect was documented. The median time on site was 6 minutes longer for patients who were provided intravenous analgesia compared with those who were not.

Analgesic strategies

The two analgesic drugs that were available and in use in our setting were fentanyl and ketamine. Both are considered safe and effective in managing moderate-to-severe pain, including pain experienced by patients during mountain rescue [1,2,8-11].

The mean dose of fentanyl used in our study is in line with the proposed doses in the literature [8,9,12-15] including in the specific setting of mountain rescue [2]. The mean dose of intra-nasal fentanyl was lower than when used intravenously, which is partially explained by a significantly higher proportion of paediatric patients in the intra-nasal group.

The mean dose of ketamine was 44 mg, which is similar to a previous study [16]. This mean dose has to be interpreted with caution because ketamine can be used in different ways and at different dosages [17-21], and it is sometimes used in association with fentanyl as reported in this analysis. The mean dose of ketamine in our study probably represents a mix of different uses and reflects the practise variability between physicians. Intra-nasal use of ketamine, which was only recently recognised as an alternative, was not reported in our study patients, but it is likely to be used in the near future [20,22,23].

Co-administration of midazolam with ketamine reduced emergence phenomenon in adult patients undergoing procedural sedation in the emergency department [24]. Although no specific recommendations exist regarding the co-administration of midazolam in our HEMS, midazolam was administrated to 70% of patients in conjunction with ketamine. The maximal dose of midazolam reported in our study was lower than in another study [16]. This difference may be due to more cautious dosing related to greater safety concerns in mountain rescue [25]. Among patients who received ketamine and midazolam, 89% also benefitted from fentanyl, although this triple therapy may increase the risk of adverse events. Sixteen patients benefitted from a fascia iliaca compartment bloc, which is increasingly recognized as a valuable option in the pre-hospital management of proximal lower limb injuries, especially femoral shaft fractures [26,27].

Monitoring, equipment and oxygen therapy

Only a small proportion of patients who received analgesia had their heart rate, blood pressure, or oxygen saturation monitored, which contrasts with some pre-hospital recommendations [28]. Care in the wilderness is often limited to the essential procedures [1,2]. The priority may be to prevent hypothermia in this challenging and sometimes/often cold environment, where electronic devices may not be as reliable [2]. Oxygen was infrequently used, but was used significantly more often when intravenous analgesia with ketamine was provided. This finding is surprising when considering that ketamine has an excellent safety profile and that supplemental oxygen is not deemed mandatory, even when it is used at dissociative doses [18]. It could however be partially explained by the fact that patient treated with ketamine suffered from more severe injuries.

Only 15 (2.6%) of the 588 patients with successful intravenous access did not benefit from intravenous analgesia. A previous study showed that only 30% of IV catheters placed in patients with an injury to a single organ system in a paramedic-based EMS were used for treatment [29]. Our much lower rate of unused intravenous catheters could be partially explained by the specific physician- and non-protocol-driven setting [30]. Similarly, only a small proportion of patients with IV access were provided a normal saline intravenous infusion. The routine connection of an IV line to an infusion has been questioned as often being an unnecessary and costly procedure [31]. Our 89% rate of saline lock is high compared with other settings [29,31] but reflects the practice adjustments to environmental factors such as infusions freezing in the tubing and the higher disconnection risk of the IV line while moving the patient in the wild or during winching. Intravenous access attempts failed in only 1.5% our patients, but this is a much lower rate than in other studies [32,33]. Our physicians have extensive training in anaesthesia or emergency medicine and continue to practice daily in the operating room or emergency department, thereby maintaining their skills. Another explanation could be the smaller size of the catheters used for analgesia in comparison with other indications, which are known to be inversely correlated to the success rate [32].

Adverse events

No serious adverse events were described in our study. Episodes of desaturation or bradypnea were self-limited, with no need for bag-mask ventilation. Rare but serious complications, such as chest-wall rigidity, did not occur [34]. Although a transient side-effect of opiates must be considered for patients who received fentanyl and experienced hypoxemia, erroneous low SpO_2 readings because of the cold environment may have also played a role. Although we cannot exclude that side-effects were either under-detected or under-reported, our findings support fentanyl as a safe analgesic, with minimal cardio-respiratory repercussions [8,11,12,35].

Scene time

Overall, the median time on scene was 6 minutes longer for patients who required systemic analgesia than for those who did not. This corresponds to an increase in scene time previously reported for traumatized patients, for whom an IV access was inserted in a paramedical-staffed EMS [36]. However, the on-scene time for an IV access in trauma patients has been shown to be considerably prolonged when splinting or immobilization procedures are required; these are procedures for which we did not collect data in our study [37]. When considering that additional time should also be considered in the specific case of analgesia for drug preparation, administration, and eventual titration, the 6 minutes required for systemic analgesia in our study can be considered efficient [38]. Having short on-scene times certainly has no influence in terms of survival of these patients [39], but could reduce exposure to hypothermia or objective dangers.

Finally, the median previously published scene times for winching missions from two other studies were of 42.5 and 48 minutes [25,40] respectively, which was twice as long as the scene time of winching missions in our study. This could be explained by differences in operating procedures, terrain, or the mix of patient cases.

Limitations

Our study has some limitations. Our study was retrospective and data came from single HEMS, which may limit the external validity of our results. Non-pharmacological measures were not systematically documented by physicians in this study (reassurance, splinting, reduction of a joint dislocation, fracture realignment, etc.) although their role in pain management is essential [1,7], even if they impact the time spent at the scene. This limitation, however, is applicable to every patient in the study. Another limitation is that only the total dose of analgesic was collected and no reliable information was available regarding the titration or timing of administration of the different agents. Therefore, it is unclear if these drugs were administered simultaneously in patients who received fentanyl and ketamine or in what sequence if administered separately. Finally, the adverse events were not specifically collected in the prehospital chart and their frequency or severity may be underestimated. We would expect, however, that the major ones would have been described in the pre-hospital chart.

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