THE EFFECTIVENESS OF A MILITARY PRE-HOSPITAL FLUID INFUSION STRATEGY

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Abstract

We performed a study to assess the effectiveness of a fluid infusion strategy currently used in the military pre-hospital environment using the patient's own body weight as an infusion device. Thirteen healthy volunteers were cannulated and 0.9% sodium chloride infused over a period of ten minutes. The volumes infused were measured and flow rates derived. A mean flow rate of 40ml per minute was seen through an 18g cannula. This strategy generates reasonable flow rates, but whether this is sufficient to the clinical aim of fluid resuscitation in pre-hospital settings is unknown.

Introduction

Resuscitation of casualties in tactical situations is a challenging area of pre-hospital care. Whilst obviously relevant to the military setting, certain civilian practitioners should be familiar with paradigm of care (e.g. police firearm units). The priorities of the patient are supervened by the operational environment– scene safety is key (1). As a result, compromise has to be reached to optimise rescuer safety, patient care and ultimately patient survival. For the remote military practitioner, isolation may also be a factor; rescue may be delayed due to operational constraints.

There are a higher proportion of penetrating and blast injuries in battlefield trauma (2). As such, battlefield casualties have higher rates of traumatic haemorrhage, which may be catastrophic. This requires early recognition and primary resuscitation. Later in the injury process, systemic inflammation supervenes and large fluid shifts occur (3).

A recent change in paradigm for the management of major trauma casualties follows the <C>ABCDE approach, emphasising the need for practitioners to recognise and control catastrophic haemorrhage (4). Judicious fluid replacement is advocated at an appropriate time and should be titrated to maintain a radial pulse. Different fluid regimes apply for the casualty with an isolated head injury (5). Management of internal haemorrhage can be more problematical far forward on the battlefield and focuses on early recognition of ongoing non-compressible haemorrhage and hypotensive resuscitation in the early period, but recognising the potential detrimental metabolic effects of long term (>2hrs) limited resuscitation.

Fluid replacement regimes should follow existing evidence-based guidelines (5-8). Military practitioners should follow recent algorithms outlined in the BATLS course (5). The fluid should be delivered through a large bore cannula or intraosseous device (9). Cannulation under fire proves challenging and for this reason, BATLS recommends attempting cannulation when the firefight is won and the threat has subsided (5). Furthermore, fluid infusion methods in civilian practice rely on gravitational drainage of fluid, requiring some degree of fixation above the patient. This will not be achievable in the field, and it is unlikely that there will be spare manpower in the immediate aftermath of the firefight to manually squeeze the fluid bag. The current solution to this problem is to expel the air from the fluid administration set and place the bag and drip set under the patient, using their own bodyweight to drive the infusion, without risk of air embolisation, releasing the medic for other tasks.

There are no reports in the literature regarding the efficacy and practicability of this technique. The current literature focuses on methods of IV access, administration set fixation methods, and type and amount of fluid to be infused (10,11). We designed the current study to assess the effectiveness of this technique by measuring the flow rates achievable in controlled circumstances.

Methods

We recruited 13 healthy volunteers to participate in the study. Each underwent cardiorespiratory examination to ensure fitness to participate and each gave written informed consent. Each subject was weighed and cannulated in the antecubital fossa by a consultant anaesthetist (PW) using a standard 18 gauge (green) cannula. A 1 litre bag of 0.9% sodium chloride was connected to the cannula via an infusion line, the air completely expelled from the system and the line clamped off. With the subject lying supine on a solid floor, the infusion bag was placed under their sacrum. The line was then unclamped and allowed to run freely for exactly 10 minutes. The drip was then clamped off and the remaining volume of fluid in the system was measured using a measuring jug. Calculation of volume infused over time yielded the average flow rate.

Results

All of the 13 participants completed the study and the weights and calculated volumes for each of the participants are shown in table 1.

Figure 1 shows the correlation between infused volume and body weight. The Pearson correlation co-efficient for the relationship between these two variables was 0.16, suggesting poor correlation. The average amount of fluid infused per minute was 40ml, with a maximum infusion rate of 61ml/minute and a minimum infusion rate of 24.5ml/minute.

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Participant Number	Mass (Kg)	Infused Volume (ml)	Infused volume (ml/Kg)	Infused volume (per minute)
1	75	375	5.00	37.5
2	60	245	4.08	24.5
3	62	300	4.84	30
4	85	600	7.06	60
5	65	325	5.00	32.5
6	94	610	6.49	61
7	79	325	4.11	32.5
8	68	400	5.88	40
9	100	419	4.19	41.9
10	70	550	7.86	55
11	79	455	5.76	45.5
12	94	320	3.40	32
13	112	275	2.46	27.5

Table 1. Mass, infused volumes and flow rates for each participant.

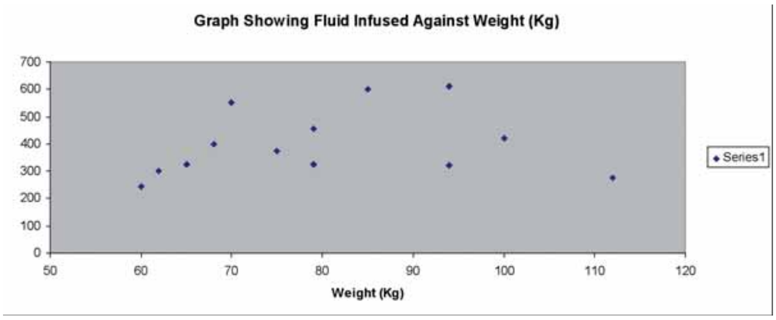

Figure 1: Correlation between participant mass and infused volume.

Discussion

In this study, we have demonstrated that the often taught but previously untested method of infusing intravenous fluid by using the patient's own body weight is only moderately effective. The average flow rate of 40ml per minute would allow a fluid challenge of 250ml (as recommended by current guidelines (5) to be given over approximately 6 minutes whilst freeing the treating soldier for other duties. There appeared to be little correlation between the patient's bodyweight and the flow rate, which was an interesting finding. Newtonian physics dictates that the force applied over the area governs pressure on the bag. Whilst the force provided by the patients weight will be constant, the area may vary according to the build of the patient. Whilst our participants were encouraged to lie still, we cannot discount the potential for small changes in posture to alter the area over which the force would be distributed. Rather than being at a potential confounder in this study, it more realistically models the behaviour of an agitated injured hypovolaemic soldier after a firefight.

Of more potential concern, is the relatively low mean flow rate observed. Replacement of 40ml/min of crystalloid solution may not be sufficient to maintain circulating volume in the face of catastrophic haemorrhage; similarly, as the aim of fluid resuscitation at this level of care is maintenance of vital end organ perfusion, it is unclear whether a mean flow rate of 40mls/min would be adequate. However, we did not use a large bore cannula, but arbitrarily selected an 18G cannula, as insertion of larger bore cannulae in the tactical field care setting may prove difficult. Use of a larger cannula increases the possible infusion rate as dictated by Pouseille's Law, with larger bore cannulae achieving higher flow rates for a given driving pressure(12). Flow rates through commercially available adult intravenous cannulae vary from 36ml/ minute (22g) to 343ml/ minute (14g). An 18g cannula can run maximal flows of 96ml/ minute. Thus, our method was able to reproduce a flow rate of approximately 40% of the maximal flow rate of an 18g cannula – or practically speaking, equivalent to a 22g cannula.

We accept that this preliminary study has limitations, which limit direct extrapolation to the battlefield. All cannulations took place in a non-hostile warm well-lit environment by a consultant anaesthetist. The weight of the participants did not correlate with the flow rates achieved as we had expected and we suspect that the variability in flow rates may be linked to either the technique of placing the fluid bag or movement by the 'patient'. We did not include a control group, i.e., a bag of fluid placed on the subject's abdomen, allowing flow to occur naturally with little gravitational aid. Clinical experience suggested that backflow of blood occurs in these situations. We did not study the flow rates for different sized cannulae or ones inserted into different calibre veins around the body, or compare to flow rates achieved by intraosseous infusion, suggesting an avenue for further work.

Conclusions

This study confirms that the common practice of placing the fluid infusion bag beneath the patient is effective in achieving an average flow rate approximately equal to 50% of the maximal flow rate of an 18g cannula. Further work is necessary to identify the optimal cannula size and site to infuse at a rate sufficient to maintain vital end organ perfusion. In terms of BATLS recommendations, the bag can be left under the casualty and should be rechecked five minutes later whence approximately 250ml of fluid will have been infused through an 18g cannula.

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