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Antibiotic prophylaxis in pre-hospital trauma care: A review of the literature

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Literature review

Antibiotic prophylaxis in pre-hospital trauma care: A review of the literature

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Abstract

Introduction

Penetrating and open wounds expose an otherwise sealed and protected body to foreign bodies, leaving the patient vulnerable to potentially fatal infection. The objective of this study was to determine if the administration of systemic prophylactic antibiotics by paramedics for penetrating and/or open wounds leads to decreased infection rates and improved patient outcomes.

Methods

A literature search of the electronic medical databases CINAHL, Cochrane, EMBASE and MEDLINE was conducted. The databases were reviewed from January 2000 to March 2013. A pre-hospital search filter was applied to each database with additional search terms of 'open wound', 'penetrating wound', 'prophylactic antibiotic'. References of retrieved articles were also reviewed. Articles were included if they reported on the administration of prophylactic antibiotics by paramedics for penetrating or significant open wounds.

Results

A total of 1280 articles were identified in the search with four articles meeting the inclusion criteria. All four articles focused on the combat setting and management of soldiers with combat-related open or penetrating wounds. Two studies supported the use of prophylactic antibiotics whereas the third did not, stating that the evidence was low level and the practice of antibiotic administration was more opinion based.

Conclusion

This study identified that there is scant evidence to support the use of systematic antibiotic prophylaxis in the civilian pre-hospital setting for open wounds. There is a need for further research to identify if this view may change in the future.

Keywords

open wound; penetrating wound; prophylactic antibiotic; emergency medical systems; emergency medical technicians

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Introduction

Systemic antibiotic prophylaxis (SAP) is currently part of the pre-hospital trauma care provided by military medics for open or penetrating wounds received in combat (1-3). The aim of SAP at the time of injury is to prevent possible infection as result of the injury sustained (1,3). Butler and O'Connor (1) strongly recommend that antibiotics be administered as soon as possible post-injury to all injured soldiers who may require surgery for wounds received.

Penetrating or open wounds received in the civilian setting may not always mimic those received in the combat setting. Nevertheless, pre-hospital care providers in the civilian pre-hospital setting attend to open and penetrating wounds, however, patients do not routinely receive antibiotics by pre-hospital care providers in the pre-hospital setting (1,4).

The predominant areas of injury examined in this review were injury to the thoracic region, abdominal region and the extremities of the body. Standard care for open wounds by pre-hospital care providers includes flushing the wound if necessary, control of bleeding if required, covering the wound and transporting the patient to the nearest appropriate facility for further care.

The aim of SAP in the pre-hospital setting is to slow bacterial growth and gain time against possible infection until the patient receives extended care in hospital if required. A Cochrane review of antibiotic administration for prevention of infection in open limb fractures concluded that if antibiotics are administered prophylactically it does have an element of protection against early infection (5). Surgical Infection Society guidelines concluded that the current data does support the use of short course antibiotics combined with prompt wound and fracture management to reduce the risk of infection (6). Both of these reviews came to their conclusions based on literature from both emergency department and hospital settings.

The aim of this study was to determine if the administration of systemic prophylactic antibiotics by paramedics for penetrating and/or open wounds decreased infection rates and improved patient outcomes.

Methods

A literature review was conducted to identify if antibiotics should be administered for open or penetrating wounds in the civilian pre-hospital setting. A search of the electronic medical databases CINAHL, Cochrane Collaboration, EMBASE and MEDLINE was conducted. The databases were reviewed from January 2000 until March 2013. A pre-hospital search filter was applied to each database (7) with additional search terms 'open wound', 'penetrating wound', 'open fractures', 'wound infection',

'wounds and injuries', 'gunshot wounds', 'anti-bacterial agents', and 'prophylactic antibiotic'.

Articles of any study design were included if their primary aim was to evaluate the use of antibiotic administration for open or penetrating wounds in the pre-hospital environment. The reference lists of included articles were also reviewed. Articles were excluded if they were not related to the pre-hospital environment, not written in English or involved animals.

Results

A total of 1280 articles were identified in the search, with four articles meeting the inclusion criteria. All four articles focused on pre-hospital care and management of soldiers with combat-related open or penetrating wounds (Table 1). Murray et al (2) conducted a systematic review; Gerhardt et al (3) undertook a retrospective cohort study; and Martin et al (8) and O'Connor (1) conducted an evidence-based review.

The Gerhardt study reviewed the records of 53 patients who were treated at a single consolidated battalion aid station in central Iraq over a period of 1 year. Of the 53 patients, 43 received SAP. Patients were included if they were receiving medical care for penetrating combat wounds, were able to return to duty after initial treatment, and did not require evacuation to a higher level of medical care (suggesting that their wounds were not very serious). Gerhardt et al divided the patients into two groups: those receiving SAP and those not. They also looked at the effect of irrigation on infection rates in both groups. Irrigation was performed with either portable water or sterile isotonic solution (3). Infection developed within 48 hours in 7% of the SAP group versus 40% of the group without SAP (3). When irrigation alone was examined they found within 48 hours infection developed in 4.5% who received irrigation and 55% who did not receive irrigation (3). The authors analysed the combined effect of irrigation and SAP and found that infection rates within 48 hours were 17% for patients who received no SAP only irrigation; 40% for patients who received SAP and no irrigation; 2.6% for patients who received both SAP and irrigation; and 75% for patients who did not receive either SAP or wound irrigation. They concluded that SAP combined with wound irrigation contributes greatly in reducing the incidence of infection as a result of penetrating injuries. They did not focus on the specific SAP used, as that was left to the discretion of the treating health care professional. Some of the antibiotics administered included parenteral ceftriaxone, and/or oral fluoroquinolones, predominantly followed by second-generation cephalosporins or amoxicillin/clavulanate. The soldiers also received antibiotics for a further 7–0 days.

Martin et al (8) and Murray et al (2) did not have a study sample size in the same manner as Gerhardt et al (3). Martin reviewed all combat data in case reports, clinical trials, meta-analyses

and previously published guidelines. Their evidence-based review was produced to include all data since the 2008 publication of the Guidelines for the Prevention of Infections Associated with Combat-Related Injuries.

The evidence-based literature review undertaken by Martin et al did not include the studies by Murray et al (2) or Gerhardt et al (3). Martin looked specifically at prevention of infection relating to thoracic and abdominal cavity injuries. They found a contrasting view on the administration of SAP in thoracic trauma and recommended that a randomised control trial of approximately 2500 patients would be required to address the issue of SAP in thoracic trauma. For traumatic abdominal wounds they stated that in their opinion there has been adequate trials to support the use of SAP in traumatic abdominal wounds. The authors only looked at thoracic and abdominal wounds.

Murray et al (2) focused on infections that were associated with combat-related extremity injuries. An evidence-based review was written and provided recommendations from military and civilian data in regards to the management of combat-related extremity injuries. Murray looked at various aspects in their paper such as utility of bacterial cultures, irrigation fluids and techniques, antimicrobial therapy, timing of surgical care, fixation, antibiotic impregnated beads, and wound closure and wound coverage with negative pressure wound therapy (2). For the purpose of our paper, the focus will be on the antimicrobial therapy aspect of their paper. Overall the literature reviewed by Murray et al covered mostly open fractures that were sustained from low-velocity gunshot wounds. This does limit the spectrum of wounds reviewed (2).

Butler and O'Connor (1) made recommendations based on what type of antibiotic to use under which circumstance. The authors argued that for SAP to be effective it must be administered as soon as possible after the injury occurs and antibiotic coverage has to be maintained until surgical debridement has been performed (1). The authors made antibiotic recommendations based on tactical needs of military medics. (Even though the military setting is different to that of the civilian setting, the recommendations made are a valuable starting reference when considering SAP in the civilian pre-hospital setting.) For patients who are able to take oral antibiotics, the authors recommended moxifloxacin or gatifloxacin (1). Of the two oral antibiotics recommended, gatifloxacin was most preferred at the time. However, since its recommendation in 2002, gatifloxacin has been withdrawn from the global market because of its adverse safety profile. The characteristics for the antibiotics recommended by Butler and O'Connor are outlined in Table 2. For patients where oral antibiotics are contraindicated, intravenous cefotetan is recommended with cefoxitin recommended as a second option (1). Cefotetan is recommended over cefoxitin as cefotetan as a longer half-life and is more cost effective.

Discussion

It is difficult to establish exactly how great the risk of infection is as each wound is unique. However, it could be reasonable to assume that significant open or penetrating wounds have an increased chance of foreign bodies entering the wound and causing infection. The risk of infection increases in patients with comorbidities such as a compromised immune system (9). This discussion will examine the possibility and practicality of implementing SAP into civilian pre-hospital trauma care, time to administration post-injury and type of prophylactic antibiotic used.

Possibility and practicality

Current SAP regimens are based primarily on expert opinion. Further research is needed to determine which type of wounds would benefit from receiving SAP in the civilian pre-hospital setting, as well as which type of antibiotic is best to use. It should be noted that SAP is not a substitute for surgical management of the wound. The aim of implementing SAP as part of pre-hospital care of open or penetrating wounds is an attempt to slow bacterial growth in the wound as well as gain time until the patient receives surgical intervention. The number of penetrating and open wounds treated in the civilian pre-hospital setting is one aspect to be taken into consideration when deciding if it is practical to implement SAP. Victoria is the only Australian state that currently has published data detailing the trauma incidents attended by emergency medical services. In 2002, Boyle et al retrospectively reviewed 53 039 trauma incidents attended during a 12 month period (10). Of the trauma incidents reviewed, a total of 738 (1.39%) cases had wounds of a penetrating nature. The highest numbers of penetrating injuries were sustained to the head/neck region and the thorax. Further research is recommended to identify the types of trauma incidents attended in other states and territories of Australia. Penetrating trauma only makes up a small percentage of the total trauma seen in Victoria (although these numbers may have changed since 2002). The benefit of administering SAP should outweigh the risk of not administering SAP for eligible open wounds and patients with penetrating trauma.

Is SAP beneficial to patient outcomes in the civilian pre-hospital setting?

The primary aim of wound care should be to prevent infection, promote healing, and achieve optimal outcomes for patients (2). In the combat setting injured patients may not receive definitive care for up to 6 hours, and at times, as long as several days. Initial wound management, such as irrigation, can often not be performed as a result of operational circumstances in combat (3). For this reason, systematic antibiotic prophylaxis administration has been considered to be a standard treatment provided by pre-hospital trauma care providers in a combat situation (2).

Currently, the use of SAP in the civilian pre-hospital environment is debatable, as initial wound management would usually be performed without great difficulty (3). Initial management in the civilian pre-hospital setting includes, irrigation, initial stabilisation and timely transport to definitive care (2). Generally in the hospital setting, whether this is military or civilian, the priority is to treat the patient, allow adequate recovery time and return the patient to a state of functioning as soon as possible while maintaining a cost-effective treatment plan. Further research is recommended to establish if placing a greater emphasis on primary preventive interventions such as SAP in civilian pre-hospital treatment for open or penetrating wounds will decrease infection rates, decrease length of hospital stay, and improve patient outcomes. Additional factors to be taken into consideration are the possibility of adverse reactions and whether this risk is outweighed by the possible patient benefits. Furthermore, the costs associated with implementing a new practice will need to be taken into consideration. This includes, but is not limited to, additional training for pre-hospital care providers and appropriate storage of antibiotics.

Administration time post-injury

The timing of SAP post-injury has been poorly studied. Jackson did a retrospective review in 1984 of soldiers who were injured during the Falklands campaign (11) and noted that of the 17 soldiers who received SAP administration within 3 hours of injury, there was no septic complications (11). Even though the data was obtained in 1984 it is still of value to provide a timeframe in which it is suggested that SAP is effective. Based on the results obtained by Jackson the ideal administration time of SAP is within 3 hours of injury (11). Further research is recommended to validate these findings. An environmental factor in the military setting worth noting is the contamination of combat wounds. Injuries received in combat are primarily as a result of shrapnel, bullets and blasts (3). The high velocity nature of these injuries may have a higher potential for wound contamination as the wound may contain multiple types of foreign bodies, be devitalised and poorly perfused. There is however, a lack of clinical data to support the theory of higher contamination rates in combat injuries (3). Due to the various environmental factors, tactical constraints and mission requirements, combat wounds are often at a greater risk of developing infection.

In the military setting, antibiotic treatment may be continued in the field for several days. Systemic prophylactic antibiotics may be the correct definition to use for treatment received after the initial injury, but as treatment continues over a period of time the aim of the treatment becomes curative rather than preventive. This is not likely to be the case in the civilian setting as it is highly unlikely that pre-hospital care providers would care for a patient over several days. Time taken to transport the patient to hospital in the civilian setting is not likely to take days, rather hours at most. It has to be noted that the aim of SAP in the civilian setting is preventive rather than curative. Further studies

are recommended to determine if administration time has an effect on patient outcome so as to warrant its implementation as part of pre-hospital care for open and/or penetrating wounds. Should studies conclude that the administration time for SAP is such that pre-hospital administration will have positive influences of patient outcome the next step should be to determine the type of antibiotic used.

Type of antibiotic

Before deciding on the type of antibiotic to be used, the flora potentially contaminating the wound should be considered. In 2004, Murray et al characterised the bacteriological features of traumatic open wounds received by soldiers in combat (12). They took two culture swabs from the wounds as the soldiers arrived at a trauma referral hospital directly from the field. There were 49 soldiers with 61 separate wounds; 49% of the wounds had bacteria present. In their results, Murray et al found that Gram-positive organisms were the most prevalent (93%) and mostly skin-commensal organisms (12). Only three Gram-negative bacteria were found, none of which were multidrug resistant (12). It is important to note that Murray only had a small and selective population size and as such it is difficult to generalise the results obtained to the general public and in particular the civilian population (12). However, this does provide a starting guideline as to which type of bacteria is likely to be seen more in traumatic open wounds. Further research is needed to validate these findings in the civilian setting. There have been numerous suggestions regarding which type of antibiotic is the best to administer prophylactically to reduce the chance of infection. Murray et al (2) recommended cefazolin or another intravenous first generation cephalosporin for all extremity injuries; Gerhardt et al (3) made no specific recommendations regarding which type of antibiotic to use for SAP as their focus was primarily on infection rates; Martin et al (8) recommended cefazolin for thoracic trauma and a combination of cefazolin and metronidazole for abdominal trauma; Butler and O'Connor (1) recommended gatifloxacin orally and if oral SAP was contraindicated cefotetan intravenously. See Table 2 for antibiotic properties, dosages and routes of administration. An aspect requiring additional consideration is the dosage level. Depending on the type of wound the dosage might need adjustment. If the wound is contused, devitalised and poorly perfused this may impact on the concentration of antibiotics reaching the wound. The dosage administered should be high enough to reach effective concentration at the wound. In addition to SAP, Gerhardt et al examined the effect of wound irrigation on infection rates (3). Wound irrigation was examined on its own as well as in conjunction with SAP. Based on their results Gerhardt et al concluded that the effects of SAP and wound irrigation might be synergistic (3).

Additional research is recommended to determine which antibiotic will be best suited in the civilian pre-hospital setting for open and/or penetrating wounds.

In the civilian setting there may be patients that belong to a vulnerable population group. Therefore it is recommended that patients with the following factors should be considered for SAP as they are at a greater risk of infection development: immune system compromise, penetrating or open wounds likely to require surgery, and a possible delay of 3 hours or more to initial treatment (11,13).

It could be worth including the elderly and children in these vulnerable groups due to their decreased ability to compensate.

Limitations of this study

A potential limitation of this review was that non-English articles were excluded. Journals that were not available electronically were not searched by hand. As a result, some potentially relevant articles may have been overlooked. The findings presented in this literature review should be interpreted with caution because of the low-level study methodologies found and the small sample sizes in the studies that were identified. The

studies all focused on different injury types and areas. Further research using randomised control trials are recommended to determine what type of injury will benefit most from prophylactic antibiotic administration and which type of antibiotic.

Conclusion

This study has identified that there is scant evidence to support the use of systematic antibiotic prophylaxis in the civilian pre-hospital setting for open and penetrating wounds. The use of systematic antibiotic prophylaxis appears to have some support in the combat environment due to different issues with wound management. Further research is strongly recommended to determine if the implementation of SAP is beneficial to civilian patient outcomes.

Competing interests

The authors declare they have no competing interests.

Author	Year	Study type	Population size and description	Summary
Murray et al (2)	2008	Evidence based medicine review	Not applicable Civilian and Combat data was analysed to provide evidence-based recommendations	Current prophylactic anti-biotic administration is not supported by good cohort controlled or randomised control trials. Current practises are based mainly on expert opinion
Gerhardt et al (3)	2009	Retrospective Cohort study	53 Wounded military personnel with penetrating injuries	Administration of SAP combined with irrigation produced significantly lower infection rates. Copious irrigation should be performed as soon as possible post injury. SAP should be administered for complex or contaminated wounds
Martin et al (8)	2011	Evidence based medicine review	Not applicable Wounded military personnel	For traumatic thoracic wounds prophylactic antibiotic use greatly contributes to reducing morbidity and mortality and is therefore recommended. Prophylactic antibiotic administration is considered standard care for traumatic abdominal injuries
O'Connor and Butler (1)	2003	Expert opinion	Not applicable Wounded military personnel	Propose that SAP be administered by combat medical personnel for all open combat wounds

Table 1. Summary of studies identified

Antibiotic	Type and coverage spectrum	Storage	Dose	Recommended for
Cefazolin	First generation cephalosporin Gram-positive (14)	Powder for injection. Store below 25°C. Protect from light and moisture Reconstituted solution. Store at 2-8°C. Refrigerate, do not freeze (14)	2 g for adults (3 g if weight is >120 kg) with a redosing recommended after 4 hours (15)	Thoracic wounds (8) Abdominal wounds (in conjunction with metronidazole) (8)
Metronidazole	Gram-positive and gram-negative coverage	Bags. Store below 25°C. Do not freeze. Protect from light. Vials. Store below 30°C. Do not freeze. Protect from light (16)	Maximum of 4 g should not be exceeded in 24 hours. 100 mL containing 500 mg of metronidazole should be administered every 8 hours (16)	Abdominal cavity injuries in conjunction with cefazolin (8)
Moxifloxacin	Gram-positive and gram-negative coverage Fourth generation fluoroquinolones Gram-positive + gram-negative coverage	- Oral tablets below 25°C - IV solutions at temperatures above 15°C but below 30°C (17)	Single dose 400 mg oral tablet or 400 mg Intravenous solution every 24 hours (17)	All open combat wounds (1)
Cefotetan	Cephalosporin second generations Gram-positive + gram-negative coverage	Powder vials to be stored away from the light at temperatures of <22°C (1)	2 g intravenously (slow-push over 3-5 minutes) or intramuscularly every 12 hours (1)	All open combat wounds (1)
Cefoxitin	Cephalosporin second generations Gram-positive + gram-negative coverage	Store below 25°C and away from the light (18)	1 g or 2 g Intramuscularly of Intravenously every 8 hours (15)	All open combat wounds (1)

Table 2. Recommendations by Murray et al (2), Martin et al (8), and O'Connor and Butler (1)

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