PREHOSPITAL CARE

Feasibility of prehospital treatment with activated charcoal: Who could we treat, who should we treat?

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Objectives: To investigate the feasibility and potential risk benefit of prehospital administration of activated charcoal.
Methods: Review of deliberate self poisoning presentations to the emergency department (ED) of a toxicology unit by ambulance over six years. Data were extracted from a standardised prospective database of poisonings. Outcomes included: number of patients attended by ambulance and number arriving in emergency within one hour. Cases were stratified by ingestion type, based on toxicity and sedative activity.
Results: 2041 poisoning admissions were included. The median time to ambulance attendance was 1 h 23 min (IQR 37 min–3 h) and to hospital attendance was 2 h 15 min (IQR 1 h 25 min–4 h). In 774 cases (38%) ambulance attendance occurred within one hour, but in only 161 (8%) did ED attendance occur within one hour. Non-sedating, highly toxic substances were ingested in 55 cases, 24 (23 with GCS>14) with ambulance attendance, and five with ED attendance, within one hour. Conversely 439 patients ingested a less toxic, sedative agent, 160 with ambulance attendance, and 32 with ED attendance, within one hour. Limiting decontamination to patients ingesting highly toxic, non-sedating compounds (GCS<14) reduces the proportion requiring treatment to 23 of the 774 (3.0%), an additional 18 patients.
Conclusion: More patients could potentially be decontaminated if all patients attended by ambulance within one hour received charcoal. However, this would expose 128 patients with sedative, low risk poisonings to the risk of aspiration, and only treat 18 extra high risk poisonings. This small potential benefit of prehospital charcoal is unlikely to justify the expense in training and protocols required to implement it

Decontamination has a unique and important role in clinical toxicology. The effectiveness of activated charcoal was first demonstrated by Tovery in 1831 when he ingested an otherwise fatal dose of strychnine in front of the Académie Française then took activated charcoal and survived.[1] Since that time, activated charcoal has been used increasingly in hospitals around the world for poisoned patients. Over the past 10 years there has been a significant increase in its use following a number of studies that demonstrated that it was equally effective as gastric lavage in poisoned patients.[1–4] However, there continues to be little evidence to guide its effective use for different drug types and the appropriate timing of its use.[1]

The relative toxicity of different drugs is clearly important in determining the cost effectiveness and the risk-benefit of using activated charcoal. For patients who ingest drugs with little or no toxicity activated charcoal is cost ineffective and has a poor risk/benefit ratio. Guidelines have suggested it should only be administered within one hour of ingestion[5] but these guidelines do not differentiate between substances ingested. A recent study has demonstrated the difficulties with adhering to these guidelines because only a small number of patients present within one hour, and even when they do, there is often a further delay in administration.[6]

In many countries this has raised the issue of activated charcoal being used as a prehospital treatment[6] either in the home by parents for children taking accidental ingestions[7] or by ambulance officers on arrival at the scene of an adult deliberate self poisoning (DSP).[8] In one study of paediatric poisoning, low risk poisonings were treated with activated charcoal at home.[7] However, because most of the children in this study were left at home, and were unlikely to ever have any complications of the poisoning, administering charcoal at home did not seem to be particularly useful.[9] In adult poisoning, it may

be potentially useful to administer activated charcoal at the scene because it has been shown that the earlier charcoal is administered the more effective it is.[1 10] This has the added safety that the patients are all still transported to hospital.

One study in adults has indicated that a greater proportion of patients would receive activated charcoal within one hour if it was administered by the ambulance service.[8] Although this study excluded heavy metals, corrosives, and patients with a decreased level of consciousness, it did not do any analysis of subgroups based on severity of poisoning or substance ingested. It was also a small study for a period of less than one year.

The administration of activated charcoal does not come without risk,[1] and although rare, aspiration of activated charcoal is a significant complication.[11] As with any treatment it is important to properly assess its benefits and risks. For activated charcoal this means assessing its effectiveness for particular poisonings, which depends on the situation and timing from ingestion, and balance this against the risk of aspiration or other complications. Ambulance officer started charcoal administration could be potentially life saving for some patients (this number depending upon the local epidemiology of poisoning), but it may also delay transport to hospital, expose a much larger population to the risk of aspiration, and may be costly in terms of training and protocol development.

To more fully examine whether it is feasible to introduce prehospital charcoal and determine the number of patients that would potentially benefit, we designed a similar study to Thakore *et al*.[8] We used an observational dataset of poisoned patients that had been prospectively collected over a six year period. We also classified the groups by substance ingested to better determine the number of patients that would benefit.

Table 1 Five subgroups of poisoned patients are defined based on the type of drug ingested, whether a single drug or multiple drugs were ingested, and the time interval in which they were seen

Group	Description	Drugs

1	Drugs regarded as highly toxic (where supportive care alone may be ineffective) or where there is no antidote available, and where early decontamination with charcoal is potentially life saving. This group included any cases where one of these drugs was ingested:
	A: cause significant early sedation
	B: less likely to cause sedation
		A Tricyclic antidepressants
		  Carbamazepine
		  Hydroxychloroquine
		  Quinine
		  Thioridazine
		
		B Theophylline
		  Calcium channel blockers
		  Colchicine
		  Arsenic, boric acid
		  Antiarrhythmics (flecainide)
		  β blockers

2	Drugs that may cause early sedation, are treated effectively with supportive care and activated charcoal is unlikely to affect major outcomes. This group included only single ingestions of these drugs or where only combinations of these drugs were taken.	Benzodiazepines Ethanol Antihistamines (excluding pheniramine and diphenhydramine) Opioids Other hypnotics (zolpidem, zopiclone)
3	Paracetamol containing analgesics where only this analgesic or analgesic combination was ingested.	Paracetamol Paracetamol/codeine Paracetamol/codeine/antihistamine
4	All other single or multiple drug ingestions not fitting criteria for groups 1–3	Available from authors

METHODS

The Hunter Area Toxicology Service (HATS) is a regional toxicology unit situated at the Newcastle Mater Misericordiae Hospital that services a population of about 350 000 people and is a tertiary referral centre for a further 150 000 people.[12] All patients admitted to the service are entered prospectively into a database that is comprehensively described elsewhere.[13] A preformatted admission sheet is used by medical staff to collect data on admission[14] and this and additional information from the medical record is entered into the database by two independent trained personnel who are blinded to any hypotheses being tested at the time. This study includes patients admitted from 1997 onwards because of the coding that started at that time for presentation and admission times.

All cases of DSP that presented to the Newcastle Mater Hospital from 1 January 1997 to 25 March 2002 were reviewed for the study. Recreational overdoses, envenomations, and iatrogenic poisonings were excluded, as were patients arriving at hospital by means other than ambulance. Any ingestions of corrosive or cleaning agents were excluded, but cases of medication injection, heavy metals ingestion, or inhalational exposure were only excluded if the patient did not also ingest another drug or poison. Admissions were also excluded if the time of overdose, presentation, or admission to hospital were not available. This information was available for 90% of cases who were brought to hospital by ambulance.

The following information was extracted from the database for each included admission: patient characteristics (sex, age), details of drug ingestion (drug type, estimated time of overdose, time of ambulance arrival, and arrival to the emergency department), and Glasgow coma score (GCS) on arrival. The time of ambulance presentation was taken from the ambulance sheet as the time of arrival at the scene. The time of admission was the time the patient was triaged at the hospital, as recorded by the emergency department information system (EDIS). A cut off point at one hour was used for both the time of presentation and the time of admission and analysis of the proportions of each was used. Patients with a GCS<14 were regarded as having an increased risk of aspiration.

The group was further subdivided based on the type of drug ingested. This was done to examine the effect on particular groups of poisoned patients. We made an a priori decision about

the level of risk of specific ingestions based on previous clinical data[15] and consensus of the three authors. The subgroups are listed and described in table 1. Group 1 contains highly toxic drugs, for which it is our practice to always decontaminate if at all possible. It is important to note that these highly toxic drugs were often exclusion criteria in the randomised controlled trials of activated charcoal and thus consensus statements and reviews have less relevance to them. There may be a possible advantage of offering decontamination after one hour—because in this group any small result of decontamination may be potentially beneficial. This group was further subdivided into drugs that cause early sedation (A) and those that do not (B). Group 2 includes drugs that we believe are unlikely to require decontamination but cause sedation and therefore potentially have an increased risk of complications from decontamination. Group 3 includes paracetamol (acetaminophen) containing analgesics. These were placed in a separate group because one previous study has demonstrated that decontamination may be beneficial for up to two hours.[16] Group 4 contains all other drugs where decontamination may potentially be beneficial but no clear data for or against exist.[5] Group 1B and group 3 were also analysed with a cut off at two hours. Where multiple drugs were ingested, if the patient had ingested a group 1A or 1B drug they were classified in that group, otherwise they were included in group 4.

For descriptive statistics, mean and standard deviation (SD) are quoted for normally distributed data, while median and interquartile range (IQR) are used for non-parametric data. The method of Kolmogorov and Smirnov was used to determine if the samples were from normally distributed populations. All statistical analysis was done using GraphPad Instat (Version 3.05, 32 bit for Win 95/NT created September, 2000).

RESULTS

There were 3610 DSP admissions recorded in the database for the period 1 January 1997 to 25 March 2002. A total of 2327 of these were transported directly to hospital by ambulance. Altogether 2103 of the cases had complete information available for analysis. In most cases with incomplete information, it was the time of the overdose that was unknown. A further 62 were excluded because they included either corrosive agents or one of the other exclusions, leaving 2041 cases. Thus,

Table 2 Subgroup analysis of patients presenting to ambulance and hospital within one and two hours. The subgroups are defined in table 1 and the number of each is entered in this table. Numbers in parentheses for groups 1A and 1B are if patients with a GCS <14 are excluded so less patients are decontaminated by ambulance, reducing the number of extra cases

Group	Number	Ambulance within one hour		Hospital within one hour		Extra cases AC	Ambulance within two hours		Hospital within two hours		Extra cases AC
		Number	%	Numb er	%	Number	Number	%	Number	%	Number
1	334	129	39	23	7	106	–	–	–	–	–
1A	279	105 (83)	38	18	6	87 (65)	–	–	–	–	–
1B	55	24 (23)	44	5	9	19 (18)	36	65	24	44	12
2	439	160	36	32	7	128	–	–	–	–	–
3	134	56	42	13	10	43	79	59	58	43	21
4	1134	429	38	93	8	336	–	–	–	–	–
Total	2041	774	38	161	8	613	1247	61	862	42	385

90% of the potential cases had information available for analysis. The median age of the group was 32 years (IQR 24–41) and there were 66% female patients. Altogether 691 admissions were for DSP with a single substance.

For the 2041 admissions, the median time to ambulance attendance (presentation) was 1 h 23 min (IQR 37 min–3 h) and the median time to hospital attendance (triage) was 2 h 15 min (IQR 1 h 25 min–4 h). The median transport time was 40 minutes (IQR 30 min–1 h). Using the first hour as the therapeutic window for activated charcoal administration, in 774 cases (38%) the time to ambulance presentation was less than one hour, while for only 161 of those cases (8%) the time to hospital attendance was less than one hour. However, if the therapeutic window is the first two hours, then in 1247 cases (61%) the time to ambulance presentation was less than two hours, while for 862 of those cases (42%) the time to hospital attendance was less than two hours.

Table 2 lists the five subgroups and the numbers that presented within one hour to the ambulance, and to hospital, or within two hours for group 1B and three drugs. Non-sedating, highly toxic substances (group 1B) were ingested in 55 cases (2.7%), of these 24 were attended by ambulance, and five arrived in hospital, within one hour. If only this high risk group were decontaminated, then only 24 patients of the 774 (3.1%) attending within one hour would receive ambulance initiated decontamination. This constitutes an extra 19 patients receiving charcoal (table 2). If the cut off were two hours, then only an extra 36 of 1247 patients (2.9%) attended within two hours would receive decontamination. Conversely, 439 patients of 2041 (21.5%) ingested a less toxic but sedative agent, and of these 160 were attended by ambulance, and 32 arrived in hospital, within one hour. If all poisonings attended within one hour were decontaminated, 160 patients of 774 (20.7%) would be unnecessarily decontaminated, potentially exposing them to the risk of aspiration because of sedation.

A total of 219 patients had a GCS<14 on admission to hospital at the time of triage. If these patients are excluded from the main group leaving all patients with GCS of 14 or 15 and the analysis is repeated, the proportions are unchanged with 38% and 8% at one hour. In group 1A, 66 of 279 patients (24%) had a GCS<14 on admission, whereas in group 1B, only 2 of 55 (4%) had a GCS<14. If patients with a GCS<14 were not decontaminated by ambulance officers, the number of patients in group 1B decontaminated within one hour by ambulance would be 23 of 774 (3.0%).

DISCUSSION

This study shows that a significant proportion of patients are attended by ambulance within one hour of poisoning, but do not arrive in hospital within one hour of poisoning. In this study 38% of all adult DSP cases were seen by ambulance within one hour, compared with 42% in the study by Thakore.[8] Only 8% arrived within one hour to the emergency department, less than in the Thakore study (20%), but in that study this only represented a total of 35 patients.[8] However, further analysis of our study revealed that of the 30% of the total group that could potentially receive charcoal within one hour by ambulance, a much smaller group of 106 (87 in group 1A and 19 in group 1B) had serious life threatening poisoning (5% of total group) based on ingested agent. An even smaller group of 19 patients (1% of total group) had severe life threatening poisoning by a drug that did not cause early sedation (group 1B), where the risk/benefit of charcoal is clearly in favour of treatment. One of these 19 patients had a GCS<14 on arrival to hospital, so only 18 would have been decontaminated. Thus, for a toxicology unit that services 350 000 people, only 18 patients seen in a six year period, would have a risk/benefit clearly in favour of charcoal, which is unlikely to justify the extra cost involved.

A large number of patients ingest substances that cause only minor effects. In these patients, the use of activated charcoal is unlikely to affect the course of the poisoning, and the risk of charcoal aspiration would outweigh the minimal benefit of such treatment. A more concerning problem is the use of activated charcoal in patients with a decreased level of consciousness, particularly if the drug ingested is unlikely to cause other major effects. In this study these patients were represented in group 2, and were typified by benzodiazepines; common agents for DSP.[15] Although benzodiazepines cause sedation and a decreased conscious level, they are rarely complicated if they are treated in hospital with good supportive care.[15] The analysis of group 2 showed that 128 additional patients (6% of the total 2041 patients or 21.7% of patients seen by ambulance within one hour) had taken sedating drugs of low toxicity and were attended by ambulance within one hour. In our hospital these patients would rarely be administered charcoal as the increased risk of aspiration is considered to outweigh any treatment benefit; for this reason we considered ambulance administration of charcoal to be not indicated.

Analysis of paracetamol (acetaminophen) poisonings (see table 2) demonstrated that 56 patients in total would have received charcoal within one hour if administered by ambulance, whereas only 58 patients would have received charcoal under two hours if administered at hospital. However, if a two hour cut off were used for ambulance administration, then 79 patients would have received charcoal. This means in addition to an extra 43 patients receiving charcoal within one hour, a further 21 would have received it within two hours. Thus, for some drugs there may be a significant additional benefit in using a two hour cut off if ambulance initiated treatment were to be done. Currently, paracetamol is the only drug where there is limited evidence that charcoal within two hours provides a benefit,[16] when defined as a requirement for N-acetylcysteine. In addition, however, for highly toxic drugs (group 1B) where a small reduction in absorption in the one to two hour time period

could possibly change outcomes, it would seem appropriate to investigate a two hour cut off.[17]

Benefit is likely to occur only if activated charcoal is limited to highly toxic drugs, where the risk-benefit ratio favours treatment. This means only 3.0% of 774 patients attended by ambulance officers within one hour would be likely to gain a potential benefit from decontamination, or 2.9% of 1247 patients attended within two hours. This differs from guidelines suggested by Thakore of decontaminating most poisonings if they present within one hour.[8] Although drugs in group 1A are also highly toxic and would potentially benefit from early decontamination, they can cause significant early sedation and would often require airway protection before decontamination. In this study 24% of these patients already had a GCS<14 on arrival to hospital, compared with only 4% in group 1B. It is more appropriate that these patients are rapidly transported to the emergency department for decontamination after airway protection.

There are a number of limitations to this study. The first is the use of triage time as the best estimate of when charcoal could be given in hospital. The study by Thakore et al examined both the time of arrival and the time that they were seen by a doctor.[8] Our time estimation is shorter and possibly unrealistic, but it is more appropriate as treatment could be started at the time of triage, before formal assessment by the medical officer. The second is the allocation to groups based on consensus opinion about need for decontamination. This decision reflects the lack of information in the literature on the value of decontamination in the rarer more toxic exposures that occur.[1][5] Although missing data may have biased the study, this is unlikely because in the 10% of excluded cases due to missing data, it was almost always only the time of overdose that was unknown. It is reasonable to exclude this group because these patients would also be excluded from any protocol developed for ambulance services.

Finally, the allocation to groups was only made for toxins seen during the study period. It is clear there are other potential toxins that could be allocated to the various groups. It might be argued that opioids should be included as high risk drugs, but these would then be put in group 1A and not change the results for group 1B drugs.

Neither this study nor that of Thakore et al[8] examined the practicalities of administration of activated charcoal by ambulance officers. This includes the problem of administering charcoal as an oral solution in a moving vehicle and the time delay involved in starting and safely administering it. It also includes the potential problems with vomiting of charcoal in the back of an ambulance. Furthermore, there remains the more difficult issue of administering such a treatment to patients who may refuse it. It is often a difficult medical decision to balance a duty of care to the patient with the potential risk of the poisoning involved. This decision may not be easy or indeed appropriate for ambulance officers to make, although it may be feasible for them to phone the base hospital for advice.

The role of activated charcoal in poisoned patients requires further investigation in large clinical studies to define for which substances there is a large effect on significant outcomes.[1] There also needs to be better definition of the time period for which activated charcoal is still potentially beneficial in severe and life threatening poisonings, where a small change in amount absorbed may affect the outcome.[17] Thus, we believe it is currently premature to introduce the widespread use of activated charcoal to ambulance and prehospital services.

The investigation of the focused use of activated charcoal for patients ingesting highly toxic drugs, unlikely to cause early sedation (group 1B), may be appropriate. However, as such an approach would require increased education and training for ambulance personnel, any study would have to include this increased cost and workload in the analysis, as well as demonstrate a decrease in morbidity. This study's results are dependent upon our local epidemiology of poisoning and the logistics of patient transport to a toxicology unit, these factors need to be considered in generalising our results to other settings. However, it does seem that the epidemiology of poisoning rather than transport time may be the greatest determinant of benefit. Within developed countries the epidemiology of deliberate self poisoning is comparatively similar and it is unlikely that in this setting the benefit of prehospital charcoal would be greater than suggested by this study.

Our study shows that there is only a small group of patients that will possibly benefit from the use of prehospital activated charcoal. To improve the treatment of this small group either a much larger group of patients must be exposed to the risk of charcoal aspiration, or protocols would need to be developed for ambulance services so that only this group receives charcoal. In addition, the introduction of charcoal to ambulance services would be costly in terms of protocols required and education and the possible small benefit may not justify this. However, if charcoal were to be used by ambulance services we would suggest that a study be done to evaluate a simpler protocol based primarily on drug type ingested and secondarily on time from ingestion. Currently we cannot recommend the use of prehospital charcoal.

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