

Activated Charcoal administration in the emergency department: Indications and tolerance

Administration du charbon activé aux urgences : Indications et tolérance

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ABSTRACT

Introduction: Activated charcoal (AC), a common decontamination method in acute poisoning, is most effective when given shortly after ingestion of an adsorbable toxin, as its high surface area enables toxin adsorption and reduces gastrointestinal absorption. We aimed to identify the most common toxins treated with activated charcoal in an intoxicated patient presenting to the emergency department (ED). Secondly, we aimed to determine the tolerance after its administration.

Methods: A retrospective and descriptive study was conducted in the ED of Mahmoud Yaacoub Center over two years (from January 2023 to December 2024). Patients aged ≥ 15 years who were conscious on admission and received a single 50 g dose of AC for acute charcoal adsorbed drug intoxication was included. Collected data encompassed demographics, intoxication characteristics, clinical and laboratory findings, and AC tolerance.

Results: We included 88 patients who received a single dose of AC. Median age was 28 years: 65.9% were female. The median delay of consultation was one hour. Most involved drugs were acetaminophen (21.6%), selective serotonin reuptake inhibitors (13.6%), metformin (12.5%), sodium valproate (12.5%) and carbamazepine (9.1%). Cases of Co-ingestion were reported in 57% of patients. AC was administered to the patient, with good tolerance in 89% of cases. Ten patients (11%) had poor tolerance (vomiting, abdominal discomfort). Multivariate analysis identified cases of co-ingestion as significantly associated with better AC tolerance (OR =6.4, 95% CI: 1.27 – 32.19; p = 0.024).

Conclusion: In our study, the most common indications for AC administration were intoxications involving acetaminophen and metformin. AC was generally well tolerated, particularly in instances of co-ingestion.

Keywords: Activated charcoal, Tolerance, intoxication, decontamination, Emergency

RÉSUMÉ

Introduction: Le charbon activé, méthode couramment utilisée de décontamination digestive lors des intoxications aiguës, est particulièrement efficace lorsqu'il est administré précocement après l'ingestion d'un toxique adsorbable, grâce à sa grande surface d'adsorption permettant de réduire l'absorption gastro-intestinale. L'objectif principal de cette étude était d'identifier les toxiques les plus fréquemment traités par charbon activé chez les patients intoxiqués se présentant aux urgences. L'objectif secondaire était d'évaluer la tolérance clinique après son administration.

Méthodes: Il s'agit d'une étude rétrospective et descriptive menée au service des urgences du Centre Mahmoud Yaacoub sur une période de deux ans (janvier 2023–décembre 2024). Ont été inclus les patients âgés de ≥ 15 ans, conscients à l'admission, ayant reçu une dose unique de 50 g de charbon activé pour une intoxication aiguë par un médicament adsorbable. Les données recueillies comprenaient les caractéristiques démographiques, les modalités de l'intoxication, les données cliniques et biologiques, ainsi que la tolérance au charbon activé.

Résultats: Quatre-vingt-huit patients ont été inclus. L'âge médian était de 28 ans, avec une prédominance féminine (65,9 %). Le délai médian de consultation était d'une heure. Les principaux toxiques incriminés étaient le paracétamol (21,6 %), les inhibiteurs sélectifs de la recapture de la sérotonine (13,6 %), la metformine (12,5 %), le valproate de sodium (12,5 %) et la carbamazépine (9,1 %). Une co-ingestion était retrouvée dans 57 % des cas. La tolérance au charbon activé était bonne dans 89 % des cas ; dix patients (11 %) ont présenté une mauvaise tolérance (vomissements, gêne abdominale). L'analyse multivariée a montré une association significative entre la co-ingestion et une meilleure tolérance au charbon activé (OR = 6,4 ; IC95% : 1,27–32,19 ; p = 0,024).

Conclusion: Les intoxications au paracétamol et à la metformine représentaient les principales indications d'administration du charbon activé. Celui-ci était globalement bien toléré, en particulier en cas de co-ingestion.

Mots clés: Charbon actif, Tolérance, intoxication, Décontamination, Urgence

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INTRODUCTION

Activated charcoal (AC) is a black, odorless powder that has been used since the early 1800s in toxicology to enhance the elimination of potentially toxic substances in the digestive tract [1]. As described in literature, AC is a chemically inert compound that works by physically binding substances. It isn't absorbed by the body and doesn't interact directly with the drugs or toxins. Instead, it uses weak forces like hydrogen bonds and other intermolecular attractions to trap molecules on its surface. This works best when the substance is dissolved and non-ionized, since ionized (charged) molecules prefer to stay in water and don't stick as well to charcoal's hydrophobic surface [1].

In practice the recommended dose is a single dose for an adult that is 50g [2]. The usual presentation of AC is in a liquid suspension in bottles. The optimal administration technique involves slow administration via nasogastric tube or oral route to minimize vomiting risk [2].

The indication for a decontamination with AC includes drugs (such as acetaminophen, angiotensin-converting enzyme inhibitors, amphetamines, antidepressants, benzodiazepines, beta blockers, calcium-channel blockers etc) and phytotoxins (such as amatoxin, colchicine, ergot alkaloids, muscarine, nicotine, ricin and digitalis glycosides) [1,3].

Signs of poor AC tolerance are primarily gastrointestinal symptoms including vomiting, constipation, diarrhea, and nausea, especially with repeated or high-dose administration. In rare cases, intestinal pseudo-obstruction or charcoal stercoliths may occur, necessitating surgical intervention [1,3]. The most serious complication is inhalation of charcoal, which can lead to pulmonary failure and potentially fatal outcomes, particularly in patients with impaired consciousness or inadequate swallowing reflexes [4].

Although its indications have been well documented in literature, little is known regarding its tolerance after ingestion in the intoxicated patient.

In this study we primarily aimed to identify the most common toxins treated with activated charcoal in an intoxicated patient presenting to the emergency department (ED). Secondly, we aimed to determine the tolerance after its administration.

METHODS

This was a retrospective, descriptive, single-center study conducted in the ED of the Center of Mahmoud Yaacoub for Urgent Medical Assistance in Tunis over a two-year period (January 2023-December 2024).

We included all patients who were aged 15 years or older and received at least one dose of AC in the ED for suspected acute drug intoxication. We did not include: Cases of intoxication other than ingestion /oral route (e.g. IV, inhalation, cutaneous), cases of intoxication with contraindications to administration of AC due to delay of consultation exceeding 2 hours for instant release drugs and up to 4 hours for extended-release drugs and

cases of non-adsorbable drug or contraindication to administration (eg drowsiness, vomiting). The single dose protocol was applied to all the patients, so no repeated doses of AC were administered. AC was administered right after a short assessment of the case's indication for GI decontamination and after eliminating the contraindication.

After selecting the subjects, patient records were collected from the archives of the ED. Anamnestic data included patient demographics, medical history, and substances involved, administration route, presumed ingested dose (PID) and delay of consultation. Clinical data included vital signs, neurological exam findings, and paraclinical results like ECG changes and laboratory tests. Management followed the ABCDE approach, providing symptomatic treatment and decontamination. Length of stay and referrals were also documented.

AC administration was documented including time of administration, and tolerance. Tolerance was defined by the absence of symptoms post AC ingestion, and poor tolerance, as the presence of symptoms such as digestive discomfort or vomiting. Complications were defined as intestinal pseudo-obstruction, AC aspiration pneumonia, respiratory failure [1,4].

Statistical analysis was performed using Jamovi 2.5.4, with significance set at $p < 0.05$. Quantitative variables were tested for normality using the Kolmogorov-Smirnov test; normally distributed data were presented as means $\pm$ SD, while non-normal data were expressed as medians with interquartile ranges. Qualitative variables were described by frequencies and percentages. Variables significant at $p < 0.05$ were included in a multivariate model with backward stepwise selection.

The literature review was conducted via PubMed, ScienceDirect, and Frontiers using relevant keywords.

No conflicts of interest were declared, patient anonymity was maintained, and local ethics committee's approval was sought.

RESULTS

Descriptive study

Our study included 88 patients who received AC from a total of 3277 consulting the ED for an acute intoxication (2.7%) (figure1).

Demographic characteristics of the study population

The median age of patients was 28 years [IQR: 15-62]. Female patients represented 65.9% with a sex ratio of 0.52. Forty-five Patients (51.1 %) had no medical history of chronic disease prior to the acute intoxication. The median delay of administration of AC post ingestion was 1 hour [0.5-4]. Fourteen patients (15.9%) were symptomatic at the time of consultation in the ED, and all the patients were conscious and clinically stable on initial examination (Table 1).

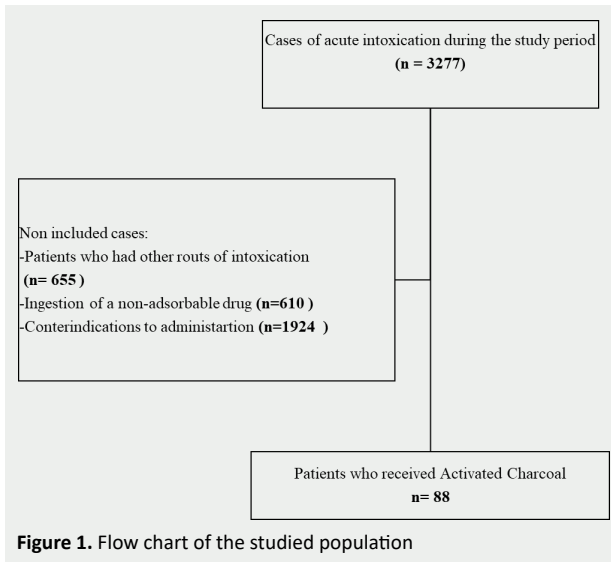


Figure 1. Flow chart of the studied population

Table 1. Demographic characteristics and clinical features

	Total number of patients (n=88)
Demographic characteristics	
Age (years)	28 [15-62]
Sex (% female)	65.9
Medical history (n (%))	43 (48.9)
Psychiatric history (n (%))	29 (32.9)
Delay of consultation (hours)	1 [0.5-4]
Initial symptoms on presentation (n (%))	
Abdominal pain	11 (12.5)
Headache	2 (2.3)
Others	1 (1.1)
Co-ingestion cases (n (%))	50 (56.8)
Clinical findings	
Cardiovascular findings	
HR (beat/min)	88.5 [61-150]
SBP (mmHg)	128 ± 12.9
DBP (mmHg)	78.6 ± 6.9
Respiratory parameters	
RR (cycle/min)	17.2 ± 2.8
SpO2 (%)	98 [93-100]
GCS	15
Plasmatic concentrations (mg/L)	
Acetaminophen	(H4) 31 [0-220]
Sodium valproate	(H6) 87.6 ± 61.2
Carbamazepine	(H6) 7.8 ± 4.6
Length of stay in ED (hours)	4.5 [0.5-14.5]
Referral (n (%))	
Discharged	39 (45.5%)
ICU admission	18 (20.5%)
Another ED referral	16 (19.3)
Self-discharged	13 (14.8)

Continuous variables were represented as median [IQR] or mean ± SD, **DBP**: diastolic blood pressure, **ED**: emergency department; **HR**: Heart rate; **ICU**: intensive care unit; **RR**: respiratory rate, **SBP**: systolic blood pressure, **SpO2**: periphery capillary oxygen saturation.

Characteristics of the drugs involved in the intoxication

Fifty patients had a case of co-ingestion of multiple substances at the same time (57%) and 38 patients had a

single substance intoxication (43%).

The most involved drugs were acetaminophen in 19 cases (21.6%), selective serotonin reuptake inhibitors (SSRIs) in 12 cases (13.6%), Metformin in 11 cases (12.5%) and sodium valproate in 11 cases (12.5%) followed by carbamazepine in eight cases (9.1%) The involved molecules and PID to toxic PID are in table 2.

Table 2. Presumed ingested doses of the most involved drug family

Drug	N (%) *	PID (mean/median) mg	Presumed ingested Toxic dose threshold N (%) *
Anticonvulsants	22 (25%)	-	19 (21.5%)
Sodium valproate	11 (12.5%)	7000 [3000-40 000]	10 (11.4%)
Carbamazepine	8 (9.1%)	3100 [1200-9200]	7 (7.9%)
Phenobarbital	2 (2.3%)	500	2 (2.3%)
Pregabalin	1 (1.1%)	750	0
Painkillers	19 (21.5%)		11 (12.5%)
Acetaminophen	19 (21.5%)	8050 ± 5011	11 (12.5%)
Oral antidiabetics	12 (13.6%)	-	8 (9.1%)
Metformin	11(12.5%)	8075 [850-31 000]	7 (7.9%)
Glimepiride	1 (1.1%)	20	1 (1.1%)
SSRIs	12 (13.6%)	-	5 (5.7%)
Paroxetine	1 (1.1%)	300	1 (1.1%)
Sertraline	2 (2.3%)	350-200	0
Fluoxetine	7 (7.9%)	200 [60-1800]	2 (2.3%)
Venlafaxine	1 (1.1%)	750	1 (1.1%)
Escitalopram	1 (1.1%)	180	1 (1.1%)
Antibiotics	11 (12.5%)	-	6 (6.8%)
Amoxicillin	2 (2.3%)	4000	0
Ciprofloxacin	3 (3.4%)	9833.3± 6125.4	3 (3.4%)
Cefpodoxime	1 (1.1%)	NA	0
Isoniazid	2 (2.3%)	1800-3400	2 (2.3%)
Rifampicin	1 (1.1%)	3600	0
metronidazole	1 (1.1%)	7500	1 (1.1%)
Clavulanic acid	1 (1.1%)	500	0
Beta Blockers	8 (9.1%)	-	7 (7.9%)
Bisoprolol	4 (4.5%)	65± 61.3	4 (4.5%)
Propranolol	1 (1.1%)	560	1 (1.1%)
Acebutolol	1 (1.1%)	NA	NA
Atenolol	1 (1.1%)	350	1 (1.1%)
ACE inhibitors	7 (7.9%)	-	6 (6.8%)
Captopril	5 (5.7%)	585± 571.6	4 (4.5%)
Delapril	1 (1.1%)	210	1 (1.1%)
Perindopril	1 (1.1%)	150	1 (1.1%)
Opioids	7 (7.9%)	-	
Codeine	5 (5.7%)	293 ± 205.1	3 (3.4%)
Morphine	1 (1.1%)	150	1 (1.1%)
Pizotifen	1 (1.1%)	60	1 (1%)
Antipsychotics	6 (6.8%)	-	4 (4.5%)
Olanzapine	3 (3.4%)	51.6± 17.5	2 (2.3%)
Amisulpride	2 (2.3%)	1250 [1000-1500]	2 (2.3%)
Aripiprazole	1 (1.1%)	60	0
Calcium Channel Blockers	5 (5.7%)	-	5 (5.7%)
Amlodipine	5 (5.7%)	133 ± 145.1	5 (5.7%)

*The percentage is derived from the total of patients in this study (=88 patients) Continuous variables were represented as median [IQR] or mean ± SD; **ACE**: Angiotensin converting enzyme; **NA**: data not available; presumed ingested dose; **SSRIs**: Selective serotonin reuptake inhibitors.

Biological findings

Standard biology markers:

Among the 63 patients who underwent laboratory testing, forty-seven (53%) had normal biological markers. Eighteen percent of patients had biological anomalies. Among those with anomalies, the most frequent finding was hyponatremia (6%), followed by anemia (5%). Less commonly observed abnormalities included cytotoxicity (2%) and hemostasis anomalies (2%). Hyperlactatemia, hypokalemia, and hyperleukocytosis were each reported in 1% of cases. The majority of blood gases revealed unremarkable findings.

Plasmatic concentration of specific drugs

The percentages shown in Table 3 indicate the proportion of patients who ingested a given drug and reached the toxic threshold (presumed ingested toxic threshold and/or plasma toxic threshold) calculated relative to all patients who ingested that same drug, rather than relative to the total study population.

Table 3. median/mean dose of the 4 most ingested drugs and their plasmatic concentrations

Drug	Plasma concentrations (mg/L)	Presumed ingested toxic dose threshold n (%)*	Plasma toxic threshold N (%) *
Acetaminophen	(H4) 31 [0-220]	11 (58)	1 (5)
Sodium valproate	(H6) 87.6 ±61.28	10 (91)	0
Carbamazepine	(H6) 7.87 ±4.63	7 (88)	1 (14)

*Percentage from the patients who ingested the respective substances; Continuous variables were represented as median [IQR] or mean ± SD

Activated charcoal administration and tolerance

Eighty-seven patients (98%) have received a total of 50g of AC with one patient aged 15 years old receiving 30g of AC. All patients completed taking the full dose of AC. AC administration was well tolerated in 78 patients (88.6%) and we did not report any incidence of AC inhalation or occlusive symptoms in this study (Figure 2).

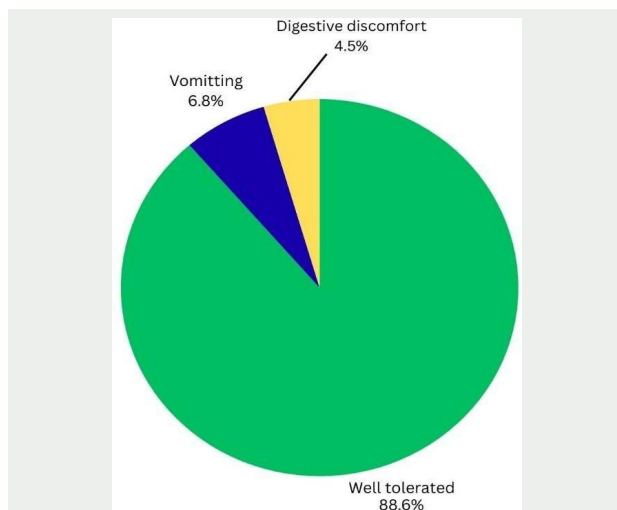


Figure 2. Distribution of patients' tolerance to activated charcoal administration

Analytical study

Univariate analysis found that cases involving co-ingestion were over six times more likely to tolerate AC administration.

Our multivariate analysis confirmed a significant association between co-ingestion intoxication and tolerance of AC administration (OR =6.4, 95% CI: 1.27 – 32.19; p = 0.024).

In our analysis, no statistically significant association was found between clinical tolerance to AC and the demographic, clinical, or toxicological characteristics of the patients. Specifically, age, sex, medical history, the presence or absence of symptoms at presentation, and the nature of the substance ingested all showed p-values greater than 0.05. Patients who received antiemetics were not associated.

DISCUSSION

Activated charcoal administration has been well documented in literature and its indications well established since the 1940s [1].

According to the American Association of Poison Control Centers (AAPCC), AC was administered in approximately 10 to 15% of all poisoning cases reported in 2020, with higher utilization in cases involving drugs with anticholinergic properties (such as tricyclic antidepressants) or delayed-release formulations [5]. In our study, good tolerance was described in 78 patients and poor tolerance in 10 patients.

The median age of our population was 28 years [range: 15–62], the majority of whom were young adults between 21 and 30 years (40.9%) with a female predominance (65.9%). This age and sex distribution is consistent with multiple studies indicating a higher prevalence of acute poisoning and subsequent AC administration among young adult females [6,7].

The majority of patients in our study presented to the ED within 1 hour post ingestion, which is within the optimal time window for AC efficacy [4,8]. In fact, the Clinical Toxicology Recommendations Collaborative Workgroup have recently advised that a single dose of activated charcoal may be administered beyond the traditional one-hour post-ingestion window for selected poisons. The exact time frame depends on the nature of the toxin and its formulation (e.g., immediate-release versus modified-release) [9].

The AC was administered in cases of acetaminophen (21.6%), metformin (12.5%), Sodium Valproate (12.5%) and carbamazepine (9.1%) intoxication, in order of frequency which aligns with the findings of systematic review by Hoegberg and al. stating the following in order of frequency: acetaminophen, phenobarbital, carbamazepine, cardiac glycosides, salicylates, theophylline, tricyclic antidepressants, and valproate intoxications [8].

In our study, AC was most frequently administered in cases of acetaminophen intoxication, consistent with findings by Cooper et al., who reported that acetaminophen was

among the most commonly treated substances with AC [10]. Metformin was the second most common indication for AC in our population. Although Tomoda et al. note that AC is not routinely recommended in metformin poisoning due to its limited effect on clinical outcomes, favoring supportive care and hemodialysis in severe lactic acidosis [11], several case reports have documented the use of AC in the initial management of severe metformin intoxication with metabolic acidosis [12,13]. Sodium valproate ranked third among substances treated with AC, aligning with evidence that anticonvulsant overdoses are frequently managed with AC, particularly in sustained release formulations [10,14,15]. Likewise, carbamazepine intoxications were commonly treated with AC in this study, which corresponds with findings from both retrospective (ED) studies and human volunteer data [8,16,17].

All patients were conscious and stable, in line with AC being contraindicated in unstable cases [4]. Biological anomalies were seen in 18%, mainly mild hepatic cytolysis and electrolyte imbalances. Four of nine patients tested had acid-base disorders, likely due to delayed presentation reducing AC effectiveness, especially with structurally toxic drugs [18].

Most patients had plasma drug levels below toxic thresholds, despite reported toxic ingestions. For acetaminophen, median H4 level was 31 [0–220] mg/L; 57.9% exceeded the oral toxic dose, but only 5% had toxic plasma levels, supporting the benefit of early AC as shown by Sato et al. [19]. Sodium valproate levels (mean H6: 87.6 ± 61.3 mg/L) were below plasma toxicity despite 90.9% exceeding the oral threshold, likely due to reduced absorption with AC, as shown by Neuvonen et al. [20]. Carbamazepine levels (mean H6: 7.87 ± 4.63 mg/L) exceeded the oral threshold in 87.5%, but only 14% had toxic plasma levels, consistent with Neuvonen et al.'s findings on AC reducing absorption and enhancing elimination [21].

These results highlight the clinical value of early triage and timely AC in reducing toxicity.

Activated charcoal oral administration and tolerance

The AC dose used matched literature recommendations [22]. Among 88 patients, 11% reported intolerance, primarily vomiting (7%) and digestive discomfort (5%). No serious complications (aspiration, respiratory failure, bowel obstruction) occurred. AC is generally well tolerated in conscious, cooperative individuals [23]; vomiting, the most common side effect (10–20%), is likely due to poor palatability [4,24]. Severe outcomes are rare and typically linked to altered mental status or incorrect administration [22,25]. Our findings align with the Sri Lankan trial by Mohamed et al., where 83% tolerated a single 50 g dose without major effects, confirming that single-dose AC is safe and acceptable in acute poisoning [23].

Associated factors with intolerance post AC administration

We found that cases of co-ingestion were associated with better tolerance of AC by 6 folds. This observation may be explained by the fact that, in our study, cases

of co-ingestion included respective doses below the toxic threshold. However, other studies have suggested otherwise and explained the association of co-ingestion and the decrease of AC tolerance by the nature of the substances ingested such as sedatives and opioids that reduce bowel movements [26]. However, no statistically significant association was found between AC tolerance age, sex, medical history, the presence symptoms at presentation, and the nature of the substance ingested. These results indicate that none of these factors significantly influenced the occurrence of adverse effects following activated charcoal administration.

While no causal relationship can be established in this observational study, these findings warrant further investigation into tailored AC tolerance and investigate the duration of AC intake.

Propositions and perspectives

Based on our findings and those of existing literature, several key recommendations emerge regarding the use of AC in acute intoxication management. AC is a generally safe and effective antidotal intervention that should be readily available in EDs and administered within the recommended therapeutic window, ideally within the first hour post-ingestion, and in the absence of contraindications. It may be administered beyond the traditional one-hour post-ingestion window for selected poisons. The exact time frame depends on the nature of the toxin and its formulation (e.g., immediate-release versus modified-release). In addition the decision to use activated charcoal should be based on an individualized risk assessment that prioritizes airway protection and carefully weighs the expected toxicological benefit against potential complications, such as pulmonary aspiration. Clinicians should remain vigilant for tolerance issues, particularly vomiting, which may lead to complications such as aspiration pneumonia.

Our results are largely consistent with previous studies, with the exception of the association between AC tolerance and co-ingestion, which may reflect differences in the substances involved rather than the intrinsic properties of AC. Standardized protocols combined with appropriate clinical and biological monitoring are essential to optimize outcomes, and further multicenter studies are needed to validate these findings and refine AC use across diverse intoxication scenarios.

We acknowledge several limitations: the monocentric design may limit generalizability to other Tunisian regions; the short follow-up period restricted evaluation to tolerance of a single AC dose; and the small sample size limited statistical power for subgroup analyses.

CONCLUSION

AC is a cornerstone in management of specific cases of intoxication emergencies. In our study, the most common indications for AC administration were intoxications involving acetaminophen and metformin. AC was

generally well tolerated, particularly in instances of co-ingestion ($p=0.017$ OR=6.4 95%IC 1.273-32.186.). These findings highlight the critical role of AC administration in the ED and raise awareness for possible poor tolerance. Further prospective studies of larger sample sizes are needed to confirm these results.

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