Improvement in the management of acutely poisoned patients using an electronic database, prospective audit and targeted educational intervention

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Data from this manuscript have been published in abstract form and were presented as an oral communication (by PD) at the North American Congress of Clinical Toxicology in New Orleans, Louisiana, USA in October 2007.

Received 12 November 2007
Accepted 13 September 2008

ABSTRACT

Problem: The need to improve the clinical assessment and management of acutely poisoned patients presenting to an NHS hospital emergency department (ED).

Design: Creation of an electronic clinical toxicology database to prospectively collect all aspects of clinical information on poisoned-patient presentations. Systematic analysis of collated information to identify shortfalls in patient assessment and management. Bimonthly audit meetings, and design and implementation of educational interventions to address identified shortfalls. Ongoing audit to demonstrate continued improvement in patient care.

Background and setting: ED in tertiary-level inner-city London teaching hospital. Study conducted by staff from the ED and clinical toxicology service.

Key measures for improvement: Demonstration of overall reduction in the incidence of predefined shortfalls in patient assessment and management during 12-month study period.

Strategies for improvement: Targeted educational lectures and case-based clinical scenarios addressing identified deficiencies in the knowledge required to effectively manage poisoned patients. Weekly case-based anonymised feedback report sent electronically to staff involved in caring for poisoned patients.

Effects of change: Implementation of targeted teaching of ED staff and regular electronic distribution of teaching cases. Between the first and second 6 months of the study, there was a significant increase in the proportion of presentations for which clinical management was graded as "good" (77.6% to 89.4%, $p < 0.0001$) and a significant reduction in the proportion of "major" (9.9% to 5.8%, $p = 0.012$) and "minor" (12.6% to 4.8%, $p < 0.0001$) shortfalls.

Lessons learnt: Systematic collection of clinical information, using a dedicated electronic database and subsequent review and audit of collated data by interested clinicians, enabled design and implementation of targeted educational interventions to address shortfalls in patient management. This process has led to significant improvements in the clinical care of acutely poisoned patients presenting to the ED.

Acute poisoning is common, and emergency department (ED) attendances following intentional self-poisoning in the UK (347 per 100 000) are among the highest in Europe, and are increasing.^{1,2} Although overall mortality from acute poisoning is low, poorly managed poisoning-related complications can lead to long-term morbidity and mortality.³ Common complications

requiring management in the ED as a result of acute poisoning include agitation, vomiting, arrhythmias, hypotension, thermoregulatory abnormalities, acid-base and metabolic disturbances, acute coronary syndrome, seizures, acute psychosis, depression of the central nervous system and airway compromise.³

There are few randomised controlled trials in clinical toxicology supporting clinical management; however, there are consensus guidelines outlining best practice.³⁻⁸ Poisons centres and other information sources such as TOXBASE are available to support the management of poisoned patients. In reality, the initial clinical assessment and management of a significant proportion of acutely poisoned patients is undertaken by junior doctors working in EDs, who have often received little formal training in clinical toxicology at either an undergraduate or postgraduate level.

Our study aimed to improve the clinical management of acutely poisoned patients presenting to our ED via a three-part approach. We decided to systematically collect data on all poisoned patients presenting to the ED. After data collection, all cases were reviewed by a member of our clinical toxicology service, to identify any shortfalls in patient management. Finally, after audit meetings and a team-based analysis of identified shortfalls, targeted educational and feedback sessions were provided to staff responsible for the care of poisoned patients. Study outcomes were monitored through ongoing prospective patient data collection and audit.

BACKGROUND

Outline of the problem

ED nurses and doctors (including senior house officers, specialist registrars, clinical fellows and consultant ED doctors) are responsible for the initial assessment and management of acutely poisoned patients presenting to our ED, as would occur in most UK hospitals. There is also a specialist clinical toxicology service (CTS) and a poisons unit based at our hospital, which provides additional advice and support for ED staff and is available on a 24/7 basis. This service is similar to that which can be accessed by all clinicians in the UK through TOXBASE and/or voice poisons information services, but also includes a consultant-led inpatient CTS. Utilisation of the CTS, whether for information and support via telephone at any time or bedside consultation in the ED

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(available during office hours), is left to the discretion of the attending ED doctor.

Poisoned patients requiring inpatient management are admitted to an observation ward under the joint care of ED doctors and the CTS. Those patients with co-existing acute medical conditions requiring management or those who are severely poisoned are admitted under the care of the CTS to a general medical or critical care bed, respectively.

CTS ward rounds occur daily, providing assessment of admitted patients and an ongoing management plan. During these reviews of admitted poisoned patients, shortfalls in the initial ED phase of clinical assessment and management were identified during review of the patient's ED medical record. A significant number of these shortfalls were realised to have the potential to cause patient harm, either through omission of an intervention or because of incorrect administration of a potentially harmful intervention.

Although feedback on shortfalls in patient management had previously been provided to senior clinicians in the ED, anecdotally this did not appear to prevent repeated occurrences of the same or similar shortfalls. Quantifying any improvement in clinical management was also difficult. It became apparent that to prevent potential patient harm, a systematic method of identifying and measuring shortfalls in clinical management together with a more formalised feedback loop was required. This feedback loop would involve provision of targeted interventions to address shortfalls, followed by measurement to demonstrate the effect on quality of poisoned-patient care.

Context

The study was conducted at the St Thomas' Hospital site of Guy's and St Thomas' NHS Foundation Trust. This is a large tertiary referral teaching hospital in central London, and, at the time of the study, the ED was managing ~120 000 presentations per year.

Poisoned patients account for ~1200 patients per year, 50% of whom present with deliberate self-poisoning, 40% with recreational drug toxicity, and 10% are unintentional or

unclassified exposures. Of the deliberate self-poisoning presentations, the most common agents involved are analgesics, representing up to 30% of all presentations. These figures are, in general, representative of poisoned-patient populations in other UK urban settings. St Thomas' Hospital is, however, unusual in having a dedicated CTS. This is not typical of all large urban UK hospitals; however, there are a number of other centres both in the UK and internationally (eg, Australia and USA) with a similar set up.

The CTS comprises consultant clinical toxicologists who are also general physician, consultants in emergency medicine with a specialist interest in clinical toxicology, and specialist registrars in clinical toxicology. The service is supported by a clinical toxicology database scientist, information specialists at Guy's and St Thomas' Poisons Information Service (24 h poisons telephone information service), and a nurse-led psychiatric liaison service supported by consultant liaison psychiatrists.

The Trust Caldicott Guardian approved the collection and storage of routinely collected data on poisoned patients as an audit. No additional patient data were entered into the database beyond that contained in the standard clinical record.

ASSESSMENT OF PROBLEMS AND STRATEGY FOR CHANGE

Details of approach taken

The initial approach was to design a system to collect clinical information (including details of management) on all poisoned patients. A pilot phase of the study was conducted to refine and validate data collection. During this phase, shortfalls in patient assessment and management were identified by analysis of collected data and through observation during clinical practice. Standards of care addressing each shortfall were defined. Systematic collection of clinical information for all poisoned-patient presentations during the main phase of the study allowed critical appraisal of each presentation against the predefined standards of care. Root cause analysis of each management shortfall occurring in a number of different presentations was undertaken to identify underlying causative factors. Interventions were then designed and implemented to address these. Finally, we undertook a re-audit facilitated by ongoing systematic collection of patient information to assess the effect on the quality of patient care.

The pilot phase of the study began in May 2005; all patients presenting to our ED with a suspected or known history, or initial medical diagnosis, of poisoning (accidental, deliberate, recreational, occupational or "other") were eligible for study inclusion. Patients with a primary diagnosis of ethanol intoxication alone were excluded. The main phase of the study was carried out during a 12-month period between 1 October 2005 and 30 September 2006.

Measurement of the problem

We decided that a systematic method was required to identify patient management shortfalls and to facilitate ongoing audit, rather than the ad hoc method of observation and patient medical record review during daily ward rounds that had alerted us to the problem initially. We decided to create an electronic clinical toxicology database. Database design was facilitated using multidisciplinary input from clinical toxicologists, ED doctors and specialist poison information scientists. Data variables for collection were compiled to encompass important demographic, epidemiological, exposure, symptom, examination, investigation, and management and outcome information.

Box 1: Predetermined potential minor shortfalls for use in classifying the standard of clinical management of acutely poisoned patients presenting to the emergency department

- ▶ Unnecessary repeat paracetamol concentrations ordered.
- ▶ Paracetamol concentration ordered less than 4 h after ingestion.
- ▶ Paracetamol concentration ordered in staggered overdose.
- ▶ *N*-Acetylcysteine (NAC) started before paracetamol concentration obtained in a single ingestion where paracetamol concentration known within 8 h of ingestion.
- ▶ Unnecessary arterial blood gas(es).
- ▶ Activated charcoal administered to conscious, non-vomiting patient in the absence of clinical indication.
- ▶ Treatment with NAC extended without indication.
- ▶ Significant deficiency in clinical documentation.
- ▶ ECG not obtained in stable patient with arrhythmia (tachy or brady).
- ▶ Unnecessary administration of naloxone (Glasgow Coma Scale score 14–15, normal respiratory function, normal blood pressure).

Box 2: Predetermined potential major shortfalls for use in classifying the standard of clinical management of acutely poisoned patients presenting to the emergency department

- ▶ No paracetamol concentration in patient with possible deliberate self-harm and history of ingestion of unknown tablets or confusion/decreased Glasgow Coma Scale (GCS).
- ▶ Dosage error in *N*-acetylcysteine (NAC) administration.
- ▶ No blood glucose recorded for patient with confusion or altered conscious state (GCS <14).
- ▶ Inadequate naloxone given to patient with evidence of opioid toxicity resulting in negative clinical outcome or need for intubation.
- ▶ Repeat plasma salicylate concentrations not requested in patient with ongoing clinical evidence of toxicity.
- ▶ No multiple-dose activated charcoal (AC) given to a patient with clinical evidence of theophylline/phenytoin/dapsone/carbamazepine/phenobarbitone toxicity.
- ▶ ECG not requested in patient who has ingested a potentially toxic amount of cardiotoxic agent.
- ▶ Flumazenil administered without good clinical reason or discussion with a senior clinician/toxicologist.
- ▶ Patient discharged without adequate observation time.
- ▶ Calcium given to digoxin toxic patient for the management of hyperkalaemia.
- ▶ Patient with risk factors suggesting possible further self-harm discharged without psychiatry team review.
- ▶ Inappropriate use of sodium bicarbonate, or withholding of sodium bicarbonate when indicated for the treatment of tricyclic antidepressant toxicity.
- ▶ Use of β -blocker to treat hypertension in sympathomimetic agent toxicity.
- ▶ Inappropriate sedation of a patient.
- ▶ Lack of cardiac monitoring when clinically indicated.
- ▶ Poor documentation leading to adverse outcome or detrimental effect on patient care.
- ▶ Poor verbal communication leading to adverse outcome or detrimental effect on patient care.
- ▶ Failure to seek senior advice in cases of severe toxicity.
- ▶ Single-dose AC indicated, but not administered.
- ▶ Urinary alkalinisation not used when indicated for salicylate toxicity.
- ▶ NAC incorrectly withheld when there was an indication for administration.
- ▶ AC administered to a vomiting patient or patient with GCS <14 in absence of indication.
- ▶ AC administered orally to a patient without a protected airway.
- ▶ AC administered to a patient who had ingested an acid, alkali or hydrocarbon.
- ▶ Salicylate concentration not ordered in a patient with an altered conscious state and a history of possible deliberate self-harm.
- ▶ Inadequate investigation (ECG, cardiac enzymes) of patient with chest pain and a history of stimulant drug exposure.
- ▶ Thrombolysis administered when not clinically indicated.
- ▶ Naloxone given intramuscularly when intravenous access was available or no clear indication for intramuscular use given.
- ▶ NAC administered without any indication.

Using these variables, one author (SG) designed a fully relational electronic database using Microsoft Access 2000 (Microsoft, Seattle, Washington, USA), with close input from the team over

Figure 1 Number of acute poisoning presentations in which the clinical management was classified as good, minor shortfall or major shortfall between 2005 and October/September 2006.

a 2-year period. Data were collected in fields using drop-down menus to ensure consistency of data entry. In addition, free text fields were included for data entry not covered by the drop-down menus.

ED medical and nursing notes were collected on patients who met the study inclusion criteria. Information entry into the database was undertaken by five clinical toxicology registrars/fellows, and all data entry was supervised and overseen by senior clinical toxicologists in the team (PD, SG, DW, AJ). Information was entered directly from the patient's standard ED clinical record used for all ED presentations to our hospital. Records were obtained during the working day after admission where possible; data entered on the day records were obtained. Data entry continued until patient discharge from hospital.

Ancillary investigation data (clinical laboratory and radiological) was obtained using the local hospital clinical information system. ECG variables were measured manually, and corrected QT intervals were calculated using Bazett's formula. Final changes to the database were made after study team discussion during the pilot phase of data collection.

The person who entered the data graded the quality of clinical care for each case. Consultant clinical toxicologists checked the validity of clinical record information entry and the appropriateness of grading using our standard criteria (described in the following section) in cases where a shortfall was identified.

Development of standards

Minor and major shortfalls in clinical assessment and management (boxes 1 and 2) were identified by the study team on the basis of their clinical experience and shortfalls identified in the pilot phase of the study. Consensus discussion by all members of the study team led to the definition of management shortfalls and their associated standards of care. Standards of care were based on local clinical practice and evidence-based guidelines including those published by the National Institute of Clinical Excellence (NICE) and National Poisons Information Service.⁵

Clinical management for each individual case was classified as: (i) good (optimal/no shortfall identified); (ii) minor shortfall (clinical management not optimal, but unlikely to result in clinically significant harm); or (iii) major shortfall (issues that were, or could be, associated with increased morbidity/mortality, or increased length of hospital stay). Where appropriate, more than one shortfall could be selected for each case.

In cases in which management was not felt to be optimal, but the shortfall did not fit one of the predetermined shortfalls, it was recorded as "other shortfall" with additional free text used to describe the shortfall. If these occurred more than once, they

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were discussed by the study team, an associated definition of the expected standard of care was defined, and they were added to the drop-down list of shortfalls.

Assessment of problem in local context

The database was programmed to produce bimonthly reports listing the proportion of cases with optimum management and minor/major shortfalls. Reports were reviewed in regular CTS audit meetings, attended by both junior and senior members of the CTS and ED teams.

All cases were anonymised and then reviewed with a focus on the shortfalls to identify areas in which management, investigation or documentation of cases could be improved. A root cause analysis was conducted informally during the discussion of each shortfall in the context of the clinical case in which it occurred. Although intervention in this study had been planned to consist primarily of targeted education and feedback (targeting deficiencies in the knowledge of the management of poisoned patients), the root cause analysis ensured that other possible causative factors (including lack of supervision, lack of appropriate medication or equipment, impaired medical practitioner) were considered. In addition to the review of individual cases, "patterns" of shortfalls that occurred over time were discussed, to determine if procedures and/or documentation could be improved to try to reduce the incidence of these.

Intervention

Before the start of the study, senior members of the CTS and ED had been responsible for providing educational sessions in the form of lectures to ED medical and nursing staff. These generally took the form of generic lectures covering the general management of the poisoned patient and management of the more common exposures.

The study intervention consisted of targeted education and feedback based on analysis of collected data, and subsequent identification of individual shortfalls or patterns of shortfalls. Planning of targeted educational sessions occurred during the audit meetings. Once an area of knowledge deficiency was identified, the task of preparing educational intervention was delegated to a member of the CTS. Targeted education took the form of lectures and interactive case-based discussions. Where it was felt that a major shortfall was of particular clinical significance, this was fed back to senior members of the ED

team for more immediate review and alteration of clinical practice.

Feedback was achieved through the generation of an anonymised case report summary that was emailed on a weekly basis to all medical and nursing staff involved in the management of poisoned patients. The case report summary detailed cases where there had been an identified management shortfall, provided written advice about best practice, and referred the reader to other resources or publications where appropriate. This allowed individuals who could not physically attend every meeting to have access to feedback material.

Measurement of change

Data were analysed using Excel and Stata. The proportion of cases experiencing a shortfall in care was compared between the first and second 6 months of the study using a two-sample test of proportions (a "Z" test). Time trends in shortfalls of clinical management were examined using the Wilcoxon rank sum test for trends.

RESULTS OF STUDY INTERVENTION

Identification of management shortfalls

There were a total of 1395 ED presentations with a suspected or known history and/or initial medical diagnosis of poisoning between 1 October 2005 and 30 September 2006. ED medical and nursing notes were retrieved for 1101 presentations (mean (SD) 78.9 (3.6)%; range 75.1–85.0% per 2 month review period).

The most common major shortfalls identified were associated with the assessment and management of recreational drug toxicity ($n = 42$). Analgesics (paracetamol and salicylate in particular) were the most common deliberate self-poisoning presentations with major shortfalls ($n = 28$) identified, followed by antidepressants ($n = 8$), anticonvulsants ($n = 8$) and benzodiazepines ($n = 7$).

The most commonly identified major shortfall was the appropriateness of measurement, or the interpretation, of paracetamol concentrations ($n = 19$). Other common major shortfalls included: inappropriate route of administration/dose of naloxone ($n = 18$); errors in use and administration of *N*-acetylcysteine ($n = 12$); investigation and management of recreational drug toxicity ($n = 8$); incorrect gut decontamination ($n = 8$); and inappropriate use of flumazenil ($n = 3$).

Educational interventions undertaken to address shortfalls

Root cause analysis of each case showed that virtually all of the management shortfalls were occurring because of a lack of knowledge by the clinicians required to address the unique problems encountered in managing poisoned patients. Therefore interventions in this study were primarily education-based.

Training of junior ED staff, conducted by senior clinical toxicology staff was adapted to focus on areas where patterns of repeated shortfalls were occurring. In particular, we focused on assessment and management of paracetamol poisoning and recreational drug toxicity, appropriate use of gut decontamination, and administration of the antidotes, naloxone and flumazenil.

During the study period, clinical toxicology specialist registrars and consultants delivered regular lectures and interactive case scenarios, supplemented by weekly electronically distributed teaching cases, based around identified shortfalls.

Figure 2 Proportion of poisoning presentations in which there was a shortfall in the initial clinical management.

Table 1 Percentages of the poisoning presentations in which the management was classified as good, or where a minor or major shortfall in the clinical management was identified

Audit period	Good management (%)	Minor shortfall (%)	Major shortfall (%)
Oct 05/Nov 05	79.1	10.7	10.2
Dec 05/Jan 06	70	18.8	11.3
Feb 06/Mar 06	82.9	8.8	8.2
Apr 06/May 06	87.3	7.7	5.0
Jun 06/Jul 06	91.1	2.4	6.5
Aug 06/Sep 06	89.8	4.3	6.0

Trends in improvement of clinical management

The overall number of presentations graded as receiving good clinical management, minor shortfall or major shortfall was 923 (83.8%), 93 (8.4%) and 85 (7.7%), respectively (fig 1). There was an increase in the number of presentations in which the clinical management was graded as good (table 1), along with reductions in the number of presentations in which there was a minor or major shortfall (fig 2, table 1).

There was a significant increase in the proportion of presentations in which the clinical management was graded as good between the first and second 6 months of the study (77.6% vs 89.4%; $p < 0.0001$). Although the incidence of both minor and major shortfalls decreased across these two time periods, there was a greater reduction in minor (12.6% vs 4.8%; $p < 0.0001$) than major (9.9% vs 5.8%; $p = 0.012$) shortfalls. Overall there was evidence for a trend in improved case management across the six review periods of the study ($p = 0.048$). Interestingly and importantly, consistent improvement occurred despite new junior medical staff (with little previous experience in caring for poisoned patients) starting work in the ED during the study period.

LESSONS LEARNT AND NEXT STEPS

This study shows that prospective, systematic collection of routinely available data on the management of acutely poisoned patients and associated analysis and audit of these data, with targeted feedback and education to clinicians has led to a clinically and statistically significant improvement in the quality of management of acutely poisoned patients in our hospital. The introduction of regular joint ED and CTS audit meetings allowed shortfalls to be reviewed anonymously, with the aim of reducing potential clinical harm to poisoned patients through improved medical and nursing staff education, conducted in a blame-free and positive manner. Overall there was a 40% reduction in the occurrence of major shortfalls in patient management during the study.

We acknowledge that a proportion of the improvement may be due to junior medical staff being aware that their management was being reviewed and audited. However, consistent improvement still occurred despite turnover of junior medical staff (and a possible corresponding reduction in baseline working knowledge) in the ED every 3–6 months during the study period.

Unlike many other medical specialties, there are few large randomised controlled trials supporting evidence-based guidelines for the management of poisoned patients.^{9–10} Most of the current toxicology “evidence” base is derived from case reports and/or small case series, sometimes supported by small clinical trials, animal models and basic principles, with few cohort or randomised controlled trial data.⁹ Previous studies have examined the introduction of protocols for “good quality

toxicological management”, and shown that these can improve recording of key indicators such as baseline physiological parameters.¹¹ The use of high-quality clinical databases has been suggested as one method to improve data collection and ultimately management of acutely poisoned patients.¹² They have been used over time to look at comparative epidemiological data between different classes of drugs, such as toxicity of selective serotonin reuptake inhibitors, tricyclic antidepressants and β -blockers.^{13–14}

The efficacy of high-quality clinical databases in improving outcome and quality of care in other medical specialties, such as general practice and anaesthesiology, has been previously reported.^{15–16} Most routine hospital datasets are administrative systems measuring activity in order to claim reimbursement and are not designed to assess quality of care. Although there are numerous clinical databases in the UK, they often lack sufficient quality of data entry and are under, or inappropriately, utilised for data analysis.¹⁷ The minimum database standards recommended for use in collating clinical data for audit, research and quality assessment include: collection of data on consecutive cases, standardised definitions for terminology within the database, accuracy of data retrieval and entry, and specific markers of outcome data. These are often not available using standard healthcare coding databases.¹⁸ In addition, use of databases to improve overall quality of healthcare-related activity should rely on routinely collected data in order that it is representative of normal practice.¹⁹ Previous studies in clinical toxicology have used standardised clerking proforma to collect data before it is collated on to a clinical database.²⁰ This has the disadvantage that the clerking proforma must be used to collate data for every case, rather than simply using routinely collected data, which are available in all circumstances. In our study, we have used only routinely collected data and have tried to ensure that data collection and analysis have complied with suggested guidelines for high-quality clinical databases.^{18–19}

Clinical data collection, regular audit meetings and data analysis coupled with targeted education and feedback continued after completion of the formal study period. Additional interventions included development of a paracetamol treatment guideline. Major and minor shortfalls were identified in 2.8% and 6.6% of cases, respectively, during the 12 months of 2007, a continued improvement since the start of the original study. Demonstration of continued improvement in care of poisoned patients has enabled funding for a full-time database scientist (responsible for initial data collection and entry, and data analysis) and utilisation of the database and associated processes as part of our standard clinical service. Additional benefits of the database will include contributions toward the evidence base of clinical toxicology, which we hope will translate into further improvements in the clinical care of acutely poisoned patients and give further insight into potential sources of error, which can be addressed by development of systems and educational awareness.

Although the improvements demonstrated in our study are probably a direct result of the targeted educational interventions that we undertook, the structured collection and analysis of patient information using the electronic clinical toxicology database was pivotal in enabling this to occur and in facilitating measurement of the intervention's efficacy. Therefore the database has become an integral part of our everyday clinical practice, where it not only contributes toward improvements in local patient care, but also contributes to the knowledge base underlying clinical toxicology. Although the database was designed to work within our hospital clinical environment, it

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demonstrates a model that has the potential to be useful in other acute healthcare systems providing care for acutely poisoned patients, both within the NHS and abroad.

Acknowledgements: We acknowledge Dr John RH Archer, Specialist Registrar in General Medicine and Clinical Pharmacology, St George's University of London, London, UK, and Dr Hanna Ovaska, Specialist Registrar in General Medicine and Clinical Pharmacology, Guy's and St Thomas' Poisons Unit, London, UK, for assistance with the data entry into the clinical database. Finally, we acknowledge Mr Christopher Bishop, the clinical database scientist who has undertaken data entry since October 2006.

Funding: The provision of a dedicated clinical toxicology database scientist and development of the database was funded by a grant from Guy's and St Thomas' Hospital Charitable Foundation (Reference: Guy's Poisons Unit Patient Toxicology Database New Services Grant, Project Code G051102).

Competing interests: None.

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