

## Efficacy and optimal dose of acetic acid to treat colonised burns woundss

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# BMJ Open Efficacy and optimal dose of acetic acid to treat colonised burns wounds: protocol for a pilot randomised controlled trial

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## ABSTRACT

**Introduction** Despite of recent advancement in the burns wound management, burn wound infection (BWI) is still one of the major cause of burns mortality. Patients who survive their burns injury still suffers from BWI related complication like delayed wound healing and poor scarring. BWI has been treated by application of topical antimicrobial agents or systemic antibiotics. Due to the global risk of developing systemic antibiotics resistance, medical research focuses on identifying single topical agent which has effective antimicrobial activity, easily available and cost effective. One such agent is acetic acid (AA). AA has been used as a topical antibacterial agent for the treatment of burns wounds for many years and has shown to have activity against gram-negative organisms including *Pseudomonas aeruginosa*. So far there has been no consensus on optimal concentration that has effective antimicrobial activity, frequency of application, duration of treatment and most importantly good patient's tolerability. A randomised control study is required to answer all these questions.

**Objective** To investigate the efficacy and tolerability of 0.5% and 2% of AA when applied to colonised burns wounds for 3 days after admittance to the Queen Elizabeth Hospital Birmingham.

**Methods and analysis** This is a double-blinded, prospective, randomised, controlled, single-centre trial. Patients will be screened for eligibility in the inpatient area and those who are found to be eligible will be randomly assigned to one of two treatment groups: group 1: 0.5% AA (10 patients); group 2: 2% AA (10 patients); total number: 20 patients.

**Outcome measures** *Primary outcome:* Efficacy will be assessed by measuring the bacterial load from microbiology wound swabs for three consecutive days. *Secondary outcomes:* (1) The assessment of antimicrobial activity of AA and the minimum inhibitory concentrations. (2) Patient's tolerance by assessing Visual Analogue Scale pain score. (3) Time to 95% wound healing of treatment area. (4) Patient's perceived treatment allocation.

**Ethics and dissemination** AceticA trial protocol was approved by the National Research Ethics Service (West Midlands—Edgbaston Research Ethics Committee; 17/WM/0407; IRAS 234132). This article refers to protocol version 5.0 dated 6 July 2020. The analysed results will be

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ It is a double blinded, randomised control trial comparing two different strengths of acetic acid (AA).
- ⇒ The study design is very simple and feasible for patients with the trial duration of only 3 days with no extra outpatient follow-ups.
- ⇒ Two different strengths of AA will be used to compare the antimicrobial efficacy, tolerability and feasibility in patients.
- ⇒ The study does not interfere with the standard burns care of the patient.
- ⇒ Difficulties in recruitment are anticipated as the number of patients with colonised burn wounds who are expected to stay as inpatients for the trial duration and not undergoing for surgical intervention may be limited.

presented at national and international conferences related to management of burn patients. The generated articles based on the trial results will be submitted to peer review journals for publication.

**Trial registration number** ISRCTN11636684.

## BACKGROUND

Burns wound infection (BWI) is a serious complication following burn injury. It is reported that BWI accounts approximately 9%–17% of all burn injury related complications.<sup>1 2</sup> Pruitt *et al* reported that invasive wound infection represents 5% of all the infections that occurred in patients admitted with severe burn injuries.<sup>3</sup> It is very concerning that morbidity and mortality of burn patients are highly correlated to the incidence of wound infection and its sequelae.<sup>4 5</sup> Other complications include delayed wound healing, poor scarring. Hence, the medical community aim to effectively manage BWI to improve patient's prognosis.

Invasive BWI are classically treated with systemic antibiotics. However, excessive use

of antibiotics has been associated with antimicrobial resistance. Alternative antimicrobial regimes are currently needed to minimise the antimicrobial resistance, as per WHO recommendations.<sup>6</sup> A wide range of topical treatments to manage BWI are available. This includes but not limited to, silver nitrate, povidone-iodine and acetic acid (AA). To date, there is no consensus in regards to effectiveness and efficiency of various topical management regimes for BWI.<sup>7</sup>

Ideal topical regime for treating BWI needs to have potent antimicrobial properties, readily available and cost effective. One such treatment is topical AA (vinegar). The antimicrobial properties of AA have been well-known for centuries. AA is included on the WHO list of essential medicines published in 2019, a list of the safest and most effective medicines.<sup>7</sup>

AA has been used as a topical agent in burn care for decades.<sup>8,9</sup> It has been used for wound management in WWI when Taylor observed the elimination of *Bacillus pyocyaneus* on using 1% AA solution.<sup>10</sup> It has been shown to be effective against multi-drug resistant organisms and biofilms.<sup>11,12</sup>

Since then, a number of studies has been conducted to assess the effectiveness and efficacy of AA in management of BWI.<sup>13,14</sup>

In vitro studies, diluted AA (1%–5%) has shown potential to reduce or eradicate bacterial load, specifically *Pseudomonas aeruginosa*.<sup>15,16</sup> Minimum inhibitory concentrations (MICs) of AA has been studied in vitro both before and after evaporation and exposure to gauze. These showed that the methicillin-susceptible strain of *Staphylococcus aureus* had an MIC of 0.312% and a methicillin-resistant strain was less susceptible to MIC of 0.625%. Strains of *Acinetobacter baumannii* also had an MIC of 0.312% and all strains of *P. aeruginosa* were susceptible to MIC of 0.166%.<sup>11</sup>

Different concentrations of AA has been studied to treat BWI.<sup>17–19</sup> Patient's tolerability to topical agent is also very important. Patients usually complain of stinging and pain on application of AA to wounds, particularly at higher concentrations, for example, strength of 5% or more.<sup>13,14</sup> In another study, 3% concentration was used with better pain tolerance and less itching.<sup>16</sup> In a recently published survey of burn centres in UK, six centres (32%), routinely use AA topically as gauze soaked with 2.5%–3.0%. This high concentration was reported to be well tolerated.<sup>20</sup>

Despite of all the previous studies, question still remains to find a good balance between AA concentration which has efficient antimicrobial activity, low toxicity and better patient's tolerability. Hence, a randomised controlled clinical trial is warranted to answer all these questions.

## METHODS AND ANALYSIS

### Trial design

This is a double-blinded, prospective, controlled and randomised pilot trial, where 20 patients will be randomised to receive treatment with either 0.5% or 2%

### BOX 1 BURN WOUND INFECTION IDENTIFIABLE BACTERIA

*Pseudomonas aeruginosa*  
*Acinetobacter baumannii*  
*Escherichia coli*  
*Proteus mirabilis*  
*Staphylococcus aureus*  
*Klebsiella Pneumoniae*  
 ESBL *E. coli*  
*Enterobacter cloacae*

AA (10 patients in each treatment arm) to treat the bacterial load in colonised burn wounds. The burn wounds will be required to be colonised with a specifically identifiable bacteria (box 1), this wound will then be treated two times a day with AA dressings for two consecutive days then once on the third day of treatment. On days 1 and 2, the trial focuses on comparing the effectiveness of AA 0.5% and AA 2% in reducing bacterial load and evaluating patient's tolerability to justify a larger scale, randomised, controlled trial. The anticipated sample size is small as this is a pilot trial with no placebo arm. The trial will be double blinded to minimise bias in the assessment of the outcome measures.

The AA concentrations chosen in this trial (0.5% and 2%) were selected based on the in vitro findings of Halstead *et al* showing efficacy of AA at lower dilutions than previously thought or used in clinical practice.<sup>21,22</sup>

This is a single site trial, in which the cohort will be generated from patients admitted to the Burns Centre or Critical Care Unit at the Queen Elizabeth Hospital Birmingham, UK (QEHB) with a colonised burn wound. The target population is patients with burns of  $\geq 1\%$  total body surface area (TBSA).

## CONDUCT OF TRIAL

### Inclusion and exclusion criteria

The trial will aim to recruit adult patients (age  $\geq 16$  years old) who sustained a  $\geq 1\%$  TBSA burn injury. At the start, the inclusion criteria was aged 18 years which was changed to 16 years, as in UK these patients are legally considered adults and this may increase the patient pool.

There was an upper limit of TBSA 10% which has been removed and changed to minimum limit of burn injury TBSA  $\geq 1\%$ . These changes were made to cover wider spectrum of patients and severity of injury. However, the total burn wound to be treated with AA will remain  $< 10\%$ .

Initially, the patients who had the capacity to give informed consent were included in the trial. During the screening process, the clinical team discovered that a large number of otherwise eligible patients could not be approached and hence recruited as they were admitted to intensive care unit and so lacked capacity to give informed consent. Changes were made in protocol to included patients who lacked capacity to give informed consent. The consent for these patients can be sought from a Professional or Personal Legal Representative.

Prior to enrolment, the targeted burn wound has to be colonised with specifically identifiable bacteria. The recruited patients are anticipated to remain as inpatients for the trial duration (3 days). At first, the trial treatment period was 5 days, with two times a day dressing change on days 1, 2, 4, 5 and once a day dressing changes on day 3. However, due to the COVID-19 pandemic and the changes in the standard care pathways to minimise the exposure by reducing the inpatient stay, the treatment period was reduced to 3 days to avoid impact on recruitment process. This proposed change of the study design was also supported by interim analysis of 11 subjects as there was an increase in bacterial colonisation on day 4, compared with days 2 and 3. Now patients will get two times a day dressing change on days 1, 2 and once a day on day 3.

Patients receiving systemic antibiotics for cellulitis were excluded initially. The clinical team suggested that these are the patients who may benefit most from topical antimicrobial treatment. In fact, AA (usually of higher concentrations) is part of routine therapy for these patients. Antibiotics are prescribed to control the systemic spread of infection and do not interfere with the wound microbial burden. Therefore, this exclusion point was removed to allow these patients the opportunity to receive 0.5% or 2% AA solution to treat their wounds. This should not affect the outcome of determining the difference in the microbial burden of the two different concentrations.

Because of all the above changes, the study design is very simple with very broad inclusive criteria so the results can have worldwide potential impact. Only patients with severe burn injury or burn which require surgery will be excluded. There was no contraindication to include pregnant patients or who are breastfeeding as the IP has no systemic effects.

Patients with burn TBSA <1% and burns solely to the face and/or genital area will be excluded in addition to patients who have received AA as part of standard therapy on admission for this burn injury (table 1). Recruitment eligibility and unsuitability will be checked by the trial investigators.

### Screening and consenting

Patients who meet eligibility criteria will be approached by a member of the research team and asked whether

they would be willing for an additional microbiology swab to be alongside their routine swab for analysis, to confirm eligibility. If the patient is unconscious, then a Personal Legal Representative or Professional Legal Representative will be approached on behalf of the patient to request the swab be taken. If the appropriate patient or legal representative agrees to this, they will be asked to sign the trial consent form for retrieval of this swab.

Once a positive microbiology test result has come back and the patient is found to be eligible according to the inclusion and exclusion criteria, the patient or their legal representative will be approached by a member of the research team for enrolment treatment with AA dressings.

At first, there were two consent forms for the study, prescreening consent form for initial microbiology swab to indicate eligibility. If patient is eligible for treatment, then informed consent form will be taken prior to start the treatment. To make consent process easier, single consent form was introduced later on for screening and treatment phase of the trial.

### Randomisation and treatment allocation

Randomisation and treatment will only begin once eligibility is confirmed by a positive microbiology test to take part in the trial. Patients will be randomised to a treatment arm in order to start the morning treatment procedure of day 1 within 48 hours of the positive microbiology result.

Patients will be randomised to one of two treatment groups:

Group 1: 0.5% AA (10 patients).

Group 2: 2% AA (10 patients).

Total number: 20 patients.

Enrolment and randomisation of the patient will be completed on the electronic the Clinical Research Tool (CREST) system (an in-house bespoke, electronic Remote Data Capture system (eRDC) developed by QEHB), on which patients' trial number and treatment pack numbers will be allocated and randomisation confirmation emails will be sent to relevant trial team members. The CREST system is also trial database system.

### Blinding

The treatment group allocation will be concealed from the patient and clinical staff throughout the trial period. Each treatment box will be numbered according to a randomisation list generated on a randomisation wizard by biostatistician. The randomisation list will be provided to the manufacturer, Stockport Pharmaceuticals, who will in turn package and label the treatment boxes.

### Unblinding process

As both arms of the trial are the same active treatment, in cases of emergency they will likely be dealt in the same way. As a result, there is unlikely to be a requirement for emergency unblinding. If the need does arise, the local pharmacy will hold the randomisation list that can provide details of what treatment each patient has

**Table 1** Summary of inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Age ≥16 years	Paediatric patients
≥1% total body surface area (TBSA) burn injury	<1% TBSA burn injury
Colonised wound with a specifically identifiable bacterium	Burns to face or genitalia
Anticipated hospital stay for at least for 3 days	Previous treatment with acetic acid

been randomised to. If unblinding needs to be carried out then a full record of the procedure will need to be recorded and maintained that is, reasons for unblinding, by whom, etc.

### Trial intervention

The burn wounds will be required to be colonised with a specifically identifiable bacteria, this wound will then be treated two times a day for the first 2 days with AA dressings. This will allow determination of whether the AA is still active after 12 hours of being in contact with a colonised burn wound. In order to ascertain if the AA is still effective after 24 hours the dressing will be changed once on day 3. The antimicrobial activity of AA extracted from the dressings, will be conducted by determining its MIC.<sup>7</sup>

A microbiological swab of the burn wound will be collected once daily during each morning dressing change and sent to the microbiology lab where it will be analysed to determine the microbial load.

The swabbing procedure will be carried out prior to burn wound cleaning. The 10×10 cm<sup>2</sup> blue gauze will be removed from the burn wound and over this area a swab moistened in normal saline will be applied and while twisting the tip the area will be swept from left to right at 1 cm intervals. The swab will be transferred to a neutralising agent (containing 30 g/L Tween 80, 3 g/L lecithin, 1 g/L histidine, 5 g/L sodium thiosulphate, 8.5 g/L sodium chloride and 1 g/L tryptone) to nullify carry over of antimicrobial activity. Serial dilutions using diluent containing 8.5 g/L sodium chloride and 1 g/L tryptone will be made, and number of CFU/mL determined.

The trial will assess tolerability of the two different strengths of AA, by assessing the patient's pain score at time of application of AA and in the following hour, using the Visual Analogue Scale (VAS). Find the Trial Schema in online supplemental file 1 and Schedule of Events in online supplemental file 2.

### Adverse event reporting and analysis

The reporting period for adverse events (AEs) starts from the time of application of the first dressing and continues until the day 3 dressing has been removed on day 4. Before COVID-19 pandemic, the reporting period for AEs started from the time of application of the first dressing and continued until the day 5 dressing had been removed on day 6. All serious AEs and adverse reactions

will be evaluated by the investigators and recorded. The National Cancer Institute's common terminology criteria for AEs (CTCAE, V.4.02, 2010) will be used to grade each AE. The coordinating trial office (CRCTU, Birmingham) will keep detailed records of all AEs reported (nature, onset, duration, severity, outcome) and perform an evaluation with respect to severity, causality and expectedness.

### Data handling, quality assurance, record keeping and retention

The trial sponsor (UHBFT) and patients are recruited from one of the sponsor's hospitals (QEHB). The sponsor worked in collaboration with CRCTU, University of Birmingham (UoB), some sponsor responsibilities were delegated to the clinical trials unit the division of key responsibilities is detailed in table 2.

The sponsor and CRCTU are fully compliant with the Data Protection Act 1998. Applicable regulations and laws associated with testing and development of Investigational Medicinal Products for human use and Good Clinical Practice. The sponsor is responsible for monitoring the trial. Confidentiality will be maintained throughout the trial and thereafter. On completion of the trial, data will be transferred to a secure archiving facility at the UoB, where data will be held for a minimum of 15 years and then destroyed.

### Case Report Forms

Case Report Forms (CRFs) included medical history and concomitant medications in the trial's electronic database, CREST. Other CRFs incorporated in the electronic database included: pain scores and burn injury examinations recorded from day 1 through to day 3; microbiology results; AE reporting and end of treatment forms. The data will be collected on paper CRFs as well as electronic remote data capture eRDC. CREST was not available at the beginning of the study. This data was then later transcribed to CREST when it was available.

### Statistical justification and outcome analysis

#### Sample size and justification

This trial is not powered to the primary endpoint. Rather, the sample size for AceticA has been selected based on what is feasible to be recruited at a single centre in a reasonable timeframe for this phase of clinical trial. It was thought that 10 evaluable patients per treatment arm, analysed using repeated measures methods, would

**Table 2** Summary of responsibilities

Responsibility	Institution
Provision of Investigational Medicinal Medicine (IMP)—acetic acid	UHBFT
Provision of electronic Remote Data Capture system (eRDC-CREST)	UHBFT
On-site monitoring	UHBFT
Regulatory submission, trial management, data storage and analysis	CRCTU
CRCTU, Cancer Research Clinical Trials Unit; CREST, Clinical Research Tool; UHBFT, University Hospitals Birmingham NHS Foundation Trust.	

provide the information needed to inform a larger, randomised controlled trial.

## Outcome measures and statistical analysis

### Primary outcome

Efficacy will be assessed by measuring the bacterial load from microbiology wound swabs, these will be taken daily from recruitment for three consecutive days.

### Secondary outcomes

Secondary outcome measures include; (1) the antimicrobial activity of AA will be measured by extracting fluid from removed burns dressings and assessing the MICs to establish if active AA is still present; (2) tolerance will be assessed by measuring a patient's pain scores with a VAS if the patient has capacity to provide scores; (3) time to 95% wound healing of the treated area of interest will be obtained from patients' records; (4) perceived treatment allocation will be assessed by asking patients after treatment completion which treatment they believed they received if they have capacity to do so.

Patient's tolerability was changed from primary to secondary outcome anticipating few patients might be sedated and ventilated and unable to respond to visual analogue pain score. Second, 'percentage of wound healed at day 21' was changed to 'time to 95% wound healing'. This amendment was done as some patients develop colonised burns wound and became eligible for recruitment after few weeks of injury. This measurement will be collected as part of burns patients' standard care and can be obtained retrospectively from the patients' medical notes.

### Analysis of outcome measures

Full details will be specified in the statistical analysis plan (SAP); however, an outline is given here. Analysis will use all patients whom are deemed to be evaluable. Patients are evaluable if all five dressing changes from the first 3 days of treatment are completed. Patients will be analysed in the groups that reflect the treatment they actually received. This is because the samples size is small, and the aim of a pilot trial is to inform a subsequent pivotal trial. Where frequentist tests are used, and unless specified otherwise, a significance level of 5% will be used to designate significance.

It is possible that many wounds could be assessed within patients. If this happens, hierarchical models will be used for wound specific outcome measures to reflect the wound-within-patient structure of the data.

### Analysis of primary outcome measure

#### Efficacy

Burn wound swabs will be taken periodically from baseline and bacterial load will be quantified by microbiology as the number of colonies forming units. To maximise information, repeated measures methods will be used. The model assuming fixed effects for the mean bacterial load, the mean change in bacterial load from baseline, and the additional mean change that is associated with receiving

2% instead of 0.5% AA, with random effects adjusting for the mean bacterial load at baseline for each patient, will be compared with the analogous model without the adjustment for treatment received. A likelihood-ratio test of the nested models would yield inference on the treatment effects through time. As detailed earlier, hierarchical structures will be considered as necessitated by the observed data.

The dependent variable could be extremely fat-tailed so appropriate transforms (eg, log) will be considered. This model could also be re-specified to use fewer parameters if load is found to be well approximated by a smooth function of time, potentially using transformations or restricted cubic splines. In this case, equivalent adaptations would be made to each model so that the method of testing nested models to isolate treatment effect is valid.

The parameters in the full model will be reported with means and SEs.

There may be particular interest in the presence or absence of a particular set of bacteria. If this is the case, these will be identified in the SAP. The expectation is that the lower concentration will be non-inferior in terms of efficacy. This suggests a one-tailed comparison.

### Analysis of secondary outcome measures

#### Tolerability

Pain scores will be collected at many points throughout the trial via the verbal pain intensity scale. Zor *et al*<sup>23</sup> collect scores in a similar manner and analyse them as numerical data, that is, they assume the scores to reflect order and scale. We initially propose to also analyse the pain scores as numerical variables. Explanatory variables will be included to reflect treatment allocation and we will present evidence on the extent to which reported pain is associated with treatment allocation.

The assumption that pain scores are numerical and not ordinal is potentially controversial. Supporting analysis may be provided that treats the scores as ordinal levels. Hierarchical structure similar to that described in the primary outcome would be used. Provision of this analysis is at least partially contingent on patients in the overwhelming majority of cases using the provided levels and not providing scores between levels. For instance, if patients frequently score pain experienced as 3.5 to convey 'between 3 and 4', then that would diminish the suitability of the described ordinal variable analysis. In that case, a re-codification of the ordinal levels, or reliance only on the analysis of the continuous data could be indicated.

#### Antimicrobial activity

The antimicrobial activity of AA will be measured by extracting fluid from removed burns dressings. The MICs will be estimated by successively halving the concentration of retrieved acid and testing whether microbial growth occurs. MICs could be modelled as numerical (after appropriate transform) and/or ordinal data.



Furthermore, group structure could be required as described above. Details of this are given in the SAP.

#### Time to 95% wound healing

Time from randomisation to 95% wound healing of the treated area will be presented using reverse Kaplan-Meier curves. In presentation of these curves, patients will be appropriately censored at the point they withdraw from or complete the trial. Presentation of these curves will account for the nested data structure as necessary.

The time to wound healing will be assessed using hierarchical (also referred to as multi-level) Cox models. The hierarchical structure will be included, if necessary, to reflect the nesting of wound through patient.

#### Perceived treatment allocation

After completion of protocol treatment, patients will be asked to identify the treatment arm to which they believe they were randomised. For each patient, identification of treatment arm will either be: correct; incorrect; or missing. Counts will be reported by arm. Association of treatment arm and identification of treatment arm could be assessed by  $\chi^2$  test.

#### End of trial

The end of trial will be the date of completion of treatment for the last patient. The Trials Office will notify the MHRA and REC that the trial has ended and will provide them with a summary of the clinical trial report within 12 months of the end of trial.

#### Patient and public involvement

Development of the research question, outcome measures and trial design were informed by meetings held with the Trial Steering Committee, which included a patient and public involvement (PPI) representative. The PPI reviewed the trial documentations and considered the overall burden of trial participation during the design process specifically the practicality of two times a day dressing of an infected burn wound.

#### Trial status

Recruitment into the AceticA trial began in February 2018 and currently the recruitment has been completed. End of trial report will be submitted in January 2023 (table 3).

#### Confidentiality and data protection

Personal data recorded on all documents will be regarded as strictly confidential and will be handled and stored in accordance with the General Data Protection Regulation

and Data Protection Act 2018. UHB NHSFT, as the sponsor for the AceticA trial, will be using information from patient medical records in order to undertake this trial and will act as the data controller for the study. The computers on this network have restricted physical access; data are stored under coded filenames and the local network has secure password access restricted to a limited set of people.

Anonymised data will be provided to UoB for data analysis and will only be accessible by authorised personnel. All AceticA participants provided specific written consent at trial entry to enable data with UoB. Otherwise, confidentiality was maintained throughout the trial and thereafter.

All the complied and analysed results will be presented at national and international conferences concerning. Results will also be submitted for peer review and publication in the subject journals/literature.

The trial results will be reported and submitted for publication in peer-reviewed journals and presentation at appropriate national and international academic meetings. Trial participants will be sent a summary of the final results, including references to full papers. Trial data may be made available to external groups wishing to undertake original analysis, subject to approval from the Trial Management Group.

## DISCUSSION

BWI is correlated with higher mortality and morbidity following burn injury.<sup>4</sup> Hence, one of the most important aims in burns wound management is to prevent infection to prevent invasive BWI and sepsis. Multiple studies has shown effectiveness of AA in managing BWI.<sup>8 10 14</sup> It is also known as an effective agent against biofilm producing micro-organisms which are notoriously difficult to decolonise, due to limited antimicrobial penetration and deactivation by biofilm matrix.<sup>22</sup> In addition, as a weak acid with a pKa close to its pH, AA can kill bacteria without being toxic to human cells, a key consideration in wound healing.<sup>24</sup> It is also very cost effective and easily available agent.<sup>14</sup> But there is not enough data to standardise its usage like effective strength, frequency, duration of treatment.

This is a prospective interventional controlled trial with a very simple trial design. The results will have worldwide impact because of its generic inclusion criteria. This study will show the outcome in BWI treated with two different strengths of AA. 0.5% and 2%. It will help in establishing a balance between the effective strength of AA against BWI, frequency and duration of treatment and patient's tolerability. As AA is very cost effective and easily available agent. The results of the study will have effects in both developed and developing countries with limited medical resources. This trial has a potential to have significant impact on development of future studies on burns wound management and treatment of BWI by incorporating AA in a dressing carrier as the active antibacterial agent.

**Table 3** Start and end dates

First site open	20 February 2018
First patient recruited	23 March 2018
Last patient last visit	8 October 2021
End of study declaration submission	5 January 2022
End of trial report submission	January 2023

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**Contributors** The concept of the AceticA trial was developed by NM (chief investigator) and TH, RI, KA (co-investigator). NM, KB, DB designed/developed the initial AceticA trial protocol. NM, DB, VH, GS developed, wrote, reviewed subsequent protocol versions. AC designed the proforma used for prescreening, microbiological lab manual and protocol procedure documentations. GS, DB, TH submitted all REC, MHRA and local RandD applications. KB and VH devised the statistical plan. GS, DB, TH and AC wrote/designed the patient information sheets, external trial information and patient CRFs. RI and TH wrote the manuscript and all authors reviewed the final version. All authors are guarantors.

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**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

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## REFERENCES

- Latenser BA, Miller SF, Bessey PQ, *et al*. National burn repository 2006: A ten-year review. *Journal of Burn Care & Research* 2007;28:635–58.
- Alp E, Coruh A, Gunay GK, *et al*. Risk factors for Nosocomial infection and mortality in burn patients: 10 years of experience at a University hospital. *J Burn Care Res* 2012;33:379–85.
- Pruitt Jr BA, McManus AT, Kim SH, Goodwin CW. Burn wound infections: Current status. *World J Surg*;22:124–45.
- Brown TPLH, Cancio LC, McManus AT, *et al*. Survival benefit conferred by topical antimicrobial preparations in burn patients: a historical perspective. *The Journal of Trauma: Injury, Infection, and Critical Care* 2004;56:863–6.
- Church D, Elsayed S, Reid O, *et al*. Burn wound infections. *Clin Microbiol Rev* 2006;19:403–34.
- Global action plan on antimicrobial resistance [Internet]. ISBN 978 92 4 150976 3.
- World health Organisation. World health organization model list of essential Medicines:21st list 2019. 2019.
- Phillips I, Lobo AZ, Fernandes R, *et al*. Acetic acid in the treatment of superficial wounds infected by *Pseudomonas Aeruginosa*. *Lancet* 1968;1:11–4.
- Milner SM. Acetic acid to treat *Pseudomonas Aeruginosa* in superficial wounds and burns. *Lancet* 1992;340:61.
- Taylor K. Treatment of *Bacillus Pyocyanus* infection. *JAMA* 1916;LXVII:1598.
- Fraise AP, Wilkinson MAC, Bradley CR, *et al*. The Antibacterial activity and stability of acetic acid. *J Hosp Infect* 2013;84:329–31.
- Tawre MS, Kamble EE, Kumkar SN, *et al*. Antibiofilm and Antipersister activity of acetic acid against extensively drug resistant *Pseudomonas Aeruginosa* Paw1. *PLoS One* 2021;16:e0246020.
- Phillips I, Lobo AZ, Fernandes R, *et al*. Acetic acid in the treatment of superficial wounds infected by *Pseudomonas Aeruginosa*. *Lancet* 1968;1:11–4.
- Sloss JM, Cumberland N, Milner SM. Acetic acid used for the elimination of *Pseudomonas Aeruginosa* from burn and soft tissue wounds. *J R Army Med Corps* 1993;139:49–51.
- Sloss JM, Cumberland N, Milner SM. Acetic acid used for the elimination of *Pseudomonas Aeruginosa* from burn and soft tissue wounds. *Journal of the Royal Army Medical Corps* 1993;139:49–51.
- Ryssel H, Kloeters O, Germann G, *et al*. The antimicrobial effect of acetic acid—an alternative to common local Antiseptics? *Burns* 2009;35:695–700. 10.1016/j.burns.2008.11.009 Available: <https://linkinghub.elsevier.com/retrieve/pii/S0305417908003616>
- Nagoba BS, Deshmukh SR, Wadher BJ, *et al*. Acetic acid treatment of Pseudomonal postoperative wound infection. *Journal of Hospital Infection* 1997;36:243–4.
- Salati S, Rather A. Management of Pseudomonal wound infection. *IJS* 2008;20:1–4.
- Madhusudhan VL. Efficacy of 1% acetic acid in the treatment of chronic wounds infected with *Pseudomonas Aeruginosa*: prospective randomised controlled clinical trial. *Int Wound J* 2016;13:1129–36.
- Nour S, Reid G, Sathanantham K, *et al*. Acetic acid dressings used to treat *Pseudomonas Colonised* burn wounds: A UK national survey. *Burns* 2022;48:1364–7.
- Halstead FD, Rauf M, Moiemien NS, *et al*. The Antibacterial activity of acetic acid against Biofilm-producing pathogens of relevance to burns patients. *PLoS One* 2015;10:e0136190.
- Halstead FD, Rauf M, Bamford A, *et al*. Antimicrobial dressings: comparison of the ability of a panel of dressings to prevent Biofilm formation by key burn wound pathogens. *Burns* 2015;41:1683–94.
- Zor F, Ozturk S, Bilgin F, *et al*. Pain relief during dressing changes of major adult burns: Ideal analgesic combination with ketamine. *Burns* 2010;36:501–5.
- Nagoba BS, Selkar SP, Wadher BJ, *et al*. Acetic acid treatment of Pseudomonal wound infections—a review. *Journal of Infection and Public Health* 2013;6:410–5.