A Pilot Multicenter Cluster Randomized Trial to Compare The Effect of Trauma Life Support Training Programs on Patient and Provider Outcomes

Trauma life support training Effectiveness Research Network (TERN) collaborators

Trial registration

This pilot study was registered with ClinicalTrials.gov (reg. no NCT05417243).

Corresponding author

Martin Gerdin Wärnberg (MGW)

Department of Global Public Health
Karolinska Institutet
171 77 Stockholm
Sweden

martin.gerdin@ki.se
+46 708 53 95 98 (mobile)

Authors

Contributors

Trauma life support Effectiveness Research Network (TERN) collaborators:

Martin Gerdin Wärnberg (MGW)

Department of Global Public Health, Karolinska Institutet, Stockholm, Sweden.

Function Perioperative Medicine and Intensive Care, Karolinska University Hospital, Solna, Sweden.

Johanna Berg (JB)

Department of Global Public Health, Karolinska Institutet, Stockholm, Sweden.

Emergency Medicine, Department of Internal and Emergency Medicine, Skåne University Hospital, Malmö, Sweden.

Prashant Bhandarkar (PB)

WHO collaboration Centre for Research in Surgical Care Delivery in LMIC, Mumbai, India.

Anirban Chatterjee (AC)

Department of Orthopaedic Sciences, Medica Superspecialty Hospital, Kolkata, India.

Shamita Chatterjee (SC)

Department of Surgery, Institute of Post Graduate Medical Education and Research, Kolkata, India.

Chintamani (C)

Department of Surgery, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India.

Li Felländer-Tsai (LFT)

Division of Orthopaedics and Biotechnology, Department of Clinical Science Intervention and Technology (CLINTEC), Karolinska Institutet, Stockholm, Sweden.

Department of Reconstructive Orthopedics, Karolinska University Hospital, Stockholm, Sweden.

Anita Gadgil (AG)

WHO collaboration Centre for Research in Surgical Care Delivery in LMIC, Mumbai, India.

Geeta Ghag (GG)

Department of Surgery, HBT Medical College And Dr. R N Cooper Municipal General Hospital, Mumbai, India.

Marie Hasselberg (MH)

Department of Global Public Health, Karolinska Institutet, Stockholm, Sweden.

Catherine Juillard (CJ)

Division of General Surgery, Department of Surgery, David Geffen School of Medicine at UCLA, Los Angeles, California, United States of America.

Monty Khajanchi (MK)

WHO Collaboration Centre for Research in Surgical Care Delivery in LMIC, Mumbai, India.

Seth G. S. Medical College and K.E.M. Hospital, Mumbai, India.

Deepa Kizhakke Veetil (DKV)

Department of Surgery, Manipal Hospital, Dwarka, New Delhi.

Vineet Kumar (VK)

Department of Surgery, Lokmanya Tilak Municipal Medical College and General Hospital, Mumbai, India.

Debabrata Kundu (DK)

Department of Surgery, Medical College Kolkata, Kolkata, India.

Anurag Mishra (AM)

Department of Surgery, Maulana Azad Medical College, New Delhi, India.

Priti Patil (PP)

WHO collaboration Centre for Research in Surgical Care Delivery in LMIC, Mumbai, India.

Nobhojit Roy (NR)

WHO Collaborating Center for Research on Surgical Care Delivery in LMICs, BARC Hospital, HBNI University, Mumbai, India.

Department of Global Public Health, Karolinska Institutet, Stockholm, Sweden.

Amit Roy (AR)

Department of Surgery, Sir Nil Ratan Sircar Medical College & Hospital, Kolkata, India.

Siddarth David (SD)

Department of Global Public Health, Karolinska Institutet, Stockholm, Sweden.

Doctors For You, Mumbai, India.

Rajdeep Singh (RS)

Department of Surgery, Maulana Azad Medical College, New Delhi, India.

Harris Solomon (HS)

Department of Cultural Anthropology and the Duke Global Health Institute, Duke University, Durham, USA.

Kapil Dev Soni (KDS)

Critical and Intensive Care, JPN Apex Trauma Center, All India Institute of Medical Sciences, New Delhi, India.

Lovisa Strömmer (LS)

Division of Surgery, Department of Clinical Science, Intervention and Technology (CLINTEC), Karolinska Institutet, Stockholm, Sweden.

Department of Surgery, Capio St Göran Hospital, Stockholm, Sweden.

Megha Tandon (MT)

Department of Surgery, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India.

Keywords

Trauma management, Accident and emergency medicine, Education and training.

Word Count

Role of study sponsor and funders

The funding sources had no role in the design of this study and will not have any role during its execution, analyses, interpretation of the data, or decision to submit results.

Abstract

Introduction Several trauma life support programs aim to improve trauma outcomes but there is no evidence from controlled trials to show the effect of these programs on patient outcomes. We conducted a pilot study to assess the feasibility of conducting a cluster randomised controlled trial comparing the effect of Advanced Trauma Life Support (ATLS) and Primary Trauma Care (PTC) with standard care on patient outcomes. **Methods and analysis** We piloted a pragmatic three-armed parallel, cluster randomised, controlled trial in India, where neither of these programs are routinely taught. We recruited tertiary hospitals and included trauma patients and residents managing these patients. Two hospitals were randomised to ATLS, two to PTC, and three to standard care. The primary outcome was all cause mortality at 30 days from the time of arrival to the emergency department. We conducted community consultations in parallel with the pilot trial. **Ethics and dissemination** We obtained ethical approval from all participating centres. **Results** Between April 2022 and November 2022 we included 206 patients and 21 residents from 5 centres. The patient recruitment rate was X and the resident recruitment rate was X. The loss to follow up rate was X. The all-cause 30 day mortality was X in the ATLS arm, X in the PTC arm, and X in the standard care arm. **Conclusions** Conducting a full-scale cluster randomised controlled trial comparing the effects of ATLS, PTC, and standard care on patient outcomes should be feasible after incorporating key lessons from this pilot.

Article Summary

Strengths and limitations of this study:

- Cluster randomized controlled trial comparing the effect of ATLS, PTC and standard care on patient and provider outcomes.
- Prospective data collection with direct observations by dedicated project officers.
- Participating centers' heterogeneity may affect the study estimates and bias the results.

Introduction

Trauma, defined as the clinical entity composed of physical injury and the body's associated response, causes 4.5 millions deaths every year[1]. Almost 10% of the global burden of disease is due to trauma and trauma is the top contributor to the burden of disease in children and adults aged 10 to 49 years[2].

Trauma care is time sensitive and early management of life or limb threatening conditions is crucial. Several trauma life support training programs have been developed to improve the early management of patients as they arrive at hospital by providing a structured framework to assessment and treatment[3–5].

The proprietary Advanced Trauma Life Support (ATLS) is the most established trauma life support training program and more than one million doctors in over 80 countries have been trained in the program[6]. Uptake in low- and middle income countries (LMIC) has been slow, potentially due to high costs[5].

The free Primary Trauma Care (PTC) program is the most widely spread alternative program. The goal of PTC is to improve trauma care in LMIC[7]. Like ATLS, doctors in over 80 countries have been trained in PTC, and the program has been endorsed by the World Health Organization (WHO), among other international organizations including several professional societies[7].

Despite the widespread use of these training programs there are no controlled trials showing that they impact patient outcomes[3–5]. A systematic review report that hospital trauma life support training is associated with a reduction in patient mortality, based on studies that were either observational or quasi-experimental without a control group[8].

We will perform a pilot study that aims to assess the feasibility of conducting a cluster randomised controlled trial comparing ATLS and PTC with standard care. Recent methodological guidelines indicate that the design of efficient cluster randomised controlled trials requires data on probable or target effect sizes, proportion of participants with the outcome (if binary), and the intracluster correlation coefficient[9]. The objectives of this pilot study will be to:

- Estimate probable effect sizes on patient outcomes associated with ATLS and PTC compared with standard care, estimate the proportion of participants with the outcome (if binary), and estimate the intracluster correlation coefficient, as a basis for future sample size calculations.
- Assess the feasibility of recruiting participants and collecting data on primary and secondary outcomes, such as mortality, in-hospital complications, length of stay, and quality of life.
- Assess how the effect sizes and directions of these effects of ATLS and PTC may differ across clinically important subgroups.

Methods

Trial Design

This study will pilot a pragmatic three-armed parallel, cluster randomised, controlled trial. There will be two intervention arms, ATLS and PTC training, and one control arm, standard care. We will collect data for four months in all three arms, first during a one month observation phase and then during a three month intervention phase (or continued observation in the control arm). This design will allow us to assess outcomes both as final values and as change from baseline. Our study is a pilot study because its objectives involves estimating quantities, such as the probable effect sizes, proportion of participants with the outcome (if binary), and the intracluster correlation coefficient, needed for the sample size calculations of a full-scale trial[9]. The full-scale trial will be planned regardless of the effect-sizes identified in this pilot study. This pilot study will also establish how many participants that can be enrolled, as well as likely drop out rates, and the feasibility of collecting primary and secondary outcomes.

Study Setting

We conducted this pilot in seven Indian tertiary hospitals, where neither ATLS, PTC, nor any other trauma life support training program is routinely taught. India is the world's second most populous country and has 20% of the world's trauma deaths. The trauma system is still developing, with limited prehospital care, and the in hospital trauma mortality as well as the proportion of preventable deaths remain high. Lack of standard trauma training for healthcare providers, limited hospital resources, inadequate processes of care, overcrowding emergency departments - are some of the factors that contribute to the high mortality and morbidity. During recent years efforts have been made to improve hospital trauma care, through capacity building for trained trauma care providers, augmenting facilities, and developing care protocols within the hospitals. We will conduct this trial in India because training providers in a trauma life support program is not yet the standard.

The seven hospitals were King Edward Memorial Seth G. S. Medical College and K.E.M. Hospital, Mumbai; Lokmanya Tilak Municipal Medical College and General Hospital, Mumbai; HBT Medical College And Dr. R N Cooper Municipal General Hospital, Mumbai; Medica Superspecialty Hospital, Kolkata; Medical College Kolkata, Kolkata; Sir Nil Ratan Sircar Medical College & Hospital, Kolkata; Postgraduate Institute of Medical Education & Research, Chandigarh.

Eligibility Criteria for Participants and Clusters

There will be two groups of participants: patients and resident doctors.

Patient Participants

Adults (15 years or older) who present to the emergency department at participating hospitals with a history of trauma. History of trauma is here defined as having any of the external causes of morbidity and mortality listed in block V01-Y36, chapter XX of the International Classification of Disease version 10 (ICD-10) codebook as reason for presenting. We will explore intervention effects across the following clinical subgroups: men, women, blunt multisystem trauma, penetrating trauma, shock, severe traumatic brain injury, and elderly, as defined by Hornor et al[10]. The consent form for patients are available as Supplemental Material 1.

Resident Doctor Participants

Resident doctors doing their speciality training in surgery (in India it is very rare to have emergency medicine managing trauma patients in the emergency department, why we decide to focus on surgical units in this pilot), who manage trauma patients in the emergency department, and who are expected to remain in the participating hospitals for at least one year. To facilitate administration each surgical department is divided into units, which manages the out patient department, emergency department, operating rooms etc on different days each week. One or two, out of typically six, units' residents will be selected from each hospital. One unit consists of at least three faculty and three to twelve residents.

To be eligible, units should have a maximum of 25% of the doctors trained in either ATLS, PTC, or similar training programs before the start of the pilot (hospitals that have so far agreed to participate have no or single current residents trained in any program). Those residents who have received training in the last five years will be considered as trained. The figure of 25% was decided through consensus in the research team, to balance feasibility and contamination of results. We will select the units by conducting a prior survey to ascertain this criteria. Consent will be sought from the residents in each of the intervention groups before they undergo the ATLS or PTC training. The consent form for residents are available as Supplemental Material 2. We will not ask for consent from residents at the units in the control hospitals as their practice will not be affected by this pilot and we will not collect any personal identifiable data on them. This is in line with ethical regulations in the study setting.

Clusters

Indian tertiary care hospitals that admit 400-800 adult patients with trauma each year. We randomise on the cluster (hospital) level to avoid contamination between intervention and control arms. To be eligible for

inclusion hospitals have to provide the following services round the clock: operation theatres, X-ray, CT, and ultrasound facilities, and blood bank. In addition the baseline admission rate should be more than 35 adult patients with major trauma per month.

Interventions

In each intervention arm one or two units', out of typically six, residents per hospital providing emergency care to trauma patients will be trained in either ATLS or PTC. For the purpose of this pilot study, we will target to train a minimum of 75% of residents in each unit. If residents drop out or change units after training but before data collection is completed we will conduct additional training if needed to meet the 75% criterion. We will not train the units' faculty, as they are typically not involved in the initial management of trauma patients.

The ATLS training will be conducted in the nearest ATLS certified training centre in India according to the standard ATLS curriculum[6]. The PTC training will be arranged in hospitals randomized to the PTC arm, according to the standard PTC curriculum[7]. These courses will be conducted over a period of 2.5 to 3 days. The residents certified "pass" will be considered as trained in respective courses.

The control group provides standard care with no intervention.

Modifications

Both ATLS and PTC are standard training programs with fixed curricula[6,7]. We will not modify the delivery or content of these programs during this pilot.

Adherence

The intervention is the training in either ATLS or PTC. Participants are required to adhere to, i.e. participate in, the training, to be eligible for passing. We will not consider adherence to training contents during care delivery as adherence to the trial intervention, but rather as a provider level outcome.

Concomitant Care

Baseline Training

The care provided by all participating hospitals at baseline is based on the training curriculum formulated by The National Medical Council of India for post graduation in General Surgery[11]. Regarding trauma, these guidelines state that the student should:

a. Have knowledge about response to trauma; burns: causes, prevention and management; wounds of scalp and its management; recognition, diagnosis and monitoring of patients with head injury, Glasgow coma scale.
b. Be able to provide and coordinate emergency resuscitative measures in acute surgical situations including trauma.
c. Choose, perform and interpret appropriate imaging in trauma - ultrasound Focused Abdominal Sonography in Trauma (FAST).
d. Undergo advanced trauma and cardiac life support course (certified) before appearing in final examination.
e. Undergo clinical posting in emergency and trauma.
f. Present or discuss cases of blunt abdominal trauma.

Although training in an advanced trauma life support course is part of the curriculum it is optional and not doing this training does not result in failure to obtain post graduation completion.

Standard of Care

At most medical colleges in India trauma patients present to the emergency department where they are assessed by a doctor and referred to the surgical bay for further management. In the surgical bay a second or

third year general surgery resident sees all the major trauma and provide the initial care, including initiating treatment and investigations. This resident informs the consultant on call who is generally an Assistant Professor. Most procedures like intercostal drainage, open wound suturing, intubation etc. would be done in the surgical resuscitation area, by the surgical resident.

Compared to other settings where a trauma team approach is adopted, nurses and other healthcare professionals are involved to a limited extent during the initial management. Their roles include assisting during intubation and other bedside procedures, charting the vitals (not recording) and giving injections. They also accompany the resident during transfers of serious patients.

After completing the assessment and starting initial resuscitation, the resident decides to send the patient for imaging (X-rays/FAST/CT-scan) or to the operation room in consultation with or after assessment by the on-call consultant. A portable X-ray and an ultrasonography machine to conduct FAST may or may not be available in the surgical bay. The patients who are operated, managed conservatively, not intubated, or with minor trauma will be sent to the surgical ward. Those who need increased monitoring or mechanical ventilation remain in the surgical bay or in the intensive care unit (ICU) depending on the availability of ICU beds. The further treatment continues in the respective ward or ICU and patients are finally discharged from the ward.

Outcomes

Our pilot study include both participant and feasibility outcomes. Prior to deciding on these participant outcomes we searched the Core Outcome Measures in Effectiveness Trials (COMET) Initiative's database but were unable to identify appropriate core outcome sets for our populations of participants.

The primary participant outcome will be all cause mortality within 30 days from the time of arrival to the emergency department. The primary outcome and most secondary outcome will be assessed and compared both as final values and as change from baseline. All outcomes that pertain to the individual participant level are detailed in Supplemental Material 3. We decided to include a large number of outcomes, including some more exploratory, so that we can test their feasibility and relevance. We may remove secondary participant outcomes during the course of the pilot study, if they prove to be too difficult to collect. If we remove outcomes we will document the reasons for doing so.

We will also assess the following feasibility outcomes, which pertain both to overall study population as well as to the individual cluster level:

- Recruitment rate. For both patients and residents this will equal the proportion of participants enrolled, out of the total number of eligible participants, over the course of the pilot study.
- Lost to follow up rate. This will apply only to patients and equal the proportion of patients that do not complete 30 day follow up, out of all enrolled patients, over the course of the pilot study.
- Pass rate. This will apply only to residents in the intervention arms and equal the proportion of residents that pass the training programme, out of the total number of trained residents, over the course of the pilot study.
- Missing data rate. This will apply to each outcome and variable and equal the proportion of missing data, over the course of the pilot study.
- Differences in distributions of observed and extracted data. This will apply to each outcome and variable and will compare the distributions of data collected by observations versus extracted from hospital records. For quantitative variables this will be the difference in means, standard deviations, medians, interquartile ranges, and ranges. For qualitative variables this will be the differences in absolute counts and percentages, across categories.

Participant Timeline

Patients

Patients will be screened for eligibility as they arrive at the emergency department. Eligible patients will be approached in the emergency department to consent to follow up, if they are conscious. If they are

unconscious a patient representative will be approached to consent to follow up. Once the patient is conscious we will approach the patient to affirm the patient representative's consent. We will follow up patients at discharge, at 24 hours after arrival at the emergency department, and at 30 days after arrival at the emergency department.

Residents

Surgical units will be screened for eligibility once hospitals confirm their participation. All residents in eligible units will be approached to consent to training if their hospital is randomised to either of the intervention arms. Training will be conducted as soon as possible after the study starts. Resident participants will be followed up 30 days after training, if they are in the intervention arms, or 30 days after the study started, if they are in the control arm.

Sample size

Given budget and time constraints, including the rotation of surgical units in Indian hospitals (which often happen on a six months basis) the feasible data collection period is four months. Each of the surgical units see 2-4 trauma patients per week. If we select a minimum of one unit per hospital then each hospital will enrol 8-16 patients per month and 32-64 patients during the four months of this pilot. With a 20% attrition rate we expect each hospital to enrol 26-51 patients, coming to a total sample size of between 156 and 306 patients for this pilot study.

Recruitment

To ensure adequate recruitment we only approach hospitals with trauma volumes high enough to allow us to reach the sample size goals detailed above. Patients will be enrolled by a dedicated project officer as they arrive at the emergency department. The recruitment period will be three months. Recruitment will be monitored weekly through online conferences. No financial or non-financial incentives will be provided to trial investigators or participants for enrolment.

Allocation

Sequence generation

We used simple randomisation to allocate sites to trial arms. We prepared seven sealed envelopes from which one representative from each pilot site selected one in a common meeting on March 7, 2022.[1]. The content of the envelopes dictated what trial arm (ATLS, PTC, or standard care) each hospital was allocated to. There were two hospitals in each of the intervention arms and three hospitals in the control arm.

Concealment Mechanism

We did not conceal the sequence.

Implementation

The random allocation sequence was generated by MGW. Clusters were enrolled by the project's core team, who also enrolled clusters. Patient participants will be included if they present during the project officers shift. Resident participants are enrolled if they are in the units selected for training. We will use simple random sampling to select units if there are more than two eligible units in a hospital. For patient participants consent for follow up is sought after randomisation from patients or patient relatives as appropriate. For resident participants consent is sought before randomisation. If residents in a unit decline to participate, so that the target of training 75% of residents in a given unit cannot be met, another unit will be selected for participation.

[1]Initially the plan was to enroll six hospitals (clusters) but we ended up enrolling seven.

Blinding

It will not be possible to blind investigators or participants to interventions. We will not blind the data analysts during this pilot, but we plan to blind the data analysts during the full-scale trial.

Data Collection

Data collection will start one month before the training is delivered, to establish a baseline. A variability of three months of the date when data collection is started between hospitals will be accepted. Each participating hospital will have a dedicated project officer to collect data. The project officers will have a masters in a health science field and should have experience in data collection.

Because participating residents are assigned designated days for trauma care for a period of 6 months, data will be collected during those particular days and shifts when these trained doctors are in the emergency department. The project officers will collect data both by observing the care delivered and by interviewing the participants, and by extracting data from hospital records.

Data collection will continue for a minimum of three months after training. The research officers will collect data of all patients, who present with trauma in the surgical bay during their duty hours. Those patients who are admitted will be followed up for complications and other in-hospital outcome measures, for example length of stay. Patients who are not admitted will be followed up telephonically for mortality outcomes and quality of life outcomes. The follow up period will be 30 days. The project officers will make at most three attempts to reach a participant or participant representative telephonically, after which the data will be recorded as missing.

The project officer will administer the study information and informed consent (consent will only be sought for data collection including follow up) to the patient, or the patient's representative as appropriate, once the patient is stabilised. They will continue to collect data once they have received the consent.

Details of data of those patients/relatives not willing to give consent will be removed from the analysis. The number of patients who opt out from data collection will be collected, as well as limited data on their age and sex. Patients will be followed up in the ward regularly for the various outcome variables. They will also be followed up telephonically after they have been discharged.

Variables

The project officers will collect data on demographics, time of injury to arrival at the participating hospital, time to recording vital signs, vital signs, and times to and management details including imaging and surgery. Details of any injury sustained will be collected and coded using ICD 10 and the Abbreviated Injury Scale (AIS). For ICD 10 coders will undergo the WHO online ICD 10 training module and for AIS they will be accredited. Based on AIS we will calculate the Injury Severity Score (ISS) and the New ISS (NISS). Supplemental Material 4 contains a full variable list, with definitions.

Patient and public involvement

In this study, we will conduct community consultations to collect inputs from patients, their caregivers, patient groups, and resident doctors to be used in the selection of outcome measures and implementation of the full-scale trial; following the Guidance for Reporting Involvement of Patients and the Public (GRIIPS 2)[12].

During the pilot study, interviews will be conducted with post-discharge trauma patients and their caregivers to identify outcomes most relevant to them. These patients will be identified through the medical registers of the participating hospitals, contacted through telephone, and after receiving their consent be interviewed as per their convenience. Their consent form is available as Supplemental Material 5. Additionally, members from non-government organizations working with trauma patients and the hospital Social Service Section will also be contacted for their views on contextual patient-centred outcomes for trauma patients. Their consent form is available as Supplemental Material 6. For feasibility, these interviews will be held in each of the cities

where the participating centres are located. The commonest patient-centred outcomes reported across all the locations will be incorporated into the evaluation of the effects of the different training programs and standardized care on patient outcomes.

Similarly, the inputs of resident doctor participants at each participating centre will be collected during the pilot study. A discussion and periodic surveys will be conducted to document any challenges or suggestions they may have in the scheduling or implementation of the training programs. These inputs will be incorporated in the final study.

A summary of the findings of the study as well as their inputs will be shared with those who participated in the interviews and surveys. A meeting will be held with the patient participants, at each city, where the changes in the measured patient-centered outcomes would be presented to them. Another meeting will be held with the resident doctors at each hospital to present the confidence of the residents after being trained. Any suggestions and reflections from the participants during the meetings will be used as inputs for planning the final study.

Data management

We will supply an online data collection tool, accessible only over a virtual private network (VPN), for each participating hospital to upload pseudonymised data to secure servers. Data validation techniques like restricted values or values of a specific range will be used to avoid ambiguous data entries and ensure the validity of the data. Ambiguous responses, data errors, if any, will be resolved after discussion with the core team during weekly meetings. An instruction manual or codebook for data variables will be prepared to ensure consistency in data entry. This manual will be referred to during the project data collection and variable descriptions are visible for each variable in the online data collection tool. Pseudonymised data will be stored at the centralised server. The data will be accessible by the project's principal investigator or by delegation of the project principal investigator only.

Data monitoring

Weekly meetings with the core team and project officers will take place and for this meeting a data status report will be automatically generated highlighting missing data and number of patients awaiting followup. We conducted an interim analysis on October 12, 2022, and decided to complete the study as participants were consenting to be included in the study and key variables including mortality outcomes could be collected. No outcomes were dropped. We did not use a data monitoring committee in the pilot study due to its limited scope.

Statistical Methods

We will analyse all pilot data using descriptive statistics. Quantitative variables will be summarised as mean +/- standard deviation, median, interquartile range and range. Qualitative variables will be presented as absolute numbers and percentages. Feasibility outcomes will be summarised both on the overall sample level as well as on the individual cluster level. We will use an empty generalised linear mixed model to estimate the intracluster correlation coefficient.

We will compare participant outcomes in three combinations of trial arms: ATLS versus PTC, ATLS versus standard care, and PTC versus standard care. In each combination we will compare both differences in final values and differences in change from baseline. For example, for the primary participant outcome of all cause mortality within 30 days from the time of arrival to the emergency department, comparing ATLS versus PTC, we will compare both the difference in mortality between the ATLS and PTC arms as well as the difference in the change from baseline in mortality between the ATLS and PTC arms.

For the intervention arms the change from baseline will be calculated as the difference between the one month period of data collection before the training was undertaken and the three month period after the training. For the control arm the data collection period will be four months and the difference from baseline will be calculated as the difference between the first one month and the following three months.

Within each combination of trial arms we will conduct subgroup analyses of men, women, blunt multisystem trauma, penetrating trauma, shock, severe traumatic brain injury, and elderly. Table S7.1 in Supplemental Material 7 shows which outcomes will be assessed in which subgroups, decided through consensus in the research team. We will further compare the results of all subgroups with the results in the whole cohort, and compare the results in the female subgroup with the male subgroup, and the results in the blunt multisystem trauma subgroup with the penetrating trauma subgroup. We are aware that the numbers in some of these subgroups are likely to be small, but we include them to help guide the formulation of the statistical analysis plan for the full-scale trial.

We will calculate both absolute and relative differences for each comparison, along with 75, 85, and 95% confidence intervals. We will use an empirical bootstrap procedure with 1000 draws to estimate these confidence intervals. We will not perform any formal hypothesis tests during the analysis of this pilot's data[13]. We will also compare the data collected through observations and interviews with the data collected from hospital records, to assess the feasibility of collecting data from hospital records in the full-scale trial.

Ethics and Dissemination

We were granted research ethics approval from each participating hospital. The approval numbers were IEC(II)/OUT/134/2022 for King Edward Memorial Seth G. S. Medical College and K.E.M. Hospital, Mumbai; IEC/214/22 for Lokmanya Tilak Municipal Medical College and General Hospital, Mumbai; HBTMC/266/SURGERY for HBT Medical College And Dr. R N Cooper Municipal General Hospital, Mumbai; CREC/2022/FEB/1(ii) for Medica Superspecialty Hospital, Kolkata; Medical College Kolkata, Kolkata; NRSmC/IEC/93/2021 for Sir Nil Ratan Sircar Medical College & Hospital, Kolkata; and PGI/IEC/2022/000/003 for Postgraduate Institute of Medical Education & Research, Chandigarh.

The protocol was published in BMJ Open[14] and was registered with ClinicalTrials.gov (reg. no NCT05417243). Amendments to the protocol after publication were determined by the core research group and updated on ClinicalTrials.gov.

The final anonymized dataset and code for analysis are released publicly. Authorship follows the International Committee of Medical Journal Editors (ICMJE) guidelines.

Results

Note that participating centres are randomly assigned to the different arms every time this manuscript is compiled

Between April 2022 and November 2022, we enrolled 206 trauma patients from 5 participating centres. The ATLS arm enrolled 77 patients, the PTC arm 103 patients, and the standard care arm 26 patients. We trained a total of 21 residents, 6 in ATLS, and 15 in PTC.

The study flowchart is shown in Figure X and patient sample characteristics across trial arms are shown in Table 1. Overall, the number of females were X (X%), the median age was X (IQR X), and the median ISS was X (IQR X). A total of X (X%) patients had the primary outcome of mortality at 30 days after arrival to the emergency department.

Patient Participant Outcomes

In the post training period, a total of X (X%) patients in the ATLS arm had the primary outcome, compared to X (X%) patients in the PTC arm, and X (X%) patients in the standard care arm. The differences between the arms were X (95% CI X - X) between the ATLS and PTC arms, X (95% CI X - X) between the ATLS and standard care arms, and X (95% CI X - X) between the PTC and standard care arms. The change from baseline for the primary outcome was X in the ATLS arm, X in the PTC arm, and X in the standard care arm. The differences between changes from baseline were X (95% CI X - X) between the ATLS and PTC arms, X (95% CI X - X) between the ATLS and standard care arms, and X (95% CI X - X) between the PTC and standard care arms. Table X shows differences in the primary outcome between trial arms with

Table 1: Patient sample characteristics

	Male	Female	Other	Unknown	Overall
	(N=153)	(N=53)	(N=0)	(N=0)	(N=206)
Patient age					
Mean (SD)	33.9 (14.3)	39.6 (16.5)	NA	NA	35.4 (15.0)
Median [Min, Max]	31.0 [17.0, 85.0]	38.0 [15.0, 81.0]	NA	NA	32.0 [15.0, 85.0]
Type of injury produced by the trauma.					
Penetrating	4 (2.6%)	1 (1.9%)	NA	NA	5 (2.4%)
Blunt	149 (97.4%)	52 (98.1%)	NA	NA	201 (97.6%)
Respiratory rate recorded in the emergency department.					
Mean (SD)	21.0 (3.09)	21.9 (3.14)	NA	NA	21.3 (3.12)
Median [Min, Max]	21.0 [12.0, 29.0]	21.0 [16.0, 31.0]	NA	NA	21.0 [12.0, 31.0]
Missing	7 (4.6%)	1 (1.9%)	NA	NA	8 (3.9%)
Saturation recorded in the emergency department.					
Mean (SD)	97.5 (2.21)	98.3 (0.812)	NA	NA	97.7 (1.97)
Median [Min, Max]	98.0 [80.0, 100]	98.0 [95.0, 99.0]	NA	NA	98.0 [80.0, 100]
Missing	1 (0.7%)	0 (0%)	NA	NA	1 (0.5%)
Heart rate recorded in the emergency department.					
Mean (SD)	89.8 (19.4)	92.0 (17.6)	NA	NA	90.4 (18.9)
Median [Min, Max]	87.0 [46.0, 144]	92.0 [48.0, 128]	NA	NA	89.0 [46.0, 144]
Missing	1 (0.7%)	0 (0%)	NA	NA	1 (0.5%)
Systolic blood pressure in the emergency department.					
Mean (SD)	126 (20.8)	126 (26.1)	NA	NA	126 (22.3)
Median [Min, Max]	124 [72.0, 210]	118 [76.0, 205]	NA	NA	123 [72.0, 210]
Missing	8 (5.2%)	1 (1.9%)	NA	NA	9 (4.4%)

75, 85, and 95% CIs. Differences in secondary outcomes between trial arms and subgroups are available as Supplementary material X.

Resident Participant Outcomes

A total of X residents were trained during this pilot. Overall their confidence in managing trauma patients was X (IQR X - X) on a 10 point Likert scale with 10 being most confident. In the post training period, the confidence in the ATLS arm was X (IQR X - X), compared to X (IQR X - X) in the PTC arm, and X (IQR X - X) in the standard care arm.

Feasibility Outcomes

Out of X potentially eligible patients, X (X%) patients were enrolled in the study. Out of X potentially eligible residents, X (X%) were enrolled in the study. The loss to follow up rate was X, with X out of X patients not completing 30 day follow up. Among residents the pass rate, after two attempts, was X (X%). The missing data rate ranged from X to X, with details per variable and outcome in Table X. The differences in distributions between observed and extracted data, for variables that were collected through observation or interview, are shown in Table X.

Community Consultations

The results of interviews with patients, caregivers and social workers will be published separately. Residents felt that...

Discussion

We show that conducting a cluster randomized controlled trial comparing ATLS with PTC and standard care is feasible in this setting provided that there are dedicated project officers to enrol participants, collect data, and follow up participants. Missing data rates were low for the primary outcome and many secondary outcomes, as well as for key variables. Some variables had very high missing data rates and may not be feasible to include in a full-scale trial.

We found that the ATLS arm had lower 30-day mortality compared to the PTC and standard care arms.

We found that the PTC arm had lower 30-day mortality compared to the ATLS and standard care arms.

We found that the standard care arm had lower 30-day mortality compared to the ATLS and PTC arms.

We found that 30-day mortality was similar in the ATLS and PTC arms but lower than the standard care arm.

We found that 30-day mortality was similar in the ATLS and standard care arms but lower than the PTC arm.

We found that 30-day mortality was similar in the PTC and standard care arms but lower than the ATLS arm.

The primary patient participant outcome, all-cause 30-day mortality, was missing in X% of patients. This may appear high, especially compared to for example the CRASH-2 and REACT-2 trials, which report missing primary outcome in less than 0.01% of patients[15,16]. Like many other trauma trials, both CRASH-2 and REACT-2 used in-hospital mortality as their primary outcome measure, whereas we attempted to follow up patients after discharge. The missing data rate for in-hospital mortality was only X%, comparable to previous trials.

During the course of this pilot we deviated from the protocol in multiple ways, and provide a detailed list as Supplementary material. Some key limitations of this pilot and therefore lessons to be learned and factored into the design of the full-scale trial include the lower than expected enrolment rates of some centres, centre specific management routines, and difficulties in collecting data on complications and cause of death. We

minimised the impact of the lower than expected enrolment rates by including a seventh centre, but on-site observations of patient volumes are likely to be needed for the full-scale trial. We decided to be pragmatic in selecting which residents to train and how to structure the data collection depending on how and by whom patients were initially managed, but this flexibility will need to be built into the full-scale trial protocol. Finally, we found that data on complications and cause of death were hard to identify and therefore the full-scale trial will need to include longer training of project officers.

Previous studies on the effect of in-hospital trauma life support training on patient outcomes are observational or quasi-experimental without a control group, with heterogeneous results[17–21]. Studies from Trinidad and Tobago, El Salvador, Rwanda, and Cambodia found no significant effect on patient mortality after implementing in-hospital trauma life support training[17–20], whereas one study from China that included 820 patients found a significant reduction in mortality, from 20 to 15%, after implementing ATLS[21].

Several controlled trials, including at least two randomized controlled trials[22,23], show that ATLS is associated with improved provider skills[3]. Observational evidence indicates that PTC also leads to improved provider skills[5]. The missing link is then how, and if, these improved skills translate into improved patient outcomes. As trauma care providers we assume, and probably rightly so, that we deliver better care if we train. The question is then how we should train, especially considering the costs associated with some of the programs offered.

We conclude that a full-scale cluster randomised trial should be feasible after incorporating the lessons of this pilot, and that this full-scale trial should, regardless of its outcome, influence how we train trauma care providers in the future.

Contributorship statement

MGW conceived of the study. AG, AM, CJ, DKV, HS, JB, KDS, LFT, LS, MH, MGW, MK, NR, PB, PP, RS, SD, and VK contributed to the design of the study. DKV, KDS, MK, and MGW drafted the first version of the protocol. AG, HS, and SD drafted the first version of the patient and public involvement activities. JB and PP drafted the first versions of the data management sections and wrote the data management plan. PB and PP drafted the first versions of the statistical analysis section. AG, AM, CJ, DKV, HS, JB, KDS, LFT, LS, MH, MGW, MK, NR, PB, PP, RS, SC, SD, and VK contributed to the refinement of the protocol. AR, AC, C, DK, GG, MK, MT, and VK are representatives of prospective participating hospitals.

Competing Interests

Several authors are Advanced Trauma Life Support or Primary Trauma Care instructors.

Funding

Doctors for You through grants awarded to Karolinska Institutet by the Swedish Research Council (grant number 2020-03779) and the Laerdal Foundation (grant number 2021-0048).

Data Sharing Statement

The final anonymized dataset and code for analysis will be released publicly.

Protocol Deviations

Trial Registration

We intended to also register our trial with Clinical Trials Registry - India but because of time constrains we had to initiate the study before registration was finalised, and Clinical Trials Registry - India only allow

prospective registration.

Number of Participating Centres

We ended up recruiting seven centres instead of six and therefore assigned two centres each to the intervention arms and three centres to the control arm.

Resident Participants

Emergency medicine in addition to surgery.

Periodic suverys to residents

We did not distribute periodic surveys to the participating residents but discussed challenges and suggestions that they had regarding the scheduling or implementation of the training programs.

Data collection from records

We decided to record data from records only for a subset of patients to reduce the project officers' workload.

References

1. Naghavi, M. *et al.* Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: A systematic analysis for the global burden of disease study 2016. *The Lancet* **390**, 1151–1210 (2017).

2. Vos, T. *et al.* Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: A systematic analysis for the global burden of disease study 2019. *The Lancet* **396**, 1204–1222 (2020).

3. Mohammad, A. *et al.* Educational and clinical impact of advanced trauma life support (atls) courses: A systematic review. *World Journal of Surgery* **38**, 322–329 (2013).

4. Jayaraman, S. *et al.* Advanced trauma life support training for hospital staff. *Cochrane Database of Systematic Reviews* (2014).

5. Kadhum, M. *et al.* Are primary trauma care (ptc) courses beneficial in low- and middle-income countries - a systematic review. *Injury* **51**, 136–141 (2020).

6. American College of Surgeons, C. on T. *Advanced trauma life support® student course manual.* (American College of Surgeons, 2018).

7. Foundation, P. T. C. *Primary trauma care course manual for trauma management in locations wih limited resources.* (Primary Trauma Care Foundation, 2018).

8. Jin, J. *et al.* Effectiveness of quality improvement processes, interventions, and structure in trauma systems in low- and middle-income countries: A systematic review and meta-analysis. *World Journal of Surgery* **45**, 1982–1998 (2021).

9. Hemming, K. *et al.* How to design efficient cluster randomised trials. *BMJ* j3064 (2017).

10. Hornor, M. A. *et al.* Quality benchmarking in trauma: From the ntdb to tqip. *Current Trauma Reports* **4**, 160–169 (2018).

11. India, M. C. of. *Guidelines for competency based postgraduate training programme for ms in general surgery.* (Medical Council of India, 2019).

12. Staniszewska, S. *et al.* GRIPP2 reporting checklists: Tools to improve reporting of patient and public involvement in research. *BMJ* j3453 (2017).

13. Lee, E. C. *et al.* The statistical interpretation of pilot trials: Should significance thresholds be reconsidered? *BMC Medical Research Methodology* **14**, (2014).

14. Gerdin Wärnberg, M. *et al.* A pilot multicentre cluster randomised trial to compare the effect of trauma life support training programmes on patient and provider outcomes. *BMJ Open* **12**, e057504 (2022).

15. Roberts, I. *et al.* The crash-2 trial: A randomised controlled trial and economic evaluation of the effects of tranexamic acid on death, vascular occlusive events and transfusion requirement in bleeding trauma patients. *Health Technol Assess* **17**, (2013).

16. Sierink, J. C. *et al.* Immediate total-body ct scanning versus conventional imaging and selective ct scanning in patients with severe trauma (react-2): A randomised controlled trial. *The Lancet* **388**, 673–683 (2016).

17. Ariyanayagam, D. *et al.* The impact of the atls course on traffic accident mortality in trinidad and tobago. *West Indian Medical Journal* **41**, 72–74 (1992).

18. Cioè-Peña, E. *et al.* Development and implementation of a hospital-based trauma response system in an urban hospital in san salvador, el salvador. *Trauma* **19**, 118–126 (2016).

19. Petroze, R. T. *et al.* Can focused trauma education initiatives reduce mortality or improve resource utilization in a low-resource setting? *World Journal of Surgery* **39**, 926–933 (2014).

20. Van Heng, Y. *et al.* Non-doctors as trauma surgeons? A controlled study of trauma training for non-graduate surgeons in rural cambodia. *Prehospital and Disaster Medicine* **23**, 483–489 (2008).

21. Wang, P. *et al.* Comparison of severe trauma care effect before and after advanced trauma life support training. *Chinese Journal of Traumatology (English Edition)* **13**, 341–344 (2010).

22. Ali, J. *et al.* Teaching effectiveness of the advanced trauma life support program as demonstrated by an objective structured clinical examination for practicing physicians. *World Journal of Surgery* **20**, 1121–1126 (1996).

23. Ali, J. *et al.* Comparison of performance of interns completing the old (1993) and new interactive (1997) advanced trauma life support courses. *The Journal of Trauma: Injury, Infection, and Critical Care* **46**, 80–86 (1999).