Selective computed tomography (CT) versus routine thoracoabdominal CT for high-energy blunt-trauma patients (Review)

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[Intervention Review]

Selective computed tomography (CT) versus routine thoracoabdominal CT for high-energy blunt-trauma patients

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Editorial group: Cochrane Injuries Group.
Publication status and date: New, published in Issue 12, 2013.
Review content assessed as up-to-date: 9 May 2013.

Citation: Van Vugt R, Keus F, Kool D, Deunk J, Edwards M. Selective computed tomography (CT) versus routine thoracoabdominal CT for high-energy blunt-trauma patients. *Cochrane Database of Systematic Reviews* 2013, Issue 12. Art. No.: CD009743. DOI: 10.1002/14651858.CD009743.pub2.

ABSTRACT

Background

Trauma is the fifth leading cause of death worldwide, and in people younger than 40 years of age, it is the leading cause of death. During the resuscitation of trauma patients at the emergency department, there are two different commonly used diagnostic strategies. Conventionally, there is the use of physical examination and conventional diagnostic imaging, potentially followed by selective use of computed tomography (CT). Alternatively, there is the use of physical examination and conventional diagnostics, followed by a routine (instead of selective) use of thoracoabdominal CT. It is currently unknown which of the two strategies is the better diagnostic strategy for patients with blunt high-energy trauma.

Objectives

To assess the effects of routine thoracoabdominal CT compared with selective thoracoabdominal CT on mortality in blunt high-energy trauma patients.

Search methods

We searched the Cochrane Injuries Group's Specialised Register, Cochrane Central Register of Controlled Trials (Issue 4, 2013); MEDLINE (OvidSP), EMBASE (OvidSP) and CINAHL for all published randomised controlled trials (RCTs). We did not restrict the searches by language, date or publication status. We conducted the search on the 9 May 2013.

Selection criteria

We included RCTs of trauma resuscitation algorithms using routine thoracoabdominal CT versus algorithms using selective CT in this review. We included all blunt high-energy trauma patients (including blast or barotrauma).

Data collection and analysis

Two authors independently evaluated the search results.

Main results

The systematic search identified 481 references; after removal of duplicates, 396 remained. We found no RCTs comparing routine versus selective thoracoabdominal CT in blunt high-energy trauma patients. We excluded 381 studies based on the abstracts of the publications because of irrelevance to the review topic, and a further 15 studies after full-text evaluation.

Authors' conclusions

We found no RCTs of routine versus selective thoracoabdominal CT in patients with blunt high-energy trauma. Based on the lack of evidence from RCTs, it is not possible to say which approach is better in reducing deaths.

PLAIN LANGUAGE SUMMARY

Regular or selected use of computed tomography (CT) scanning to reduce deaths in people who have a high-energy blunt-traumatic injury

Background

Trauma is the fifth leading cause of death in the world, and in people younger than 40 years of age, it is the leading cause of death. Since the 2000s, computed tomography (CT) has been increasingly used in the trauma bay. It is more sensitive and specific than conventional radiography and ultrasonography. By the 2010s, with technical and infrastructural improvements, CT has evolved into a reliable and important method of diagnostic imaging in trauma.

Blunt injury may occur following a direct impact (e.g. forced against a steering wheel or floor) or an indirect impact (e.g. acceleration-deceleration). It is difficult to identify which part of the body is injured following blunt injury and quick and accurate diagnoses are essential to reduce disability and death. The Advanced Trauma Life Support (ATLS®) system is the most commonly used approach and involves a clinical examination and use of diagnostic methods that recognise the most life-threatening injuries that should be treated first. In the ATLS® approach, conventional diagnostic imaging is performed first (e.g. X-rays and focused abdominal sonography), followed by selective use of CT of specific body regions if required. In contrast, the use of routine thoracoabdominal (chest and abdomen) CT ensures that therapeutic decisions can be made based on detailed anatomical information of the injuries rather than clinical suspicion. This may lead to quicker and more accurate assessment of injuries present. Consequently, this may lead to improved outcomes.

Study characteristics

We searched medical databases for publications of randomised controlled trials (a clinical study where participants are randomly allocated into treatment groups) comparing the usual approach versus selected use of CT scanning. We included studies of all types of blunt trauma and excluded studies with people with penetrating injuries (e.g. gunshot or knife wounds) and pregnant women. The searches are up-to-date to May 2013.

Key results

We found no published or ongoing randomised controlled trials that compared routine versus selective thoracoabdominal CT in blunt-trauma patients. At this time, it is not possible to say which approach is better for patients, or reduces death.

BACKGROUND

Trauma is the fifth leading cause of death in the world, and in people younger than 40 years of age, it is the leading cause of death. Incidents causing blunt injuries result in a worldwide mortality of 9%, which is equivalent to five million deaths each year (WHO 2008). In Europe, injuries account for approximately 800,000 deaths each year (10% of all deaths) (WHO Eur 2008; WHO 2012), and are an important source of health-related costs. During initial resuscitation of blunt-trauma patients, timely and accurate diagnoses are essential for planning further therapy. To

guide the primary analysis and treatment of trauma patients, the Advanced Trauma Life Support (ATLS®) is predominantly used worldwide (ATLS 2012). Because physical examination alone is not sufficiently accurate, additional radiological examinations are performed. According to the ATLS® guidelines, conventional diagnostics are performed first, for example, conventional radiography (CR) and focused abdominal sonography in trauma (FAST), followed by selective use of computed tomography (CT) of specific body regions, if indicated.

Since the 2000s, CT has been increasingly used in the trauma bay (Deunk 2007; Trupka 1997). CT has higher sensitivity and specificity compared with CR and FAST (Brink 2008; Deunk 2009). In the 2010s, with technical and infrastructural improvements, CT has evolved into a reliable and important method of diagnostic imaging in trauma. Both organ and osseous injuries can be diagnosed and (potentially life-threatening) bleeding sites may be identified. In addition to the diagnostic value of CT in imaging patients presenting with traumatic injury to individual organs (Pal 2002; Rhee 2002), CT has been reported to be a valuable modality for imaging in terms of better patient management and diagnostic accuracy (Huber-Wagner 2009). However, there are several disadvantages such as radiation exposure, extra costs and the need for transport to the CT room if the scanner is not located in the trauma bay (Devine 2010; Inaba 2011).

As a consequence of these developments, currently applied imaging guidelines may be outdated. The use of routine thoracoabdominal CT is currently rapidly implemented in trauma protocols worldwide (Maurer 2008). Most studies focus on the additional diagnostic value of CT, but there are few studies that address additional value with respect to patient outcome. It is assumed that improved diagnostics will lead to improved survival, which will lead to an increasing use of thoracoabdominal CT. However, the question is if there is sufficient evidence to justify the implementation of routine thoracoabdominal CT after blunt high-energy trauma.

Description of the condition

Blunt injury may occur during a motor vehicle, bicycle or pedestrian crash or a fall from a height, resulting in a direct impact (e.g. forced against a steering wheel or floor) or an indirect impact (acceleration-deceleration). Blunt-injury patients need a different type of physical examination than patients with penetrating injuries. In blunt injury, it may be difficult to identify which part of the body is injured. During initial evaluation of blunt-trauma patients, timely and accurate diagnoses are essential, as inappropriate or delayed diagnoses may result in unnecessary morbidity and mortality (Davis 1992; Fakhry 2000). Worldwide, the ATLS®, developed by the American College of Surgeons, is the most commonly used approach during the initial evaluation of blunt-trauma patients (ATLS 2012). These guidelines are based upon the principle 'treat first that kills first'. A systematic approach involving clinical examination and use of diagnostics recognises the most life-threatening injuries that should be treated first. Since it is known that physical examination alone is not sufficiently accurate, additional (radiological) examinations are needed. According to the ATLS® principles, conventional diagnostic imaging is performed first (e.g. X-rays and focused abdominal sonography), followed by selective use of CT of specific body regions if indicated.

Description of the intervention

CT, with technical and infrastructure improvements, along with high specificity and accuracy, has evolved into a reliable and important method of diagnostic imaging in trauma. CT enables fast and detailed diagnoses for well-founded planning of therapy. As a consequence, current guidelines following the ATLS® may no longer represent the optimal primary imaging algorithm (Kool 2007). In many hospitals around the world, rapid CT scanning is available and it is possible that routine thoracoabdominal CT scanning may result in more appropriate care than treatment according to ATLS®.

How the intervention might work

With the use of routine thoracoabdominal CT, decisions can be made based on detailed anatomical information rather than clinical suspicion. With the use of selective CT, scanning can be performed based on aberrant findings during physical examination and CR. It is known that the performance of physical examination and CR alone have a low sensitivity. When these examinations are the trigger for performing additional CT, this might lead to a greater chance of underdiagnosis and missing injuries. The use of routine thoracoabdominal CT may lead to quicker and more accurate assessment of injuries, and, consequently, outcomes may be improved.

Why it is important to do this review

There are two different commonly used diagnostic strategies: 1. the use of physical examination and conventional diagnostic imaging, potentially followed by selective use of CT if indicated; 2. the use of physical examination and conventional diagnostics, followed by a routine (instead of selective) use of thoracoabdominal CT. It is unclear which of the current diagnostic strategies used in blunt high-energy trauma patients is the most appropriate. The aim of this systematic review was to evaluate mortality using the two different diagnostic strategies in patients with blunt high-energy trauma.

To 2013, there are data available from cohort studies, but these mostly consider prospective observational and retrospective cohort studies with a before-and-after design (see Characteristics of

excluded studies table). The results of non-randomised studies frequently differ from results of randomised studies of the same intervention. Non-randomised studies may still give seriously misleading results when treated and control groups appear similar in key prognostic factors and, in some situations, adjusted results may appear more biased than unadjusted results. There are instances in which observational data can be useful and randomised controlled trials (RCTs) unnecessary. This can be reasonable, but such instances are rare (Deeks 2003; Ioannidis 2001; Jakobsen 2013; Papanikolaou 2006). Before observational data can be used for assessing benefits, a bias risk assessment has to be conducted. The risk of systematic errors (bias) is one dimension of internal validity and the risk of random errors ('the play of chance') is another, and these two should not be confused (Keus 2010). Therefore, although the studies cumulatively have a high number of participants, this does not compensate for a higher risk of bias. We believe that randomised trials considering this issue are feasible, and there is currently a randomised trial recruiting in the Netherlands which confirms that the scientific community is uncertain (REACT-2). Data from this study may be included into this review in the future.

OBJECTIVES

To assess the effects of routine thoracoabdominal CT compared with selective thoracoabdominal CT on mortality in blunt high-energy trauma patients.

METHODS

Criteria for considering studies for this review

Types of studies

We included data from RCTs that compared blunt-trauma resuscitation algorithms using routine thoracoabdominal CT versus algorithms using selective thoracoabdominal CT. We included RCTs irrespective of blinding, number of participants randomised and the language of the study report. We also included cluster-randomised trials.

Types of participants

We included randomised trials that evaluated people who had sustained all types of blunt high-energy trauma (including blast or barotrauma). We excluded trials that evaluated people with penetrating injuries, such as gunshot or stab wounds. We excluded trials that evaluated pregnant women.

Types of interventions

We considered diagnostic strategies that used routine thoracoabdominal CT as the experimental intervention. We considered usual care to be the control intervention and may have included physical examination followed by conventional radiological examination (X-rays of the pelvis/thorax and FAST), followed by selective use of thoracoabdominal CT.

Types of outcome measures

Primary outcomes

- Overall mortality (30-day survival).

Secondary outcomes

- Adverse events:
    - non-therapeutic laparotomy (i.e. performed for false-positive findings of index tests or misclassification of organ injury);
    - morbidity until discharge (i.e. systemic inflammatory response syndrome, sepsis, nosocomial pneumonia, abdominal compartment syndrome, acute respiratory distress syndrome);
    - rates of missed injuries irrespective of therapeutic consequences (findings of unplanned laparotomy/laparoscopy, autopsy, follow-up during hospital stay or readmission following discharge due to false-negative findings).

Adverse events as total numbers.

- Time spent at the trauma bay (emergency department) until surgery, admission to intensive care unit (ICU), peripheral wards or ambulation.
- Length of hospital and ICU stays (days) among people who survived until discharge.

Search methods for identification of studies

We did not restrict searches by date, language or publication status.

Electronic searches

The Cochrane Injuries Group Trials Search Co-ordinator searched the following electronic databases:

- Cochrane Injuries Group's Specialised Register (9 May 2013);
- Cochrane Central Register of Controlled Trials (Issue 4, 2013);
- MEDLINE (OvidSP) (1946 to May week 1 2013);
- Embase Classic + Embase (OvidSP) (1947 to 8 May 2013);
- CINAHL Plus (EBSCO) (1937 to May 2013).

Details of the search strategies can be found in Appendix 1.

Searching other resources

We checked the reference lists of all relevant studies retrieved from our search and from relevant, published systematic reviews to identify other possibly relevant studies for inclusion. We conducted an Internet search for grey literature and other information on the topic. In addition, we contacted the authors of included trials by letter or email to request further information and to ascertain whether they have knowledge of any further published, unpublished or ongoing trials.

Data collection and analysis

We conducted the review according to the recommendations of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011). We used Review Manager 5 to conduct the review (RevMan 2012).

Selection of studies

Two review authors (RvV, DK) independently performed the study selection process. A third review author (ME) would have arbitrated in case of any disagreement on study inclusion. We perfomred the first selection based on the titles and abstracts identified from the searches and selected potentially relevant articles. In case of any uncertainty, we would have included the article. We based further selection on the full text. Publications selected for full-text analysis are listed with their reasons for inclusion (Characteristics of included studies) or exclusion (Characteristics of excluded studies) according to the criteria for considering studies for this review.

Data extraction and management

We found no studies meeting our inclusion criteria. However, two review authors (RvV, DK) would have independently extracted all relevant data. The following information would have been extracted for each included study: number of people in each group; age; gender; mechanism of injury; Glasgow Coma Scale score (on scene and on arrival at the emergency department); Revised Trauma Score; study design; sample size information; inclusion and exclusion criteria of the study; follow-up period; loss to follow-up; and information regarding the (missed) diagnosis, rates of non-therapeutic interventions, morbidity, time spent on trauma bay, time of admission to ICU/hospital, data needed for methodological quality assessment of the study, and primary and secondary outcomes.

Assessment of risk of bias in included studies

We found no RCTs meeting our criteria. However, based on the available empirical evidence and the recommendations of the *Cochrane Handbook for Systematic Reviews of Interventions* the methodological quality of (cluster-) RCTs would have been assessed using the tool for assessing risk of bias (Higgins 2011). The following definitions would have been used.

Random sequence generation

- Low risk: if the allocation sequence was generated by a computer or random number table. We would have considered drawing of lots, tossing of a coin, shuffling of cards or throwing dice as adequate if a person who was not otherwise involved in the recruitment of participants performed the procedure.
- Unclear: if the trial was described as randomised, but the method used for generation of the allocation sequence was not described.
- High risk: if a system involving dates, names or alternating allocation was used for the allocation of participants.

Allocation concealment

- Low risk: if the allocation of participants involved a central independent unit, on-site locked computer or sealed opaque envelopes.
- Unclear: if the trial was described as randomised, but the method used to conceal the allocation was not described.
- High risk: if the allocation sequence was known to the investigators who assigned participants.

Blinding of outcome assessment (mortality)

Blinding in the resuscitation of trauma patients is in many instances impossible. In this review, with the diagnostic strategy considered as an intervention in this research question, blinding was considered impossible.

Incomplete outcome data assessed

- Low risk: if the percentage of dropouts did not exceed 20%, and numbers and reasons for dropouts and withdrawals in all intervention groups were described.
- Unclear: if the report gave the impression that there had been no dropouts or withdrawals, but this was not specifically stated.
- High risk: if the percentage of dropouts exceeded 20%, or the numbers and reasons for dropouts and withdrawals were not described.

Selective outcome reporting

- Low risk: if it was clear that the published report included all expected outcomes, including those that were prespecified in the study protocol.
- Unclear: if insufficient information was provided to permit clear judgement of this aspect.

- High risk: if not all relevant outcomes and all the study's prespecified outcomes were reported, or if they were incompletely reported.

Other sources of bias

- Low risk: if the study appeared to be free of other sources of bias.
- Unclear: if a risk of potentially important bias existed, but sufficient information to assess this bias was lacking.
- High risk: if one or more sources of potentially important biases could be identified in the study (e.g. extreme baseline imbalances or other imbalances in study design).

Particular biases considered in cluster-randomised trials were related to recruitment bias: participants may have differed due to the differences that may have existed between the participating clusters.

Measures of treatment effect

In the future, if studies are included in an update of the review, we will present dichotomous data in proportions. We will present normally distributed continuous data as means with their standard deviations (SD). We will present non-normally distributed numerical data as medians with ranges and interquartile range (IQR), where appropriate.
For dichotomous data, we will use risk ratios as the summary statistic. For continuous outcomes, we will use mean differences as the summary statistic. However, study authors often present their results in medians with ranges due to suspicion of skewed data, while means with their SDs are needed for meta-analysis. In these cases, we will first contact study authors for additional data. If we cannot retrieve the means, we will also perform a sensitivity analysis, imputing data for missing means and SDs (Hozo 2005).

Unit of analysis issues

In the study reports, the number of observations in the analysis should match the number of participants that were randomised. Participants should be individually randomised to one of two intervention groups. A single measurement for each outcome from each participant should be collected and analysed.
If we identify RCTs when this review is updated, we will consider data analysis from cluster-randomised trials in the primary analysis. If the randomisation was performed on clusters rather than individuals, we will perform approximately correct analysis with the use of effective sample size (Rao 1992), in order to prevent a unit of analysis error (Whiting-O'Keefe 1984). We will carry out this analysis when the following data can be extracted: number of clusters randomised to each intervention group (or mean size of each cluster), outcome data ignoring the cluster design for the total number of individuals and an estimate of the intracluster correlation coefficient (Donner 1980).

Dealing with missing data

If outcome or summary data are missing from a study identified when this review is updated, we will try to retrieve these data by contacting the authors of the article concerned.

Assessment of heterogeneity

Considerable variation in results, particularly inconsistency in the direction of effect, may represent clinical heterogeneity. We found no RCTs meeting the criteria for inclusion in this review. However, if substantial clinical heterogeneity is present in RCTs identified in an update of this review, we will not perform a meta-analysis. We will calculate statistical heterogeneity using the Higgins Chi ^{2} test and quantify the inconsistency in study effects using the I ^{2} statistic (Higgins 2002). We will consider a Chi^2 test with a P value < 0.10 to indicate the presence of heterogeneity, while we will consider an I^2 statistic greater than 50% to suggest a marked inconsistency in effect between studies.

Assessment of reporting biases

If we identify RCTs in a future update of this review, we will use a funnel plot if there are 10 or more studies included in an analysis. This may help identify the presence of publication or other types of biases (Macaskill 2001).

Data synthesis

We aimed to compare routine thoracoabdominal CT versus selective CT in the resuscitation of high-energy blunt-trauma patients through meta-analysis. If we identify RCTs in a future update of this review, for the meta-analysis, we will use a fixed-effect model first and then a random-effects model if the fixed-effect model is inappropriate based on a value of the I^2 statistic greater than 50% (Higgins 2011). We will conduct statistical analysis using the statistical package Review Manager 5 provided by The Cochrane Collaboration (RevMan 2012). We will consider differences to be significant when the P value is less than 0.05.

Subgroup analysis and investigation of heterogeneity

If heterogeneity greater than 50% is present based on the I^2 statistic, we will re-checked the data first. If heterogeneity persists, we will excluded extreme outliers if appropriate. In the event of missing data, we will impute median or mean values.
We will perform subgroup analysis based on gender, age and differences in the severity of trauma.

Sensitivity analysis

If sufficient data are available for a future update of this review, we will perform sensitivity analyses based on allocation concealment.

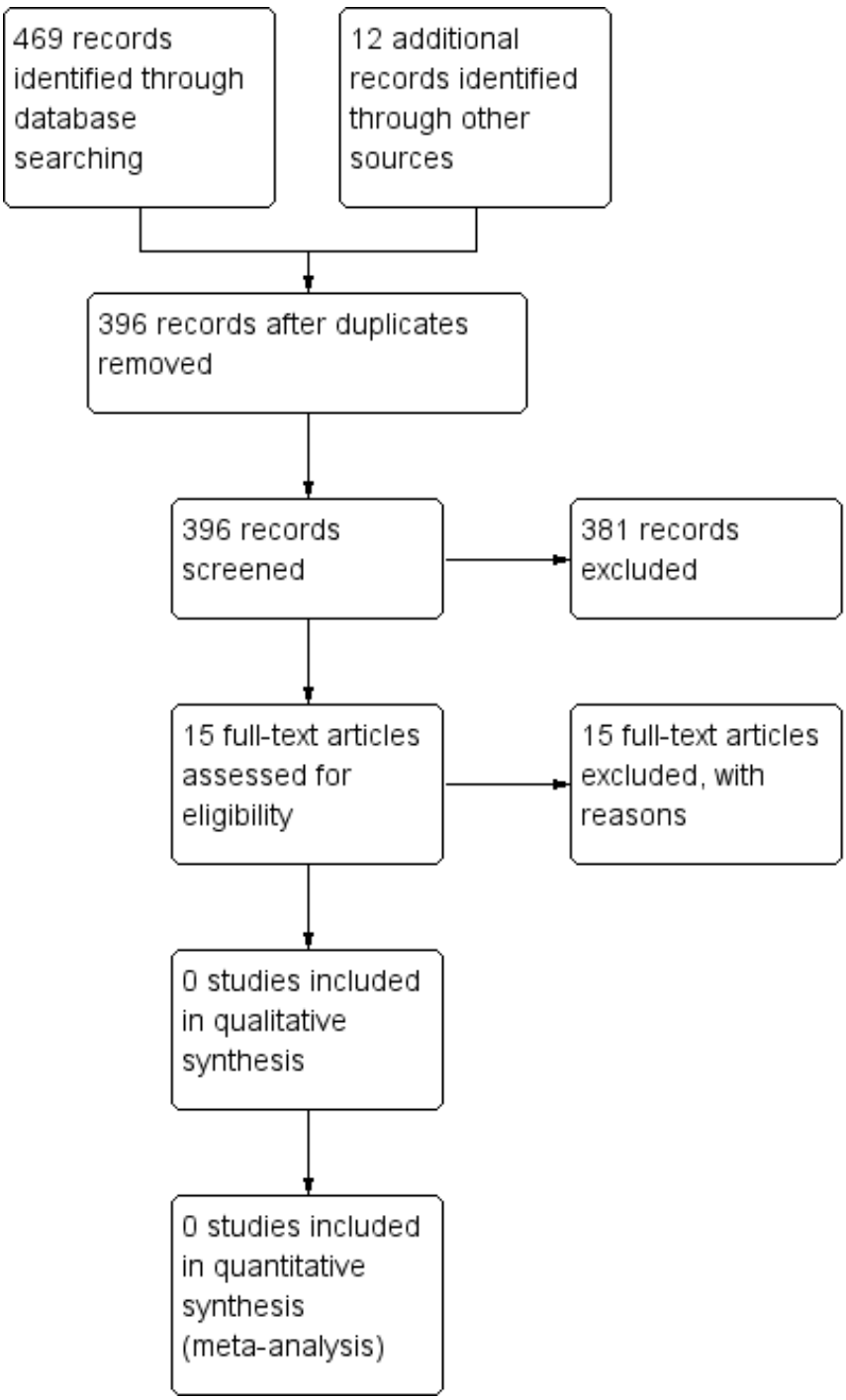
RESULTS

Description of studies

Results of the search

We identified 396 studies using the search strategy. The study selection process is summarised in the PRISMA flow diagram (Figure 1).

Figure 1. Study flow diagram.



Included studies

We found no randomised or cluster-randomised studies comparing routine thoracoabdominal CT versus selective thoracoabdominal CT in blunt high-energy trauma patients.

Excluded studies

We excluded 396 studies because they were irrelevant to the topic of the review. Of the 396, 381 were excluded based on the abstract and title, because these studies did not compare routine versus selective thoracoabdominal CT. We assessed 15 articles for eligibility. Of these, we subsequently excluded six studies because they were prospective observational studies (Deunk 2009; Rieger 2009; Salim 2006; Sampson 2006; Tillou 2009; Yeguiayan 2012), seven were retrospective cohort studies (Huber-Wagner 2009; Hutter 2011; Self 2013; Smith 2011; Weninger 2007; Wurmb 2009; Wurmb 2011), one was an overview (Stengel 2009), and one was a technical CT study (Okamoto 2002). See the Characteristics of excluded studies table.

Risk of bias in included studies

We included no studies in this review.

Effects of interventions

We included no studies in this review.

DISCUSSION

We found one report of an RCT comparing routine versus selective thoracoabdominal CT in blunt high-energy trauma patients, which is currently recruiting in the Netherlands. As no data are currently available from completed RCTs, the current practice of using routine thoracoabdominal CT is based on non-randomised, observational and retrospective studies.

Due to the paucity of RCTs, evidence to support one of the diagnostic strategies is limited. RCTs with low risks of systematic and random error comparing routine versus selective (thoracoabdominal) CT are needed and it is possible to evaluate the benefits and harms of this diagnostic strategy as an intervention. The results may guide the evidence base of further implementation of CT in blunt high-energy trauma patients. One ongoing international multicentre RCT in the Netherlands is aiming to provide evidence on the value of immediate total-body CT scanning during the primary survey of severely injured trauma patients. If immediate total-body CT scanning is found to be the best imaging strategy in severely injured trauma patients it could replace conventional imaging supplemented with CT in this specific group (REACT-2).

Summary of main results

We included no studies in this review.

Potential biases in the review process

Although a specialist information scientist composed as extensive and sensitive search, which was run on different databases, it is possible that articles were missed by the search.

AUTHORS' CONCLUSIONS

Implications for practice

Patients sustaining blunt high-energy trauma need an accurate and rapid evaluation to optimise their management with the goal of increasing survival. Routine thoracoabdominal computed tomography (CT) has the potential to have an important role during the resuscitation of a trauma patient. While the diagnostic value of CT seems clear, its benefits on mortality cannot be established as no randomised trials have been conducted. Randomised controlled trials with low risks of bias are needed to guide recommendations.

Implications for research

Good-quality randomised controlled trials comparing routine versus selective (thoracoabdominal) CT for patients with blunt high-energy trauma are needed. These prospective trials should focus on mortality as a primary outcome measure, but should also assess adverse events such as non-therapeutic laparotomies, morbidity, costs, and rates and consequences of missed injuries.

ACKNOWLEDGEMENTS

The authors thank Emma Sydenham, Deirdre Beecher, Karen Blackhall and the staff of the Cochrane Injuries Group editorial base.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Deunk 2009	Retrospective study (n = 50) determining the agreement between and within surgeons concerning the influence on treatment plan of routine versus selective MDCT findings in blunt-trauma patients. All surgeons agreed that the traumatic injuries additionally found by routine MDCT frequently resulted in a change of treatment plan. There was a moderate-to-excellent agreement between and within surgeons that these additional findings resulted in a change of treatment plan
Huber-Wagner 2009	Retrospective study using the German Trauma Registry to calculate a difference in predicted survival (TRISS methodology) for blunt-trauma patients with ISS > 16 in whole-body CT (n = 1494) vs. non-whole-body CT (n = 3127) between 2002 and 2004. Probability of survival significantly increased with the use of whole-body CT
Hutter 2011	Retrospective cohort study of blunt-trauma comparing an era before introduction (2000-2002, n = 313) and after introduction (2002-2007, n = 608) of a liberal pan-scan. 2.7% of the variance in mortality was believed to be caused by the use of pan-CT
Okamoto 2002	Prospective randomised study (n = 36) in blunt-trauma comparing incremental CT versus dynamic spiral CT after initially fluid resuscitation and plain X-ray films. Primary screening with early-phase dynamic spiral CT for haemorrhagic multiple trauma was found to be useful for determining the applications of subsequent angiographic intervention as well as evaluating lesions caused by injury
Rieger 2009	Observational study (2006, n = 88) assessing time management and diagnostic quality when using a 64-multidetector-row whole-body CT to evaluate polytraumatised patients (ISS > 18) in an emergency department
Salim 2006	Prospective observational study (2004-2005) in blunt conscious multitrauma patients (n = 592) evaluating changes in treatment as a direct result of pan CT, showing that clinically significant abnormalities are not uncommon, resulting in a change in treatment in nearly 19% of patients
Sampson 2006	Prospective observational study (1997-2004, n = 296) to assess the impact of the introduction of a CT for multitrauma patients on the workload, overall diagnostic yield, and effect on detection of cervical spine injury and pneumothorax. The overall impact on workload was small. A wide range of significant injuries was demonstrated rapidly, accurately and safely
Self 2013	Retrospective cohort study (2000-2001) to evaluate the role of routine CT of the chest, abdomen and pelvis as a screening tool for patients (n = 457) already undergoing cranial CT studies. 38% of patients undergoing cranial CT scanning had a unexpected finding on body scans, resulting in changes in 26% of the study group
Smith 2011	Retrospective cohort study (2007-2008) to evaluate changes in treatment in a period before (n = 116) and after (n = 2008) the introduction of a major trauma CT protocol, based on mechanism of injury. Substantial changes in clinical management were made in a small number of patients (2.2%) without any increase in adverse events

(*Continued*)

Stengel 2009	Overview of knowledge of the value of CT, stating that diagnostic accuracy of MDCT for clearing various anatomical regions in trauma patients is, at best, unclear. Little is known about the accuracy of pan-CT as a whole, which weakens statements about its effectiveness and prevents inferences about survival advantages
Tillou 2009	Prospective observational study (2007) evaluating injuries in patients with blunt-trauma (n = 284) receiving a pan-CT. Physicians were willing to omit 27% of scans. If this was done, 2 injuries requiring immediate actions would have been missed initially, and other potentially important injuries would have been missed in 17% of patients
Weninger 2007	Retrospective study evaluating 2 periods in which different emergency protocols were used. First diagnostic protocol included physical examination, conventional radiography, sonography and further procedures if necessary (2001-2002, n = 185). In the second period (2003-2004, n = 185), blunt-trauma patients underwent immediate CT after admission. There was a non-significant difference in inhospital mortality (16% vs. 17%) . CT in blunt major trauma leads to more accurate and faster diagnosis, and reduction of early clinical time intervals
Wurmb 2009	Retrospective description of time requirement of 2 different diagnostic approaches to multiple injuries. 1 with whole-body CT as the sole radiological procedure (2004, n = 79) and 1 with conventional use of radiography, combined with abdominal ultrasound and organ focused CT (2002, n = 82). In the first, time intervals were shortened
Wurmb 2011	Retrospective study comparing data of trauma patients treated with conventional trauma protocol (2001-2003, n = 155) with data from trauma patients treated with whole-body CT trauma protocol (2004-2006, n = 163). Mortality remained unchanged in both groups, time interval shortened to start emergency surgery in patients with multiple injuries undergoing whole-body CT
Yeguiayan 2012	Prospective observational study (2004-2007) to assess the impact of whole-body CT (n = 1696) compared with selective CT (n = 254) on mortality and management of patients with severe blunt trauma. CT strategy was chosen by treating team or physician. Whole-body CT was associated with a significant reduction in 30-day mortality (22% vs. 16%, P value = 0.02)

CT: computed tomography; ISS: Injury Severity Score; MDCT: multidetector-row computed tomography; TRISS: Trauma and Injury Severity Score.

Characteristics of ongoing studies *[ordered by study ID]*

REACT-2

Trial name or title	REACT 2
Methods	An international, multicentre randomised controlled trial. All participating trauma centres have a multislice CT scanner located in the trauma room or at the emergency department. Randomisation will be computer assisted

REACT-2 (*Continued*)

Participants	All adult, non-pregnant, severely injured trauma patients according to predefined criteria will be included. Patients in whom direct scanning will hamper necessary cardiopulmonary resuscitation or who require an immediate operation because of imminent death (both as judged by the trauma team leader) are excluded
Interventions	The intervention group will receive a contrast-enhanced total-body CT scan (head to pelvis) during the primary survey. The control group will be evaluated according to local conventional trauma imaging protocols (based on ATLS guidelines) supplemented with selective CT scanning
Outcomes	Primary outcome will be inhospital mortality. Secondary outcomes are differences in mortality and morbidity during the first year after trauma, several trauma work-up time intervals, radiation exposure, general health and quality of life at 6 and 12 months post trauma and cost-effectiveness
Starting date	1 April 2011
Contact information	j.c.sierink@amc.nl
Notes	

ATLS: Advanced Trauma Life Support; CT: computed tomography.

DATA AND ANALYSES

This review has no analyses.

APPENDICES

Appendix 1. Search strategies

Cochrane Injuries Group Specialised Register
1 ((blunt or non-penetrat*) AND (trauma* or injur* or wound*)) AND (INREGISTER) [REFERENCE] [STANDARD]
#2 ((spleen or splenic or liver or hepatic or abdomen or abdominal or stomach or thorax or thoracic) AND (trauma* or injur* or ruptur* or bleed*)) AND (INREGISTER) [REFERENCE] [STANDARD]
#3 #1 OR #2 [REFERENCE] [STANDARD]
#4 ((x-ray or xray or tomography or ct)) AND (INREGISTER) [REFERENCE] [STANDARD]
#5 #3 AND #4 [REFERENCE] [STANDARD]
Cochrane Central Register of Controlled Trials (*The Cochrane Library)*
#1 MeSH descriptor Tomography, X-Ray Computed explode all trees
#2 (CT near3 (cine or scan* or x?ray* or xray*)):ti,ab,kw
#3 (CT or MDCT):ti
#4 ((electron?beam* or comput* or axial) near3 tomography):ti,ab,kw
#5 (tomodensitometry):ti,ab,kw
#6 (#1 OR #2 OR #3 OR #4 OR #5)
#7 MeSH descriptor Wounds, Nonpenetrating explode all trees
#8 MeSH descriptor Thoracic Injuries explode all trees
#9 MeSH descriptor Abdominal Injuries explode all trees
#10 ((Nonpenetrating or blunt) near3 (wound* or injur*)):ti,ab,kw
#11 MeSH descriptor Liver explode all trees with qualifier: IN
#12 MeSH descriptor Diaphragm explode all trees
#13 MeSH descriptor Intestine, Small explode all trees with qualifier: IN
#14 MeSH descriptor Intestine, Large explode all trees with qualifier: IN
#15 MeSH descriptor Colon explode all trees with qualifier: IN
#16 MeSH descriptor Spleen explode all trees with qualifier: IN
#17 MeSH descriptor Aorta, Thoracic explode all trees with qualifier: IN
#18 MeSH descriptor Urinary Bladder explode all trees with qualifier: IN
#19 MeSH descriptor Heart Injuries explode all trees
#20 MeSH descriptor Ribs explode all trees
#21 MeSH descriptor Sternum explode all trees with qualifier: IN
#22 MeSH descriptor Lung Injury explode all trees
#23 MeSH descriptor Shock, Traumatic explode all trees
#24 MeSH descriptor Splenic Rupture explode all trees
#25 MeSH descriptor Aorta, Abdominal explode all trees
#26 (#7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25)
#27 (#26 AND #6)
MEDLINE (OvidSP)
1. (CT adj3 (cine or scan* or x?ray* or xray*)).ab,ti.
2. CT or MDCT.ti.
3. ((electron?beam* or comput* or axial) adj3 tomography).ab,ti.
4. tomodensitometry.ab,ti.

5. exp Tomography, X-Ray Computed/
6. 1 or 3 or 4 or 5
7. exp Wounds, Nonpenetrating/
8. exp Thoracic Injuries/
9. exp Abdominal Injuries/
10. exp Hernia, Diaphragmatic, Traumatic/
11. ((Nonpenetrating or blunt) adj3 (wound* or injur*)).ab,ti.
12. exp Liver/in [Injuries]
13. exp Diaphragm/in [Injuries]
14. exp Intestine, Small/in [Injuries]
15. exp Intestine, Large/in [Injuries]
16. exp Colon/in [Injuries]
17. exp Spleen/in [Injuries]
18. exp Splenic Rupture/
19. exp Aorta, Abdominal/in [Injuries]
20. exp Aorta, Thoracic/in [Injuries]
21. exp Urinary Bladder/in [Injuries]
22. exp Heart Injuries/
23. exp Ribs/in [Injuries]
24. exp Sternum/in [Injuries]
25. exp Lung Injury/
26. exp Shock, Traumatic/
27. ((Injur* or trauma* or blunt or non?penetrat*) adj5 (abdom* or liver or spleen or splenic or diaphragm* or aorta or thorax or thorac* or bowel or intestine* or colon* or bladder* or heart or rib* or lung*)).ti.
28. 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27
29. 6 and 28
30. randomi?ed.ab,ti.
31. randomized controlled trial.pt.
32. controlled clinical trial.pt.
33. placebo.ab.
34. clinical trials as topic.sh.
35. randomly.ab.
36. trial.ti.
37. 30 or 31 or 32 or 33 or 34 or 35 or 36
38. (animals not (humans and animals)).sh.
39. 37 not 38
40. 29 and 39

EMBASE Classic + EMBASE (OvidSP)

1. exp computer assisted tomography/
2. (CT adj3 (cine or scan* or x?ray* or xray*)).ab,ti.
3. ((electron?beam* or comput* or axial) adj3 tomography).ab,ti.
4. tomodensitometry.ab,ti.
5. CT.mp. or MDCT.mp.
6. 1 or 2 or 3 or 4 or 5
7. exp blunt trauma/
8. exp thorax injury/
9. exp abdominal injury/
10. exp diaphragm hernia/
11. ((Nonpenetrating or blunt) adj3 (wound* or injur*)).ab,ti.
12. exp liver injury/
13. exp diaphragm injury/
14. exp intestine injury/
15. exp large intestine/

16. exp colon injury/
17. exp spleen injury/
18. exp spleen rupture/
19. exp abdominal aorta/
20. exp thoracic aorta/
21. exp bladder injury/
22. exp heart injury/
23. exp rib fracture/
24. sternum/
25. exp lung injury/
26. exp traumatic shock/
27. ((Injur* or trauma* or blunt or non?penetrat*) adj5 (abdom* or liver or spleen or splenic or diaphragm* or aorta or thorax or thorac* or bowel or intestine* or colon* or bladder* or heart or rib* or lung*)).ti.
28. 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27
29. 6 and 28
30. randomi?ed.ab,ti.
31. (randomised or randomized or randomly or random order or random sequence or random allocation or randomly allocated or at random or controlled clinical trial$).tw,hw.
32. clinical trial/
33. 30 or 31 or 32
34. human/
35. exp animal/
36. exp experimental animal/
37. animal experiment/
38. 35 or 36 or 37
39. 38 not 34
40. 33 not 39
41. 29 and 40
42. limit 41 to exclude medline journals

CINAHL Plus (EBSCO)

S1 (MH "Clinical Trial+")
S2 PT Clinical trial
S3 TX clinic* n1 trial*
S4 TX ((ingl* n1 blind*) or (ingl* n1 mak*)) or TX ((doubl* n1 blind*) or (doubl* n1 mak*)) or TX ((tripl* n1 blind*) or (tripl* n1 mak*)) or TX ((trebl* n1 blind*) or (trebl* n1 mak*))
S5 TX randomi* control* trial*
S6 (MH "Random Assignment")
S7 TX random* allocat*
S8 TX placebo*
S9 (MH "Placebo")
S10 (MH "Quantitative studie")
S11 TX allocat* random*
S12 S1 or S2 or S3 or S4 or S5 or S6 or S7 or S8 or S9 or S10 or S11
S13 (MH "Tomography, X-Ray Computed+")
S14 TI (ct or mdct)
S15 AB (tomodenitometry)
S16 AB (electron?beam* or comput* or axial) n3 AB (tomography)
S17 AB (cine or can* or xray* or xray*) n3 (ct)
S18 S13 or S14 or S15 or S16 or S17
S19 (MH "Wound, Nonpenetrating+")
S20 (MH "Thoracic Injurie+")
S21 (MH "Abdominal Injurie+")
S22 (MH "Hernia, Diaphragmatic+")

S23 AB (Nonpenetrating or blunt) n3 (wound* or injur*)
S24 (MH "Liver/IN")
S25 (MH "Diaphragm/IN")
S26 (MH "Intestine, mall+/IN")
S27 (MH "Intestine, Large+/IN")
S28 (MH "Colon+/IN")
S29 (MH "Spleen/IN")
S30 (MH "Splenic Rupture")
S31 (MH "Aorta, Abdominal/IN")
S32 (MH "Aorta, Thoracic/IN")
S33 (MH "Urogenital system+/IN")
S34 (MH "Heart Injurie+")
S35 (MH "Rib/IN")
S36 (MH "Sternum/IN")
S37 (MH "Lung Injury+")
S38 (MH "Shock, Traumatic+")
S39 TI (Injur* or trauma* or blunt or non?penetrat*) n5 (abdom* or liver or spleen or splenic or diaphragm* or aorta or thorax or thorac* or bowel or intestine* or colon* or bladder* or heart or rib* or lung*)
S40 S19 or S20 or S21 or S22 or S23 or S24 or S25 or S26 or S27 or S28 or S29 or S30 or S31 or S32 or S33 or S34 or S35 or S36 or S37 or S38 or S39
S41 S12 and S18 and S40

CONTRIBUTIONS OF AUTHORS

RvV and DK reviewed the study references. All authors contributed to writing the review.

DECLARATIONS OF INTEREST

None known.

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

None.

INDEX TERMS

Medical Subject Headings (MeSH)

Abdominal Injuries [*radiography]; Thoracic Injuries [*radiography]; Tomography, X-Ray Computed [*methods]; Wounds, Nonpenetrating [*radiography]

MeSH check words

Humans