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[Intervention Review]

Damage control surgery for abdominal trauma

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ABSTRACT

Background

Trauma is one of the leading causes of death in any age group. The 'lethal triad' of acidosis, hypothermia, and coagulopathy has been recognized as a significant cause of death in patients with traumatic injuries. In order to prevent the lethal triad two factors are essential, early control of bleeding and prevention of further heat loss. In patients with major abdominal trauma, damage control surgery (DCS) avoids extensive procedures on unstable patients, stabilizes potentially fatal problems at initial operation, and applies staged surgery after successful initial resuscitation. It is not currently known whether DCS is superior to immediate surgery for patients with major abdominal trauma.

Objectives

To assess the effects of damage control surgery compared to traditional immediate definitive surgical treatment for patients with major abdominal trauma.

Search methods

We searched the Cochrane Injuries Group Specialised Register, CENTRAL (*The Cochrane Library* 2012, Issue 12 of 12), MEDLINE, EMBASE, Web of Science: Science Citation Index & ISI Proceedings, Current Controlled Trials MetaRegister, Clinicaltrials.gov, Zetoc, and CINAHL for all published and unpublished randomised controlled trials. We did not restrict the searches by language, date, or publication status. The search was through December 2012.

Selection criteria

Randomised controlled trials of damage control surgery versus immediate traditional surgical repair were included in this review. We included patients with major abdominal trauma (Abbreviated Injury Scale > 3) who were undergoing surgery. Patient selection was crucial as patients with relatively simple abdominal injuries should not undergo unnecessary procedures.

Data collection and analysis

Two authors independently evaluated the search results.

Main results

A total of 2551 studies were identified by our search. No randomised controlled trials comparing DCS with immediate and definitive repair in patients with major abdominal trauma were found. A total of 2551 studies were excluded because they were not relevant to the review topic and two studies were excluded with reasons after examining the full-text.

Authors' conclusions

Evidence that supports the efficacy of damage control surgery with respect to traditional laparotomy in patients with major abdominal trauma is limited.

PLAIN LANGUAGE SUMMARY

Surgery for unstable trauma patients

Trauma is one of the leading causes of death across all ages. Some patients with major abdominal trauma develop what is known as the 'lethal triad' -- impaired coagulation, metabolic acidosis, and hypothermia. This is a life-threatening condition which significantly contributes to illness and death. To prevent this lethal triad, doctors need to control bleeding and prevent further heat loss.

Traditional management of major abdominal trauma involves surgery to repair the torn organs or abdominal tissue. For trauma patients, immediate surgery may pose a risk as the patient may be in an unstable state because of blood loss.

Damage control surgery (DCS) is an alternative approach. It involves three steps to help the patient. First, a surgeon repairs the major tears, and the patient is cared for in the intensive care unit. Once the patient is stable, surgeons carry out an operation to repair any of the remaining smaller tears. The advantage of the DCS approach is that surgeons only do the more thorough, and therefore longer, surgery once the patient is stable so the chance of an adverse outcome, such as death from severe blood loss, could be lower.

The authors found no published or pending randomised controlled trials that compared DCS with immediate and definitive repair in patients with major abdominal trauma. Evidence that supports efficacy of DCS compared with traditional laparotomy is therefore limited.

BACKGROUND

Trauma is one of the leading causes of death in every age group, it is the leading cause of death for people aged one to 44 years (Feliciano 2007). Abdominal trauma is subdivided into two groups based on the mechanism of injury, which may be penetration or blunt trauma. Motor vehicle crashes account for about 75% of blunt abdominal trauma cases, while gunshot and stab wounds are the main mechanisms of injury in cases of penetrating trauma. For blunt abdominal trauma, non-operative management has become the standard treatment in most trauma centres.

In major abdominal trauma patients, impaired coagulation, metabolic acidosis from low tissue perfusion, haemodynamic instability, infections, and pulmonary complications significantly contribute to morbidity and mortality (Moore 1998). During initial operative and resuscitation efforts, the presence of acidosis, hypothermia, and coagulopathy is associated with high mortality in patients with traumatic injuries (Mikhail 1999; Moore 1996). Consequently, suitable interventions are needed to control bleeding and prevent further heat loss (Zacharias 1999).

In the early 1980s, Harlan Stone described the first damage control procedure performed on a patient who developed coagulopathy during a laparotomy performed for trauma (Stone 1983). The term 'damage control surgery' (DCS) was first described for trauma treatment by Rotondo and Schwab, who, in 1993, outlined a three-phase procedure for patients with major abdominal trauma (Rotondo 1993). DCS avoids extensive procedures on unstable patients and may stabilize potentially fatal problems at initial operation. Extensive procedures are later applied in staged surgery after the successful initial resuscitation (Lee 2006). The DCS strategy is fundamentally based on 'damage control laparotomy', which is also called 'abbreviated laparotomy'. This phase is essentially aimed at obtaining surgical control of haemorrhage and contamination as quickly as possible. It is then followed by temporary abdominal closure (Burch 1992). The main methods for achieving control of haemorrhage are ligation, suturing, or temporal shunting of vascular injuries; packing of liver injuries; and splenectomy (in the presence of splenic injury) (Sharp 1992). Due to bowel oedema, trauma patients' abdominal walls may not feasibly be closed because of the risk of intra-abdominal hypertension (IAH) (Raeburn 2001). The simplest option for abdominal closure, direct suture of the abdominal wall, is not the preferred technique as it results in tissue tension and IAH. Several techniques have been suggested for abdominal closure in order to prevent abdominal compartment syndrome. These are towel clip closure of the skin, temporary silos, vacuum-assisted wound closure, open packing, and absorbable or permanent meshes (Letoublon 2005). In phase three, which usually takes place within 24 to 36 hours of phase one, the abdominal packs are removed, definitive repairs take place, there is a second look laparotomy for missed injuries, and then the abdomen is closed (Germanos 2007).

Description of the condition

In major trauma patients, impaired coagulation, metabolic acidosis, haemodynamic instability, infections, and pulmonary complications significantly contribute to morbidity and mortality (Moore 1998). During initial operative and resuscitation efforts the presence of acidosis, hypothermia, and coagulopathy is associated with high mortality (Mikhail 1999).

Description of the intervention

Damage control surgery is characterized by a staged approach to patients with major abdominal trauma. The approach considers, when necessary, the immediate arrest (with packing or vascular clamps and suture ligatures) of severe bleeding from parenchymal injuries (liver, spleen, pancreas, and kidney), major vessels injuries, retroperitoneal injuries, and the stapling of the intestines for the temporary control of peritoneal contamination from hollow visceral injuries (stomach, small bowel, colon-rectum, and bladder). Initial resuscitation, if necessary, is followed by a brief initial laparotomy, intensive care unit management, and a final planned re-operation. In the final stages of surgery, the abdomen is left open to avoid abdominal compartment syndrome.

The rationale for damage control surgery is that mortality in surgical patients who develop hypothermia, acidosis, and coagulopathy (the 'lethal triad') is extremely high unless patients' physiologic stability is re-established. The control intervention in this review is immediate, traditional surgical treatment for the injuries.

How the intervention might work

The advantage of damage control surgery is the immediate control of severe haemorrhage and the rapid correction of hypothermia, acidosis, and coagulopathy. The disadvantages include the need for further surgical repair with the possibility of high morbidity. The immediate and definitive repair of the injuries (for example bleeding from liver trauma, retroperitoneal injuries, or peritoneal contamination from traumatic bowel perforation) presents the advantages of not requiring re-operation for definitive surgical treatment. The disadvantage is a long operative time for a complex repair of injuries.

Why it is important to do this review

The effects of the damage control surgery approach compared to traditional immediate surgical repair is an unanswered clinical question.

OBJECTIVES

To assess the effects of damage control surgery compared to traditional immediate definitive surgical treatment for patients with major abdominal trauma.

METHODS

Criteria for considering studies for this review

Types of studies

Randomised controlled trials (RCTs).

Types of participants

Patients with major abdominal trauma (Abbreviated Injury Scale > 3 (Champion 1989)) undergoing surgery. Patient selection is crucial as patients with relatively simple abdominal injuries should not undergo unnecessary procedures. Haemodynamic instability, manifested by hypotension, tachycardia and tachypnoea, coagulopathy, or hypothermia, is an important indication for the damage control approach. The control intervention is immediate, traditional surgical repair of the injuries.

Types of interventions

Damage control surgery for major abdominal trauma (Abbreviated Injury Scale > 3) versus immediate, traditional surgical repair in the management of major abdominal trauma.

Types of outcome measures

Primary outcomes

- Overall short-term mortality (within 30 days of surgery)

Secondary outcomes

- Overall short-term morbidity (within 30 days of surgery)

Search methods for identification of studies

Searches were not restricted by language, date, or publication status.

Electronic searches

We searched the following electronic databases:

1. Cochrane Injuries Group Specialised Register (19 December 2012);
2. CENTRAL (The Cochrane Library 2012, Issue 12 of 12);
3. MEDLINE (OvidSP) (1946 to December (week 1) 2012);
4. EMBASE (OvidSP) (1980 to December 2012 (week 51);
5. ISI Web of Science: Conference Proceedings Citation Index-Science (1990 to Dec 2012);
6. ISI Web of Science: Science Citation Index Expanded (SCI-EXPANDED) (1970 to Dec 2012);
7. CINAHL (1982 to 19 December 2012);
8. Zetoc (19 December 2012);
9. Current Controlled Trials metaRegister (29 December 2012);
10. Clinicaltrials.gov (searched 29 December 2012).

Details of the search strategies can be found in [Appendix 1](#).

Searching other resources

We searched abstracts presented at the following international scientific society conferences:

- American Association for the Surgery of Trauma (1999 to December 2012);
- American College of Surgeons (2000 to December 2012);
- Eastern Association for the Surgery of Trauma (2005 to December 2012);
- Società Italiana di Chirurgia (1985 to December 2012).

We checked the reference lists of all relevant studies retrieved from our search and from relevant, published systematic reviews in order to identify other possible studies for inclusion. We conducted an Internet search for grey literature and other information related to our topic.

Data collection and analysis

We conducted the review according to the recommendations of The Cochrane Collaboration ([Higgins 2008](#)) and the Cochrane Injuries Group. We used [Review Manager \(RevMan\)](#) software to conduct the review.

Selection of studies

Two authors (RC, IA) assessed titles or abstracts of all studies identified by the initial search and excluded clearly irrelevant studies. We obtained the full text of potentially relevant studies, including any studies with unclear methodologies. Two authors independently assessed the full-text articles to determine whether they met the inclusion criteria for this review and to evaluate the method of randomisation and adequacy of allocation concealment. We resolved disagreements about study inclusion by discussion and, if necessary, with the assistance of an independent third author (AM).

Data extraction and management

In the future, if studies are included in the review, two investigators (IA, RC) will independently extract the following information for each included trial: method of outcome, blinding of outcome evaluators, and balance of prognostic factors.

Assessment of risk of bias in included studies

Methodological quality

In the future if studies are included in the review, IA and RC will record whether the authors of the studies used a sample size calculation, and whether or not they performed the analysis using an intention-to-treat method. IA and RC will assess the methodological quality of each trial independently. IA and RC will clarify any unclear or missing information by contacting the authors of the specific trials. We will resolve differences in opinion between the authors extracting data through discussion. AM will serve as arbitrator when differences in opinion persist.

Assessment of methodological quality of studies

In the future if studies are included in the review, IA and RC will assess the methodological quality of the trials independently, without masking of the trial names. The review authors will follow the instructions given in the Cochrane Handbook for Systematic Reviews of Interventions ([Higgins 2008](#)) and by the Cochrane Injuries Group. Due to the risk of biased overestimation of intervention effects in randomised trials with inadequate methodological quality ([Schulz 1995](#); [Wood 2008](#)), IA and RC will consider the methodological quality of the trials by evaluating the reported randomisation and follow-up procedures in each trial. If information is not available in the published trial, IA and RC will contact the authors for this information. IA and RC will assess generation of the randomisation sequence, allocation concealment, blinding, and follow up.

Sequence generation

Adequate: if a computer-generated or random number table was used.

Unclear: if the trial was described as randomised, but the report failed to describe the method of allocation sequence.

Inadequate: if patients were allocated according to names, dates, admittance numbers, etc. These are known as quasi-randomised trials and we will exclude them from the review.

Allocation concealment

Adequate: if centralised or pre-numbered containers are administered serially to patients, an on-site computer with

allocations in a locked unreadable file, or sequentially numbered sealed opaque envelopes.

Unclear: if the trial is described as randomised, but failed to describe the method of allocation concealment.

Inadequate: if a completely transparent procedure was used. For example, if case record numbers, dates of birth, or an open list of random numbers was used.

Follow up

Adequate: if the numbers and reasons for dropouts and withdrawals in all intervention groups were described or if it was specified that there were no dropouts or withdrawals.

Unclear: if the report gave the impression that there had been no dropouts or withdrawals, but this was not specifically stated.

Inadequate: if the number or reasons for dropouts and withdrawals were not described.

IA and RC will record sample size and duration of follow up.

Measures of treatment effect

In the future if studies are included in the review, we will analyse dichotomous data with risk ratio (RR) or odds ratio (OR). Absolute effects will be measured with risk differences. We will calculate 95% confidence intervals (CI) for these measures of effect. We will perform intention-to-treat analysis by extracting the number of patients originally allocated to each treatment group, irrespective of compliance. If numbers extracted by the two authors are different, a third author (FS) will resolve differences. We will use the Mantel-Haenszel method for the meta-analysis (Greenland 1985; Mantel 1959). We will present results on a forest plot.

Dealing with missing data

If studies are included in the review in the future, we will contact trial investigators if additional information is required.

Assessment of heterogeneity

If studies are included in the review in the future, we will use the Chi² test and I² statistic to assess heterogeneity. An I² value of > 50% will be used as an indicator of statistical heterogeneity. If outcomes were measured with continuous scales, we will analyse data of treatment effects using the mean difference. Where different trials used different scales, we will standardise and combine the results (using the standardised mean difference).

Assessment of reporting biases

In the future if there are 10 or more studies included in the review, we will use a funnel plot to explore publication bias (Egger 1997; Macaskill 2001). We will perform linear regression using the approach described by Egger et al to determine the funnel plot asymmetry (Egger 1997).

Sensitivity analysis

In the future if trials are included in the review, IA and RC will independently perform a sensitivity analysis by examining the trial inclusion criteria, re-assessing excluded studies, re-analysing data imputing, and re-analysing data using the DerSimonian and Laird method (DerSimonian 1986).

RESULTS

Description of studies

Results of the search

A total of 2551 studies were identified by the search. The study selection process is summarized in the PRISMA flow diagram (Moher 2009; see Figure 1)

Figure 1. Study selection according to PRISMA (Moher 2009) flow diagram (searches from first publication to Dec 2012).

Included studies

No randomised controlled studies comparing DCS with immediate and definitive repair in patients with major abdominal trauma were found.

Excluded studies

A total of 2551 studies were excluded because they were not relevant to the topic of the review, two studies were excluded because they were case-controlled studies (Rotondo 1993; Stone 1983).

Risk of bias in included studies

No studies were included in this review.

Effects of interventions

No studies were included in this review.

DISCUSSION

We found no published or pending randomised controlled trials that compared DCS with immediate and definitive repair in patients with major abdominal trauma for inclusion in this review.

Most of the current information relating to DCS comes from case studies (Colombo 2005; Kudera 2004) and observational studies (Bach 2008; Cotton 2008; Feliciano 1988; Hirshberg 1994; Rotondo 1993; Saifi 1990; Sharp 1992).

In light of the paucity of studies, evidence that supports efficacy of DCS compared to immediate, traditional laparotomy is limited. Good quality randomised controlled trials comparing DCS and traditional, immediate repair are warranted. A carefully designed RCT of this intervention is possible, and the results of such a trial will help to improve the critical decision making of multidisciplinary teams in the future.

AUTHORS' CONCLUSIONS

Implications for practice

Patients with major trauma are usually unstable and are at risk of complications including bleeding, acidosis, hypothermia,

and coagulopathy. Damage control surgery avoids extensive procedures on unstable patients by applying staged surgery after the patient has stabilised. However, its benefits cannot be established as there are no published randomised controlled trials. Good quality randomised controlled trials are needed to produce reliable recommendations.

Implications for research

Good quality randomised controlled trials comparing DCS with immediate surgical repair for patients suffering major abdominal trauma are needed. These prospective trials should have as major outcomes measures short-term mortality and morbidity, and hospital and intensive care unit stays.

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Abramson D, Scalea TM, Hitchcock R, Trooskin SZ, Henry SM, Greenspan J. Lactate clearance and survival following injury. *Journal of Trauma* 1993;**35**(4):584-8.

Arvieux 2003 {published data only}

Arvieux C, Cardin N, Chiche L, Bachellier P, Falcon D, Letoublon C. Damage control laparotomy for haemorrhagic abdominal trauma. A retrospective multicentre study of 109 cases [La laparotomie écourtée dans les traumatismes abdominaux hémorragiques. Étude multicentrique rétrospective sur 109 cas]. *Annales de Chirurgie* 2003;**128**:150-5.

Bach 2008 {published data only}

Bach A, Bendix J, Hougaard K, Christensen EF. Retroperitoneal packing as part of damage control surgery in a Danish trauma centre - fast, effective, and cost-effective. *Scandinavian Journal of Trauma Resuscitation and Emergency Medicine* 2008;**64**(5):4.

Colombo 2005 {published data only}

Colombo F, Sansonna F, Baticci F, Corso R, Scandroglio I, Maggioni D, et al. Liver trauma: experience in the management of 252 cases. *Chirurgia Italiana* 2005;**57**(6):695-702.

Cotton 2008 {published data only}

Cotton BA, Gunter OL, Isbell J, Au BK, Robertson AM, Morris JA Jr, et al. Damage control hematology: the impact of a trauma exsanguination protocol on survival and blood product utilization. *Journal of Trauma* 2008;**64**(5):1177-82.

Feliciano 1981 {published data only}

Feliciano DV, Mattox KL, Jordan GL Jr. Intra-abdominal packing for control of hepatic haemorrhage: a reappraisal. *Journal of Trauma* 1981;**21**(4):285-90.

Feliciano 1988 {published data only}

Feliciano DV, Burch JM, Spjut-Patrinely V, Mattox KL, Jordan GL Jr. Abdominal gunshot wounds. An urban trauma center's experience with 300 consecutive patients. *Annals of Surgery* 1988;**208**(3):362-70.

Hirshberg 1994 {published data only}

Hirshberg A, Wall MJ, Mattox KL. Planned reoperation for trauma: a two year experience with 124 consecutive patients. *Journal of Trauma* 1994;**37**(3):365-9.

Hultman 2005 {published data only}

Hultman CS, Pratt B, Cairns BA, McPhail L, Rutherford EJ, Rich PB, et al. Multidisciplinary approach to abdominal wall reconstruction after decompressive laparotomy for Abdominal Compartment Syndrome. *Annals of Plastic Surgery* 2005;**54**(3):269-75.

Kudera 2004 {published data only}

Kudera JS, Aanning HL. Damage control for blunt hepatic trauma: case presentation and historical review. *South Dakota Journal of Medicine* 2004;**57**(10):449-53.

McLeod 2003 {published data only}

MacLeod JB, Lynn M, McKenney M, Cohn S, Murtha M. Early coagulopathy predicts mortality in trauma. *Journal of Trauma* 2003;**55**(1):39-44.

Miller 2005 {published data only}

Miller R, Morris JA, Diaz JJ, Herring MB, May AK. Complications after 344 damage-control open celiotomies. *Journal of Trauma* 2005;**59**(6):1365-74.

Moore 1998 {published data only}

Moore EE, Burch JM, Franciose RJ. Staged physiologic restoration and damage control surgery. *World Journal of Surgery* 1998;**22**(12):1184-91.

Pachter 1979 {published data only}

Pachter HL, Spencer FC. Recent concepts in the treatment of hepatic trauma: facts and fallacies. *Annals of Surgery* 1979;**190**(4):423-9.

Richardson 2000 {published data only}

Richardson DJ, Franklin GA, Lukan JK, Carrillo EH, Spain DA, Miller FB, et al. Evolution in the management of hepatic trauma: A 25-year perspective. *Annals of Surgery* 2000;**232**(3):324-9.

Rotondo 1993 {published data only}

Rotondo MF, Schwab CW, McGonigal MD. Damage control: An approach for improved survival with exsanguinating penetrating abdominal injury. *Journal of Trauma* 1993;**35**(3):375-83.

Saifi 1990 {published data only}

Saifi J, Fortune JB, Graca L, Shah DM. Benefits of intra-abdominal pack placement for the management of non mechanical haemorrhage. *Archives of Surgery* 1990;**125**(1):119-22.

Stone 1983 {published data only}

Stone HH, Strom PR, Mullins RJ. Management of the major coagulopathy with onset during laparotomy. *Annals of Surgery* 1983;**197**:532-5.

Additional references

Champion 1989

Champion HR, Sacco WJ. A revision of the trauma score. *Journal of Trauma* 1989;**29**:623-9.

Moher 2009

Moher D, Liberati A, Tetzlaff J, Altman DG. The PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *BMJ* 2009;**339**:b2535.

Wood 2008

Wood L, Egger M, Gluud LL, Schulz KF, Juni P, Altman DG. Empirical evidence of bias in treatment effect estimates in controlled trials with different interventions and outcomes: meta-epidemiological study. *BMJ* 2008;**336**:601-5.

CHARACTERISTICS OF STUDIES

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

Study	Reason for exclusion
Abramson 1993	A prospective evaluation of serum lactate levels and oxygen transport measures in 76 consecutive patients with multiple trauma admitted directly to the intensive care unit (ICU) from the operating room or emergency department.
Arvieux 2003	A retrospective multicentre study of 109 patients who underwent damage control laparotomy for haemorrhagic abdominal trauma.
Bach 2008	An article on training sessions in retroperitoneal packing as part of damage control surgery in a trauma centre.
Colombo 2005	Retrospective analysis of 252 patients admitted to the emergency surgery department for liver trauma.
Cotton 2008	A trauma exsanguination protocol that systematically provides specified numbers and types of blood components immediately upon initiation of resuscitation among the most severely injured patients.
Feliciano 1981	A case series of 10 patients treated with intra-abdominal packing for control of hepatic haemorrhage.
Feliciano 1988	Retrospective analysis of 300 consecutive patients with penetrating gunshot wounds to the abdomen causing visceral or vascular injuries.
Hirshberg 1994	Retrospective analysis of 124 patients treated with a planned re-operation for trauma.
Hultman 2005	Retrospective analysis of 82 consecutive critically ill patients who underwent decompressive laparotomy for abdominal compartment syndrome.
Kudera 2004	A case report.
McLeod 2003	The authors reviewed prospectively collected data on trauma patients presenting to a Level I trauma centre. A logistic regression analysis was performed of prothrombin time (PT), activated partial thromboplastin time (PTT), platelet count, and confounders to determine whether coagulopathy was a predictor of all-cause mortality.
Miller 2005	Retrospective analysis of complications in 344 patients who underwent damage control celiotomies and underwent different wound closures: primary fascial closure, temporizing fascial closure (skin only, split thickness skin graft, absorbable) and prosthetic fascial repair (prosthetic fascial repair using non-absorbable prosthetic mesh).
Moore 1998	A narrative review.
Pachter 1979	A retrospective analysis of 85 consecutive patients treated for hepatic trauma.
Richardson 2000	A retrospective analysis of treatment of 1842 patients with liver injuries.
Rotondo 1993	Case-control study. Analysis of 46 patients with penetrating abdominal injuries requiring laparotomy and urgent transfusion of greater than 10 units of packed red blood cells for exsanguination. This study compared the damage control technique with definitive laparotomy and repair.

Study	Reason for exclusion
Saifi 1990	A retrospective study to evaluate the severity of metabolic disturbances after massive non-mechanical bleeding following severe liver injury at the time of pack placement. The onset of non-mechanical bleeding and a coagulopathy marks a grave prognosis for the patient, and consideration should be given at this time for pack placement.
Stone 1983	Case-control study. Analysis of 31 patients who developed major bleeding diatheses during laparotomy. Management of 14 patients was by standard haematologic replacement, completion of all facets of operation, and then closure of the peritoneal cavity, usually with suction drainage. Another 17 patients had laparotomy terminated as rapidly as possible to avoid additional bleeding. After the correction of the coagulopathy, the abdomen was re-explored and definitive surgery was completed.

APPENDICES

Appendix 1. Search strategies

Cochrane Injuries Group Specialised Register

(abdominal or abdomen) and (injur* or trauma* or perforat* or penetrate*) and (surg*)

CENTRAL (The Cochrane Library)*

#1MeSH descriptor: [Abdominal Injuries] explode all trees
#2(abdominal or abdomen) near/5 (injur* or trauma* or perforat* or penetrat*)
#3(abdominal or abdomen) near/5 (multiple trauma or polytrauma)
#4(wound* or stab* or gunshot or shot or penetrat*) near/3 (abdomen* or abdominal or stomach or splenic or spleen)
#5(#1 or #2 or #3 or #4)
#6MeSH descriptor: [General Surgery] explode all trees
#7damag* near/5 control* near/5 surg*
#8(surgery or surgical):ti (Word variations have been searched)
#9(surgery or surgical):ab (Word variations have been searched)
#10#9 or #8
#11#6 or #7 or #10
#12#5 and #11

*For this 2012 update the CENTRAL search strategy has been slightly modified due to recent development of the database new search interface but the keywords and MeSH have not been changed.

MEDLINE (OvidSP)

1. exp Abdominal Injuries/
2. exp Thoracic Injuries/
3. ((abdominal or abdomen) adj3 (injur* or trauma* or perforat* or penetrat*)).ab,ti.
4. exp Multiple Trauma/
5. (multiple trauma or polytrauma).ab,ti.
6. 4 or 5
7. exp Hemoperitoneum/
8. h?emoperitoneum.ab,ti.
9. exp Retroperitoneal Space/
10. retroperitoneum.ab,ti.
11. exp abdomen/
12. (abdomen* or abdominal).ti,ab.
13. 7 or 8 or 9 or 10 or 11 or 12
14. 6 and 13
15. (damag* adj3 control*).ti,ab.
16. (1 or 2 or 3 or 14) and 15
17. (abdominal adj3 compartmental adj3 syndrome).ab,ti.
18. (Hernia* adj3 Diaphragm* adj3 Trauma*).ab,ti.
19. ((splenic or spleen) adj3 rupture*).ab,ti.

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20. ((stomach or gastric) adj3 (rupture or perforation or injur* or burst*)).ab,ti.
21. exp Wounds, Stab/
22. exp Wounds, Gunshot/
23. exp Rupture/
24. 21 or 22 or 23
25. 13 and 24
26. ((wound* or stab* or gunshot or shot or penetrat*) adj3 (abdomen* or abdominal or stomach or splenic or spleen)).ab,ti.
27. ((spleen or splenic) adj3 (wound* or injur* or trauma* or perforat* or penetrate*)).ab,ti.
28. ((liver or hepatic) adj3 (wound* or injur* or trauma* or perforat* or penetrate*)).ab,ti.
29. 1 or 2 or 3 or 14 or 16 or 17 or 18 or 19 or 20 or 25 or 26 or 27 or 28
30. exp Surgery/
31. exp Laparotomy/
32. (laparotomy or re-laparotomy).ab,ti.
33. surgery.fs.
34. "minilaparotom*".ab,ti.
35. (laparotom* or re-laparotom*).ab,ti.
36. or/30-35
37. 29 and 36
38. randomi?ed.ab.
39. randomized controlled trial.pt.
40. controlled clinical trial.pt.
41. placebo.ab.
42. clinical trials as topic.sh.
43. randomly.ab.
44. trial.ti.
45. or/38-44
46. humans.sh.
47. 45 and 46
48. 47 and 37

EMBASE (OvidSP)

1. exp Abdominal Injury/
2. exp Abdomen/
3. exp Hemoperitoneum/
4. exp retroperitoneum/
5. 2 or 3 or 4
6. exp Multiple Trauma/
7. 5 and 6
8. 1 or 7
9. ((abdominal or abdomen) adj3 (injur* or trauma* or perforat* or penetrat*)).ab,ti.
10. ((stab* or gunshot or shot or wound*) adj3 (abdomen* or abdominal)).ab,ti.
11. 8 or 9 or 10
12. exp Abdominal Surgery/
13. exp Laparotomy/
14. 12 or 13
15. exp Injury/
16. 14 and 15
17. ((laparotomy or re-laparotomy or minilaparotomy) adj3 (injur* or trauma*)).ab,ti.
18. ((surgery or surgical) adj3 (abdomen or abdominal)).ti.
19. 16 or 17 or 18
20. 11 and 19
21. (damag* adj3 control*).ti,ab.
22. 19 and 21
23. 20 or 22
24. Human/
25. (placebo or 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.
26. 24 and 25
27. 23 and 26

**ISI Web of Science: Conference Proceedings Citation Index-Science;
ISI Web of Science: Science Citation Index Expanded (SCI-EXPANDED);**

Damage control surgery for abdominal trauma (Review)

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Topic=(abdominal or abdomen or spleen or splenic or stomach or gastric or retroperitoneum or hemoperitoneum or haemoperitoneum or thoracic or thorax) AND Topic=(injur* or trauma* or wound* or perforat* or penetrate* or multiple trauma or polytrauma) AND Topic=((surgery or surgical or laparotomy or re-laparotomy or minilaparotomy) and (damage control)) AND Topic=(random* or group* or trial or study or placebo)
Timespan=All Years. Databases=STP.

Current Controlled Trials MetaRegister: <http://www.controlled-trials.com/>

((surgery or surgical or laparotomy or re-laparotomy or minilaparotomy) and (damage control))

Clinicaltrials.gov

(abdominal OR abdomen) AND (injury OR trauma) AND (surgery)

Zetoc

abdom* injur* surg* random*

abdom* trauma* surg* random*

CINAHL (Ebsco Host)

TX (abdominal or abdomen or spleen or splenic or stomach or gastric or retroperitoneum or hemoperitoneum or haemoperitoneum or thoracic or thorax) and TX (injur* or trauma* or wound* or perforat* or penetrate* or multiple trauma or polytrauma) and TX ((surgery or surgical or laparotomy or re-laparotomy or minilaparotomy) and (damage control)) and TX (random* or group* or trial or study or placebo)

WHAT'S NEW

Date	Event	Description
31 January 2013	New search has been performed	The search has been updated to 19 December 2012. No new studies were identified. The conclusions remain the same.
31 January 2013	New citation required but conclusions have not changed	The search has been updated to 19 December 2012. No new studies were identified. The conclusions remain the same.

CONTRIBUTIONS OF AUTHORS

All authors contributed to the production of the review.

DECLARATIONS OF INTEREST

None known.

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External sources

- No sources of support supplied

INDEX TERMS

Medical Subject Headings (MeSH)

Abdominal Injuries [complications] [*surgery]; Acidosis [*prevention & control]; Blood Coagulation Disorders [*prevention & control]; Critical Care [methods]; Hypothermia [*prevention & control]

MeSH check words

Humans