Minimally invasive surgery versus open surgery for the treatment of solid abdominal and thoracic neoplasms in children (Review)

de Lijster MS, Bergevoet RM, van Dalen EC, Michiels EMC, Caron HN, Kremer LCM, Aronson DC

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[Intervention Review]

Minimally invasive surgery versus open surgery for the treatment of solid abdominal and thoracic neoplasms in children

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ABSTRACT

Background

Minimally invasive surgery (MIS) is an accepted surgical technique for the treatment of a variety of benign diseases. Presently, the use of MIS in patients with cancer is progressing. However, the role of MIS in children with solid neoplasms is less clear than it is in adults. Diagnostic MIS to obtain biopsy specimens for pathology has been accepted as a technique in paediatric surgical oncology, but there is limited experience with the use of MIS for the resection of malignancies.

Objectives

To ascertain the differences in outcome between the minimally invasive and open approach in the treatment of solid intra-thoracic and intra-abdominal neoplasms in children, regarding overall survival, event-free survival, port-site metastases, recurrence rate and surgical morbidity.

Search methods

We searched the electronic databases of MEDLINE/PubMed (from 1966 to February 2011), EMBASE/Ovid (from 1980 to February 2011) and CENTRAL (*The Cochrane Library* 2011, Issue 1) with pre-specified terms. In addition, we searched reference lists of relevant articles and reviews, conference proceedings and ongoing trial databases.

Selection criteria

Randomised controlled trials (RCTs) or controlled clinical trials (CCTs) comparing MIS and open surgery for the treatment of solid intra-thoracic or intra-abdominal neoplasms in children (aged 0 to 18 years).

Data collection and analysis

Two authors performed the study selection independently.

Main results

No studies that met the inclusion criteria of this review were identified.

Authors' conclusions

No RCTs or CCTs evaluating MIS in the treatment of solid intra-thoracic or intra-abdominal neoplasms in children could be identified, therefore no definitive conclusions could be made about the effects of MIS in these patients. Based on the currently available evidence we are not able to give recommendations for the use of MIS in the treatment of solid intra-thoracic or intra-abdominal neoplasms in children. More high quality studies (RCTs and/or CCTs) are needed. To accomplish this, centres specialising in MIS in children should collaborate.

PLAIN LANGUAGE SUMMARY

Minimally invasive surgery (MIS) compared to open surgery for the treatment of solid tumours located in the chest or the abdomen of children

MIS is an upcoming new surgical technique, which is used as a diagnostic instrument (i.e. to retrieve biopsies) and is also used for the resection of tumours. However, there is limited experience with the use of MIS for the resection of tumours in children.

This systematic review focused on (randomised) controlled studies. The authors could not identify any randomised controlled trials (RCTs) or controlled clinical trials (CCTs) on this subject to support the therapeutic use of MIS in children with solid tumours in the chest or abdomen. More high quality studies are needed.

BACKGROUND

Minimally invasive surgery (MIS) is an accepted surgical technique for the treatment of a variety of benign diseases. After the introduction of laparoscopic cholecystectomy, other surgical procedures such as appendectomy, fundoplication, splenectomy and nephrectomy were soon performed with the use of MIS (Bax 2005; Georgeson 2000; Georgeson 2003; Johnson 1997; Schmidt 2007; Ure 2000). In the short term, MIS showed postoperative advantages compared to open surgery, i.e. less pain, a shorter duration of postoperative ileus and better pulmonary function, leading to a more rapid recovery and shorter hospital stay (Bax 2005; Leung 2004; Milsom 1998).

In patients with cancer, the use of MIS is progressing. Although randomised studies in adult cancer patients have increasingly been published, in general it still remains controversial whether MIS will be the appropriate technique for the resection of many types of neoplasms with regard to long-term survival rates. Prospective studies comparing laparoscopy with laparotomy in adults in regard to resection of colon carcinoma initially showed short-term postoperative advantages (Leung 2004; Milsom 1998). However, the development of port-site metastases (Berends 1994; Lacy 2002) concerned surgeons as to the safety of tumour clearance through port sites, as did the long-term survival after laparoscopic resection as a consequence of this phenomenon (Lacy 2002). It became clear that any initial excitement had to await the results of randomised controlled trials (RCTs) that reported on longer-term follow-up data, i.e. overall survival (OS) and event-free survival (EFS). Lacy et al showed that the laparoscopic approach might have survival advantages over the conventional method, but this difference did not reach statistical significance (Lacy 2002). A meta-analysis by Liang et al showed that compared to open resection for colorectal cancer the laparoscopic approach did not increase the rates of overall recurrence, local recurrence, distant metastases and port or wound-site recurrences (Liang 2008). In a trial comprising 1248 adult patients randomly assigned to either laparoscopic or open resection for colon cancer, a small difference in disease-free survival at three years in favour of open colectomy could not be ruled out (Buunen 2009).

The role of MIS in children with solid neoplasms is less clear than it is in adults. There is growing experience in the use of MIS as a feasible technique to resect malignancies (Iwanaka 2004; Saenz 1997; Spurbeck 2004). Although the existing studies are all very positive about the growing role MIS may play in treating paediatric solid tumours in the future, most of the assumptions in this direction are based on results from studies in adults. Due to differences in tumour biology in children, and in the treatment

and prognosis of paediatric tumours, the extrapolation of results from studies in adults to children is quite controversial. To date MIS seems mostly to have a reliable diagnostic use in children (Metzelder 2007).

Up to date, therapeutic MIS is increasingly used to treat solid intra-thoracic and intra-abdominal neoplasms in children without (extensive) evidence (Al-Shanafey 2008; Castilho 2002; Leclair 2007; Warmann 2003). This is an update of the first systematic review evaluating the state of evidence on this topic, focusing on randomised controlled trials (RCTs) and controlled clinical trials (CCTs).

OBJECTIVES

Primary objective

To ascertain the differences in outcome between the minimally invasive and open approach in the treatment of solid intra-abdominal or intra-thoracic neoplasms in children regarding overall survival (OS), event-free survival (EFS), port-site metastases and recurrence rate.

Secondary objective

To ascertain the differences in surgical morbidity between the minimally invasive and open approach.

METHODS

Criteria for considering studies for this review

Types of studies

Randomised controlled trials (RCTs) or controlled clinical trials (CCTs) comparing minimally invasive surgery (MIS) and open surgery for the treatment of intra-thoracic or intra-abdominal solid neoplasms. A CCT is a study that compares one or more intervention groups to one or more control groups (Higgins 2005).

Types of participants

Children (aged 0 to 18 years at diagnosis) with solid intra-thoracic or intra-abdominal neoplasms who were treated with MIS or open surgery (irrespective of previous therapy).

Types of interventions

MIS (laparoscopy or thoracoscopy) compared to open surgery (laparotomy or thoracotomy).

Types of outcome measures

Primary outcomes

- Overall survival (OS): defined as the time from surgery to death from any cause.
- Event-free survival (EFS): as defined by the authors of the original study.
- Port-site metastases: defined as tumour recurrence in trocar sites or surgical wounds.
- Recurrence rate: defined as the rate of either local or distant recurrence.

Secondary outcome

- Surgical morbidity, with regard to length of operation, intra-operative blood loss, postoperative complications (such as wound infection and bleeding), restart of oral intake, pain score and length of hospital stay.

Search methods for identification of studies

We searched the following electronic databases: MEDLINE/PubMed (from 1966 to February 2011), EMBASE/Ovid (from 1980 to February 2011) and CENTRAL (*The Cochrane Library* 2011, Issue 1).

The search strategies for the different electronic databases (using a combination of controlled vocabulary and text word terms) are shown in the Appendices (Appendix 1; Appendix 2; Appendix 3). We located information about trials not registered in MEDLINE, EMBASE or CENTRAL, either published or unpublished, by searching the reference lists of relevant articles and reviews. We also scanned the conference proceedings of the International Society for Paediatric Oncology (SIOP) and American Society of Clinical Oncology (ASCO) from 2003 to 2010, if available electronically and otherwise by handsearching. We searched for ongoing studies in the ISRCTN Register and the National Institutes of Health (NIH) register on www.controlled-trials.com (searched in February 2011). We imposed no language restriction.

Data collection and analysis

Study identification

After employing the search strategy described previously, two authors independently undertook identification of studies meeting the inclusion criteria. Discrepancies were resolved by consensus; no third party arbitration was needed. Any study seemingly meeting the inclusion criteria on the grounds of title, abstract, or both, was obtained in full for closer inspection. We clearly stated details of reasons for exclusion of any study considered for the review (see the Characteristics of excluded studies table).

Risk of bias in included studies

If eligible studies had been identified, two independent authors would have assessed the risk of bias in these studies according to the criteria of the Cochrane Childhood Cancer Group (Module CCG). However, since no eligible studies were identified the assessment of the risk of bias was not applicable.

Data extraction

Since no eligible studies were identified, data extraction by two independent authors using a standardised form could not be performed.

Data analyses

No eligible studies were identified. As a result, data analyses could not be performed.

RESULTS

Description of studies

See: Characteristics of excluded studies.

After performing the searches of the electronic databases of MEDLINE/PubMed, EMBASE/Ovid and CENTRAL, we identified 378 references (129 in the update). Initial screening of the titles and/or abstracts excluded 372 references which clearly did not meet all criteria for considering studies for this review. We obtained six articles in full. However, these studies were not randomised controlled trials (RCTs) or controlled clinical trials (CCTs) evaluating MIS in children with solid intra-thoracic or intra-abdominal neoplasms and were thus not eligible for inclusion in this review (see the Characteristics of excluded studies table).

Scanning the reference lists of relevant studies and reviews, and scanning the conference proceedings of SIOP and ASCO, did not identify any other eligible studies. Scanning the ongoing trials databases did not identify any eligible (ongoing) studies.

In summary, our search did not identify any eligible RCTs or CCTs evaluating MIS for the treatment of solid intra-thoracic or intra-abdominal neoplasms in children.

Risk of bias in included studies

Since no eligible studies were identified, the assessment of the risk of bias in included studies is not applicable.

Effects of interventions

Since no eligible studies were identified, the effects of MIS versus open surgery for the treatment of solid intra-thoracic or intra-abdominal neoplasms in children remain unclear.

DISCUSSION

Minimally invasive surgery (MIS) is well established for many operative procedures in adults, including biopsies to confirm a diagnosis, staging of malignancies and surgical treatment of malignancies (Buunen 2009; Spurbeck 2004). The use of MIS in the evaluation and treatment of solid neoplasms in children has increased rapidly over the last decade (Al-Shanafey 2008; Castilho 2002; Duarte 2009; Leclair 2007; Metzelder 2007; Sailhamer 2003; Spurbeck 2004; Varlet 2009; Warmann 2003). This is an update of the first systematic review evaluating the current state of evidence on the therapeutic use of MIS in children with solid intra-thoracic or intra-abdominal tumours.

To evaluate the role of MIS in the treatment of solid intra-thoracic and intra-abdominal childhood tumours adequately the best study design, with the highest level of evidence, is a randomised controlled trial (RCT). Unfortunately, we could not identify any such study. We similarly also identified no eligible controlled clinical trials (CCTs).

Even though results from adult RCTs in patients with colon cancer are promising (Buunen 2009; Lacy 2002; Leung 2004), extrapolation of results from studies in adults to children is not possible, given the different tumour biology of adult and paediatric malignancies, and the differences in the therapy and prognosis of cancer in children. For example, the short-term advantages of MIS in adults as compared to the open approach might be less in children, since children recover faster after an open surgical procedure than adults. RCTs in children with solid intra-thoracic or intra-abdominal neoplasms are therefore needed. In the past, a RCT was started to evaluate the role of MIS in children with cancer, but unfortunately this study failed (Ehrlich 2002). Reasons for failing included failure to accrue patients, lack of surgical expertise with MIS procedures within surgical teams and preconceived surgeon bias towards each surgical approach. When using MIS as a new technique, most complications occur during the learning curve (Song 2009); only with experience can the constraints of MIS be overcome. However, in the paediatric field the number of patients is limited, making the learning curve longer. Despite the small size of the abdominal cavity in children, which can restrict adequate

visualisation, Iwanaka et al have shown that laparoscopic resection of solid tumours, such as neuroblastomas, is feasible (Iwanaka 2004). Another difficulty in comparing MIS with open surgery in the paediatric oncologic population is the ongoing progress with different pre- and postoperative chemotherapy and radiotherapy treatments. Long-term follow-up results (survival) will therefore be difficult to compare, unless the operative technique becomes part of the trial.

Even though RCTs are the highest level of evidence, it should be recognised that data from non-randomised studies on the use of MIS in different types of solid intra-thoracic and intra-abdominal childhood tumours are available. The results are promising (Al-Shanafey 2008; Castilho 2002; Duarte 2009; Iwanaka 2004; Leclair 2007; Metzelder 2007; Sailhamer 2003; Shanberg 2006; Spurbeck 2004; Varlet 2009; Warmann 2003). Most of these studies included retrospective cohort studies; only a few prospective cohort studies were performed. Duarte et al, for example, concluded that laparoscopic nephrectomy for Wilms' tumour is a feasible and safe procedure in the short term in a selected group of children after chemotherapy. They mentioned that MIS has important advantages, such as shorter hospital stay and cosmetically more acceptable incisions (Duarte 2009).

However, the role of MIS as a primary curative technique compared to open surgery in children with solid intra-thoracic or intra-abdominal tumours can only be adequately determined through evaluation within prospective RCTs. Hence, surgeons have to realise that currently MIS for solid intra-thoracic or intra-abdominal neoplasms in children has to be regarded as an experimental treatment that should only be performed in the context of a trial.

AUTHORS' CONCLUSIONS

Implications for practice

Since no randomised controlled trials (RCTs) and controlled clinical trials (CCTs) evaluating the role of minimally invasive surgery (MIS) in solid intra-thoracic or intra-abdominal neoplasms in children are available, no definitive conclusions can be made about the effects on anti-tumour efficacy (i.e. overall survival (OS) and event-free survival (EFS)) and surgical morbidity of this treatment. Based on the currently available evidence, we are not able to give recommendations for clinical practice. MIS for solid intra-thoracic or intra-abdominal neoplasms in children currently must be regarded as an experimental treatment that should only be performed in the context of a trial. The role of MIS for paediatric solid tumours therefore remains a challenge and has yet to be defined.

Implications for research

We identified no RCTs or CCTs evaluating the role of MIS in solid intra-thoracic or intra-abdominal neoplasms in children. Before conclusions can be made about the effects on anti-tumour efficacy and surgical morbidity high quality RCTs and/or CCTs need to be undertaken. These RCTs and CCTs should be performed in homogeneous study populations (for example, with regard to tumour type and stage of disease). They should have a long-term follow up and the number of included patients should be sufficient to obtain the power needed for the results to be reliable. To obtain adequate numbers of patients, centres specialising in MIS in children should collaborate.

ACKNOWLEDGEMENTS

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Ehrlich 2002 *{published data only}*
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Iwanaka 2004 *{published data only}*
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De Lijster MS, Bergevoet RM, van Dalen EC, Michiels EMC, Caron HN, Kremer LCM, et al.Minimally invasive surgery versus open surgery for the treatment of solid abdominal and thoracic neoplasms in children. *Cochrane Database of Systematic Reviews* 2010, Issue 3. [DOI: 10.1002/14651858.CD008403]

* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

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

Study	Reason for exclusion
Duarte 2006	Not a RCT/CCT; case series
Ehrlich 2002	Not a RCT/CCT; questionnaire
Iwanaka 2004	Not a RCT/CCT; retrospective cohort
Malek 2010	Not a RCT/CCT; retrospective chart review
Shanberg 2006	Not a RCT/CCT; letter to the editor regarding case reports
Stanford 2002	Not a RCT/CCT; retrospective cohort study

RCT: randomised controlled trial; CCT: controlled clinical trial

DATA AND ANALYSES

This review has no analyses.

APPENDICES

Appendix 1. Search strategy for PubMed

1. For the **different surgical interventions** the following MeSH headings and text words were used:
(MIS OR Surgical Procedures, Minimally Invasive OR Minimally Invasive Surgery OR Procedures, Minimal Access Surgical OR Procedures, Minimal Surgical OR Procedures, Minimally Invasive Surgical OR Minimal Access Surgical Procedures OR Minimal Surgical Procedures OR Procedure, Minimal Surgical OR Minimally Invasive Surgical Procedures OR Minimal Surgical Procedure OR Surgical Procedure, Minimal OR Surgical Procedures, Minimal OR Surgical Procedures, Minimal Access OR minimally invasive surgical procedure OR minimal access surgical procedure OR laparoscopy OR laparoscopies OR laparoscope OR laparoscopes OR laparos* OR laparoscopic OR Celioscopy OR Celioscopies OR Peritoneoscopy OR Peritoneoscopies OR Surgical Procedures, Laparoscopic OR Procedures, Laparoscopic Surgical OR Surgery, Laparoscopic OR Laparoscopic Surgical Procedure OR Procedure, Laparoscopic Surgical OR Laparoscopic Surgical Procedures OR Laparoscopic Surgery OR Laparoscopic Surgeries OR Surgeries, Laparoscopic OR Surgical Procedure, Laparoscopic OR thoracoscopy OR thoracoscopies OR thoracoscope OR thoracoscopes OR thoracos* OR thoracoscopic Endoscopy, Pleural OR Endoscopies, Pleural OR Pleural Endoscopies OR Pleural Endoscopy OR Pleuroscopy OR Pleuroscopies OR Surgical Procedures, Thoracoscopic OR Surgical Procedure, Thoracoscopic OR Thoracoscopic Surgical Procedure OR Surgery, Thoracoscopic OR Surgeries, Thoracoscopic OR Thoracoscopic Surgeries OR Thoracoscopic Surgery OR Thoracoscopic Surgical Procedures OR VATS OR VATSS OR Surgeries, Video-Assisted Thoracic OR Surgery, Video-Assisted Thoracic OR Thoracic Surgeries, Video-Assisted OR Thoracic Surgery, Video Assisted OR Video-Assisted Thoracic Surgeries OR Surgery, Thoracic, Video-Assisted OR Video-Assisted Thoracic Surgery OR Video Assisted Thoracic Surgery OR Video-Assisted Thoracoscopic Surgery OR Surgeries, Video-Assisted Thoracoscopic OR Surgery, Video-Assisted Thoracoscopic OR Thoracoscopic Surgeries, Video-Assisted OR Thoracoscopic Surgery, Video-Assisted OR Video Assisted Thoracoscopic Surgery OR Video-Assisted Thoracoscopic Surgeries OR videolaparoscopy OR videolaparoscopies)
2. For **childhood cancer** the following MeSH headings and text words were used:
(((lymphoma OR lymphom* OR hodgkin OR hodgkin* OR T-cell OR B-cell OR non-hodgkin OR sarcoma OR sarcom* OR sarcoma, Ewing's OR Ewing* OR osteosarcoma OR osteosarcom* OR wilms tumor OR wilms* OR nephroblastom* OR neuroblastoma OR neuroblastom* OR rhabdomyosarcoma OR rhabdomyosarcom* OR teratoma OR teratom* OR hepatoma OR hepatom* OR hepatoblastoma OR hepatoblastom* OR PNET OR medulloblastoma OR medulloblastom* OR PNET* OR neuroectodermal tumors, primitive OR retinoblastoma OR retinoblastom* OR meningioma OR meningiom* OR glioma OR gliom*) OR (pediatric oncology OR paediatric oncology)) OR (childhood cancer OR childhood tumor OR childhood tumors)) OR (brain tumor* OR brain tumour* OR brain neoplasms OR central nervous system neoplasm OR central nervous system neoplasms OR central nervous system tumor* OR central nervous system tumour* OR brain cancer* OR brain neoplasm* OR intracranial neoplasm*)
3. For **children** the following MeSH headings and text words were used:
infant OR infan* OR newborn OR newborn* OR new-born* OR baby OR baby* OR babies OR neonat* OR perinat* OR postnat* OR child OR child* OR schoolchild* OR schoolchild OR school child OR school child* OR kid OR kids OR toddler* OR adolescent OR adoles* OR teen* OR boy* OR girl* OR minors OR minors* OR underag* OR under ag* OR juvenil* OR youth* OR kindergar* OR puberty OR puber* OR pubescen* OR prepubescen* OR prepuberty* OR pediatrics OR pediatric* OR paediatric* OR peadiatric* OR schools OR nursery school* OR preschool* OR pre school* OR primary school* OR secondary school* OR elementary school* OR elementary school OR high school* OR highschool* OR school age OR schoolage OR school age* OR schoolage* OR infancy OR schools, nursery OR infant, newborn
4. For **Cochrane RCTs/CCTs** the following MeSH headings and text words will be used:
((randomized controlled trial[pt]) OR (controlled clinical trial[pt]) OR (randomized[tiab]) OR (placebo[tiab]) OR (drug therapy[sh]) OR (randomly[tiab]) OR (trial[tiab]) OR (groups[tiab])) AND (humans[mh])
Final search 1 AND 2 AND 3 AND 4
[pt = publication type; tiab = title, abstract; sh = subject heading; mh = MeSH term; *=one or more characters;RCT = randomized controlled trial; CCT = controlled clinical trial]

Appendix 2. Search strategy for Embase (OVID)

1. For the **different surgical interventions** the following Emtree terms and text words were used:
1. (MIS or minimally invasive surgical procedures or minimally invasive surgery or minimal surgical procedure or minimal access surgical procedures or minimal surgical procedures or minimally invasive surgical procedure or minimal access surgical procedure or minimally invasive procedure or minimally invasive procedures).mp.
2. (laparoscopy or laparoscopies or celioscopy or celioscopies or peritoneoscopy or peritoneoscopies or laparoscopic surgical procedure or laparoscopic surgical procedures or laparoscopic surgery or laparoscopic surgeries).mp.
3. (laparoscope or laparoscopes or laparos$ or laparoscopic).mp.
4. (thoracoscopy or thoracoscopies or pleural thoracoscopic endoscopy or pleural thoracoscopic endoscopies or pleural endoscopy or pleural endoscopies or pleuroscopy or pleuroscopies or thoracoscopic surgical procedure or thoracoscopic surgical procedures or thoracoscopic surgery or thoracoscopic surgeries).mp.
5. (thoracoscope or thoracoscopes or thoracos$ or thoracoscopic).mp.
6. (VATS or VATSS or videolaparoscopy or videolaparoscopies or (video adj assisted thoracoscopic surgery) or (video adj assisted thoracoscopic surgeries) or (video adj assisted thoracic surgery)).mp.
7. minimally invasive surgery/ or laparoscopy/ or laparoscope/ or thoracoscopy/ or thoracoscope/ or abdominal surgery/ or thorax surgery/ or laparoscopic surgery/ or endoscopic surgery/
8. or/1-7
2. For **childhood cancer** the following Emtree terms and text words were used:
1. (lymphoma or lymphom$ or hodgkin or hodgkin$ or T-cell or B-cell or non-hodgkin).mp.
2. (sarcoma or sarcom$ or Ewing$ or osteosarcoma or osteosarcom$ or wilms tumor or wilms$).mp.
3. (nephroblastom$ or neuroblastoma or neuroblastom$ or rhabdomyosarcoma or rhabdomyosarcom$ or teratoma or teratom$ or hepatoma or hepatom$ or hepatoblastoma or hepatoblastom$).mp.
4. (PNET or medulloblastoma or medulloblastom$ or PNET$ or neuroectodermal tumors or primitive neuroectodermal tumor$ or retinoblastoma or retinoblastom$ or meningioma or meningiom$ or glioma or gliom$).mp.
5. (pediatric oncology or paediatric oncology).mp.
6. ((childhood adj cancer) or (childhood adj tumor) or (childhood adj tumors) or childhood malignancy or (childhood adj malignancies) or childhood neoplasm$).mp.
7. ((pediatric adj malignancy) or (pediatric adj malignancies) or (paediatric adj malignancy) or (paediatric adj malignancies)).mp.
8. ((brain adj tumor$) or (brain adj tumour$) or (brain adj neoplasms) or (brain adj cancer$) or brain neoplasm$).mp.
9. (central nervous system tumor$ or central nervous system neoplasm or central nervous system neoplasms or central nervous system tumour$).mp.
10. intracranial neoplasm$.mp.
11. LYMPHOMA/ or brain tumor/ or central nervous system tumor/ or teratoma/ or sarcoma/ or osteosarcoma/
12. nephroblastoma/ or neuroblastoma/ or rhabdomyosarcoma/ or hepatoblastoma/ or medulloblastoma/ or neuroectodermal tumor/ or retinoblastoma/ or meningioma/ or glioma/ or childhood cancer/
13. or/1-12
3. For **children** the following Emtree terms and text words were used:
1. infant/ or infancy/ or newborn/ or baby/ or child/ or preschool child/ or school child/
2. adolescent/ or juvenile/ or boy/ or girl/ or puberty/ or prepuberty/ or pediatrics/
3. primary school/ or high school/ or kindergarten/ or nursery school/ or school/
4. or/1-3
5. (infant$ or newborn$ or (new adj born$) or baby or baby$ or babies or neonate$ or perinat$ or postnat$).mp.
6. (child$ or (school adj child$) or schoolchild$ or (school adj age$) or schoolage$ or (pre adj school$) or preschool$).mp.
7. (kid or kids or toddler$ or adoles$ or teen$ or boy$ or girl$).mp.
8. (minors$ or (under adj ag$) or underage$ or juvenil$ or youth$).mp.
9. (puber$ or pubescen$ or prepubescen$ or prepubert$).mp.
10. (pediatric$ or paediatric$ or peadiatric$).mp.
11. (school or schools or (high adj school$) or highschool$ or (primary adj school$) or (nursery adj school$) or (elementary adj school) or (secondary adj school$) or kindergar$).mp.
12. or/5-11
13. 4 or 12
4. For Cochrane RCTs/CCTs the following Emtree terms and text words were used:

1. Randomized Controlled Trial/
2. Controlled Clinical Trial/
3. randomized.ti,ab.
4. placebo.ti,ab.
5. randomly.ti,ab.
6. trial.ti,ab.
7. groups.ti,ab.
8. drug therapy.sh.
9. or/1-8
10. Human/
11. 9 and 10
Final search 1 and 2 and 3 and 4
[mp = title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name; sh = subject heading; ti,ab = title, abstract; / = Emtree term; $=zero or more characters ; RCT = randomized controlled trial; CCT = controlled clinical trial]

Appendix 3. Search strategy for Cochrane Central Register of Controlled Trials (CENTRAL)

1. For the **different surgical interventions** the following text words were used:
(MIS OR Minimally Invasive Surgery OR Minimal Access Surgical Procedures OR Minimal Surgical Procedures OR Minimally Invasive Surgical Procedures OR Minimal Surgical Procedure OR minimally invasive surgical procedure OR minimal access surgical procedure OR laparoscopy OR laparoscopies OR laparoscope OR laparoscopes OR laparos* OR laparoscopic OR Celioscopy OR Celioscopies OR Peritoneoscopy OR Peritoneoscopies OR Laparoscopic Surgical Procedure OR Laparoscopic Surgical Procedures OR Laparoscopic Surgery OR Laparoscopic Surgeries OR thoracoscopy OR thoracoscopies OR thoracoscope OR thoracoscopes OR thoracos* OR thoracoscopic OR Pleural Endoscopies OR Pleural Endoscopy OR Pleuroscopy OR Pleuroscopies OR Thoracoscopic Surgical Procedure OR Thoracoscopic Surgeries OR Thoracoscopic Surgery OR Thoracoscopic Surgical Procedures OR VATS OR VATSS OR Video-Assisted Thoracic Surgeries OR Video-Assisted Thoracic Surgery OR Video Assisted Thoracic Surgery OR Video-Assisted Thoracoscopic Surgery OR Video Assisted Thoracoscopic Surgery OR Video-Assisted Thoracoscopic Surgeries OR videolaparoscopy OR videolaparoscopies):ti,ab,kw
2. For **childhood cancer** the following text words were used:
(lymphoma OR lymphom* OR hodgkin OR hodgkin* OR T-cell OR B-cell OR non-hodgkin OR sarcoma OR sarcom* OR Ewing* OR osteosarcoma OR osteosarcom* OR wilms tumor OR wilms* OR nephroblastom* OR neuroblastoma OR neuroblastom* OR rhabdomyosarcoma OR rhabdomyosarcom* OR teratoma OR teratom* OR hepatoma OR hepatom* OR hepatoblastoma OR hepatoblastom* OR PNET OR medulloblastoma OR medulloblastom* OR PNET* OR primitive neuroectodermal tumors OR retinoblastoma OR retinoblastom* OR meningioma OR meningiom* OR glioma OR gliom* OR pediatric oncology OR paediatric oncology OR childhood cancer OR childhood tumor OR childhood tumors OR brain tumor* OR brain tumour* OR brain neoplasms OR central nervous system neoplasm OR central nervous system neoplasms OR central nervous system tumor* OR central nervous system tumour* OR brain cancer* OR brain neoplasm* OR intracranial neoplasm*):ti,ab,kw
3. For **children** the following text words were (will be) used:
(infant OR infan* OR newborn OR newborn* OR new-born* OR baby OR baby* OR babies OR neonat* OR perinat* OR postnat* OR child OR child* OR schoolchild* OR schoolchild OR school child OR school child* OR kid OR kids OR toddler* OR adolescent OR adoles* OR teen* OR boy* OR girl* OR minors OR minors* OR underag* OR under ag* OR juvenil* OR youth* OR kindergar* OR puberty OR puber* OR pubescen* OR prepubescen* OR prepuberty* OR pediatrics OR pediatric* OR paediatric* OR peadiatric* OR schools OR nursery school* OR preschool* OR pre school* OR primary school* OR secondary school* OR elementary school* OR elementary school OR high school* OR highschool* OR school age OR schoolage OR school age* OR schoolage* OR infancy):ti,ab,kw
Final search 1 AND 2 AND 3
The search will be performed in title, abstract or keywords
[*=zero or more characters]

WHAT'S NEW

Last assessed as up-to-date: 7 August 2011.

Date	Event	Description
15 June 2011	New citation required but conclusions have not changed	Unfortunately, no new studies could be included in the review. As a result the conclusions have not changed
15 June 2011	New search has been performed	The search for eligible studies was updated to February 8th 2011

HISTORY

Review first published: Issue 3, 2010

CONTRIBUTIONS OF AUTHORS

Manou de Lijster designed the study and wrote the protocol, identified studies meeting the inclusion criteria, interpreted the results, and wrote the manuscript and revised the manuscript.

Rosemarijn Bergevoet identified studies meeting the inclusion criteria, searched for unpublished studies, interpreted the results and wrote the manuscript.

Elvira van Dalen designed the study, developed the search strategy, identified studies meeting the inclusion criteria, searched for unpublished and ongoing studies, interpreted the results, and wrote and revised the manuscript.

Erna Michiels designed the study, identified studies meeting the inclusion criteria, interpreted the results and critically reviewed the manuscript.

Huib Caron designed the study, interpreted the results and critically reviewed the manuscript.

Leontien Kremer designed the study, identified studies meeting the inclusion criteria, interpreted the results and critically reviewed the manuscript.

Daniel Aronson designed the study, identified studies meeting the inclusion criteria, searched for unpublished studies, interpreted the results and critically reviewed the manuscript.

All authors approved the final version.

DECLARATIONS OF INTEREST

None known.

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- Dutch Cochrane Centre, Netherlands.

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- Stichting Kinderen Kankervrij (KIKA), Netherlands.

INDEX TERMS

Medical Subject Headings (MeSH)

*Surgical Procedures, Minimally Invasive; Abdominal Neoplasms [*surgery]; Thoracic Neoplasms [*surgery]

MeSH check words

Child; Humans