Effect of heated and humidified carbon dioxide on patients after laparoscopic procedures: a meta-analysis
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CRD summary
This review concluded that heated humidified carbon dioxide during laparoscopy was more effective than dry carbon dioxide in pain reduction, analgesic use and risk of hypothermia, and should be considered as first choice for pneumoperitoneum in laparoscopic procedures. Given several limitations with the included studies and potential for bias, the authors’ conclusions should be interpreted with caution.

Authors' objectives
To compare the after effects of using standard dry carbon dioxide (CO\textsubscript{2}) versus heated and humidified CO\textsubscript{2} to create pneumoperitoneum (insufflation of the abdomen) in patients who underwent laparoscopic procedures.

Searching
MEDLINE, PubMed, EMBASE, CINAHL and The Cochrane library were searched up to September 2007. Search terms were reported. References of retrieved articles were manually searched.

Study selection
Clinical trials of abdominal laparoscopic procedures (performed under general anaesthesia) that compared use of standard dry CO\textsubscript{2} versus heated and humidified CO\textsubscript{2} to create pneumoperitoneum in patients were eligible for inclusion. The outcomes of interest were postoperative pain, total analgesia use, hospital stay, hypothermia and lens fogging. Included studies were of patients who underwent the following types of surgery: gynaecologic; cholecystectomy; fundoplication; bariatric; or diagnostic laparoscopy. Postoperative pain was measured using a visual analogue scale (0 to 10). The same type of CO\textsubscript{2} humidifying device was used in seven studies.

Two reviewers screened the relevant articles for inclusion. It was unclear how discrepancies were resolved.

Assessment of study quality
The quality of included studies was assessed using the following criteria: method of randomisation; allocation concealment; blinding; baseline comparability; intention-to-treat (ITT) analyses; and sample size calculation. The authors did not state how many reviewers performed the validity assessment.

Data extraction
Two reviewers independently extracted continuous data (pain score, hypothermia and use of analgesia) to calculate mean differences, and binary data (hospital stay and lens fogging) to calculate odds ratios (ORs), with their 95% confidence intervals (CIs). Where necessary, outcome data on pain were converted into units of the visual analogue scale using a standard (self-designed) format. Data extraction was checked by a third reviewer.

Methods of synthesis
Fixed-effect and random-effects models were used to pool standardised mean differences (SMDs) and odds ratios, and their 95% CIs, taking into account the inverse of the variance. A score of 0.5 was added to each outcome variable that scored zero. Attempts were made to assess for publication bias using a funnel plot. Statistical heterogeneity was assessed using the Cochran Q statistic. Potential causes of methodological and clinical heterogeneity were investigated.

Results of the review
Ten randomised controlled trials (RCTs) (n=565) were included in the review. Sample sizes ranged from 20 to 101 patients. Quality of included studies was reported to be adequate; nine RCTs were blinded and allocation was adequately concealed.
Heated and humidified CO\textsubscript{2} was significantly more effective than standard dry CO\textsubscript{2} in reducing postoperative pain (SMD -1.60, 95% CI -2.52 to -0.69; nine RCTs, random-effects model) and reducing the need for postoperative analgesia (SMD -0.81, 95% CI -1.63 to -0.0007; eight RCTs, random-effects model). There was evidence of significant statistical heterogeneity among trials that reported each of these outcomes (all p=0.0000).

The authors reported that there were no significant differences between treatment groups in lowering the risk of hypothermia, lens fogging and length of hospital stay. However, graphical presentation of the results in the forest plot indicated that standard CO\textsubscript{2} was significantly more effective than heated humidified CO\textsubscript{2} in lowering the risk of lens fogging (OR 2.61, 95% CI 2.0 to 3.41; seven RCTs).

**Authors' conclusions**

Laparoscopic procedures that used heated and humidified CO\textsubscript{2} reduced postoperative pain, lowered the risk of postoperative hypothermia and lowered analgesic use in patients with pneumoperitoneum and should be considered as first choice for pneumoperitoneum in laparoscopic procedures.

**CRD commentary**

The review question was clear. Appropriate inclusion criteria were stated, although criteria for study design were a little unclear. An adequate literature search was undertaken (five electronic databases and one other appropriate source). There was no apparent search for unpublished data, which meant that relevant papers may have been missed. Attempts were made to assess for publication bias, but this was hindered by the small number of trials. It was unclear whether the search included articles in any language, so it was unclear whether language bias may have been introduced.

Study quality was assessed using appropriate criteria and the quality of the trials was adequate. The authors made some attempt to reduce potential for reviewer error and bias during study selection and data extraction by performing these in duplicate. However, this was not the case for validity assessment and so reviewer error and bias could not be ruled out completely. Appropriate methods were used to combine results and investigate heterogeneity, but evidence of significant clinical and methodological heterogeneity suggested that it may not have been appropriate to combine the trials. Details on patient and study characteristics were limited, as were data presented in the forest plots. There was a discrepancy in reporting the results for lens fogging, which suggested that standard CO\textsubscript{2} was more effective than heated and humidified CO\textsubscript{2} and was not reflected in the authors' conclusions. Confidence intervals were not detailed on the forest plots, but looked wide for some trials and often crossed zero or one, which questioned the robustness of the results. Sample sizes were small (most studies included less than 100 patients).

Although the authors' conclusions appeared to reflect the evidence, the above limitations mean their conclusions should be interpreted with caution.

**Implications of the review for practice and research**

**Practice**: The authors stated that heated and humidified CO\textsubscript{2} could not be recommended for all laparoscopic procedures due to the variations in the type and length of operations.

**Research**: The authors stated that a large procedure-specific multicentre randomised controlled trial was required to investigate the effects of heated and humidified CO\textsubscript{2} in laparoscopic procedures.

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